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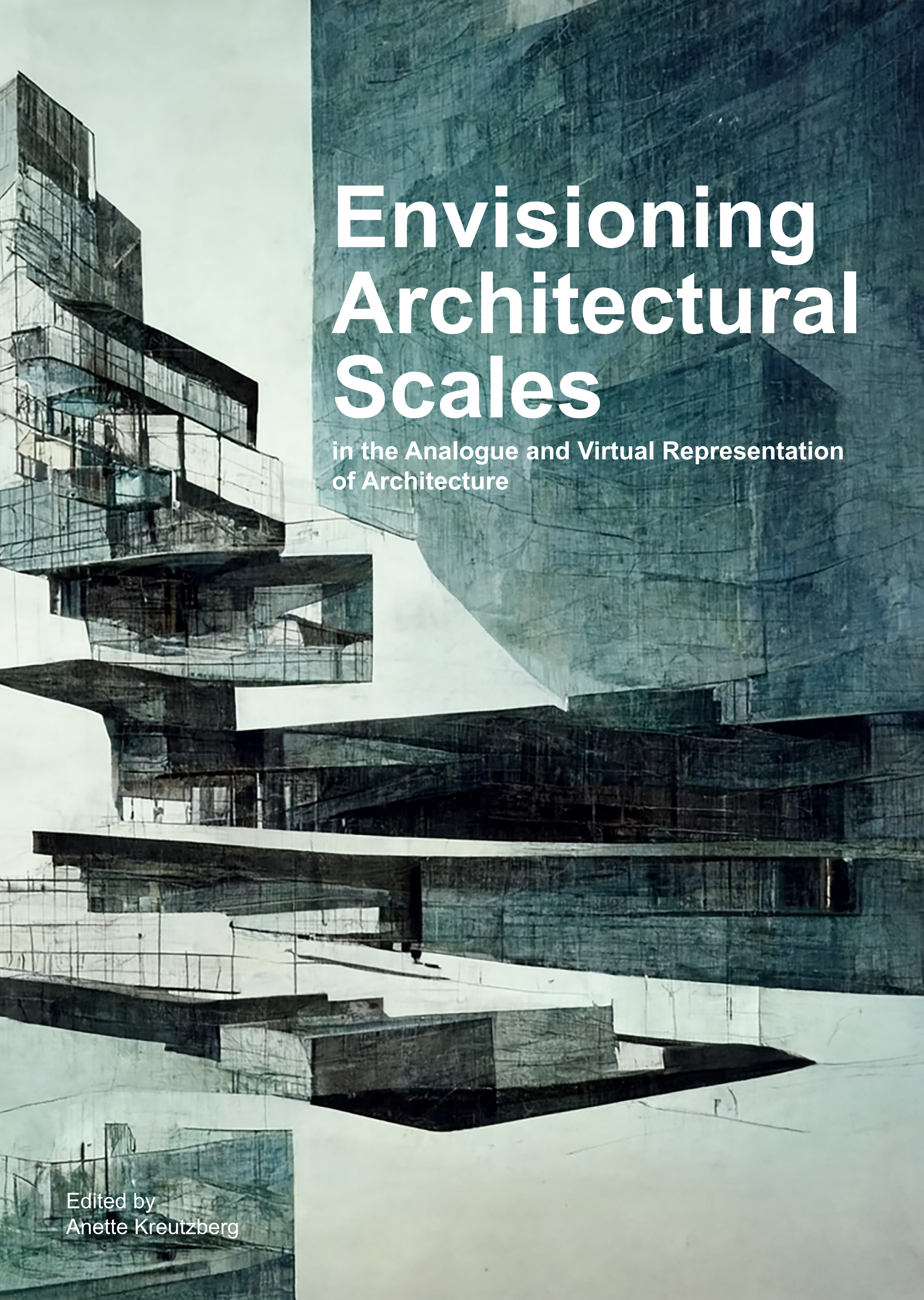

Envisioning Architectural Scales

in the Analogue and Virtual Representation of Architecture

Edited by
Anette Kreutzberg

EAEA16

Envisioning Architectural Scales

in the Analogue and Virtual Representation of Architecture

Proceedings of the 16th International Conference of the
European Architectural Envisioning Association

August 30th - September 1st 2023
Royal Danish Academy
Architecture, Design, Conservation
Copenhagen, Denmark

Edited by
Anette Kreutzberg

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Contents

EAEA16: Envisioning Architectural Scales in the Analogue and Virtual Representation of Architecture

Introduction

This monograph is the result of the 16th European Architectural Envisioning Association Conference, entitled 'Envisioning Architectural Scales in the Analogue and Virtual Representation of Architecture' hosted by the Department of Architecture and Design, Royal Danish Academy, Copenhagen, Denmark, August 30st to September 1st 2023.

Following the mission of the European Architectural Envisioning Association, the conference was intended as a platform for communication and exchange of experience, experimentation, research and collaboration in the field of envisioning architecture, and for this 16th edition with a special focus on architectural scales.

We were particularly pleased to host the bianual conference this year with Copenhagen designated the World Capital of Architecture by UNESCO and hosting the UIA World Congress of Architects.

The EAEA16 theme

The theme 'Envisioning Architectural Scales in the Analogue and Virtual Representation of Architecture' addresses both the broad theoretical and the applied use of the term 'scale' within the architecture and related fields. Understanding the many aspects of scale within architecture will provide a foundation for understanding scale and its impact in architecture and its representations. Scale is widely used both as a measure of geometrical space in relation to buildings and landscape in the physical and virtual world, but also as a measurement of sound, colour, light, and time. With a focus on the architectural scales in relation to all aspects of scale, the conference aims at expanding the knowledge of the use of scale in architecture.

The importance of scale as an analytical awareness on size and its relations is a phenomenon within architecture that can be addressed in numerous ways. The human scale, the scalelessness of virtual or digital models, or the scaling up and down through a variety of parameters in a representational architectural model, just to mention a few. But how can the concept of scale be used to clarify and operationalize the vast number of possible inputs influencing the creation of architecture and relate them to our physical world of living people and architecture users?

EAEA 2023 provided an opportunity to explore and discuss architectural scale and its multifaceted definitions, uses, and impacts in manifestations of virtual or analogue architectural representations and models.

Considering the multiple applications of scale in architecture, the EAEA2023 Conference sessions were organized in three different topics/areas of investigation, which addressed several research questions. The emphasis was on envisioning architectural scales in the analogue and virtual representation of architecture. Inter-disciplinary and cross-disciplinary approaches which include architecture and related disciplines were also encouraged.

Scale and theory

Definitions of architectural scale are important to ensure a common language in addressing the build environment both in its physical, geometrical shape, but also as an aesthetic terminology that can be used to determine relation between varied sizes and their relational impact. What are we talking about with the term architectural scale? Why are the definitions important and how can they be applied effectively?

Scale and the senses

Many of the fundamental tangible traits of architecture can be measured and evoked through different uses of the term scale. How does the scalability of architectural height, width, depth, color, and light inflict the ways of thinking and working with design and research within the field? What are the key features of a scalability through the senses?

Scale and representation

The scale and scalability as applied and used in the architectural models of representation has always been a means of communicating design ideas before the full-scale architecture can be built. The representation models operate through a conceptually defined use of scale, but what happens in the digital regime? Is scale and its inherent scalability in the digital realm indeed scaleless, and to what extent, and by what terms, can we address and discuss the scalability within digital and analogue architecture?

The monograph

The layout of this book has been designed following the requirements for a multi-authored monograph. The monograph is composed of three parts reflecting the three main tracks of the EAEA16 Conference. Accepted papers have been adapted to chapters within each part.

The papers published in this monograph were selected through two double-blind peer review processes, one for the abstracts and a second one for the full papers. With the great help of the EAEA16 International Scientific Review Committee, each submission was double-blind reviewed by two members independently. Then, submitted papers went through the second stage of the assessing process, and finally, the book was reviewed by an independent reviewer.

Acknowledgements

We would like to thank the former EAEA conference chairs Danilo de Mascio and Anetta Kępczyńska-Walczak for their support, and we would also like to thank the DCA and eCAADe associations for the dissemination of information and giving opportunity to promote this conference. We thank the reviewers for the care taken in selecting the articles and giving constructive feedback to the authors.

Keynote Speakers

It was an honour to have as confirmed keynote speakers at the conference a group of locally based architects and designers with diverse and multifaceted work approaches to architectural scales.

Phil Ayres

Professor, Chair for Biohybrid Architecture, Centre for Information Technology and Architecture (CITA), Royal Danish Academy

Professor Phil Ayres holds the Chair for Biohybrid Architecture, which is located within the Centre for Information Technology and Architecture (CITA) at the Institute for Architecture and Technology (IBT), Royal Danish Academy.

Phil's research focuses on the design and production of novel bio-hybrid architectural systems that aim to symbiotically couple technical and living complexes, together with the development of complimentary design environments. This research has been pursued in the context of the EU projects flora robotica, Fungal Architectures and the newly funded EIC Pathfinder project, Fungateria.

Kjeld Kjeldsen

Curator, Louisiana Museum of Modern Art
Kjeld Kjeldsen graduated from the School of Architecture in Aarhus in 1971. He started curating exhibitions at the Louisiana Museum in 1973. Since 1984, he has had special responsibility for culture, architecture and design exhibitions at the Museum.

Kjeld is also a member of the Artists Association, a member of the Board of Danish Art Museums 1998 – 2004, editor of Louisiana Revy between 1991 – 2000 and acted as censor at the Department of Art History at the Universities of Copenhagen and Aarhus. He has received various awards for communication about architecture.

Arthur Steijn

Freelance Designer & Artist (MFA), Part time Associate professor at Royal Danish Academy, Institute of Visual Design.

Arthur Steijn has a background in electronics from Technical School in The Hague as well as in Installation Art and Design in Spatial Context from the Academy of Fine Arts, Rotterdam, Holland. He designs and delivers animation & motion graphics for online use & video projections for opera-, dance- and theatre performances. He works with spatial design for scenography and exhibitions, as well as concept design for games.

Special presentation

We were also pleased to welcome Professor Peili Wang for a special presentation on Rapid Watercolor Visualization & Full Detail 3D Walk-through Realization.

Peili Wang

Peili Wang is a Professor of Interior Design Department, School of Building Arts, Savannah College of Art and Design. He has received numerous awards and recognitions, including the Award of Excellence International Competition of Architecture Illustration (AIP). He was awarded the exhibition "Visualizing Architectural Design Exhibition (VAD)" at UIA2011, The 24th World Congress of Architecture, Tokyo, Japan; he received the excellence award in both observation and design drawings for the professional category at the 2018 Design Communication Association Conference (DCA) at Cornell University. He hosted some workshops.

About EAEA

The EAEA was founded in 1993 in Tampere, Finland, and has reconvened every two years since then. What had originally started as a platform for European academic institutes making active use of optical endoscopy instrumentation, gradually but steadily evolved into a wider range of design visualisation and simulation interests.

The founding meeting, hosted by the department of Architecture of Tampere University of Technology in Finland, was the first international meeting of experts in the field of architectural endoscopy, coming from fifteen universities.

The association was intended to become “a platform for communication and exchange of experiences, experimentation, research and collaboration in the field of endoscopy and environmental simulation.” Initially, the focus of the European Architectural Endoscopy Association lay exclusively upon the visual simulation of the effects of environmental interventions using optical instruments: ‘capturing’ photographic or analogue (video) images using physical scale models, generally using a viewing pipe.

Essentially, the first meeting was a gathering of academic professionals in this field, with the delegates representing institutes with some form of ‘endoscopic’ apparatus. During the conference the participants took part in a workshop session, using the facilities of the Tampere laboratory.

From the first session onward the exclusive focus on optical endoscopy began to shift, first gradually, then more and more steadily towards other environmental visualization opportunities, notably using digital media.

This clearly proved to be the case during the presentations of the second EAEA conference in 1995, hosted by the department of Spatial Simulation at the Vienna University of Technology. In particular, the interdisciplinary conference workshop – ‘the (in)visible city’ – stimulated the integration and comparison of analogue and emerging digital technologies.

For this workshop initiative participating institutes were sent a study model via the post and asked to prepare environmental simulations using their institute’s facilities. The varied results were presented and evaluated during the conference.

Similarly, an important element of the third meeting, held at the Architecture faculty at Delft University of Technology in 1997, was formed by a creative study initiative: the ‘Imaging Imagination’ workshop. Essentially, conceived as a professional confrontation between ‘Optical’ and ‘Digital’ Endoscopy. In this case study, the participants were free to choose between a physical modelling package and a digital file, incorporating texture mapped ‘facades’. Some fifteen visualisation proposals were prepared, brought to the conference and viewed and discussed during a special Imaging Imagination conference session.

Apart from the quality and content of visualization, the aspect of the Modelling as such also became a recurring theme. This was particularly the case during the fourth conference, at the Architecture faculty of the Dresden Technical University of 1999, whereby participants took part in an impromptu hands-on modelling exercise using an interior-scale model.

During the subsequent conferences (the 5th conference at the Institute of Urban Design and Planning at the University of Essen, the 6th conference at the faculty of Architecture at the Slovak University of Technology in Bratislava, the 7th conference at the faculty of Architecture at the University of Applied Sciences Dortmund and the 8th conference at the Moscow Institute of Architecture) the shift from ‘straightforward’ optical endoscopy towards new techniques and topical issues became more and more evident. Noteworthy developments included the increasingly adaptable, distinctive and indeed elegant modes of digital representation, but also the use of digital photography and film, the opportunities of combined media and graphics, but also the introduction of disciplines such as Experimental Aesthetics and Virtual Archaeology.

This led to recurring discussions concerning the association’s name. To what extent should endoscopy be considered a fitting ‘identity’ for the increasingly diverse enterprises of architectural imaging and environmental visualization addressed at the meetings?

Generally, the sentiment tended to be to uphold the established ‘label’ and to keep the EAEA fraternity relatively exclusive and small-scale in comparison to other, more computer-oriented academic and professional platforms.

During the 2009 Cottbus conference, the thematic differentiation of architectural visualisation approaches and interests once again became manifest during the varied presentations, leading to renewed discussions concerning the EAEA’s meaning and role.

What might be an appropriate name that would do justice to the reputation and tradition of (optical and digital) Endoscopy, whilst at the same time giving expression to the steadily unfolding of fields of interest?

Rather than Endoscopy, Envisioning was eventually agreed upon, as it was felt that this fittingly evokes the shared ambitions for a dynamic architectural visualisation practice and the continued exchange of ideas concerning the imaginative conception of future environments.

The EAEA – the European Architectural Envisioning Association

It was hoped that this small, but significant, name change would broaden the appeal of the association on an international level, amongst academics involved with architectural visualisation in the broadest sense, researchers and teachers, whilst at the same time stimulating the deepening of the intellectual discourse.

Previous conferences

15 EAEA Conference | 2021 | Huddersfield | University of Huddersfield (virtually)
14 EAEA Conference | 2019 | Nantes | Graduate School of Architecture of Nantes
13 EAEA Conference | 2017 | Glasgow | Glasgow School of Art
12 EAEA Conference | 2015 | Lodz | Lodz University of Technology
11 EAEA Conference | 2013 | Milan | Politecnico di Milano
10 EAEA Conference | 2011 | Delft | Delft University of Technology
09 EAEA Conference | 2009 | Cottbus | Brandenburg University of Technology
08 EAEA Conference | 2007 | Moscow | Moscow Institute of Architecture (MARCHI)
07 EAEA Conference | 2005 | Dortmund | University of Applied Sciences
06 EAEA Conference | 2003 | Bratislava | Slovak University of Technology
05 EAEA Conference | 2001 | Essen | University of Essen
04 EAEA Conference | 1999 | Dresden | Dresden University of Technology
03 EAEA Conference | 1997 | Delft | Delft University of Technology
02 EAEA Conference | 1995 | Vienna | Vienna University of Technology
01 EAEA Conference | 1993 | Tampere | Tampere University of Technology

Anette Kreutzberg & Anders Hermund
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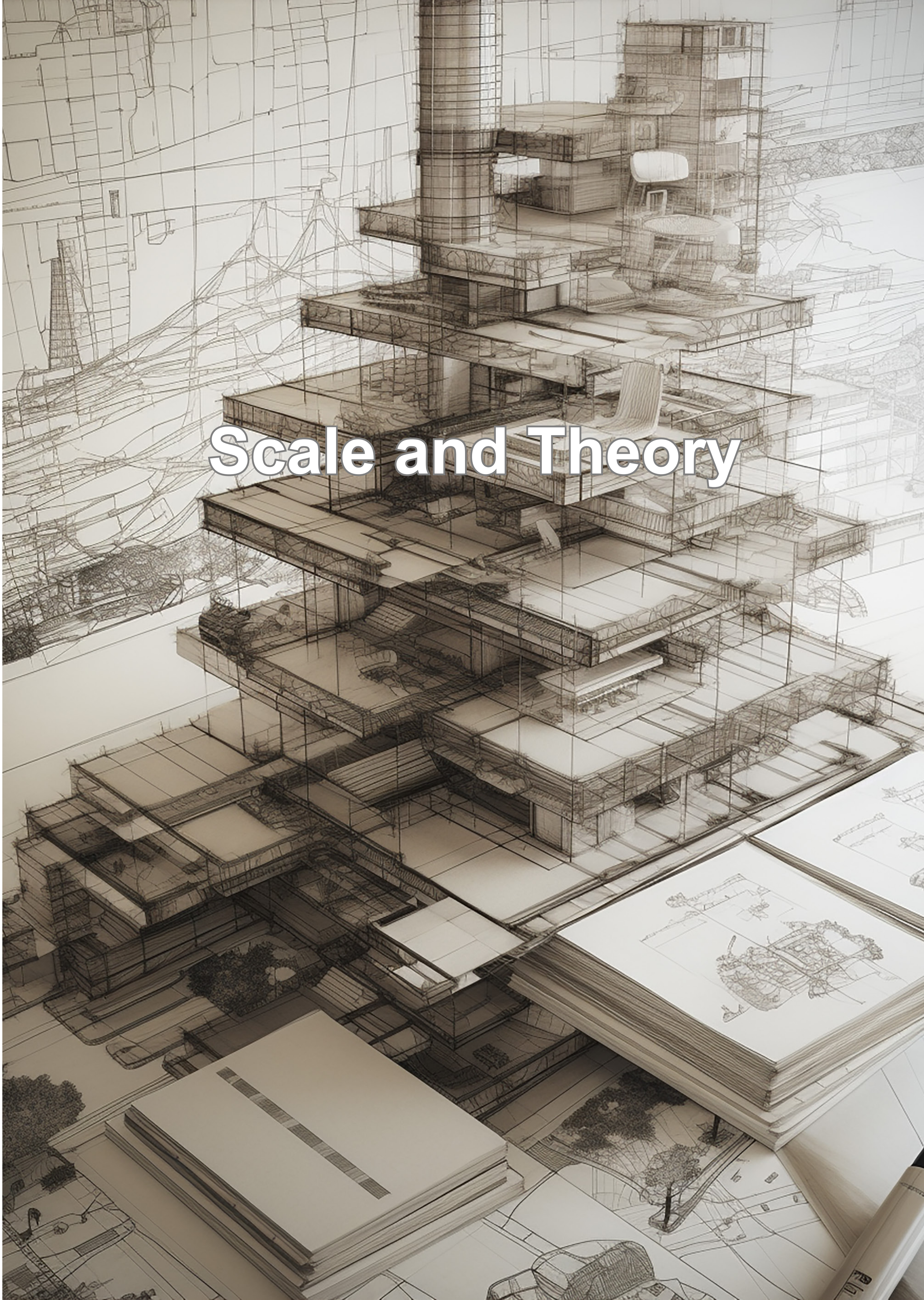
Nick Webb, University of Liverpool, United Kingdom

Scale and Theory



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Nordic Architecture of Regionalism: Digital Wood in Multi-storey Buildings

Introduction

Wood as an archetype material is of particular interest in the discourse of regionalism, as it is not newly invented, and its application has existed in high-rise and long-span wood structures since when wood was crafted with manual tools. The prepared wood or timber has been used for expression, structure, and construction of buildings. The inherent characteristic of timber and its link to the past makes it relevant to the current regionalism theme in architecture. “In the long history of architecture, wood plays an almost continuously dominant role as a building material. Buildings that still stand today showcase intricate construction systems made from posts and beams.” (Correa, et al., 2019, p. 63) Many mass and tall timber buildings were designed with lasting, durable details which have survived over thousands of years, within a varied ecological aesthetic and sympathy with context, while extending aspects of traditional, vernacular, and regional architecture.

Nordic countries have a rich history of using timber as a primary building material, with traditional vernacular architecture showcasing the beauty and functionality of wood construction. Wood appears not only in single family houses, but also in relatively high-rise structures, known as Stave churches, for instance, Heddal Stave Church (1250 CE) in Notodden, Norway, (Fig. 01) which is the largest stave church in Norway.

In the contemporary era, there are more reasons to build taller wooden buildings. “The resurgence of timber as a large-scale construction material has come about because of both social and technological reasons”, and for the most important reasons to be economic and efficient. (Svilans, et al., 2019, p. 95) Specifically, to say, solid timber has many advantages over modern conventional structural materials, in a way that it “requires less energy than concrete or steel for its production.” (Gordon, 2003) “As a renewable resource with a negative carbon footprint and low embodied energy, timber is central in the discourse on carbon-neutral, energy- and resource-efficient construction.” (Bucklin, et al., 2018, p. 425)

Fig. 01. Heddal Stave Church, Notodden, the largest stave church in Norway

Source: Micha L. Rieser; in the Norwegian Directorate for Cultural Heritage database.

The discourse of architectural scale plays a crucial role in envisioning timber high-rises. In early-modernism, timber has been associated with low-rise and mid-rise structures due to perceived limitations in its load-bearing capabilities. However, advancements in engineering, computational design, and manufacturing technologies have challenged this notion. Through the integration of engineered wood products such as cross-laminated timber (CLT), glulam, and laminated veneer lumber (LVL), architects and engineers are pushing the boundaries of what is possible in terms of height and scale. One maginificent effort is the Mjøstårnet building in Brumunddal, Norway, known as the Wood Hotel, which is officially the world's tallest wooden building, and it contains a hotel, apartments, offices, restaurant, common areas and a swimming facility. (Fig. 02)

Fig. 02. Mjøstårnet at its opening in March 2019.

Source: Nina Rundsveen (Published in Wikipedia)

As the use of timber in high-rise construction gains attraction in Nordic countries, the problem of scale has emerged as a significant challenge. While timber offers numerous advantages, including sustainability and aesthetics, its application in tall buildings introduces complexities related to structural integrity, fire safety, and building regulations. This essay explores the problem of scale in timber high-rises in Nordic countries, delving into the key issues and potential solutions that architects and engineers are grappling with.

Due to the scale of these universal edifices, they have larger environmental and visual impact. Normally single-family houses in the urban fabrics have only a direct visual relationship with its immediate vicinity, whereas taller buildings have potentially visual impact with many places far and wide in the city within its form. Therefore, it is of the utmost importance to bring about a change in how taller buildings would be revolutionized. Mass wood construction could not only satisfy the need with regards to density and sustainability, but it should also contribute to a more regionally valued built environment.

Methods

The research is conducted upon the previous paper by the author named 'Rethinking of Critical Regionalism in High-rise Buildings', herein specifically within wood high-rises in Nordic countries. We would like to know whether these potential places might stand as a reference of regional architecture for other parts of Europe or elsewhere. This paper presents a qualitative assessment of multi-storey timber buildings through the lens of computational regionalism, struggling to reconcile the tensions of conflicting forces of localization and globalization, for instance, local craftsmanship versus standard pre-fabrication, and to introduce a computational approach at the intersection of vernacular and digitalization.

In this regard, a groundwork should be established "on the fertile overlap of critical regionalism and digital process" as it is named the 'computational regionalism' realm, to find potentially sophisticated and adaptive structural solutions for hyper-complex geometries in which these new complex surface geometries might be interpreted regionally, and how they might be translated in terms of conveying meanings. We believe that automated performance-based contemporary solutions might constitute a new 'digital vernacular'. (Connolly, 2015, p. 8) To fulfil this purpose, it is important to "translate the strategies of regional responses that were applied in the past to be adapted to today's high-rise buildings; in other words, make it critically regionalist." (Zahiri, et al., 2017, p. 13) This could be also formulated in the context of critical regionalism[1] to setup a synthesis of the vernacular with modernism when it comes to wood as the most primitive material as well as modern one. In the following sections, the paper investigates three aspects of Nordic regionalism; place, culture, and tectonics. And then it discusses the potential of digital wood to bound these three aspects in the design and construction processes of high-rise timber buildings.

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[1] Critical regionalism, as a resistance medium strives to counter the placelessness and lack of identity of the International Style

Place

The reason we specify 'place', and consequently shrink our investigation in only Nordic countries, arises from the loss of regional identity in architecture, or what is to say the issue of 'placelessness'.

> "The problem of place-making is critical when it comes to high-rise constructions [which] tend to become disjunctive in this regard, although one may still relate such works to existing topographic features or, alternatively, to other high-rise structures." (Frampton, 2006, p. 382)

By defining the 'place', the recollection of traditional wood techniques then become abstracted values from cultural traditions – what we call it 'added values' – resulting in an architecture that celebrates humanist and creative interpretation based on vernacular technology and regional tendencies. This approach biases the idea of an anti-human machine aesthetic, and instead, embraces place and human context in design.

"The way a society thrives as a cultural identity is directly related to their built environments, and vice versa." (Connolly, 2015, p. 29) The place is strongly connected to the definition of identity, but it should not be over-looked at very far before this concept actually becomes deadly, like in Nazi Germany with "its national romanticism [which] relied on misinterpretations or distortion of Nordic legend." (Canizaro, 2006, p. 25)

Another issue yet is that this retrospective conceptualization of the place should contain the increasing movement of immigrant people in the age of globalization. Defining the place inherently shrinks the room for diverging. Especially Scandinavians who have been at peace for at least half a century, who are an affluent and tolerant nation. So, one thing is the conserving effect that this has on the architecture of such low-populated countries.

Nordic countries are rich in the discourse of regionalism. For example, Kenneth Frampton's essay "Towards a Critical Regionalism from 1983 has been particularly important, as it seemed to hold up the Nordic countries as examples of a locally rooted architecture." (Frampton, 2006) Frampton advocates for an architecture that "rejects centrist ideals and promotes regional design independence as a reflection of that area's character." (Frampton, 2007, p. 327) In this regard, the Norwegian architectural theorist, "Christian Norberg-Schulz, particularly in his later works, gives to the idea of Genius Loci[2], has had far-reaching consequences. . . in Norway." (Frampton, 2006) Genius Loci is the "Latin description for 'spirit of a place.' The idea has existed for centuries in various aspects with a morphing definition." (Connolly, 2015, p. 11)

To envision the multi-storey timber utopia outside the mainstream of a universal template, it seems practical to deploy a site-specific approach to the design of timber multi-storey buildings, rather than adaptation to a placeless global template.

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[2] Latin description for 'spirit of a place'

By looking from this regionalism framework, it would be easier to develop a site-specific solution to the problem of place-making in Nordic countries.

Therefore, a resistance medium is therefore necessary to counter the placelessness and lack of identity of homogenized timber processes. The result should manifest a shift from placeless mass-production to place-driven products to solve complex design problems.

Material Culture

Wood has been an integral part of Nordic people culture for centuries, serving as a versatile and sustainable material for various applications. From furniture and tools to housing and infrastructure, wood has played a crucial role in shaping their civilization. However, as small nordic societies have evolved and scaled up, the problem of scale in wood culture has emerged as a significant challenge. There are complexities and considerations associated with scaling up wood culture, addressing issues such as sustainability, resource management, and technological advancements.

Scandinavians, from the builders of Viking ships to the Stave churches and farmstead, nearly a millennium, used wood as the dominant material of construction. Wood culture survived over centuries with minimum changes in architectural results. The woodwork has been momentum in progression because Scandinavia was overall a much more agriculturally oriented society than the rest of Europe. The daily life occurred on farmsteads that were often in isolated communities with less contact to the outside. (Fig. 03)

Fig. 03. Eiktunet, Gjøvik, Norway. Langloft from Øvre Gjøvik (left), and the barn from Søndre Breiskallen (right)

Source: Author

Wood is extensively machinable, brought by the opportunity to create innovative and aesthetic appealing forms. Digital fabrication facilitates enormous capacity to rethink wood's setup and its associated traditional processes to reconcile the "tensions between traditional craft-based knowledge and the need to externalize and re-implement tacit material knowledge, a complex, which Achim Menges referred to as 'material culture'". (Kilian, 2017, pp. 211-212)

Technological advancements play a vital role in addressing the problem of scale in wood culture. Traditional woodworking techniques and tools may not be sufficient to meet the demands of large-scale production. Advancements in timber processing, such as computer-aided design and manufacturing (CAD/CAM), robotic automation, and digital fabrication, have revolutionized the efficiency and precision of wood production. These technologies enable the optimization of timber utilization, reduce waste, and improve the overall productivity of wood culture. Embracing and integrating these technological advancements is essential for the successful scaling up of wood-based industries.

However, one of the primary concerns when scaling up wood culture is the sustainability of timber resources. As demand for wood products increases, there is a risk of overexploitation and deforestation, leading to ecological imbalances and habitat loss. Sustainable forestry practices, such as selective logging, reforestation, and responsible sourcing, are essential to ensure the long-term viability of wood culture. Collaboration between industry stakeholders, policymakers, and environmental organizations is crucial in developing and implementing strategies that balance the utilization of wood resources with the preservation and regeneration of forests.

Furthermore, the perception and cultural acceptance of wood in large-scale applications also need to be addressed. In Nordic countries, wood is not only associated with smaller-scale, so promoting the use of wood in larger-scale applications requires less education, awareness, and showcasing successful examples of wooden structures. Demonstrating the aesthetic, functional, and sustainable qualities of wood in high-rise examples across the peninsula can shift cultural attitudes and encourage the adoption of wood culture at scale.

Vernacular Tectonics

Nordic countries have a rich history of using timber as a primary building material, with traditional vernacular architecture showcasing the beauty and functionality of wood construction. However, as the demand for larger and more complex structures grows, the problem of scale arises in the context of vernacular timber tectonics. Scaling up traditional timber construction methods to meet the requirements of modern buildings presents challenges related to structural integrity with certain level of local practicing of wood.

The strength of regional wood craft techniques and methods for construction reacts with natural phenomena of its direct environment. “Tectonics is based on a thorough knowledge of the nature of materials, stemming from local traditions, which are reinterpreted so as to be applicable in the late modern globalized world.” (Holst, 2019, p. 72) This constitutes a systematic setup in wood’s application for spatial makeup in the development of the Nordic urban environment.

Wood has been the main building material for ancient Nord men, not only in ship crafting, but also in their homes. “Norwegian vernacular wood architecture is characterized by stave and log[3] construction.” (Adamic, 2016, p. 126) Wood has a long precedent in Nordic log houses; what they call lafting, an efficient technique passed down through first-hand practices, (Fig. 04 (a)) which has been forsaken under the shadow of mass timber production. Many timber projects are in combination with steel connections or fasteners, which may be geometrically interlocked, but extensively rely on complex secondary material. “While these hybrid materials have opened new markets such as multi-storey housing, separating the component materials

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[3] Nor. stav og laft

of such products is not economically feasible, and the reduction of carbon emissions from timber are largely negated by the high emissions of secondary materials." (Hegger, et al., 2006) (Bucklin, et al., 2018, p. 425) (Fig. 04 (b)) This complexity could be solved through rethinking of such vernacular techniques and translate them to novel interlocking joinery system by the possibilities that robotic fabrication could bring forward. Unlike in mass timber construction which is bound to capabilities of the machines, which favor 90° or 180° angle joints, the digitalized spatial pocketing plane could favor non-orthogonal morphologies. (Fig. 04 (c))

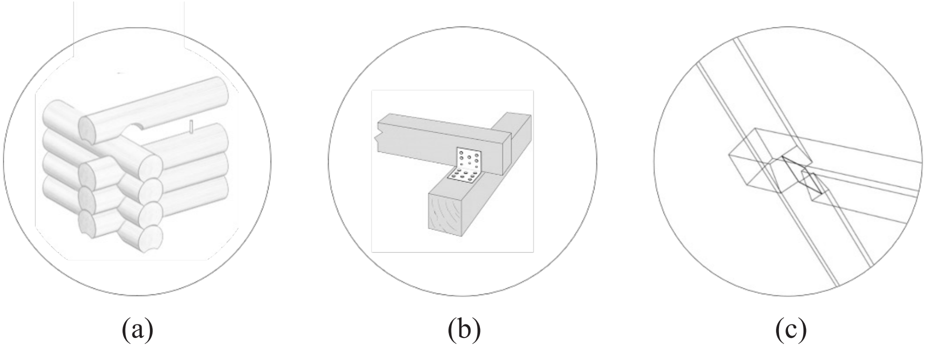

Fig. 04. (a) Vernacular log joint (b) Timber beam connection via steel plates and fasteners (c) Interlocking non-planar joinery

Source: Author

The existence of traditional wood works played on the basic attraction to architectural influences. Vernacular tectonics could be formulated in the context of digital regionalism to setup a synthesis of the vernacular with modernism when it comes to wood as the most primitive material as well as modern one. At the level of vernacular, these influences have existed as a pragmatic decision to address locally established problems, with specific techniques, what is understood as reflection practice.

Discussion: Digital Wood

By 'digital wood', herein, we mean the processed wood acquiring digital fabrication and production, brought up by the question that how digital wood can reconcile wood construction with increasing use of globalized prefabricated products towards added-value complex products, without becoming "a strain of 'meta-wood' that transcends the sentimental kitsch of the vernacular . . . where it engages in dialogue with the divergent and emergent field lines. As a meta-wood system depicting regional independence, 'place' is created within the physicality of the wood phenomena." (Connolly, 2015, p. 164) Placelessness will be the result of machinist approaches towards universal architecture, leading to mechanically air-conditioned timber buildings, whose wood surfaces do not reflect any climatic justifications. This box is a monoculture global template that reduces things to universal civilization. It is often momentum in creativity and unable to address contemporary issues regarding the local values.

> "Similar to the Arts & Crafts movement that happened as a reaction to the Industrial Revolution, now in contemporary design the tradition of craftsmanship is clearly gaining increasing value and appreciation in today's reality of the technological world as these reflect the traditions of a people's identity. Just as the individuals involved around promoting the Arts & Crafts as an alternative to the monotony of a machine-aesthetic." (Connolly, 2015, pp. 33-34)

There has been a culture-specific trend which is gaining strength universally and one could foresee a renewed interest in Nordic architecture, where there is a response to this universal movement which calls for a back-to-basics approach to the local practice of wood. Touching upon the phenomenological discourse of the Finnish theorist, Juhani Pallasmaa, carved wood has had certain levels of haptic qualities in the long history of Nordic wood crafting. For instance, "The wood carver understands how to whittle with the grain rather than across it" (Connolly, 2015, p. 36), something that has not been respected by digital machines. We often see the fuzzy edges are left on many wood machine operators. One important feature with wood is the experience of the quality of the material in a populist era which emphasizes more on images and makes people unresponsive to other senses. But the experience of wooden buildings on a tactile level is also important.

In the realm of architecture and construction, the disconnection between haptic methods of tectonics and digital methods in timber construction has become an increasingly prevalent concern. Haptic methods refer to the tactile and sensory aspects of craftsmanship, where skilled artisans work directly with materials, engaging in a physical dialogue with the building process. On the other hand, digital methods encompass the use of computer-aided design (CAD) tools, computational algorithms, and robotic fabrication techniques to optimize construction processes. While both approaches have their merits, the growing divide between them raises questions about the impact on timber construction and the quality of architectural experiences.

A holistic approach to timber construction would entail leveraging the precision and efficiency of digital methods while retaining the human touch and craftsmanship that haptic methods offer. Embracing a hybrid approach, where digital tools are used to optimize design and fabrication processes, but with an understanding and respect for the materiality and sensory qualities of timber, can lead to more enriching architectural experiences.

Furthermore, collaboration and knowledge exchange between digital experts and craftsmen are essential. Bridging the gap between these disciplines can foster a deeper understanding of the material's behavior and its potential within a digital framework. By fostering interdisciplinary dialogue and embracing a balanced approach, architects and builders can ensure that the benefits of both haptic and digital methods are maximized.

Conclusion

Due to the long history of regional woodwork in Nordic countries, it would be arguably difficult to challenge the pre-conceived notions and to make a radical change in the language of wood architecture. The Nordic architectural configuration of volume depends greatly on its specific location and climate. The translation of this configuration into high-rise is difficult, especially when climate varies significantly with height, and each storey cuts across multiple climate zones.

The problem of scale in timber high-rises in Nordic countries presents multifaceted challenges that extend beyond structural considerations. The complex phenomenological aspect is related with the tactile quality of wood; as a natural material, has distinct sensory qualities that set it apart from more conventional construction materials like concrete or steel.

Addressing these challenges requires collaboration, innovation, and a holistic approach. By addressing the problem of scale in timber high-rises, Nordic countries can continue to lead the way in sustainable and innovative construction practices, shaping a future where tall timber buildings become a viable and environmentally responsible option.

We shall employ a site-specific approach to the design of multi-storey buildings, rather than adaptation to a global template. By regarding multi-storey buildings as an adaptive organism, there is an opportunity to develop a site-specific solution to the problem of place-making in Nordic countries. Thereby, generative design and optimization strategies in the initial phase of design lead to tremendous amounts of saving energy pertaining to material and energy.

Creating a sustainable built environment shall comply with regional justifications. The goal should establish a regionalist framework of tall timber buildings, where for example, a high-rise building in a Nordic city functions more or less the same as in Chinese wooden towers in terms of energy efficiency and other contributed climatic factors but feels part of a local vernacular culture and response. This requires a deep understanding of historical vernacular vertical forms (e.g., comparing stave churches versus pagodas as references for tall buildings).

Integrative regional design becomes critical for timber high-rises, due to their enormous heights and scales, which require the most advanced wood technologies and have a greater impact on Nordic urbans and even global context. In parallel with the popularity of wood in the high-rise construction sector, there is this interest to discuss the topic also in scientific literature. While most of the scientific literatures on high-rise wood construction have investigated the general concepts of energy, structural, or environmental problems, the present paper focuses on a specific regional scope. This means an expanded view of knowledge in the discourse of the regional architecture of tall timber buildings, which can significantly contribute to a greater and better exploitation of the potential of timber construction in Nordic countries and elsewhere.

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BIMaHEAD on the search of a social BIM

Introduction

Scales...what a fantastic subject for architectural education. In this article, we will assess a specific aspect of innovative teaching using immersive technologies. But we can't jump right into the topic without first discussing architectural research. We believe that teaching innovation necessitates a significant paradigm shift, which will be presented. The BIMaHEAD project will be used to illustrate our proposal. BIMaHEAD is a European project that seeks to develop novel educational and operational methodologies for architectural design. Its primary objective is to streamline arduous processes, freeing up architects to concentrate on their core competencies and areas of expertise.

The BIMaHEAD project is a collaboration between five partners from EU countries including France, Germany, Sweden, Poland, and the Republic of North Macedonia. The National School of Architecture of Nantes (ENSAN) is the main promoter of the project, while the Swedish University HalmStad (HU) is a renowned partner for its research on innovation. The Private Institute for Research in Environment, Civil Engineering, and Energy (IECE) in Skopjé (North Macedonia) was created by a company of engineers and architects, and has a focus on research, training, and consultancy. HafenCity University of Hamburg (HCU) specializes in architecture, urban projects, and civil engineering, with a focus on exploring what cities of the future might look like. The Faculty of Civil Engineering, Architecture, and Environmental Engineering at the Polytechnic University of Lodz (TUL) is very active on an international level, and its excellence is widely recognized.

In simple terms, there are two approaches to the project. The first method involves solving constraints in a sequential manner, where the form, structure, or organization of the flows are addressed first, and then the related problems are iteratively resolved. This approach is often guided by personal experience and aims to isolate constraints and focus on a single solution. On the other hand, the second approach is facilitated by algorithmic, generative, and upcoming AI methods. It involves integrating constraints concurrently, allowing them to interact and generate multiple solutions, which are then refined by revising the input data or through training. We propose the acronym DIM, which stands for Design Innovative Method, to complete the BIM in the BIMaHEAD project.

Scale 1, research in architecture

Is it possible to conduct architecture research that focuses solely on architecture, and can such research also provide knowledge that can benefit other fields? In 2008, a study by Martin Rosvall and Carl T. Bergstrom (2008) found that architecture is not commonly referenced or self-referential in other disciplines. The question of whether architecture research is feasible and how to define its scope remains a topic of debate, as discussed at the 2014 EPFL colloquium "*What is research in architecture?*" One of the main challenges faced by architecture researchers is how to limit the scope of their research without excluding important aspects or becoming overwhelmed by the complexity of the subject[1]. Research in architecture emerged in the aftermath of the rapid transformation of cities in the late 1960s, with the creation of schools and research initiatives. Objectives of architecture research include:

- creating a community of researchers,
- acquiring and disseminating knowledge and methods,
- establishing a link between practice and research to benefit society.

In France, mathematician and architecture enthusiast André Lichnerowicz, wrote a report in 1970 that helped establish the objectives of research in architecture, leading to the creation of CORDA (Comité de la recherche et du développement en architecture) (Fauquet 2021)[2], in 1972 under the directive of Jacques Duhamel, the Minister of Cultural Affairs. The objectives of the research include the creation *of a community of researchers; the acquisition and dissemination of methods and knowledge, some fundamental, others concerning programming, design and production processes;* but especially *the creation of university workshops of architecture to allow a constant link between practice and research at the service of the community."* (Lichnerowicz 1973)

We can clearly see the difficulties of developing a research in architecture and then be validated by friendly disciplines. As Thierry Verdier (2018) points out, *"architecture, through the infinity of knowledge and skills that it represents, cannot be circumscribed within the narrow framework of an academic or university discipline. Can we accept that the doctorate in architecture is forced to submit to the great scientific and watertight frameworks distinguishing the university disciplines from each other? Certainly not"* (Verdier 2014). In fact, this is accompanied by a strong scattering of the production of research and therefore the identification of a common root. The corollary is that the researcher-architect, depending on the circuits in which he publishes, may have the impression of abandoning part of his thinking or his competence to enter the disciplinary framework proposed to him. It is, indeed, the legacy of a quarrel between a fundamental architectural research, rather tinged with human sciences against an applicative architectural research, rather colored hard or physical sciences, seeking to free itself from a perception of non-scientific research led by practitioners. Because the "project" is the identity marker of architectural culture, an important nuance must be recorded between knowledge and know-how, between the reflection that one develops on a practice and the practice itself. A strong tendency seeks to reduce knowledge to know-how because, as Mies van der Rohe could say, *"In the term 'architecture' we prefer that of 'building'; and the best results belong to the realm of the "art of building". Many schools get lost in sociology and design,*

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[1] http://contour.epfl.ch/fr/what-is-research-in-architecture-2/

[2] https://ensarchi.hypotheses.org/1677

with the result that they forget to build. The art of building begins with the careful joining of two bricks " (Norberg –Schulz 1996). Architecture schools being the place where practice is taught, there is always an ambiguous relationship with research. As if the PHD could not characterize an excellence of practice or be an alteration of knowledge.

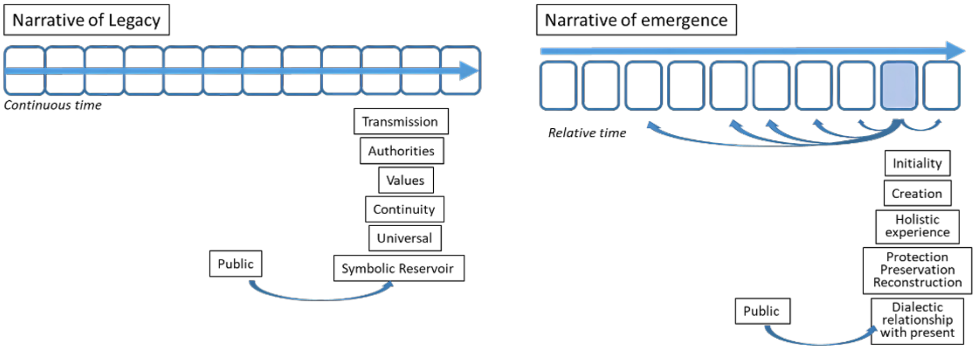

Figure 1 - Concept of Legacy / Emergence

Fig. Lescop

In fact, if we frequently discuss the recognition of the practice as equivalent to a third-cycle level, it would be more consistent with CORDA's goals to acknowledge in "doctors in architecture" the knowledge and skills required to adapt to the social and technological changes in their field, and to identify new practices, potentially leading to a transformation of the architecture profession. This trend is evident in many other fields, such as engineering, where the emergence of themes like "digital city" and "sustainable development" highlights the need for multidisciplinary, specialized, academic, and project-based training for professionals. Essentially, we are now facing two distinct modalities, legacy and emergence, which represent different approaches to the field of architecture. (LESCOP 2018 and Figure 1)

The legacy modality entails the transmission of content and represents continuity. Within the context of architecture, the notion of legacy pertains to the professional, scientific, and technical legacy, which is constructed as a sequence of interdependent periods, each aiming to exhaust a theoretical or technical paradigm. In this field, there are two modes of legacy. The first one is related to the profession, which ensures the transmission of content and a protocol integrating the origin and subsequent organization of the content through practice and education. Interestingly, in the quest to identify proper architectural research, a second mode of legacy has been integrated into the university academic research, which defines and organizes the scientific production of teacher-researchers. This transmission is imbued with certain values, disciplinary and scientific, which justify the exclusion of elements that do not preserve the prior meaning. It is a transmission that upholds and defends legitimacy, which can only be acquired by mastering codes and recognition by peers. Authorities are required to perpetuate and function this modality as a teleology, with the primary objective of preserving and transmitting a status. The Guild of Architects, academic institutions, training and validation of knowledge are all part of this narrative with the aspiration of achieving a register of universality. This approach has a transcendent quality, involving the creation of symbols and rites that the public will recognize, in order to establish social adherence to professional and scientific authority.[3].

Thierry Verdier mentioned above recalls that " *there is a great risk of believing that when the architect designs a project, he does research. No, he's just doing his job. Research in architecture is precisely about going beyond the profession to, little by little, question the production of this complex thought* . This entails devising specific research methods that maintain rigor and intellectual ambition. This approach, in contrast to the legacy modality, can be characterized as the emergence modality. Unlike the legacy modality, the emergence modality does not operate on the principle of succession, nor does it follow a linear path. Rather, it is a modality that needs to be activated and performed. Once activated, it can, and above all, must demonstrate the continuity of what is recognized as such. The authority that activates this modality recognizes its origin and therefore validates its authenticity. The emergence modality aims to ensure fidelity to the origin, namely the project's production and academic canons, resulting in the pursuit of a holistic meaning and a total experience. As architectural research involves a dialectical relationship between research in architecture and society, this relationship must be maintained to address contemporary issues, identify the emergence of new practices, and paradoxically, preserve the value of the architect's own practice by pursuing holistic plenitude. This is precisely what is at stake in the BIMaHEAD project.

Scale 2 Education

Education and research are interrelated and mutually reinforcing but operate differently. By recognizing their distinctive roles in the current context, we can strengthen education and foster research. In pedagogy, the relationship to the project is built on three pillars: the notional, referential, and projectual. The notional pillar encompasses major fields of knowledge, identifying current ideas and conceptual tools, while situating them within the context of evolving ideas. Architecture is inherently multidisciplinary, drawing on diverse theoretical and technical sources. The referential pillar identifies trajectories within the architectural discipline, such as historical styles, construction techniques, or ideologies that accompany architectural achievements. Finally, the projectual pillar encompasses the approaches and techniques used to create built spaces.

By following the referential of modalities detailed above, a pedagogy of legacy and a pedagogy of emergence will be found in pedagogy. The license is rather the place of the pedagogy of the legacy and founds the notional, referential and projectual or technical bases which give to the students a range of skills and references which allow them to pass from the execution of a solution by the means given to them for developing original solutions. Over the course of the three years of License, the pedagogy builds this course of emancipation by measuring the theoretical and

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[3] Since the covid crisis, there has been a persistent trend among architecture students in France to denounce this legacy as being responsible for the climate crisis and the failure to adapt to new social concerns.

technical acquisitions which respond to each other. In the Masters, we highlight what can be identified as a pedagogy of emergence mainly due to the installation of digital technology in practice, our production capacities and our relationship to the world. Digital tools have moved in twenty years from academic sectors and specialized companies to consumer sectors in which we find the creative, entertainment and cultural industries. This movement was not made without resistance and Antoine Picon (2010) commenting on the field of architecture, recalls that the question was the subject of "an essentially doctrinal or even doctrinaire literature emanating from proselytes, technophiles and other prophets of microscopic neo-avant-gardes. » The advent of the Digital Natives, who were born in the 21st century, has ushered in a new era characterized by the widespread availability and ease of learning technological tools, their mass distribution, and greater acceptance by preceding generations. Heritage mediation, Smart-Cities, the preservation of resources are part of this movement: they are integrated into a global vision of a palimpsest city (Cormerais 2015), a smart and connected city . We are only at the beginning of this change, the stakes of which will be above all democratic before being technological.

Scale 3 Institutions

The connection between pedagogy and research is integral to the functioning of an educational institution and must align with the overall mission and objectives of the school. This involves addressing internal concerns such as recognizing and evaluating the time dedicated to research, and developing innovative educational content. Additionally, establishing international networks is crucial, which includes supporting students to study abroad, welcoming foreign students, and offering international courses. Attending scientific and educational conferences globally can also be valuable in fostering cross-cultural exchange and promoting specific research initiatives in architecture.

As discussed in the first part, schools and research laboratories training doctoral students in architecture face the challenge of convincing the society that a thesis in architecture is a valuable addition to the operational field. It enhances technical and conceptual skills, enabling graduates to tackle contemporary challenges of construction and sustainable development. Third-cycle training does not replace practical knowledge, but rather adds applied knowledge. Students engage in research dissertations and laboratory internships to move back and forth between the academic and operational worlds, identifying opportunities to develop a specialization that will set them apart in the job market.

To achieve this, it is important to create opportunities for students to find internships and work, and offer specificities in their range of skills, which will place the School at the forefront of societal and technical issues. This has a strong impact on the students' course, as they identify movements in society that will organize their specialization. The course and follow-up of graduate students are major concerns, and their production is valued by the choice of projects carried out and the notoriety they can acquire, as well as communication about their work.

To facilitate publication and visibility of their work, formatting constraints must be integrated early on in the pedagogical process. The pedagogy/research articulation is a part of the school's overall system and must participate in the general policy of the establishment, consolidating its general project. Internal issues, such as teacher evaluation of time devoted to research and development of renewed educational content, must be addressed, as well as the development and maintenance of international networks through encouraging students to study abroad, welcoming foreign students, and participating in international meetings at the scientific or educational level, to recognize specific research in architecture.

Scale 4 Proposals

Reflective thinking is a component of the BIMaHEAD program, which is a collaboration between five European countries - France, Germany, Poland, Sweden, and Macedonia - aimed at developing innovative educational material. The new courses are required to use distinct methods and themes while offering students topics that will equip them with the necessary skills to tackle new design challenges. The program began with a comparative analysis of educational programs in ten European countries, to assess the extent to which BIM concepts are incorporated into the curriculum. Overall, the analysis indicates a comparable approach that does not go much beyond the use of 3D models with IFCs.

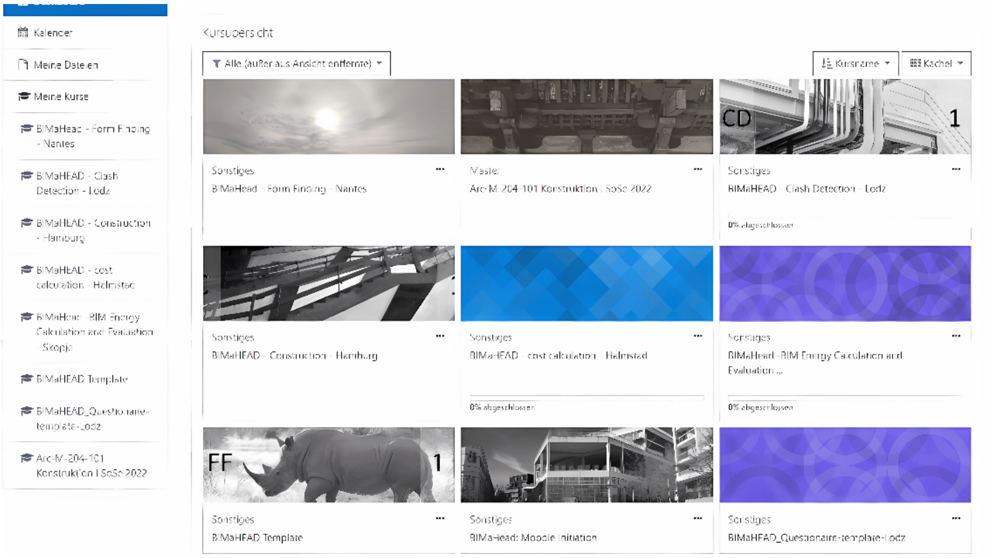

Figure 2 - The temporry BIMaHEAD Moodle page

During the process of creating the content, we observed two changes in the concept of emergence that require our attention. The first pertains to immersion and our ability to design, examine, and present projects at a 1:1 scale. Virtual reality and metaverses are the tools that enable us to achieve this level of immersion, which opens up numerous possibilities and issues that we must carefully consider. The second paradigm shift is brought about by generative design, which is experiencing a resurgence thanks to algorithmic software and the rapid advancement of Artificial Intelligence. This approach redefines the very notion of design principles, allowing us to explore thousands of solutions based on predefined criteria. While these techniques might suggest that anyone can design, they also highlight the importance of expertise and the potential for increased complexity in projects.

The content is accessible with Moddle, other platforms are tested. (Fig 2)

Form Finding Nantes

This module is focused on using environmental elements as inspiration for designing shapes, and it starts with the software Grasshopper. Grasshopper is a plugin for Rhinoceros, a 3D modelling software, that allows designers to create complex shapes and structures through visual programming. The module then moves on to using Unity and metaverses to create a virtual experience of the design proposals. Unity is a game engine that enables designers to create interactive and immersive experiences. By using Unity, students can create a virtual environment where users can experience the design proposals at a 1:1 scale. This allows users to experience the proposed design in a more realistic and interactive way, making it easier to visualize the final product. (fig.3)

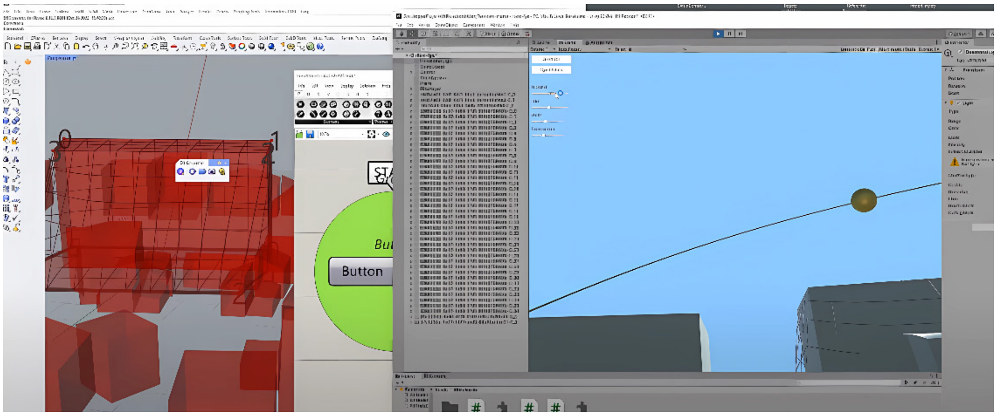

Figure 3 - Solar study in real time using Grasshopper inside Unity

Construction Hamburg

This module utilizes virtual reality technology to help students better understand how to assemble complex building structures. By using virtual reality, students can interact with 3D models of the building structure and get a sense of its size, shape, and overall design. SimLab is the software used in this module to create virtual reality experiences. SimLab is a software that is created specifically for virtual reality applications. It allows designers to create 3D models of buildings and other structures, and then simulate the assembly process in a virtual environment. By using SimLab, students can see how different building materials interact with one another, and test out different construction methods and techniques. One of the key features of SimLab is its ability to dynamically adjust materials based on the virtual environment. Overall, this module provides a unique approach to designing and assembling complex building structures. By using virtual reality technology and SimLab, students can gain a better understanding of how different building materials interact with one another, and test out different construction methods in a virtual environment. This can help save time and resources in the actual construction process while also improving the overall quality and performance of the final structure. (Fig. 4)

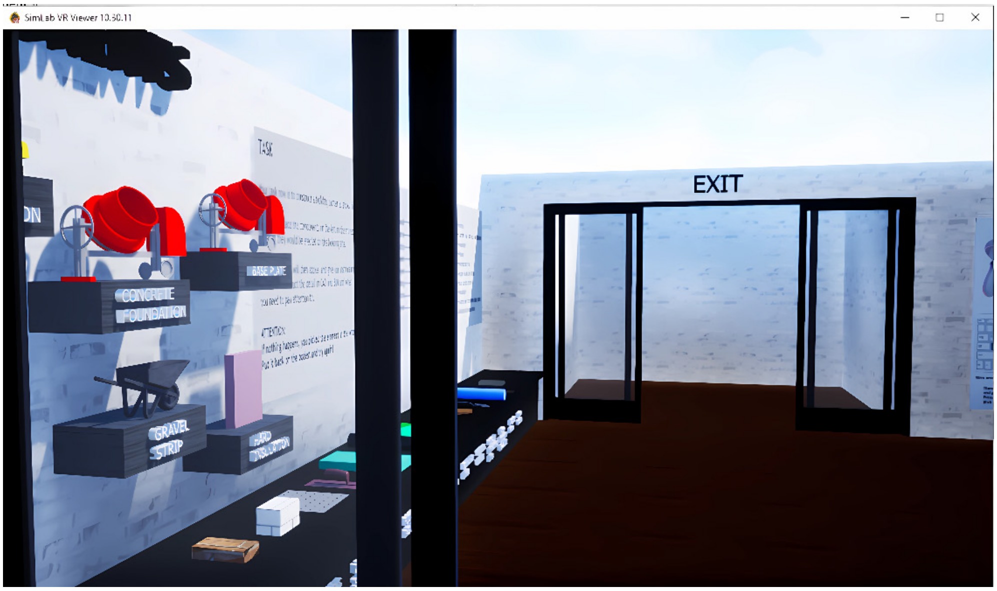

Figure 4 - Construction module with Simlab

Cost calculation - Halmstad

The objective of the course is to help students understand the process of digital calculation and the differences between this process and more traditional manual methods. To achieve this objective, the course is divided into two parts. In the first part of the course, students will review digital construction processes and their characteristics. They will also review software applications and practical examples in digital environments. This part of the course will conclude with a quiz or test to assess students' understanding of the material covered. The second part of the course will focus on software applications. Students will review various software applications and examples of their use. They will also review a digital calculation presented in a PDF file that contains amounts and figures. This part of the course will conclude with questions related to the PDF file. Overall, the course aims to provide students with a comprehensive understanding of digital construction processes and software applications. Through the quizzes and tests, students will be able to demonstrate their understanding of the material and their ability to apply it in practical situations. (Fig 5)

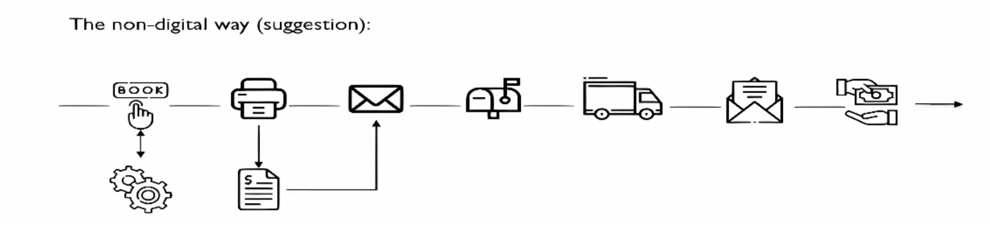

Figure 5 - Cost calculation

Clash Detection Łódź

The Clash Detection Module is an integral part of the BIMaHEAD Course, which aims to equip students with advanced knowledge and skills in Building Information Modelling (BIM) and help them detect clashes and collisions in AEC (Architecture, Engineering, and Construction) projects. By identifying errors and inconsistencies in projects at an early stage of design, engineers and architects can save resources, materials, costs, and time, thereby contributing to a more sustainable built environment.

Figure 6 - The Immersive part of clash detection where knowledge is tested

The Module introduces theory and practices through a sequence of tasks, enabling learners to acquire the skills needed for future architects and engineers in the AEC sector. It is designed to take learners through a game-like experience with different levels to be achieved and scores to be collected. Successful completion of the Module may result in the award of a certificate. The Clash Detection Module is an essential component of BIM education, as it emphasizes the significance of early identification of issues in the design process. By utilizing the tools and techniques introduced in this Module, students can develop the critical skills needed to detect and resolve clashes and collisions in AEC projects, leading to more efficient and sustainable construction practices. The Module's approach of combining theoretical knowledge with practical applications makes it an effective learning tool for students in the AEC sector. (Fig 6)

Energy Calculation and Evaluation

This course is designed to teach students how to use BIM (Building Information Modeling) as a digital tool to enhance the energy efficiency of buildings throughout their life cycle. The course covers various topics, including the concepts of energy consumption in buildings, energy and cost life cycle assessment, and the basic definitions associated with energy values and variables. Additionally, students will learn about the classification of energy-efficient buildings based on commonly used European codes and the methodology of energy balance based on BIM models. Furthermore, the course emphasizes the advantages of BIM over traditional methods of project delivery. The goal is to provide learners with advanced knowledge and skills that can help them improve energy efficiency in their work as professionals in the AEC (Architecture, Engineering, and Construction) sector. Therefore, the course is suitable for all professional profiles in the AEC sector who wish to enhance their knowledge of BIM and energy-efficient building design.

Conclusion

It is important to distinguish between technical advancements resulting from improved tools and the evolution of paradigms related to the representation and communication of knowledge. As new technologies replace old paradigms, it is crucial to pay close attention to emerging paradigms. Conversely, when paradigms are being reformulated, it is important to trace the continuities from past preoccupations to present tensions. In our pedagogy of emergence, we propose projects to students that establish a strong dialectic with the business world and institutions, probing the evolutions of architectural practice. (Fig. 7)

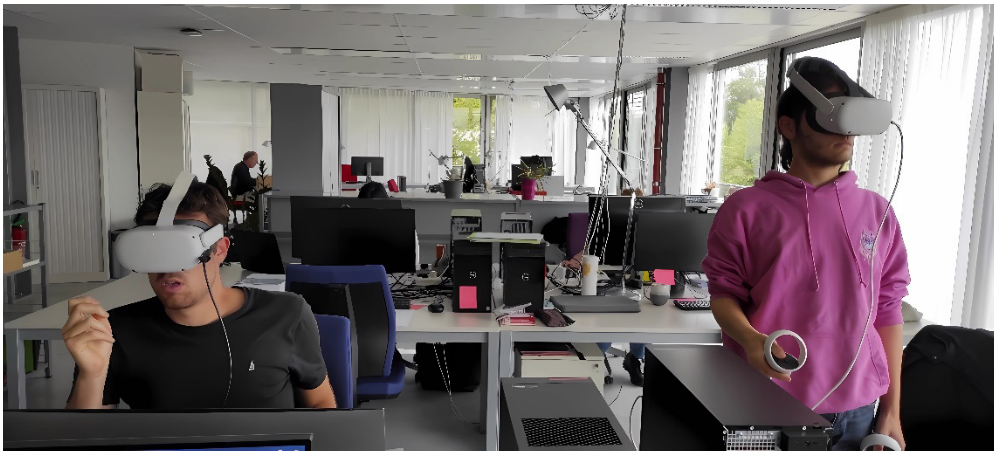

Figure 7 - BIMaHEAD being tested by PDH students

We prioritize real, involved projects, often built in the form of full-scale prototypes. Students develop their own skills, which they acquire through their specialization and education rather than solely identifying themselves as architects. We are committed to linking these projects to the creation of new positions in companies or research labs. Over the past few years, we have witnessed the emergence of new professions in fields such as arts, traditional and playful scenography, tourism, light, and digital, alongside the careers of operational architects

Undoubtedly, the challenges and demands for pursuing a PhD in architecture are influenced by the economic context of a given country. In some places, like France, there is significant pressure and challenges for architects to find work, whereas in Germany there may be more opportunities available. However, the need to reinvent the world of construction in response to climate change requires a significant shift in pedagogy for architecture, which may include the pursuit of a PhD. Despite the difficulties, it is important for the field of architecture to continue to invest in research and specialized knowledge, in order to develop solutions and approaches that are better equipped to meet the contemporary challenges of sustainable development.

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Principles of Collective Form in Campus Planning

Scale in Recognition

Collective form refers to a set of scattered independent architectural groups and other elements that create a city or part of a city based on a common factor, which Maki (1964) referred to as linkage. Linkage is not only limited to static order, which refers to the physical order, such as axes and unified design, but also includes an unpredictable and complex dynamic order, which includes human activities, such as the flow and assemblies of people. Therefore, linkage has spatial and temporal aspects. Charles and Ray Eames' *Powers of Ten* (1977) shows the continuous and infinite scaling of objects from the gigantic, such as space, to the minuscule, such as molecules, through human eyes. However, every scene is an abstract moment constructed by the subject. Even one-to-one-scale real objects are only for the subject's recognition. The large or small scale is the objective hierarchy of physical scale in a static order; however, the more profound dimension is the connections of subjective experiences of viewers who perceive and act upon it (Latour, 2014). Linkage exists in such objective scales, as well as in non-scale dynamic orders.

In urban design, Congrès International d'Architecture Moderne (CIAM) Modernism was founded on ideological and abstract concepts, while Team X and Metabolism introduced empirical and concrete concepts, including urban and dynamic phenomena such as street life and mobility (Yatsuka, 2022). In addition to this change, the question regarding how to assemble multiple buildings and still maintain order while allowing growth and freedom was investigated in the 1960s by those architects. Although they realized their theory of collective form in their design works and proposals that presented a profound potential for organic spatial organization, enthusiasm to explore collective form decreased as the urban population growth slowed. However, the concept of linkage and how it can be achieved, can still be expanded to understand and improve the spatial structure of contemporary cities, some of which are conversely shrinking. This study examined university campuses in Saitama Prefecture in Japan, and analyzed the relationship between architectural groups and their constituent elements to clarify the spatial characteristics and structural principles that comprise collective form in various scale and non-scale orders. Therefore, this study aimed to illustrate that the objective physical order, which can be scaled, is reinforced by the intervention of another layer: the empirical dimension that is created by human perception and movements, and which mediates between collections of buildings and other elements to achieve united identities.

Typology of Campus Components

As a case study of collective form, we selected university campuses because, similar to a city, they are composed of multiple buildings focused on a single identity (master plan); however, its expansion and change may occur over time. In particular, we selected 24 out of 45 campuses in Saitama Prefecture, which contain more than 10 buildings, but did not include other functions, such as hospitals. They are examples of suburban and relatively new (mostly founded in the latter half of the 20th century) campuses. We first analyzed the physical aspects of the campuses from a birds-eye view, such as campus boundaries, open spaces, main axes, topography, and grains by making diagrams to clarify their structure at urban and neighborhood scale and campus scale. We also made diagrams to show the years when each building was built and the transition by which the campuses were formed to examine how order of collective form developed over time.

Urban and neighborhood scale

We analyzed how the campus area distinguished itself from its surroundings on urban and neighborhood scales. We focused on the relationship between topography, campus boundaries, and open spaces. Based on their characteristics, campuses were categorized as the island type (13 campuses) and urban tissue type (10 campuses). Rissyo University campus did not fall into either category.

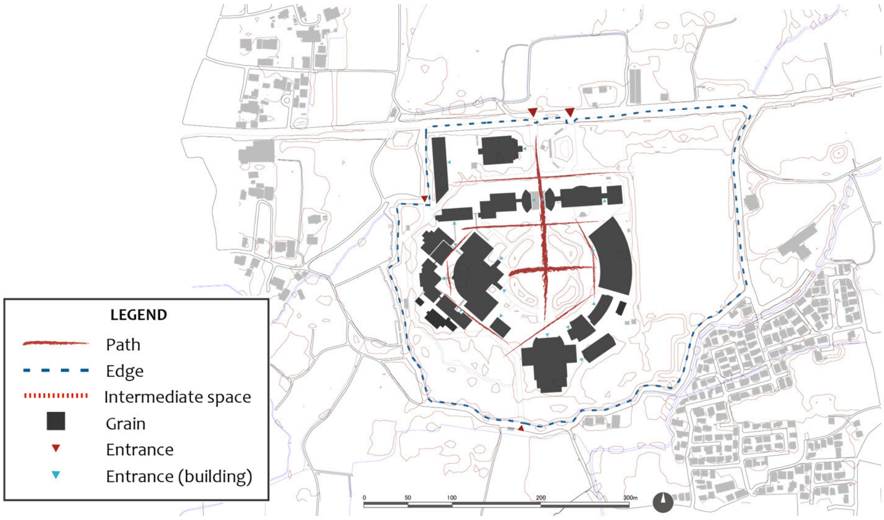

Fig. 01. Island-type campus and its evolution: Shobi Gakuen University

Source: Author

The island type (Fig. 01) was introverted and isolated from its surroundings, similar to medieval walled cities. In most cases, they were located in the middle of a field, and the campus boundary was defined according to topography and had an indefinite shape. Several campuses studied did not have a physical edge, such as a fence. Many campuses of this type had a centripetal square in the middle of campus. As these campuses often float in less dense regions, they may require strong symbolic centers to retain their identity.

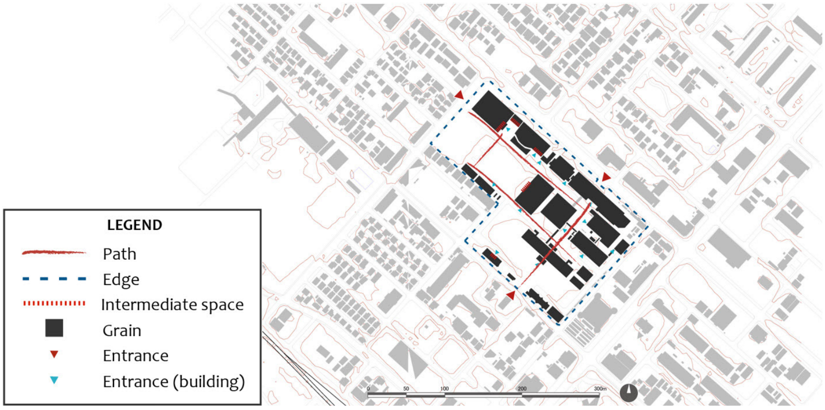

Fig. 02. City-type campus and its evolution: Jyoshi Eiyo University

Source: Author

The spatial structure of the urban tissue type (Fig. 02) was in harmony with that of the neighboring area, which was mostly residential. The axes on the campus were often drawn in the same direction as the surrounding streets and blocks. The boundary between the campus and the neighboring area was in accordance with the city grid, and the domain of the campus was only made clear by a physical fence.

The average size of the grain of campus buildings for the island and urban tissue types was 1,215 sqm and 980 sqm, respectively. The suburban context of the former required a larger contrast from the surroundings to establish an identity as a university campus. The principle of the latter was integration with the surrounding residential area; therefore, the contrast of the grain with the neighboring buildings was smaller.

Campus scale and its dominant frame

Next, we studied closer-up campus scale in order to analize the relationship between the main axes and assemblages of buildings. Most campuses had a clear main axis, which started perpendicular to the existing main street, forming a T shape. The main axis direction could be categorized into focus (13 campuses) and passage (7 campuses).

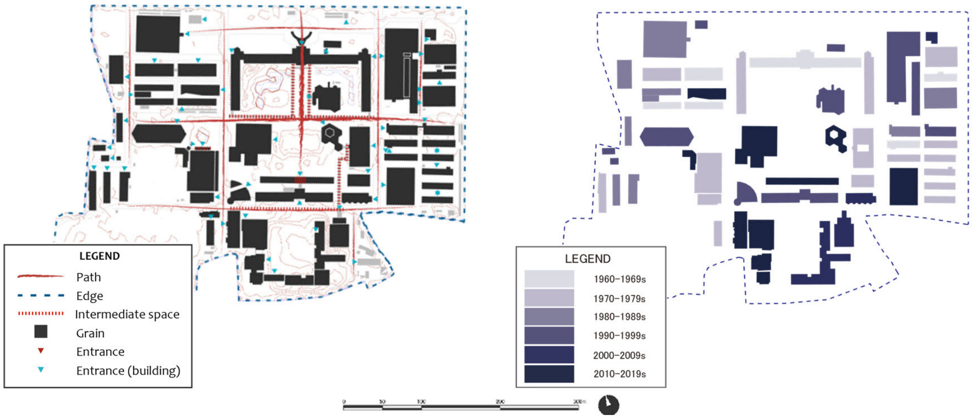

Fig. 03. Focus-type campus: Nihon Kogyo University

Source: Author

The focus type (Fig. 03) had a symbolic element at the end of the axis. This was a composition with a landmark. This symbolic element could be a physical building or plaza (void), both of which were distinct from the other buildings by their size. Most campuses of this type had a classic spatial composition of buildings symmetrically placed on both sides of the main axis. The symbolic voids were either semi-open or closed courtyards. New buildings were often added around a semi-open courtyard during campus expansion, closing it, and reinforcing the static composition of the campus.

The passage type had no symbol at the end of the axis, and was a composition on procession. Some axes of this type were interiorized or arcades. When the axis was merely void without a goal, the static order was less stable than the focus type.

Non-Scale Dynamic Order: Mediation

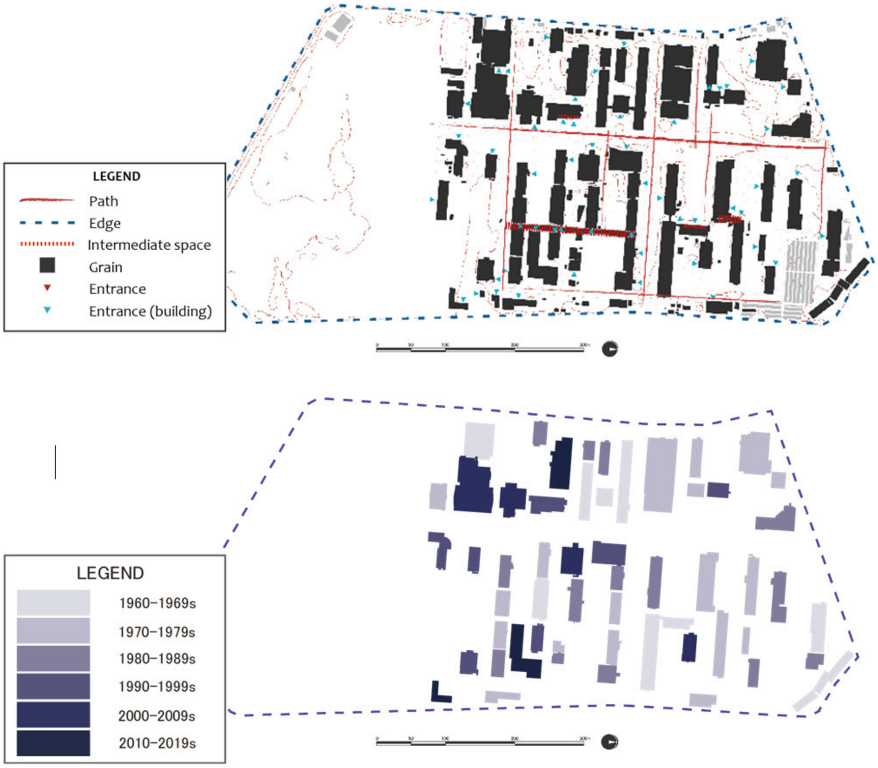

Fig. 04. Repetition-type campus: Saitama University

Source: Author

We analyzed the physical and strong spatial order on two objective scales above, and found that most island-type campuses had a composition of focus type, with a symbolic element and symmetrical positioning of buildings. This classic composition caused campus buildings to form a united entity, distinct from its surroundings, with a hierarchical order. However, the spatial characteristics with landmark may evoke strong images, but they were not necessarily positive (Ewing, 2013, p.19). They tended to be static and introverted, which was against the current demand of opening up the university campus to society. We formulated a hypothesis that the collective form can be made more flexible and organic with the non-hierarchical dynamic order of linkage.

Non-compositional type

We found that many urban tissue type campuses on the urban and neighborhood scales had a different order from the focus type. Rather than having a distinctly large symbolic building or plaza, these campuses had grains and open spaces of similar sizes along gridded passages. We referred to this as the non-compositional pattern repetition type (Fig. 04). This type consisted of blocks and streets, similar to a city. The spatial structure was more flexible to accommodating changes while maintaining the campus identity. However, it was rather homogeneous, and spatial experiences and sequences tended to be repetitive.

While most campuses consist of collective forms with objective elements, Rissyo University (1968), originally designed by Maki, had an exceptional composition that did not fall into these categories on the urban and campus scales. Prior to the design of Rissyo University, Maki (1964) presented approaches to collective form into three categories: compositional form, megastructure, and group form. In compositional form, the relationship between individual elements is preconceived on a two-dimensional and formal master plan, which often coincides with what we observed in the focus type. The megastructure is a large frame that physically connects constitutes elements. These two types are easily understood but have a more rigid collective form. Originally inspired by historical and local settlements, group form has no hierarchical order or master framework; however, the relationships between elements "have their own built-in link" (Maki, 1964, p. 8). It is a flexible and organic collective entity similar to the repetition type; however, the elements are more heterogeneous, and their allocation is seemingly arbitrary. The elements are united not only by physical linkages, such as walls or small open spaces, but also by the sequential experience of the subjects.

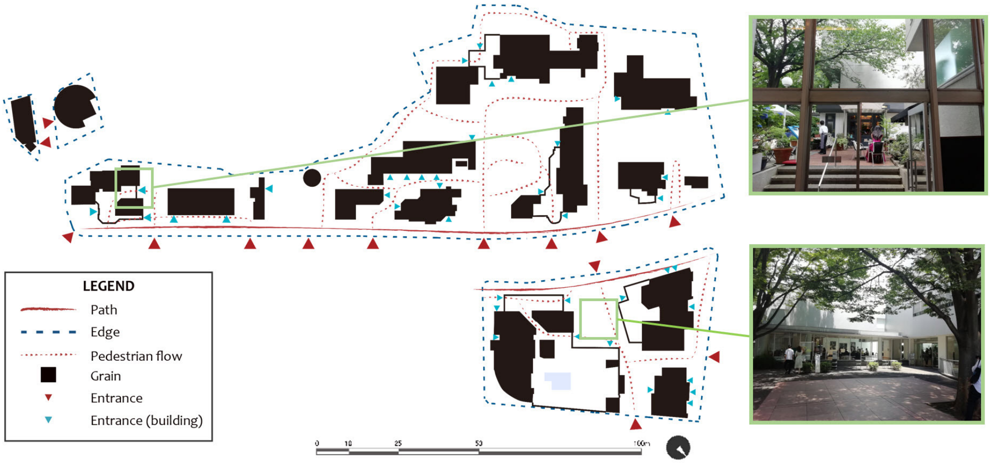

Fig. 05 Group form in modern architecture: Hillside Terrace

Source: Author

One of the best examples of group form in modern architecture is Hillside Terrace (1969–1992), a residential and commercial complex in Tokyo designed by Maki. Sequentially developed over 25 years, it comprises 14 buildings of similar scale, forming a united identity cluster (Fig. 05). By making the diagram to indicate the circulation and assemblages of buildings, we analyzed that Hillside Terrace has no single symbolic axis or landmark. As observed from eye-level, although the forms and exterior finishes of the buildings differ, common physical factors are subtly embedded in architectural and landscape design, such as corner entrances, the height of eaves, and the integrated use of existing trees and historical elements.

However, the empirical layers orchestrated by these physical linkages make this collective form unique. Carefully designed pedestrian circulation lanes and small courtyards give visitors various experiences of inside and outside, up and down, wide and narrow, light and dark. These open spaces and physical linkages instigate empirical order that mediate buildings—constructed in different years—spatially and temporally. Moving from one building to another through these visible and invisible mediators feels like traveling to a different period.

Group form in Hillside Terrace was made possible by its relatively small and dense site of approximately 12,000 sqm. For university campuses, which are 20–30 times larger than Hillside Terrace, one cannot simply apply the same principles by merely enlarging them. As there are absolute limits to scale transformation in the physical world owing to the nature of materials, human senses also have a limited functional range in the degree of distance reception (Gehl, 2011). The question is how we can employ this dynamic order, which relies on human behavior at a more expansive scale.

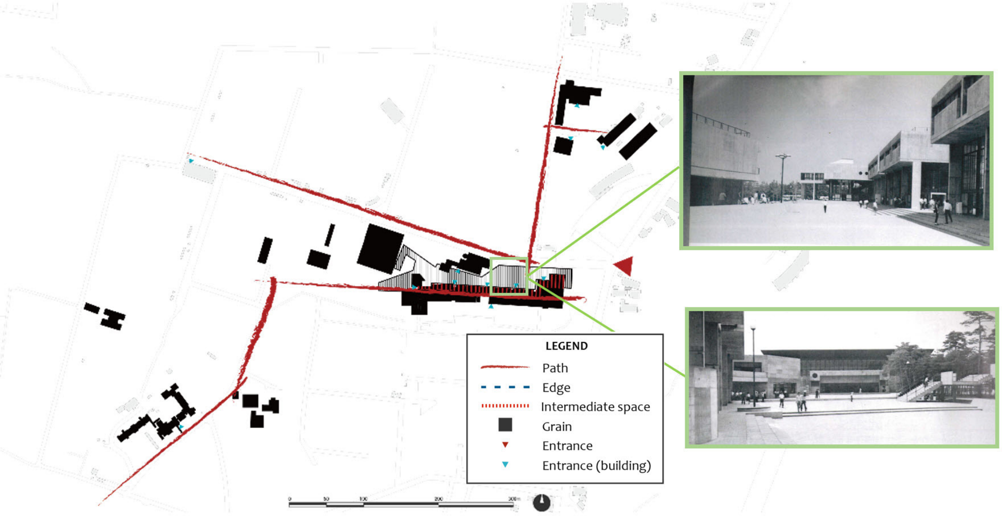

Fig. 06. Compositional form with a clear focus: Rissyo University (1968)

Source: Author

Maki argued that the three approaches to collective form are not exclusive, but can be combined. In the master design of Rissyo University, whose site area was 360,000 sqm, he integrated compositional and group forms to unite the university buildings as a town. Located in the middle of the thicket in suburban Kumagaya, Saitama, Rissyo University has a boundary of indefinite shape following the island type, but does not have a centripetal or symmetrical composition as the focus type. Moreover, it was originally composed of two sets of L-shaped axes and a triangular plaza between them (Fig. 06). The university exhibits a variation of compositional form with a clear focus and main axes, which gives a master frame for this vast campus, as well as open-ended axes, suggesting possibilities for the future expansion.

Over the layer of the static order of campus buildings, dynamic linkage of group form was embedded at various scales. The form of each building on campus was heterogeneous and derived from its function. However, the common design at the micro-scale, such as the usage of handrails and light fixtures, gave them a united identity. Small hangout spots were placed at the intersections of students' circulation lanes inside and outside of buildings to slow the traffic down, encouraging interaction among students. The changes in floor levels facing the plaza provided students with various experiences of seeing and being seen. The accumulation of these spatial manipulations activated the connectivity of the buildings. Rissyo University's design successfully took advantage of the clarity of compositional form and dynamics of group form.

Time mediation failed

Fig. 07. Rissyo University after renovation (2007)
Source: Author

The disadvantage of group form is that the rules for assemblage are only implied and invisible. When Rissyo University administrators decided to reorganize and expand the campus in 2007, it did not follow the subtle structure of the original design – they demolished most of Maki's buildings, and replaced the gymnasium with a massive 6-story classroom building (Fig. 07). The original axes, part of which were interiorized, faded, and the boundary of the intimate triangular plaza was erased by the demolition of the original buildings. Even if the original buildings needed to be demolished owing to a demand for increased campus facilities, the master design of group form would have been flexible enough to adapt to campus transformation if certain rules, such as common factors and time mediating elements, were maintained.

However, Rissyo University, after renovation, has no clear objective composition as the focus type, and it lost the layer of time mediation of group form.

Conclusion

We examined 24 university campuses from the objective and physical orders of urban and campus scales, and illustrated the importance of the empirical layer for constructing the collective form. In many campuses, dominant and totalizing scales with the physical linkage of clear axes and symbolic elements were used to unite buildings, indicating the focus type. They have strong but introverted identities, and their static character does not easily allow changes.

Conversely, some campuses had empirical layers that supplemented geometric compositions to reinforce the connectivity of campus life. This non-scale dynamic order indicated group form. This order does not strongly organize people's spatial experiences, but invisible linkage mediates their space and time and could be considered a weak order owing to its subtleness. As the latest concept out of linkage, Maki (2015) emphasized the potential of open spaces for spontaneous public interactions. An open space can be a large formal plaza, which takes a clear physical scale used in a compositional form; it can also create latent linkage, which facilitates people's activities and movements, embedded in group form. Given that it exists in people's subjective experiences, intangible and weak order of linkage in group form could hold a sense of unity in cities with thinning density as the population decreases. Therefore, group form, combined with other approaches with an objective hierarchy of physical scale, can create a sustainable and open collective form.

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Filipino Vernacular Scales and Their Use in Construction

Introduction

Scale has been defined as: 'The size of a building in relation to its surroundings, or the size of parts or details of the building, particularly in relation to the scale of a person. Scale refers to the apparent size, not the actual size.' (State of Victoria (Department of Environment, Land, Water and Planning 2016)) Divya Khotari in her discourse on "The Psychology Behind Scale In Architecture" mentions that scale in architecture is a ratio based on the architectural elements with each other and their surroundings being in harmony with the human body. The measurements of architectural elements in a building are based on the measurements of a human body (Khotari 2022).

But what if the human body itself, and its parts, are used to measure the building elements? Then they become the units of measurements in creating a space. We also know that there are variations in the sizes of humans which are dependent on their locations, nutrition and economy.

The Filipinos would have different body measurements from other races which have been shaped not only through genetics but by their experiences. But it is also interesting to note that the Filipinos are explorers, and since the start of Filipino history have been finding ways and means of survival and inventive processes, even in the field of architecture and construction. It can therefore be theorized that they must have also used the parts of the human body as vernacular scales in the course of construction.

The term "vernacular scale" was coined from its association to "vernacular architecture". The phrase "vernacular architecture" was used by Sir George Gilbert Scott in 1857, in the first chapter of his book "Remarks on Secular & Domestic Architecture, Present & Future." He wrote:

"Vernacular architecture usually serves immediate, local needs; is constrained by the materials available in its particular region; and reflects local traditions and cultural practices. Traditionally, the study of vernacular architecture did not examine formally schooled architects, but instead that of the design skills and tradition of local builders, who were rarely given any attribution for the work."

In a children's story book written by Mimi Navales entitled "*Ang Panukat ni Kat"* (Kat's Measuring Tool) and published by the Department of Science and Technology of the Philippines in 2022 and geared for children 3 years of age and above, four common scales based on the Filipino anthropometrics were identified: *piranggot* (length of the pointer finger, about 4"), *dangkal* (length of the extended pointed finger and thumb, about a span of 7-8"), *talampakan* (one foot), and *dipa* (length of the arms or fathom which is about 5-6 ft.). In the book, the author suggests that measurements of rooms can be done even without the use of a measuring tape through the parts of the body. (Navales 2022)

Statement of the Problem

This paper will explore Philippine vernacular scales (the four common scales that have been mentioned by Ms. Navales in her book) and their use in the Philippine construction industry at the present time.

The research questions that will be tackled will include the following:

- Are the vernacular scales still being used for construction in the cities, particularly in the vicinity of Metro Manila?
- Are there other vernacular scales that are used aside from these four common scales?
- How are the scales used by construction workers?
- Do they consider using the scales as efficient or not?
- Will the body measurements of these construction workers be close to the standard sizes defined by Ms. Navales?

Significance of the Problem

The paper can contribute to the understanding of scales and its association with the construction industry. It can also give credence to the move by the Philippine Department of Science and Technology to teach the children about vernacular scales and its practical uses which the children can later on adopt even in adulthood.

Scope and Limitations of the Study

The paper discusses a short history of the Filipino vernacular architecture and the possibility of the use of vernacular scales in traditional building, provides a glimpse of the current Philippine industry, particularly in Metro Manila, and includes the results of surveys made among construction workers. Due to lack of time and availability of the construction workers during the study period, only a total of 51 construction workers were surveyed and limited to a construction project within the city of Paranaque in Metro Manila

Review of Related Literature

Filipino Vernacular Architecture

There are five principal features that pertain to the vernacular mode of building according to the book chapter "Philippine Vernacular Architecture and its Austronesian Ancestry" of *Arkitekturang Filipino* by Dr. Gerard Lico. These are: (1) the builders, whether artisans or those planning to live in the buildings, are non-professional architects or engineers; (2) there is consonant adaptation, using natural materials, to the geographical environment; (3) the actual process of construction involves intuitive thinking, without blueprints, and is open to later modifications; (4) There is a balance between social/economic functionality and aesthetic features; and, (5) architectural patterns and styles are subject to a protracted evolution of traditional styles specific to an ethnic domain. (Lico 2008)

Fig. 1 Bahay Kubo

Source: 3D Warehouse

In the Philippines, vernacular architecture has been identified with the bahay kubo, the traditional Filipino house, and the bahay na bato, which is an amalgamation of Spanish and traditional architecture. The pre-Hispanic bahay kubo utilizes building materials that are abundant and immediately available, is of simple construction, and may also be easily reconstructed, according to Senen Antonio in his discussion in "Lean Interpretations from Philippine Vernacular Architecture". He also mentioned that the bahay kubo by nature is an impermanent structure with light and simple structure that may be constructed by less-than-skilled labor. (Antonio 2014) We can also surmise that the construction of the bahay kubo and similar indigenous structures would also have been with the use of what we may call as vernacular scales.

The *bahay na bato* was introduced during the Spanish Colonial Period in the Philippines. In 1521, Ferdinand Magellan discovered the Philippine islands but it was not until 1565 when the first colony was established by Miguel Lopez de Legazpi. Although the first colonies were made of clusters of *bahay kubo* and structures of similar characteristics, the *bahay na bato* was later introduced in 1587 with the desire for structures which will last with more durable materials like stone or bricks. and upon the edict of the Governor General Santiago de Vera who commanded that all buildings in Manila were to be made of stone. (Lico 2008). Earthquakes though, called for structures that would be more resilient so that the *bahay na bato* was characterized with materials that would be light on the second floor and heavier on the ground floor. Even though skills on making the *bahay na bato* would also evolve, it still can be argued that the scales they used in the construction would still be vernacular scales since the measuring tape or meter tape was not invented by British metalworker James Chesterman until 1829. (Zibell 2020)

Fig. 2 Bahay na Bato

Source: Pinterest – Oil on Canvas by JBulaong 2014

Philippine Construction Industry

The Philippine construction industry was the fastest growing industry in the Asia-Pacific region before the Coronavirus (COVID-19) pandemic. It diminished the growth of the industry from positive 14.9% in 2018 to a negative growth 27.2% in the first quarter of 2020 because of the containment measures of the government. However, the government continued its programs of ”Build, Build, Build” under the Duterte administration, which was centered on major infrastructure projects, so that the construction industry reached a record high growth by the end of 2021. In 2022, the industry was projected to grow by 14.9% and expand by an annual average rate of 7.8% up to 2025 according to a report by an analyst entitled ”Construction in Philippines - Key Trends and Opportunities to 2025 (Q2 2021)”. (Reportlinker 2021)

The Philippine Statistics Authority has also reported that in the first quarter of 2022, the number of constructions from approved building permits was posted at 37,270. By type of construction, residential buildings reported the highest number of constructions of 26,546 or 71.2 percent of the total number of constructions during the quarter. (PSA 2022) Residential buildings include: single-attached homes, single-detached homes, condominiums, apartments and townhouses. (Property Source 2021)

This type of construction expanded at a rate of 4.0 percent, which was slower compared with the annual increment of 10.0 percent in the same quarter of 2021. Although majority (85.9%) of the total residential constructions were single-type houses, residential condominiums posted the highest average cost of Php 18,347 per square meter during the quarter, while residential duplex/quadruplex recorded the lowest at Php 8,798 per square meter. (PSA 2022)

The regions that posted the highest spending in the construction industry were the following:

- Region IVA - CALABARZON, Php 20.22 billion (23.3%);
- National Capital Region or Metro Manila, Php 14.79 billion (17.0%); and
- Region III - Central Luzon, Php 10.26 billion (11.8%). (PSA 2022)

The government promotes the development of affordable housing, medical facilities, transport and renewable energy infrastructures which will support the expansion of the construction industry for the years to come.

Philippine Construction Workers

The top five sub-sectors in the Philippines with the highest increase on the number of employed persons from October 2021 to October 2022 according to the article ”Employment Rate in October 2022 is Estimated at 95.5 Percent – Philippine Statistics Authority” are:

a. Wholesale and retail trade; repair of motor vehicles and motorcycles (672 thousand);
b. Transportation and storage (553 thousand);
c. Construction (426 thousand);
d. Accommodation and food service activities (407 thousand); and
e. Administrative and support service activities (366 thousand).

In the study ”Real-time Simulation of Construction Workers Using Combined Human Body and Hand Tracking for Robotic Construction Worker Systems”, the authors stated that construction is an inherently less safe sector than other sectors because it exposes workers to harsh and dangerous working environments, and that the nature of the construction industry results in a comparatively high incidence of serious injuries and death caused by falls from a height, musculoskeletal disorders and being struck by objects, which is why they have proposed the use of robotic systems to help construction workers from being exposed to these dangers. (Kurien, et al. 2018).

The study ”How Adoption of Coping Behaviors Determines Construction Workers’ Safety: A Quantitative and Qualitative Investigation” also states that safety problems have long been prominent in the construction industry, with huge numbers of injuries and fatal incidents annually among construction workers. Construction workers also suffer high levels of stress, and unmanageable stress can lead to problems of reduced safety. Practical recommendations are made to facilitate the adoption of effective coping behaviors by construction workers, including team-building exercises, safety empowerment and stress management programs. (Liang, et al. 2021). Since the construction workers should be taking precautions, usage of vernacular scales might in some way be useful to them in their work.

A study conducted on Filipino workers in export zones by Jinky Leilanie Del Prado-Lua entitled “Anthropometric measurement of Filipino manufacturing workers” among 1805 individuals, composed of 53.3% females and 46.7% males, majority of the subjects were between 150 and 174 cm in height. Anthropometric measurements of workers show that the mean standing height for males is higher than that for females at 167.0 cm and 153.9 cm, respectively. Meanwhile, the mean sitting height is 84.8 cm for males and 79.9 cm for females. Other anthropometric measurements of the workers taken were body circumferences, grip strength, depth (forward reach), breadth (elbow to elbow span), all of which are essential in the work place, the export zones in this case, so that they can be designed efficiently. (Lua 2007)

For this study, a proposed survey of construction workers on their anthropometric measurements will be done similar to that of Lua's study, but the measurements will be centered on the vernacular scales that was pointed out by Navales in her book. These are *piranggot* (length of the pointer finger, about 4"), *dangkal* (length of the extended pointed finger and thumb, about a span of 7-8"), *talampakan* (one foot), and *dipa* (length of the arms or fathom which is about 5-6 ft.)

Figs. 3-6 Illustrations of 1) *piranggot* 2) *dangkal* 3) t*alampakan* 4) *dipa*
Source: Mimi Navales book

Research Methodology

The study was done in the National Capital Region (Metro Manila). A descriptive survey method was used to determine construction workers perception of the vernacular scales. Probabilistic stratified random sampling was used.

The respondents chosen based on their availability were 51 construction workers of Prompt Managers and Construction Services, Inc. (PMCSI) working on a residential and commercial condominium project in Paranaque City called the Central Link. The Filipino-owned company is known to offer and provide the highest quality of construction management services. Their main policy as an organization is to "recognize that people are the essence of any good business". (PCSMI Company Profile, January 2023).

The respondents were informed about the study's purpose. Informed consent was asked from each respondent before answering the survey questionnaire. The office of the construction engineer of the project assisted in the process. Before the respondents left, tokens of food were distributed to them.

The survey questionnaire consisted of demographic questions like age, province of origin and years of work with the construction industry. Since all of the interviewees and construction workers were men, gender was not part of the questionnaire.

Questions related to the vernacular scales, their use, or observed use were included. The vernacular scales were demonstrated by the researcher to the respondents to explain them visually. The respondent's knowledge and identification of other vernacular scales not mentioned in Navales' book, as well as the usefulness and practicality of use were also investigated. Measurements of the body parts of the construction workers related to the four vernacular scales were made. These will be compared to the measurements that Navales mentioned.

Results and Analysis of the Survey

The ages of all male respondents ranged from 24 years – 54 years old. As to the provinces where they came from, 25 provinces of the Philippines were mentioned (Figure 7). One respondent each came from the provinces of Aurora, Bulacan, Camarines Sur, Laguna, Mindoro, Pangasinan, and Quezon, which are all found in Luzon; from the provinces of Antique, Northern Samar and Western Samar, which are found in the Visayas; and from the provinces of Agusan del Norte, Lanao del Norte, and Misamis Occidental, which are found in Mindanao; two respondents each came from the provinces of Isabela and Marinduque (Luzon), Leyte and Negros Oriental (Visayas), and the Bicol region; three respondents each came from Albay, Metro Manila, and Sorsogon (Luzon); four respondents each came from Cavite and Rizal (Luzon), which are provinces adjacent to Metro Manila; five respondents came from Zamboanga del Sur (Mindanao) and six respondents came from Nueva Ecija (Luzon). The data shows that construction workers hail from the three biggest island groups of the Philippines.

They were asked to indicate the years of their experience in the construction industry as follows:

a. 1-5 years (17 construction workers)
b. 6-10 years (4 construction workers)
c. 11-15 years (20 construction workers)
d. 16-20 years (7 construction workers)
e. more than 20 years (3 construction workers)

Table 01. Frequencies for Years in the Construction Industry

Years	Frequency	Percent	Valid Percent	Cumulative Percent
1-5 years	17	33.333	33.333	33.333
6-10 years	20	39.216	39.216	39.216
11-15 years	7	13.725	13.725	13.725
16-20 years	4	7.843	7.843	7.843
More than 20 years	3	5.882	5.882	5.882
Missing	0	0.000		
Total	51	100.000		

Source: generated through the use of JASP program

Aside from Metro Manila, they have worked in 18 other provinces. These are in Agusan del Norte, Albay, Batangas, Cavite, Davao, General Santos City, Ilocos Norte, Isabela, Laguna, Marinduque, Negros Oriental, Nueva Ecija, Pampanga, Pangasinan, Quezon, Rizal, Sorsogon and Zamboanga del Sur. This question was asked in order to identify whether the construction skills of workers were honed while they worked in their provinces.

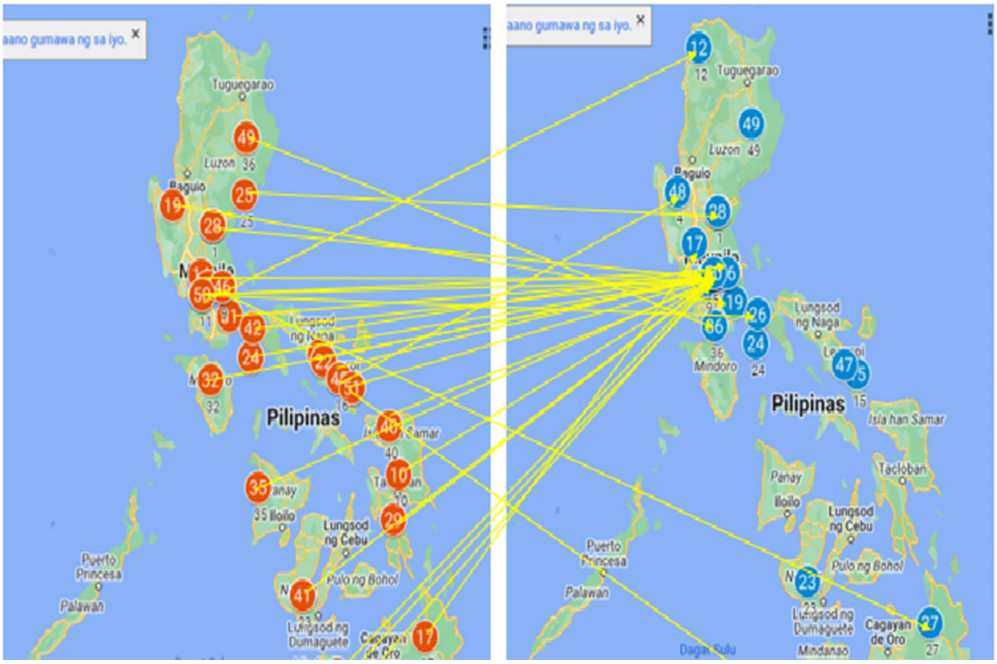


Fig. 7 Correlation of workers places of residence to their places of work

Source: Power Point by John Mark Mercado

When asked about their familiarities with the vernacular scales: piranggot (length of the pointer finger, about 4”), dangkal (length of the extended pointed finger and thumb, about a span of 7-8”), talampakan (one foot), and dipa (length of the arms or fathom which is about 5-6 ft.) and if they have used it in their construction work, the following data were generated:

Table 02. Frequencies for Familiarity and Use of Vernacular Scales

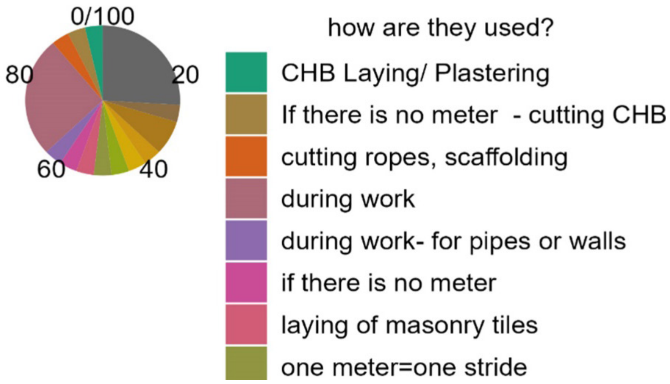
Familiarity and Use	Piranggot	Dangkal	Talampakan	Dipa
Frequency				
Minimum 0 – No	32	22	31	22
Maximum 1-Yes	19	29	20	29
Percent – No	62.745	43.137	60.784	43.137
Valid Percent – No	62.745	43.137	60.784	43.137
Cumulative Percent – No	62.745	43.137	60.784	43.137
Percent – Yes	37.255	56.863	39.216	56.863
Valid Percent – Yes	37.255	56.863	39.216	56.863
Cumulative Percent – No	100.000	100.000	100.000	100.000
Missing	0.000	0.000	0.000	0.000
Total	51	51	51	51

Source: formulated through the help of JASP program

The above data would show that most construction workers were familiar and would actually use two vernacular scales – dangkal and dipa – with similar percentages of 56.863 among the Yes answers (29 out of 51 respondents). The scale which they are least familiar with and thus would not commonly use would be piranggot which has a percentage of 62.745 with No answers (32 out of 51 respondents). Talampakan has almost the same percentage as piranggot with 60.784 of No answers (31 out of 51 respondents).

In terms of how they are used, only 27 construction workers gave their answers. They answered from the very general topic – during work – to the more specific tasks as follows: for concrete hollow blocks (CHB) laying and plastering, for cutting concrete hollow blocks (CHB), for cutting ropes and scaffolding work, for pipes and walls, for laying of masonry tiles, and for ground surveying. Some have been candid to say that they use the scales when they forget to bring their meter to the 12th floor (highest part of the construction). Knowing that there are many dangers involving construction work, it could be a safety measure. Some identified the carpenters and masons to be the users of the vernacular scales. There are also those who surmised that they may be only used in small constructions because rules in the construction company prohibits the use of inaccurate measurements.

Table 03. Distribution of the Use of Vernacular Scales in Construction



Source: formulated through the help of JASP program

As to the question of whether or not they can identify other vernacular scales used in construction, only 17 out of the 51 respondents gave their answers and the most common were the *kalahating dipa* (from one shoulder to the tip of the fingers of the other arm) and *taas* or their height.

Table 04. Descriptive Statistics for Identification of Other Vernacular Scales and Observed Use

Identification and Observation	Other vernacular scales	Identification	Observation
Valid	51	17	51
Missing	0	34	0
Mean	0.431		0.471
Std. Deviation	0.500		0.504
Minimum (No)	0.000		0.000
Maximum (Yes)	1.000		1.000

Note. Not all values are available for Nominal Text variables

Source: generated through the help of JASP program

When asked about the convenience of using vernacular scales, majority answered No (39 out of 51 respondents). Here are the frequencies for convenience:

Table 05. Frequencies for Convenience of Vernacular Scales

Convenience	Frequency	Percent	Valid Percent	Cumulative Percent
No	39	76.471	76.471	76.471
Yes	12	23.529	23.529	100.00
Missing	0	0.000		
Total	51	100.000		

Source: generated through the use of JASP program

Finally, the anthropometric measurements of the surveyed construction workers were measured and the following table gives us a glimpse of the results.

Table 06. Descriptive Statistics for Vernacular Scale Measurements among the Construction Workers

Anthropometric Measurements in Inches	Piranggot	Dangkal	Talampakan	Dipa
Valid	51	51	50	51
Missing	0	0	1	0
Mean	3.336	6.815	10.320	65.526
Std. Deviation	0.275	0.626	0.566	3.180
Minimum	3.000	5.000	9.000	57.000
Maximum	4.000	8.000	12.000	73.000
Navales	4.000	7.000-8.000	12.000	60.000-72.000

Source: generated through the help of JASP program with one modification

Comparing the results with the measurements given by Navales in her book, we can see that the maximum results are very close to her stated measurements. There are also results below the minimum measurements which she has stated. It is worthy to note that there is a high standard deviation for *dipa*, pointing to the inaccuracy of this particular vernacular scale.

Conclusions and Recommendations

Based on the results of the investigation, the following conclusions were drawn:

- Vernacular scales are still being used for construction in the cities, particularly in the vicinity of Metro Manila. Half of the number of construction workers surveyed were familiar with all vernacular scales mentioned. Other vernacular scales mentioned by the workers that were not included in the survey form were *kalahating dipa* and *taas*.
- Most of the users of the vernacular scales are carpenters and masons, and the usual application includes masonry work and ground surveying.
- Majority think that the use of vernacular scales is not as efficient as the meter tape, and would use the latter for efficiency and accuracy in the construction.
- The high standard deviation for the measurement of *dipa* points to the inaccuracy of this measurement.

As a recommendation, introducing vernacular scales to children would be a means for them to develop practical skills which they could find useful in adulthood. This art could be neglected if they get used to more accurate measures, however, their use in the history of vernacular architecture can always be acknowledged. The move of the Philippine Department of Science and Technology (DOST) to teach them to children through books and school lessons is a commendable step towards this end.

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From projection to building and vice versa

Perception scale of *trompe l'oeil* and its resurgence in a particular kind of contemporary architecture

Introduction

After three decades of formal experimentation guided by digital design tools, it is interesting to observe the return of architectural *trompe l'oeil* in some projects. This presumably indicates a desire to establish a crossplay between architectural design canonical projections (plan / section / elevation / perspective) and the constructed space. Insofar as this device is mainly based on the use and diversion of architectural drawing projective principles, it is interesting to question its resurgence in architectural design contemporary technological context.

This paper is driven by two concerns. On one hand, to understand how projective (and perspective) devices in architectural drawing can influence our physical perception of the world and its scale; and, on the other hand, to consider the architectural survey as a moment of knowledge (Lo Buglio and De Luca, 2011). While these two concerns may seem to have little in common, they both question the persistence of projections in the architectural object and their ability to disrupt our perception. Through studying the functioning of a singular accelerated perspective (forced perspective), this paper intends to understand why this particular type of projective device (architectural *trompe l'oeil*) is reappearing in a particular kind of contemporary architectural production.

In order to examine this link, we propose first to observe Seneffe castle's small theatre (late eighteenth century, Belgium), a singular accelerated perspective project built by French architect Charles De Wailly. One of the peculiarities of this small building is its interior space, which proposes an accelerated perspective (special case of *trompe l'oeil*). This optical illusion, mainly used during the Baroque period, plays with monocular perspective to distort a space and our comprehension of its scale in order to make it look longer or shorter than it really is.

The question we attempt to answer is: what does this illusion tell us about the built space and its scale? This question underlies the study of projections in the conceptual act and the way these approaches still find an echo in a number of contemporary architectural practices. In this sense, the survey of the theatre could allow us to better apprehend the accelerated perspective particular device and consequently the role of drawing in the project. Based on that, the question arises of using a *trompe l'oeil* for a building that could have been built without optical distortion due to the space available around the building (fig.3). Considering the architect first proposes a conceptual posture, this obviously leads us to question the place of projections as a composition paradigm. The accelerated perspective, more than any other approach, highlights the close link between projection and constructed space. Even though we do find exemples of forced perspective or other optic illusion in many fields (such as the theater, painting, photography or the cinema), it is in architecture, more than anywhere else, that the accelerated perspective transforms the physicality of our relationship to the material space.

By examining this projective system, which is mainly found in Baroque architecture, it is tempting to try and understand what such a comeback can mean in particular contemporary projects. This is all the more relevant as the current digital context tends to erase the cultural and conceptual contribution of canonical projection systems that have existed in architectural design for five centuries. Beyond the aesthetic dimension, some recent European projects suggest a gradual return of *trompe l'oeil* devices, which seems to reflect a desire to re-establish a dialogue between space and projections. In the context of technological increase and the gradual domination in design of 3D visualisation tools, the return and transgressive use of canonical projective systems probably reflect the need to place the project at the heart of a cultural practice of architecture. It has been built over the last five centuries by developing drawing methods that allow to downplay the project's complexity to abstract and synthetic representations. This last point also suggests examining some recent projects that help understand the re-emergence of this link between projection and constructed space.

To summarize, the following points intend:

a. to explain the process used to survey and analyze – through representation – the accelerated perspective of the Seneffe castle (Belgium) (fig.1),
b. to deconstruct it in order to find the space undistorted by the *trompe l'oeil*, hence the building's "real" projected scale (fig. 2),
c. to understand what a *trompe l'oeil* induces spatially and to evaluate its relevance in contemporary production.

Study of an accelerated perspective

The survey of the Seneffe castle's small theatre

In order to understand what an accelerated perspective is and how it is constructed, the survey of the Seneffe castle's small theatre was carried out by a group of students from the ULB Faculty of Architecture La Cambre-Horta, as part of the course entitled "survey and architectural representation". This building was designed in the 18th century by Charles De Wailly, the renowned French architect who designed the Royal Castle of Laeken, the royal family of Belgium's residence.

The unique layout of the *Petit Théâtre du Château de Seneffe*'s interior space is mainly due to the presence of a *trompe l'oeil* arrangement that results in making the stage look longer than it actually is. This accelerated perspective is constructed to exaggerate the optical narrowing between the foreground and the background of the stage. While many *trompe l'oeil* designs were found during the Baroque period, they were essentially wall frescoes whose effect was to modify our perception of physical space. Apart from some famous great examples such as the Scala Regia at the Vatican (Antonio da Sangallo the Younger) or the Palazzo Spada (Francesco Borromini), fewer *trompe l'oeil* design directly apply the monocular perspective principles to the built space. Though it is a late example, the Little Theater is therefore a singular case of anamorphosis directly applied to architecture.

In order to understand the construction and the deformations inherent in the place, the lasergrammetric and photogrammetric surveys of the interior and exterior spaces were carried out. While lasergrammetry is an indirect measurement technology commonly used today, photogrammetry is increasingly being developed when it comes to conducting heritage surveys. In terms of documenting architectural elements, photomodelling (surveying, 3D modelling and representations from images) has reached a point where costs, accessibility, quality and the diversity of results can meet many surveys' needs and constraints at architectural (technical and disciplinary) scale (Lo Buglio, 2018).

The surveys of the small theatre reveal a neoclassical ensemble with a cross plan made up of three square spaces adjoining a central space, also with a square plan. In the main axis stands a colonnade; each column's sections and their centre distance decrease as one moves away from the central space (fig.1). While it looks like a deformation from the side wings, it becomes visually coherent when taking up position in the centre of the building.

From this point of view, the stage seems to take on another scale (longer and wider than it really is). Another interesting aspect is that the *trompe l'oeil* illusion seems to work not only from the central axis but from whatever position from the central space.

Deconstruction of an Accelerated Perspective and Construction of the Induced Space

Fig. 01. Transversal and longitudinal section coming from the lasergrammetric survey of the interior space of Seneffe castle's small theatre.

Source: David Lo Buglio/ Alexandre Van Dongen / Arnaud Schenkel / Henry-Louis Guillaume, 2020

The survey not only made it possible to precisely document the existing situation but also to deconstruct the accelerated perspective of the stage. It is all about determining the viewer's ideal position but also understanding the geometric principles used to design that space.

Looking at the section's orthogonal projection (fig.1, left-hand side) naturally seems to reveal the conical perspective of a space with a larger scale (or depth) than perceived. However, on the basis of these documents and the plan re-drawn during the survey, the challenge is first to locate the respective positions of the vanishing point, the picture plane and the observer.

If the picture plane is at the intersection of the building's central space (not deformed) and the stage of the theatre, the vanishing point can be determined by extending the path of the colonnade's shortened perspective projected on the plan (and the section) of the survey. Things are somewhat different when determining the observer's position. It can only be located by knowing the distance point vis-a-vis the picture plane. Obviously, from the section showing the shortened perspective, it is already possible to draw the diagonal from the picture plane to the distance point on the horizon line (fig. 2, the upper part of the figure).

Another solution is to deduce the built space (or the space as it might have been built) without anamorphosis (fig. 2, bottom part). Based on the building's composition in its "non-deformed" parts, the "real" depth of the stage is drawn, in other words, it is the depth without deformation. This new plan allows transferring the distance to the picture plane (previously found on the perspective), to identify the observer's location but also and above all to understand where the best position is to appreciate the *trompe l'oeil*.

This has not yet been mentioned, but unlike the conical perspective drawn from the undeformed building (fig. 2, bottom part), the orthogonal projection of the surveyed anamorphosis reveals several vanishing points (fig. 2). We find three vanishing points on the vertical axis of the scene (on several theoretical horizon lines). If this may seem like an error, the precision of these three points rather suggests a voluntary construction.

It is possible to hypothesise that their existence results in playing with our perception of space. More specifically, these multiple vanishing points extend the area from which the space of the stage appears to be coherent. This principle is also reminiscent of particular Renaissance pictorial constructions, where vanishing points were multiplied, allowing several observers to appreciate the *trompe l'oeil* simultaneously (Panofsky, 1976). In addition to extending the scale of the perceived space, multiple vanishing points increase the physical space from which the anamorphosis works. The painting "*Convito in Casa di Levi*" by Veronese (1573) produced for the refectory of the Dominican convent "*Santi Giovanni e Paolo*" is a good exemple of this principle.

The study of the painting by Alberto Sdegno et al. reveals the existence of almost 7 perspective vanishing points within the same graphic space (Sdegno and Masserano, 2016) (fig. 3). But what is even more intriguing is that observing the scene generally does not help understand the perspective distortions. Apparently, the painting was meant for the upper part of the wall at the bottom of the refectory, over a width of 13 m. The primary objective of this *trompe l'oeil* and its particular position is to heighten the perspective of the room by the presence of this painted gallery. On the other hand, the multiplication of vanishing points on the vertical axis makes it possible to appreciate the effect of different positions in the space of the room.

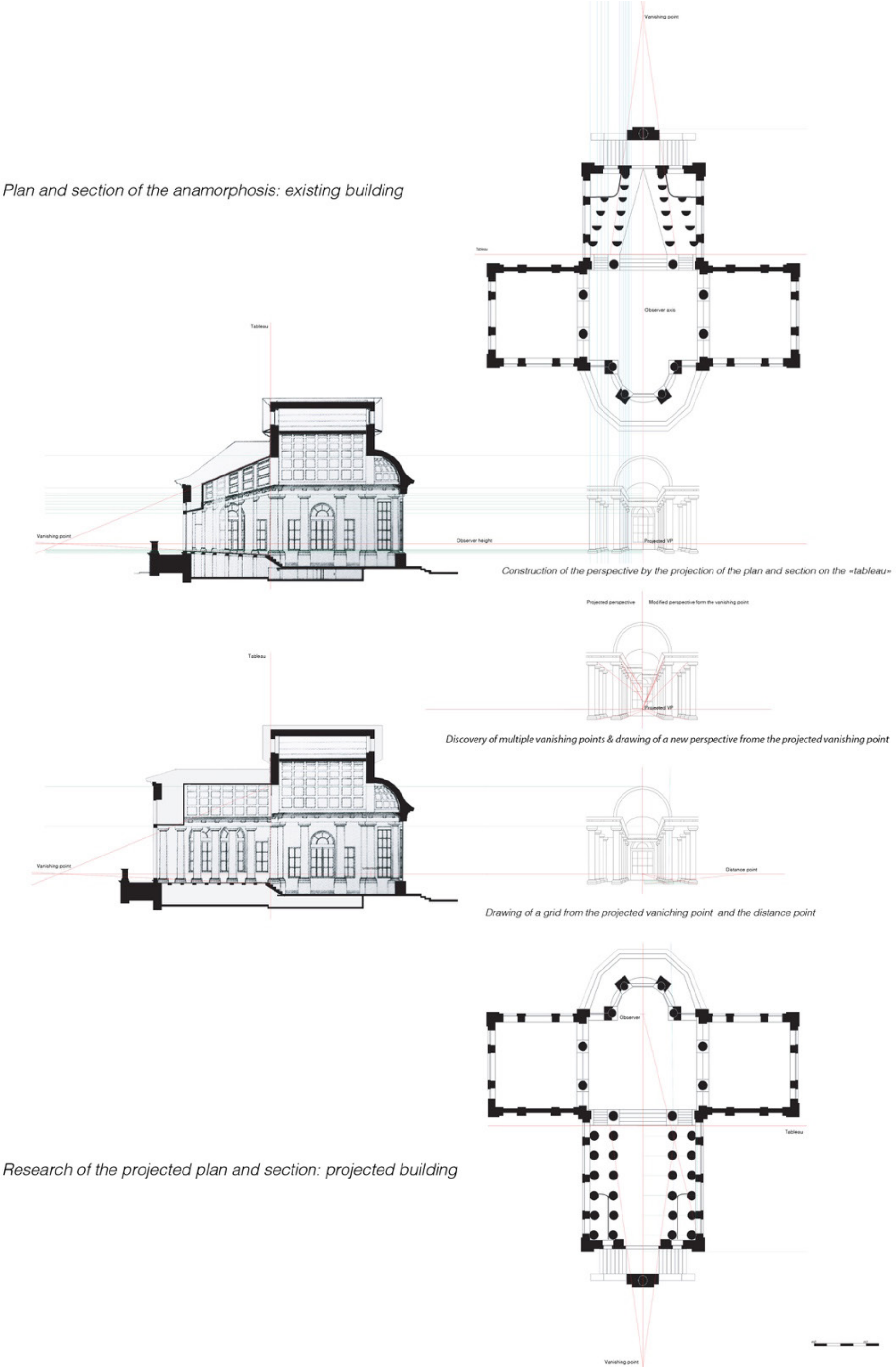

Fig. 02. Survey and analysis of the accelerated perspective of the Seneffe castle's small theatre. *Image : Myriem Saoud / Pauline Virtt, 2019*

Returning to the Seneffe castle's small theatre, we realise that, in addition to the principles of monocular perspective, the deformations due to these numerous vanishing points are, in the manner of Veronese's painting, likely to extend the operation of the *trompe l'oeil* in space. While this may seem necessary in the case of a scene observed from many positions, the accelerated perspective applied to the building demonstrates a desire to play with space, its scale and the senses. For the architect, it is undoubtedly a matter of forcing the spatial experience by crystallising the links between the project's composition and the projective medium that are at its origin (fig. 4).

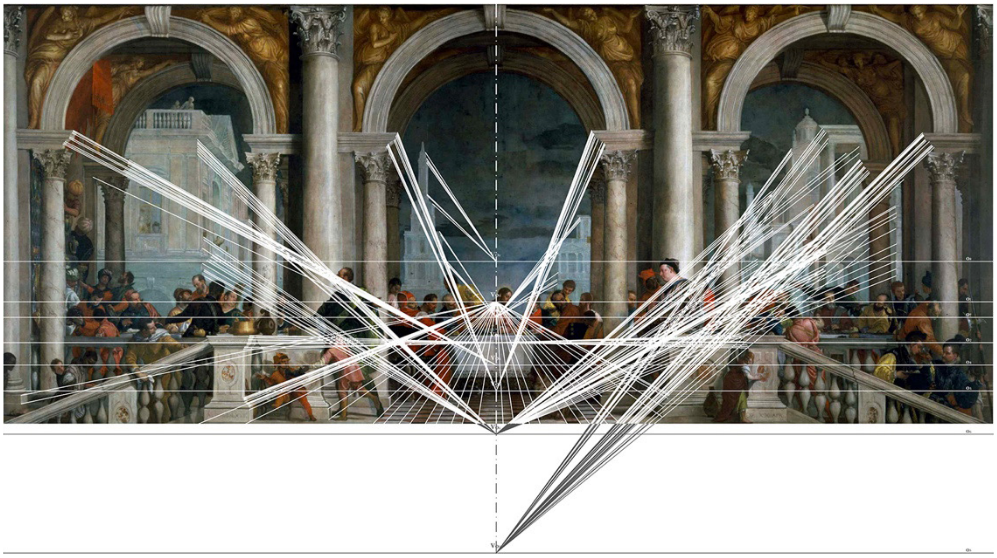

Fig. 03. Perspective study of the painting "Convito in Casa di Levi" (Veronese) by Silvia Masserano and Alberto Sdegno.

Picture: Silvia Masserano and Alberto Sdegno

Fig. 04. 3D printing of the accelerated perspective of the small theatre's inner space.

Model: Valéry Fortune / Valentin Foulon, 2019

The projection as a means of playing and perverting the real and its scale

After three decades of formal experimentation guided by digital design tools, it is interesting to observe the return of architectural *trompe l'oeil* in a number of projects. While the comeback of accelerated perspective or other anamorphic devices seems to have regained a significant place in architectural composition, can we really consider it as a "return" to the Baroque?

One cannot understand Baroque architecture without pointing out a certain praise of unity. As Norberg-Schulz describes, Baroque architecture, "does not exclude any aspect of the overall architectural experience, but it aims at a great synthesis" (Norberg-Schulz, 1997, p. 315). Beyond any plastic or aesthetic dimension, the resurgence of some architectural devices in contemporary architecture echoes various experiments on space, such as those proposed by Francesco Borromini. Norberg-Schulz describes them this way: "He [Borromini] takes the decisive step by deliberately introducing space as the constituent element of architecture […] these spaces are complex totalities, given as indivisible figures. This characteristic is underlined by all the means at its disposal". (Norberg-Schulz, 1997, p. 292). This notion of "means" also evokes the place given to projective devices during the Baroque period, not only as a tool for designing the project but as a tool for transforming reality.

Indeed, the matter of proportion or composition cannot be disconnected from perspective, especially since it was theorized precisely during the Baroque period. While it can be considered central during the Renaissance, particularly through Filippo Brunelleschi's understanding demonstrated in his Tavoletta (a wooden panel created for observing the Baptistery of San Giovanni in Florence), the concept of infinity did not yet exist, and its representation through a vanishing point was even less developed (Damisch, 1993, p. 174). The Tavoletta suggests the position of an observer and a picture plane where the vanishing point serves as the counter-eye of the composition rather than expressing infinity. While this initial device provides a coherent understanding of perspective, it is only with Leon Battista Alberti's treatise "De pictura" in the 15th century that there emerged an early geometric theorization based on "a scientific rationalization of empirical processes" (Mediati, 2008, p. 72). Therefore, it is in the Baroque period that the spatial representation of infinity is suggested by a vanishing point where all parallels converge, and perspective emancipates itself from the realm of painting to integrate the field of mathematics. It fully frees itself from its symbolic significance thanks to figures like Girard Desargues in the 17th century (and later Gaspard Monge) and becomes an instrument for reproducing the visible world. The projective mastery of perspective was essential to the development of projects such as Francesco Borromini's gallery at Palazzo Spada (17th century). This accelerated perspective is a perfect example of how composition, space and perspective coexist within a coherent whole. The interplay that Borromini is trying to establish between the building and the scale of its perceived spatiality could not have existed without the diversion and "literal" application to the constructed space of the projective and perspectival drawing systems.

Today, if we look at the architectural production of some young European offices, we note the emergence of an against-the-flow practice that attempts to reintroduce the projective issue into the heart of the conceptual act. In 2008, the OFFICE Kersten Geers and David Van Severen built a bridge spanning one of the canals of the city of Ghent to reach the cultural centre “Handelsbeurs” (OFFICE-KGDVS, 2008). Like Borromini’s gallery, this bridge offers an accelerated perspective whose vocation is to extend its length and, as a corollary, to stage one of the building’s entrances by making it appear more monumental than it is (fig. 5). While being spaced almost three centuries apart, these two projects offer a similar *trompe l’oeil* arrangement. However, beyond the proximity of architectural responses, today the bridge by Office acts primarily as a manifesto. It re-establishes a dialogue between the project, its cultural dimension and representing means that are at the origin of it (Chancel, 2015).

While the use of this type of device in contemporary architectural practice remains marginal, office DVVT’s production could also be observed. Several of their projects tackle the themes of mimicry or copy, but they have in common that they materialise the link between the project and its representation. One of the most singular examples of this merger is that of the Twiggy store (Belgium) (DVVT, 2013). It is a project to extend and refurbish an old building into a commercial store (2013). In order to accommodate a new vertical circulation, part of the building was modified by a simple operation: the orthogonal “translation” of a part of the facade (fig. 6).

Unlike the previous example, which uses the principle of accelerated perspective to deceive the eye, here the gaze is not deceived insofar as one can clearly distinguish the extrusion carried out there. However, even in the absence of anamorphosis, the geometric operation clearly refers to the projection modes of architectural drawing. If trickery there is, it occurs first in the drawing, insofar as it erases any intervention (fig. 6). The extrusion disappears completely and displays an “ordinary” facade. The geometric drawing contains the anamorphosis and the building refers to the abstraction of the drawing. Although the main issue is to maintain the existing one as much as possible, the trickery meant to surprise the spectator is never far off. Here DVVT first proposes a questioning on the place of drawing in the act of conception; a dialogue between a projective system and the real embodied in the building.

This project is a perfect illustration of the place given by some architects to canonical devices but also of their ability to divert them (here the geometric projection) to alter the perception of the building. This discussed posture is obviously not unique to these contemporary architects. Whether it is Eisenman with the anamorphosis of an axonometric impossibility for the model of “house X” or the literal geometric operations by Gordon Matta-Clark on the Office Baroque (Belgium), many examples can be found in the history of architecture that allow us to consider the building as a represented matter (Chancel, 2015). These postures show us heightened awareness on the part of architects to mobilise representation as a medium to act on reality and alter its reading.

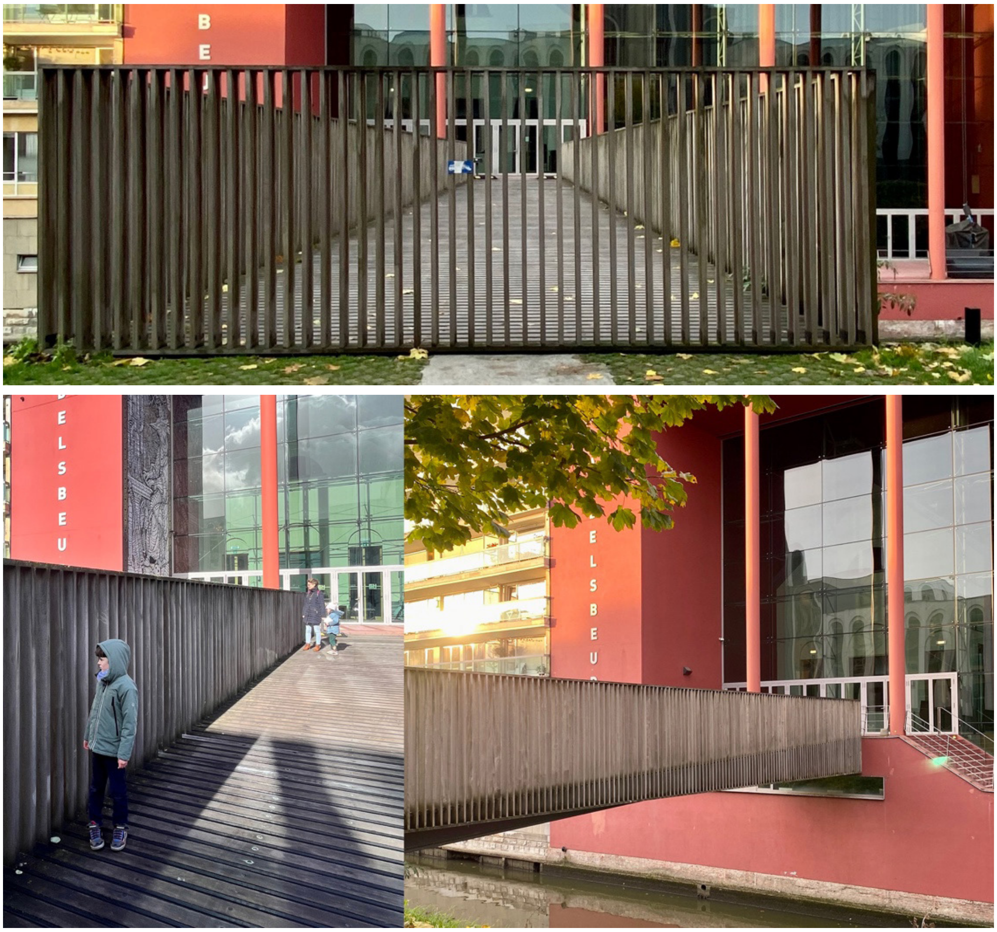

Fig. 05. Bridge of the “Handelsbeurs” cultural centre. OFFICE Kersten Geers office David Van Severen. Ghent, 2008.

Photos: Myriem Saoud (Photographs above and below right) / David Lo Buglio (Photograph at the bottom left), 2023

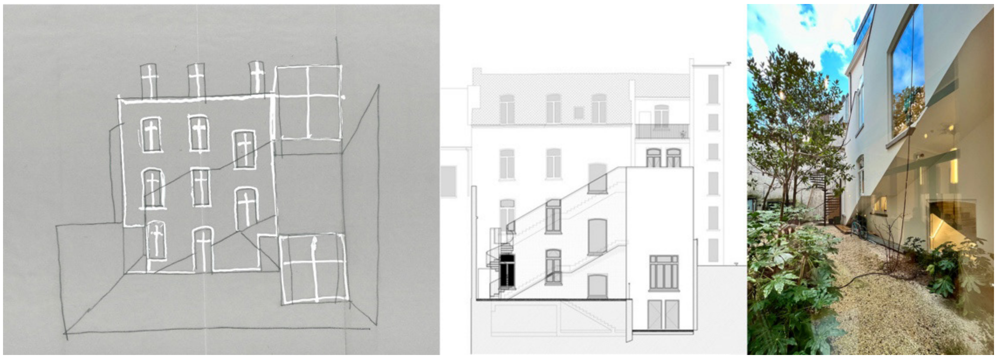

Fig. 06. Twiggy store. *Architecten De Vylder Vinck Taillieu*. Ghent, 2013.

Pictures: Twiggy, Architecten De Vylder Vinck Taillieu, 2012 (on the left) / David Lo Buglio, 2023 (photograph on the right)

Geometry to Reintegrate the Cultural Dimension of Architecture

With regard to these examples, it is interesting to return to one of the questions above: can we speak of a "return" to the Baroque? The few projects mentioned here are obviously not numerous enough to generalise a point of view; nevertheless they highlight the links between architecture and its representation.

Baroque can be seen as a quest for divine perfection through mathematical mastery. Now, the architectural complexity of baroque space is also inseparable from the development of mathematics in general and geometry in particular. In this context, *trompe l'oeil* and the theorization of perspective, like the other devices used during the period spanning the 17th and the 18th centuries, allow to increase the sensitive experience of space. While religious architecture transcends reality in order to tend towards the divine, the spatial amplification of a *trompe l'oeil* also seeks to extend the sensitive experience of architecture by altering the perception of the "real" and its scale.

Baroque cannot be dissociated from its cosmological dimension, which implies a connection between the experience of the sacred and architecture. Nevertheless, "once geometry had lost the symbolic attributes in traditional philosophical speculation, perspective ceased to be the preferred vehicle for transforming the world into a meaningful human order. Instead, it became a mere representation of reality, […]" (Perez-Gomez and Pelletier, 2000, p. 112). Perez-Gomez's terms allow us to understand that Baroque architecture cannot be considered only through its symbolic purpose but it also crystallizes a moment of rupture.

Insofar as it is difficult to observe a "return" to the Baroque in some contemporary architects' spatial experiments, the use of representation to disturb the "real" and our understanding of its scale further reflects the need to restore the design medium at the heart of the architectural discipline. As Robin Evans mentioned, representation (and therefore the tools of geometric transformation) remains the preferred means to access the project. " What might have occurred in architecture – but did not – occurred outside it, and indeed outside painting and sculpture, in so far as these are categorically defined. To insist on direct access to the work, drawing can be designated as the real repository of architectural art" (Evans, 1997, p. 157). For him, the artwork is the most immediate way to access painter's or sculptor's "oeuvre", but this is not necessarily the case for the architect and its building. According to Evans, the architect's work is primarily accessible to him through drawing and, by extension, the spatial design geometric mediums that contain the project.

Beyond the return of anamorphosis or accelerated perspective in a number of contemporary practices, the transgression of architecture by its mediums first refers to these architects' cultural positioning. It is legitimate to think that some European offices' spatial experiments first aim to reintegrate the cultural dimension of architecture at the heart of its practice.

At the same time, this posture also evokes a departure from the digital context. While architecture has been conceived, for centuries, through a projective medium that called upon an important power of abstraction, today, 3D interfaces move design into figurative universes far from any projective notion (Rippinger, 2020). The geometric complexity of designed objects is less and less understood through its orthogonal projections but directly from the three-dimensional space of the drawing interfaces. While this is not a problem in itself, the completeness necessary for 3D drawing leaves little room for the geometric abstraction inherent to the architectural drawing. The loss of synthesis in favour of an object figuration removes a necessary dimension of architectural design.

In contrast, the projects mentioned above tend to show us practices that try to reinvestigate the abstraction of the figure (Bergilez, 2011) through an exploration at the border of canonical projections and the constructed space. This attitude expresses a departure from the flow of what Antoine Picon calls "digital architecture" (Picon, 2010).

As a first step, this paper discusses the survey as a practice of "reverse design" but also tries to demonstrate the tenuous link between the building and the projection tools used to design it. This reading-key gives new theoretical arguments to locate and refine our understanding of the place left to drawing projections in contemporary production. Here, we wanted to consider the projection, not as a shared convention of drawing in architecture, but as a cultural vector allowing our discipline to find the means of its reinvention within and by itself.

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Cultivating Creative Minds: The missing scale, the architecture studio's necessary evolution.

Introduction

In recent years studio pedagogy has inspired countless books and public presentations from business innovators, teachers, and best-selling authors such as Mr. Daniel Pink. Pink in his book 'A whole new mind' advocates the need to learn drawing, and the wisdom of playing games, as helpful means to advance creativity. He introduces creativity as the currency of the future. In contrast, the thinnest slice of our society now controls most of the world capital, furthermore, industrial streamlining is gradually replacing human production lines with robots and machines vanishing jobs and further depressing communities. Lastly, we in the U.S. have foolishly built our domestic economy on an ever-expanded thirst for mass consumption exhausting our planet's ability to regenerate. In short, we have constructed ourselves into a cruel and unsustainable world. Yes, the future is complex and requires further understanding through multidisciplinary collaboration and the ability to synthesize complex information into workable solutions. We know the world must be designed. And design is best served by studio education. So, for us to survive, we are called as people to abandon the competitiveness of the one (greed), in favor of the benefit of humanity. Our design challenge must be reset at the scale of our planet. While the value of design has risen drastically in recent years, our communities are still falling behind and demand justice and equality for all citizens. Health, comfort, and happiness surpass their status as stated goals, edging closer to becoming human rights. These foundational community concerns align perfectly with the architect's mission. However, we must ask ourselves, has our architectural educational model kept up with these dramatic changes? In our studios, our students seem to focus on the manipulation of building form, seeking the fleeting value they perceive in developing dramatic form. Process and discipline are replaced by software, twisting, and Boolean operations, which often result in admittedly alluring images. This observation is not to demean these incredible new innovative design tools. For they are appreciated and equally useful. But rather, to highlight the lack of understanding of them, as some students confuse tools with process, and always think the first to be the extent of the last. The design studio must be reconsidered. We hope to discuss and propose a new studio pedagogical model designed to meet the challenges we face today.

Methodology

Our search includes books, articles, web searches, examining three groundbreaking architectural schools. Additionally, we reviewed published research reports commissioned by the American Collegiate Schools of Architecture (ACSA).

The three examined architectural programs are, the Ecole des Beaux Art in France, the Bauhaus in Germany, and Taliesin in the United States. Three iconic schools that symbolize the historical continuum of contemporary iterations and adaptations of most U.S. architecture programs ever since inception in 1865 'when a course was established at MIT (Massachusetts Institute of Technology) (Bosworth & Jones 1932), followed by the Armour Institute, IIT's predecessor (Illinois Institute of Technology), and the Art institute of Chicago merging to establish their school of architecture in 1895 (IIT's website) which later was led by Ludwig Mies van der Rohe whom previously directed the Bauhaus and later became IIT's architecture program head in 1938. Mies and the Bauhaus, inarguably, has had a tremendous impact on our programs and profession. Finally, we explore Taliesin and Taliesin West (1937). A new model school founded and run by Frank Lloyd Wright and his wife Olgivanna, two influential and charismatic professionals and educators who also left their mark on architecture as a profession. One can add other iconic programs that fall within this same category, for one, the Cranbrook Academy, in Bloomfield Hills, Michigan, however, to focus the scope of the study, and to stay within the limitations of this paper, these three influences may be considered most essential and representative of the evolution and history of contemporary schools of Architecture in the U.S. This brief examination sets the stage for the second part of our curricular proposal derived from a four-year experiment at our own institution. The experiment is focused on the design studio, and its needs to evolve. Data used for this purpose is derived from qualitative analysis of the work produced. Measures include rate of success and quality of work. Our control is other work not using this method produced in parallel sections of the same studio. The expected outcome is a new method that expands students' inquiry's breadth and depth.

Three Architecture Schools' imprint on contemporary curricula

We begin with a brief review of the three selected architecture schools deemed important to the evolution of architecture education in the U.S.

Ecole des Beaux-Arts, Paris, France

In the turn of the past century, the Ecole des Beaux-Arts in Paris, became the principal destination for Americans seeking to study architecture. Many American architectural educators of the period were also trained in Paris and were called to teach in the first architectural courses in the United States, such as those at Yale, Harvard, and the University of Pennsylvania. The Ecole has a distinguished history among the most prominent European schools. It was among the first to develop methods and techniques designed to educate future architects and artists. The school organized students into ateliers (studios) (O'Connell, 2020) each working with a prominent teacher:

> Originally housed in an old regime convent reclaimed in the 1790s by arts aficionados to hold *spolia* of the Revolution, the École compound was expanded by one of its star progeny, Félix Duban, in the 1830s and became the center of an arts neighborhood, heartbeat of artistic production later in the century. The instructional core of the school, the so-called système des Beaux-Arts, featured

> an atelier structure, with students clustered in studios run by influential patrons; and a competition-based model of practice, with all exercises culminating in multi phased contests pitting students against one another for coveted prizes. *1*

In 1895 students between the ages of 15 and 30 could compete for positions at the Ecole. These included a growing number of international students, including a substantial contingent from the United States. Every year in the period between February-March and June-July, students had the opportunity to take a battery of entrance exams that would develop their standing and their potential admission to the studio. The school offered painting, sculpture, and architecture. The curriculum consisted of attending courses, completing exercises, taking tests, participating in competitions, and completing projects in studio.[2] Projects and exercises were juried by a select panel of professors. Courses included: General history, Anatomy, perspective for painters and architects, mathematics, descriptive geometry, physics and chemistry, the chemistry of colors, stereotomy and drawing plans, construction, building law, theory of architecture, literature, history of archeology, history of art and esthetics, history of architecture, drawing of ornament, decorative composition, and practical sculpture. All focused on the formation of a cultivated artist/builder. It is hard to overestimate the influence of the Parisian school on architecture education in the United States. In a published study conducted by Bosworth Jr. And Jones in 1932 for the Association of Collegiate Schools of Architecture (ACSA) one can note that the authors' survey of the 50 US and Canadian collegiate programs found many mirror instructions at the Ecole. The study also mentions direct influence from both American architects trained in Paris, as well as, several Frenchmen engaged to head the design studios of leading institutions, 'A significant factor in the picture of schools in the United States has been the practice of employing French critics of design'[3] (Bosworth Jr. and Jones 1932) These critics were exclusively men and had significant influence on the design studios syllabi of most American schools.

The Bauhaus, Weimar, Dessau, and Berlin, Germany

Walter Gropius in his manifesto proposes a new school that would erode the space between the trade crafts, art, and architecture:

> The art schools of old were incapable of producing this unity—and how could they, for art may not be taught. They must return to the workshop. This world of mere drawing and painting of draugtsmen and applied artists must at long last become a world that builds. When a young person who senses within himself a love for creative endeavour begins his career, as in the past, by learning a trade, the unproductive "artist" will no longer be condemned to the imperfect practice of art because his skill is now preserved in craftsmanship, where he may achieve excellence.

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[1] From O'Connell, L. Ecole des Beaux-Arts, Oxford Bibliographies, 2020

[2] Reglement De L'ecole, Ecole Nationale et Speciale Des Beaux Arts, Edition de 1895, Paris

[3] Bosworth Jr. And Jones (1932) A study of Architecture Schools, New York

His curriculum, and even some of the school's early exercises have persisted to this day. First year students go through an intense and specialized foundation course (Vorlehre or Vorkurs). Using exercises that many of our students still complete in our studios today. This course was intended to transmit the fundamentals necessary for any artistic work. The Bauhaus curriculum is represented by a circular diagram that layers the preparation of architects into four concentric rings.

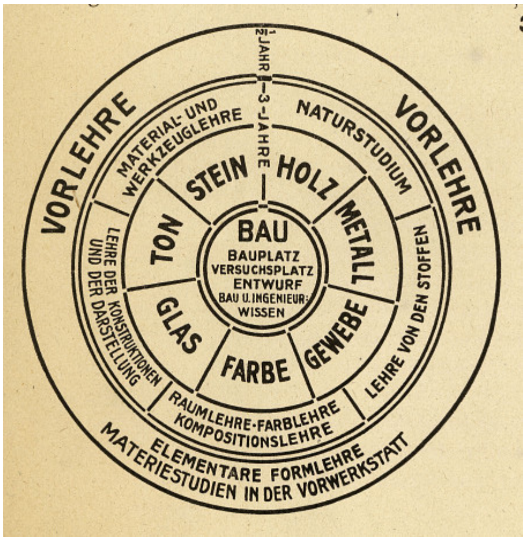

Figure 1: Bauhaus Curriculum Diagram, Walter Gropius 1922.
Source Bauhaus-Archiv.

The new school wanted to challenge current thinking and beliefs. Many schools of the period in Europe and the United States offered curricula revolving around design as indulging in forms and images of the classical orders of ancient and epic settings found in Greece, Egypt, or Rome. However, latest ideas of architecture were being simultaneously advanced, and circulated by new thinkers with strong influences from the Arts and Crafts movement of 1880 England, as well as the constructivist ideas of technology inspired design as the melding of processes between craft and industry. However, the Arts and Crafts movement was disinterested in mass production. Furthermore, Walter Gropius had been a leader in the German Werkbund. He was attentive to the needs of improving the quality of life of the populus. He sought mass fabrication to realize his goal. So, for him intellectual, artistic, and technical knowledge is essential for the study of design. 'The curriculum and the pedagogical approach of the Bauhaus brought together previous separate fields of arts, crafts, business, mathematics, engineering, and industry' (White-Hancock 2022). Students and faculty collaborated with industry on developing designed pieces sold to market and the returning proceeds were distributed to the design team including students.

Students benefited from this immersive model of making and integration. Goals and outcomes for each design are clearly understood as teachers and students teamed with technicians, industrial engineers, and business enterprises to execute their designs. The space between problem definition, users, and realization is diminished. In his manifesto (1919) Gropius states:

> The school is the servant of the workshop and will one day be absorbed by it. Therefore, not teacher and students at the Bauhaus but masters, journeymen, and apprentices

Students are expected to learn/master a trade, whether rug-making, iron work, furniture building, or jewelry. 'After becoming director in 1919 he issued a four-page brochure carrying his first Bauhaus proclamation' (Dearstyne 1986). Gropius said:

> The final goal of all artistic activity is architecture. Its embellishment was once the noblest task of the plastic arts, which were inseparable parts of the great art of building.

He later describes the program at Weimar,

> The character of teaching derives from the nature of the workshop:
> Organic creation developed out of skill in handwork. Avoidance of all inflexibility; advancement of the creative; individual freedom, but hard study…Constant contact with leaders of the craft and of industry in the province [of Thuringia]. Contact with public life and with the people by means of exhibition and other events… Promotion of friendly intercourse between masters and students outside of work; to this end theater, lectures, poetry, music, costume festivals…

The Bauhaus interest in simplicity, abstraction, and the essence of artistic expression where faculty and students blurred the boundaries between roles, left us a new way of teaching by doing and perfecting skills and knowledge. Such an open system of experimentation and discovery is bound to lead to disruption and innovation. Lessons and curricula developed by the school endure well beyond its closing in 1933. Exercises used by beginning studios of most architectural schools in the US are still modeled using projects and problems developed by Itten and Albers' Vorkurs (Preliminary Course).

Taliesin West, Scottsdale, Arizona, USA

While Bauhaus students referred to themselves as 'collaborators', those studying at Taliesin and Taliesin west were known to join the 'fellowship'. While both programs are built on the apprenticeship model, the latter implies the devotion and following of an accomplished 'brilliant creative mind'. The first talks of the blurring of boundaries between teachers and students, built on the questioning of established ways. Both schools had influential and strong personalities running them, 'fellowship' emphasizes the supremacy of the teacher over student. Both faculties introduced new learning cultures that one can enter willingly, so long they fully commit themselves to pursuing a holistic way of life. In both schools' students mounted entertainment, cultural events, exhibits, theater, and concerts, were often held for the benefit of building community. At Taliesin, the fellowship highlighted the ultimate cultural immersion for the fellows. They not only studied, but they also lived and worked at the property. They built their own quarters, prepared meals, provided entertainment, and completed assigned shores such as maintenance and upkeep of their living desert compound. Learning from the farm in Wisconsin, Mr. Wright understood the importance of such activities in learning. During tough times, just before the great depression ended in 1939, they had to rely on resources available on the land. Food, building material, energy, and water must be developed on site in collaboration with nature. All of this was accomplished with a relentless pursuit for beauty and architecture. The result is an inspiring legacy that points the way towards a more essential, green, and sustainable model that is gentle and works positively with the land. Mr. Wright said, 'Organic architecture' his own concept of design, 'is distinguished from the facade-making which passes for modern architecture today, as you can see in our home, Taliesin West.' He believed, 'architecture is organic and part of human life,' where there is continuum between site, landscape, and interior spaces. He said:

> One must consider the site, the building, as well as the times in which it was being built, creating a harmony among all the different human and natural elements.

He then started referring to his work as 'Usonian style architecture', a reference to uniquely American architecture from the United States. His two books published by Wasmuth in 1910 in Germany 'changed the course of architecture in Europe.'

Mr. Wright began taking in students in the late 1930s. The land in Scottsdale Arizona was purchased in 1937. Taliesin West was intended to serve as his winter home and desert laboratory. The school represents Frank Lloyd Wright's ideas for educating American architects. In a New York Times Magazine interview, when asked about 'what he advises a young man going into architecture school he said:

> Well in my new book there is a lecture I gave in Chicago in 1931 and these are the things I told him concerning ways and means. To forget the architectures of the world except as something good in their way and in their time, not to go into architecture to get a living unless they loved it as a principle at work, to beware of architectural school except as an exponent of engineering, to go into the field to see the machines and methods at work that make modern buildings. I said they should immediately form the habit of thinking "why" concerning effects, challenge every feature, learn to distinguish the curious from the beautiful and get the habit of analysis. I told them to "think in simples" as my old master used to say, meaning to reduce the whole to its arts. And to abandon as poison the American idea of the "quick turnover," to avoid getting into practice "half-baked" and to take time to prepare even ten years.

Taliesin West is currently a UNESCO World heritage site. The curriculum is built on 'fellowship' executing hands-on architectural projects that are complemented by an active calendar of lectures, evening entertainment, concerts, and theatrical performances.' As described by the Frank Lloyd Wright Foundation website. Taliesin is a remarkable educational experiment that endures and continues to inspire new architectural students.

Three pedagogical models at three different scales

The echo of these three programs still reverberates at various degrees in the halls of many of our contemporary architecture programs. As presented earlier, the Beaux Arts curriculum requires the students to acquire knowledge necessary to execute 'proper' buildings of the period. This included courses in archaeology, chemistry of color, the study of Greek orders, decoration, and sculpture, carving and bas-relief. Mostly concerned with the architectural scale of one object or structure at a time. A great deal of energy is invested on the composition, symmetry, and reinterpretation of ancient precedent including Greek, Roman, Romanesque, Baroque, and other magnificent styles of the past. Plans, elevations, and sections were specific subjects of course study. In a sense the architect manipulates solutions already available to them from past masters. Remixing and reconstructing new architectural patterns drawn from a reservoir of acceptable solutions. A difficult and costly process that could not keep pace with the upcoming public need for frugality, the age of the machine, and the industrial revolution. The built object scale drove this curriculum.

The Bauhaus curriculum introduced a new way of thinking for the arts and architecture. The school grew from the merging of guilds, craft, the arts with business, and industry. Finding solutions through an innovative blurring of boundaries among participants and the holistic integration across domains and expertise, especially between engineering and the arts. The school gave us the idea of workshops. These, through their name, imply teamwork and the synthesis of expertise for the development of a product. Field trips to manufacturing facilities (Dearstyne 1986) such as wallpaper factories, as well as collaboration among teachers and students with the aim of commercialization of design. The school designs and sells its creations. Students and faculty can get remunerated and rewarded financially from their designs. A sort of open, liberalized, progressive, and socially enterprising pedagogical system. The school's scale is internationally focused aiming to solve the problems of ordinary people, while also embracing the industrial revolution allowing design to be within everyone's reach. The esthetics are those of the essential, the minimal, and the necessary. Solutions are international, intended to work in any context. Ornamentation is a byproduct of the design and not applied to it. Rigor is in finding simplicity. Craft, business, and the industrial scale propel this work.

Taliesin brings us the importance of organic. The imperative of site and building as one. The impact of the design on nature. The importance of understanding regions and time periods for each project. Aiming to define a uniquely American architecture. Horizontality and 90-degree repetitive angles are the product of new drawing tools like the T-square and triangle, having their sway on the architecture. The importance of practical engineering and the use of local materials. Unity Temple being among the first in the U.S. to use cast concrete as an exterior finish building material. A curriculum inspired by an amalgam between ethics derived from the agrarian sensibilities of midwestern farms, indigenous holistic thoughts of land and environment, combined with the importance of open plans and transverse horizontal spaces that allow the outside and inside to flow through the design. All-important tenants that seem to be sometimes both fading and returning to present architectural schools. In this case the pertinent scale is that of the local.

The missing scale

Our experiment aims at developing a studio learning structure that broadens and deepens the students' design work. The essence of the method is to approach design through a process of what we call 'layering of tiers.' These are designed to address a missing scale in architectural design pedagogy. The discussion must exceed the design of the object as professed by the Ecole, or the concerns of purity of essence, or mass industry and enterprise learned at the Bauhaus, or even the noble focus on land aiming for a harmonious regional fit as inspired by Frank Lloyd Wright, but genuinely consider all these lessons while also adding to them a strict dedication to social justice for all species and environments through the deep understanding of systems at the planetary scale. Designers must learn to gauge performance and strive for positive impact on all levels if we are to address an overburdened natural order. The task is monumental, and time is clearly running out. The key we propose lies in predictive analysis based on data. Our method was introduced as a response to our students' solitary fascination with object form-making, inspired by their introduction to powerful 3D modeling and representation software. The ability to extrude, twist, follow along rails, add, and subtract using Boolean operations, are all marvelous capabilities that must somehow put our young designers in a trance and prevent them from developing their ideas beyond the pure sculpting of objects. This technology is powerful and useful if employed to improve performance. It gives designers the power to develop solutions that might be closest to nature and the evolutionary process. However, the designers must also set their objectives and develop their assessment criteria.

Our Layered Tiers Method

The proposed method simply introduces along the traditional design brief (problem statement) a separate document, containing a strategic annotated 'table of content.' These two main documents combine to initiate the studio project. The final deliverable is a report organized by chapters as informed by the table of content. This new simple device grately improves the focus, depth, and breadth of the students' inquiry. Below we will present the table of content chapter structure and rationale.

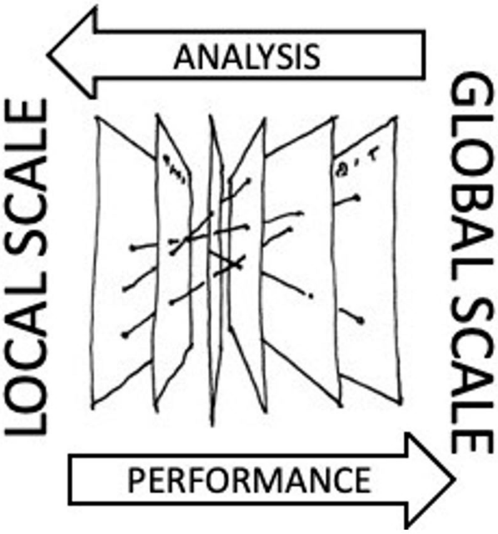

Figure 2: Layered Tiers Method Diagram

Chapter one

Clarifying the students' design beliefs so they may claim their design position. This chapter asks the students to define success for this design. They must develop their guiding principles as they respond to the problem at hand. The chapter attempts to clarify what we call 'This I believe' (TIB). The TIBs set the stage for an essential discussion regarding both design and process. Attitudes regarding approach/process, site, materials, contextual fit, ecology, culture, energy are among the TIBs examples developed by our students. The burden is on each student finding their unique voice as architects.

Chapter Two

This chapter asks the designers to 'find the art.' Understanding the context from both the natural and cultural dimensions. Decoding the site and learning its unique hidden potential. How can a new proposal connect to the existing natural system? What might be the cultural and human role here? What research and method are appropriate in this case? How can we come to understand all dimensions of a site and context? This work is focused on research and the development of methodology. Finding precedent and casework that might shed light on the questions above.

Chapter three

Entitled 'Synthesis and clarity' is the first mark on one's blank paper. Here the designer's ability to integrate by addressing their position, their research influences their ability to develop their architecture. Finding the most suitable idea requires taking one's concepts and measuring their success using their TIBs. Having several different approaches is critical. Developing multiple alternatives seems unusually challenging to our students. This step is important and often requires patience and encouragement from the studio critic.

Chapter Four and Five

Performance evaluation, simulation, and predictive outcomes are the essential stage. Beyond reflecting on the functional success of the design, the impact and behavior of the architecture is considered from structural, environmental, and material palette's embodied carbon. Digital tools such as Safayra, Cove tool, Tally and WUFI are immensely helpful at this stage of the process. Safayra helps with the passive and active environmental impact of the design. Giving live feedback as siting alternatives are considered. The software can also help with input on daylight performance for critical spaces. Cove tool informs material selection and embodied carbon's footprint.

Chapter Six

The Concluding chapter is concerned with the communication of the proposed design and the development of the final report combining all chapters into one publishable pdf book. Each project becomes a compact study of issues discovered by the designer.

Analysis, and Evaluation

The proposed 'layering tiers' method does improve the depth and breadth of students' design projects. It assists the class with the examination of design criteria that extends beyond just the manipulation of form. Based on student interviews, using this technique fosters clearer understanding of their own process and design position. The 'Layering Tiers' method reintroduces young designers to the broader scope of design. It allows them to question influential works currently celebrated by our media. The Process also equips them with a skeletal structure for meaningful inquiry when considering their own design choices.

Table 01. Analysis of student participants' success.

Year	Participants	Fail	Low Pass	High Pass
2022	14	0	2	12
2021	13	0	0	13
2020	14	0	2	12
2019	14	0	0	14

Source: Author, 2023.

Conclusions

The design studio is an important model of educating creative students. Many disciplines have translated and adopted this model to fit their own knowledge domains. In contrast Architecture schools were among the first to teach in studios but seem to have not evolved this critical part of the curriculum to include broader expertise and wider outlooks. We must review, reassess, reinforce, and open once again our curriculum to allow the studio to play its vital role in the education of future citizen architects. Where the concern is shifting from object scale to our planet's scale. Our Layered Tiers Method might offer a means to improve the depth and breadth of our students' design inquiries.

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Thematic agency and spatial manifestations in heritage places with nuanced scale

Introduction

Overview

In broad strokes, this paper contemplates events occurring in heritage places through time as the framing variables for discussion with a consideration to the holistic connotations of scale, size, and growth. In this vein, the paper explores the notion of cultural theme, a trend or a phenomenon understood to mean the accumulation of related events or actions occurring in a historic district, town, or urban settlement over time. In parallel, the paper explores the physical, spatial manifestations in the place where a theme dominates.

Urban events or changes accumulate in some broad aspects of society such as health system or water provision. Changes, innovations, or additions in health planning or water engineering fields can be expressed through distinct events or trends of occurrences situating under the umbrella of the health system theme or water engineering theme, respectively. The buildings, landscapes, and infrastructures associated with health system or water service are the physical and spatial manifestations of such themes—reflecting the cultural imaginings of the society on how to go about living. Occurrences under a theme naturally breed changes in the place—say a medical discovery in some historic period results in the creation of a type of evolving hospital laboratory. The accumulation of events under a theme and the parallel accumulation of changes in place, as spatial manifestations, go hand in hand.

This study takes the inseparable thematic agency and spatial manifestations notions as a lens through which heritage districts and cities can be scrutinized to understand the history and culture of the place, and ultimately, to influence development plans and intervention projects. To define the thematic and spatial characteristics of an archeological site or a historic downtown involves identification, classification, and ordering tasks facilitated by assessment processes grounded in the use of evaluative tools such as measures, metrics, and criteria. These tasks and tools dovetail with the expanding definitions of scale. Dabiri and Blasteche (2019) stated the many meanings of scale and the scale dependence on context; as an example, they relayed three aspects of scale in human geography including size, level, and relation. This expanded, holistic understanding of scale goes with the development outlook for this paper.

Study Challenges and Objectives

This study springs from a knowledge gap in understanding the thematic agency in heritage preservation and the spatial manifestations thereof. Such gap forfeits the opportunity of using the paired thematic agency and spatial manifestations best for heritage urban development plans and projects. Further, the ambiguity of scale in its expanded epistemological and utilitarian senses adds to the reasons for the study. Table 01 summarizes the challenges and corresponding objectives.

Table 01. Research challenges and objectives

Challenges	Objectives
Appropriating the term "theme" to specific purposes with anticipated outcomes is difficult to achieve.	Explore the notion of thematic agency in historic preservation.
The relationship between the theme construct and the associated spatial manifestations is not readily comprehensible.	Explore the notion of spatial manifestation associated with thematic agency.
Knowledge about the interpretation of scale and its expanded connotations is still limited.	Explore scale and associated principles in evaluating thematic agency and spatial manifestation.

Methods and Organization

Because the thematic agency and spatial manifestation are time-bound constructs of heritage cities, districts, and landscapes, subjecting examples of these heritage resources to scrutiny will be a defining methodical element for the study. Of the many resources available, one site inscribed on the UNESCO World Heritage List is chosen, the Petra site in Jordan (Figure 01). Petra is a rich framework for extracting and organizing information for analyzing the cultural themes of the site and associated spatial manifestations. As a World Heritage Site, Petra garners several cultural themes that we have reduced to the number sufficient to address the study objectives. As part of the methodology, we aimed to use the notions of scale, measure, and size in their expanded meaning to support the analysis.

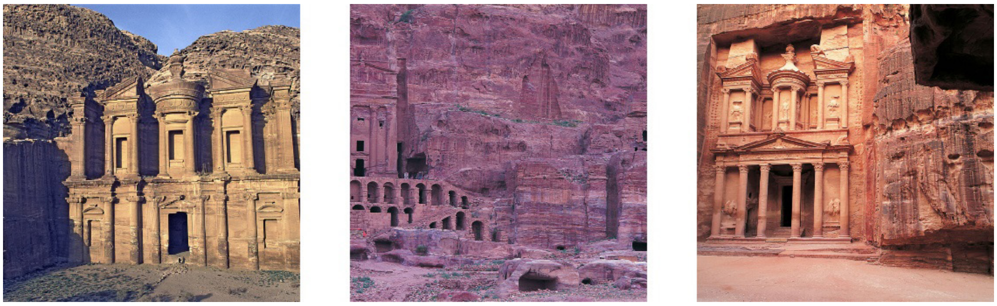

Figure 01. Some archaeological sites in Petra.

Source: Gelbert; Gray.

The discussion of this study is organized around a set of cultural settings that we have identified for the Petra site. A cultural setting as used here connotes a defined theme together with its associated spatial manifestations. We have adopted three settings: a) Engaging nature, b) Water management, and c) Design inventiveness. These are relevant and sufficient, in number, to support the study objectives. Other potentially useable settings, including international trade and religious life, were not considered for the indicated reasons.

Implications

This study will add to the theoretical understanding and use of the thematic and spatial dimensions of historic towns, urban districts and archeological sites for the purpose of devising development plans. The present understanding of cultural themes and associated spatial resources will be elevated to workable constructs, thus enabling an improved navigation of the landscape thematic and spatial complexities to benefit development plans. Further, the results will shed light on the value of scale and scalability in their holistic and expanded connotations. The workability of scale in terms of supporting the characterization of the thematic and spatial dimensions of heritage sites will be defined.

Petra and the Nabateans

Timeline

The history and culture of Petra and the Nabateans are intwined (Figure 02). Petra was founded and developed by the Nabateans as a capital of the kingdom and reached cultural heights between the middle of the 2nd century BC and early AD 2nd century with an estimated span of 275 years. Marking the foundation of the State under the leadership of Aretas I, the first historical monarch of the Nabateans, the year 168 BC ushered to the golden age of the Nabateans. Of tribal origins and commercial savviness, these people crossed boundaries and connected with near and far nations, a humanistic undercurrent (National Geographic, Meeting Hinat) not common among societies at the time. While some sources establish the presence of the Nabateans in the area as far back as 600 BC, the emergence of these people can be situated more confidently in the 4th century BC (Mouton and Schmid, 2013).

Petra and its region endured the appetite of world powers reaching out to control the Near East. The Nabatean lavish trading in Arabian frankincense, myrrh, and other commodities stirred the envy of the Greek, then in Damascus, who led an unsuccessful military campaign to seize Petra in 312 BC. The annexation of the region as Arabia Petrea by Rome in AD 106 under Emperor Trajan dealt a blow to the Nabatean independence and funneled Petra’s rule and urban development in service of the occupier’s wishes. Some sources, however, confirm that the city continued in vitality under the Roman regime, and, for long years under the succeeding Byzantines, starting in AD 355. With the advent of Islamic rule about AD 636, Petra was not a functioning city and subsequently fell out of world’s memory till it was investigated by some European explorer in AD 1812.

Natural Context

The geographic, geologic, topographic, and hydrologic features of the Petra region mediated the dynamic of the Kingdom of Nabataea with its contemporary neighbours and the outlying superpowers acting across the Near East at the time as well as with the natural resources needed to support the growth of the city—into a

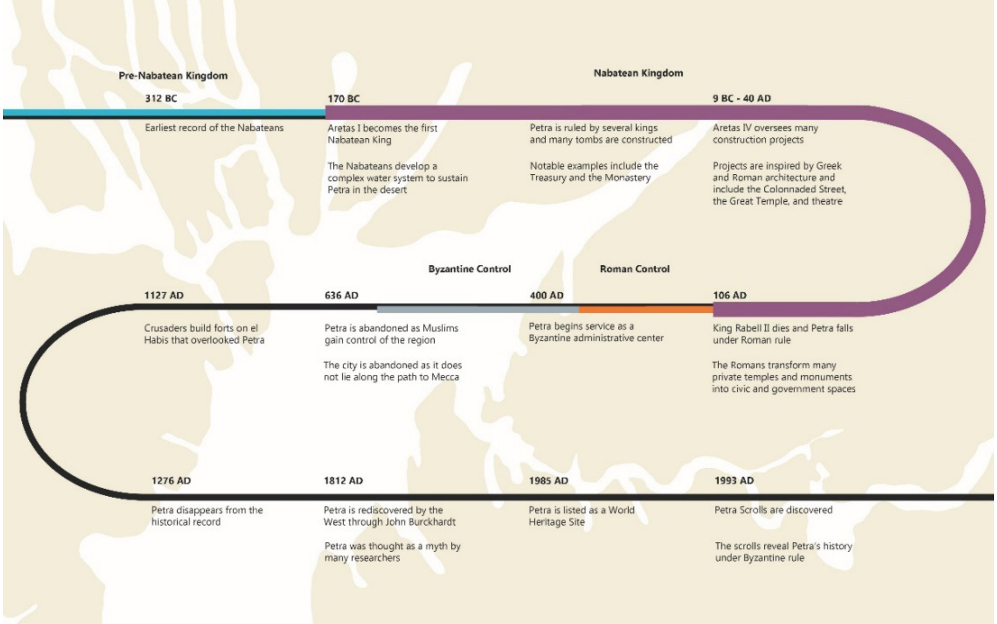

Figure 02. Timeline of Petra.
Adapted from the credited sources

Sources: Kendackji; Petra Development & Tourism Regional Authority, 2012; Reynolds, 2012.

metropolis. The setup of each of the four natural features offered opportunities, and limitations, for the Nabateans to consider for developing and protecting their capital city. First, Petra geographic location had the potential to facilitate trade exchanges with and between commercial centres in the four cardinal directions including Mediterranean seaports, Arabia, Egypt, and China. Promoting the nation's prosperity, Kouki (2012, p.15) recognizes the Nabatean adept trade with South Arabia and the eastern Mediterranean and highlighted the importance of the crossroad location of Petra as a commercial centre. Second, the geological formations where Petra sprang up in this part of ash-Sharah Mountains offered massive ranges of sandstone and limestone of potential to cut and shape for constructing monuments, facilities, homes, and tombs. Third, the stark topographic variations of Petra landscape with summits, steep ridges, and valleys offered the potential for judicious adaptation of construction projects to the site features. For the same reason, the topographic characteristics offered opportunities for defence of the city from adverse tribes and competing nations. Fourth, although falling in a hot-arid desert environment with meagre water sources, the Petra environs possessed scattered springs at varied mountainous elevations that could be harnessed. Further, regardless of scarcity of rain, the area witnessed torrential pours resulting in massive amounts of water that could be, again, harnessed.

Themes and Produced Works

Figure 03 depicts layout of Petra with salient physical development projects. The Nabateans thematic agency had been at work throughout the nation's historic epochs acting within the region's natural forces to produce the Petra's infrastructure, buildings, and landscapes we now come to know. Working hand in hand, a thematic agency and its produced works, otherwise spatial manifestations, coalesce into a unified construct we here appropriate as "setting." Because of the complexity of urban societies, we imagine that thematic agencies and corresponding spatial manifestations materialize in multiple settings for the archaeological city of Petra, and for any city for that matter. In pairing the research methods and objectives, we have appropriated for discussion the three most conspicuous settings of Petra. These are engaging nature, water management, and design inventiveness.

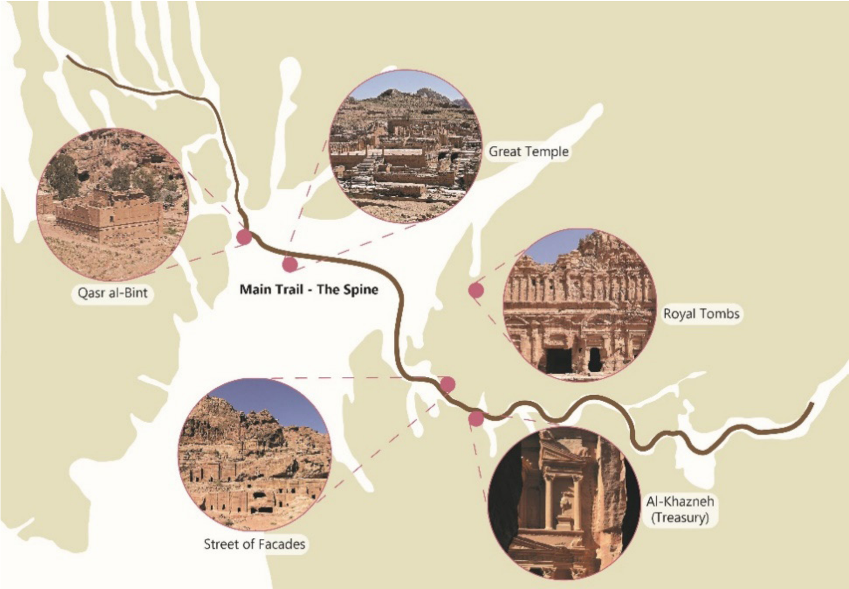

Figure 03. Layout of Petra with major development projects. Adapted from the credited sources
Sources: Azurfrog, 2013; Gagnon, 2010; Petra Development & Tourism Region Authority.

Setting 1: Engaging Nature

Overview

The daily encounters with nature seem to have developed the Nabatean capacity for taking advantage of natural opportunities to support community living. Among these opportunities stands out the use of the natural environment for shielding the city from invaders and for shaping public places and community dwellings. At the importance scale, defending the city must have been an utmost consideration during the incipient phases of building the kingdom. Although never waned, this consideration gave grounds to another intent, using ecological resources for city development in terms of sheltering, trading, and administration.

Defence

The geography and topography of Petra corroborate the perceived defense needs of the city amidst the region's tribal and kingdom nations' strives since about the middle of the 4th century BC, believed the documented time of first Nabatean presence. Formidable to breach, the rugged mountains and difficult topography of the Petra environs were natural defense considerations for locating the settlement that had grown to an estimated size of twenty to thirty thousand people. The location and the configurations of the Siq, the 1.5-kilometer-long gorge triggered at the main entrance to the city, speak for the Nabateans physical adaptation of the natural environment to control access to the city. The narrowness and depth of the gorge made blocking this only passage to the city effective in defending against invading adversaries. Generally, "high walls and surrounding mountains served as intimidating defenses against raiders tempted to plunder the city's wealth" (Strange, 2008).

Ecological

Besides its importance as indigenous craft, the Nabatean carving of buildings and complexes out of mountain cliffs was an adaptive practice hardly observed in ancient times at such a scale. As opposed to "brick and mortar" construction, carving that weaved the physical development of the city of Petra by cutting into the hard rock is indicative of the appreciation and environmental use of the natural resources for the communal good. Further, cliff carving left an enclosure into the depth of rock with the geothermal qualities known to help condition the environment of the space. This thermal mass and the geothermal effects must had been welcome to the space users who otherwise had to endure the harsh summer temperatures of the hot-arid climate of this ancient part of the Near East. With their thermal properties, the rock hollowed-out enclosures tend to have a temperature close to the average annual temperature of the region. This transmutes to a cooler inside temperature in the summer and warmer inside temperature in the winter—than the outside temperature. Further, traditionally built (uncarved) construction projects have used stone and other local materials extracted from the immediate rocky hills, similarly an environmentally sound practice.

Setting 2: Water Management

Overview

As roaming tribes with firsthand knowledge of the Levantine terrain to the east and south of the Dead Sea, the Nabateans were cognizant of the water supply challenges in the environs of Petra where they settled for a home. The development of the now reasonably identified water system infrastructure that the Nabateans engineered, installed, and used may have started in the middle of the 4th or the 3rd century BC and continued through the middle of the 2nd century BC—the kingdom foundation phase, and from there with leaps to the end of the Nabatean reign. By 106 BC, the water system developed into the configurations that we have come to know about this otherwise genius hydraulic engineering feat. Hamarneh (2023) confirms that the "Nabataeans were specifically keen to showcase their ingenuity and wealth, as they were situated in a dry and arid area. For this, an extensive network of channels, pipes and aqueducts were built to draw water from the numerous springs situated in the karst of the ash-Sharah Mountains."

Water Resources

The city tapped on many water springs at different mountain elevations across the rugged landscape of the eastern fringes of the city and set them as sources of water draw. Al Farajat and Salameh (2010, p.322 and p.328) studied nine of these water springs but described the coordinate locations of at least twenty. The historical significance of water sources is underscored by authors' proposition of the vulnerability of these water sources to the Roman control, speculating further that such control might have contributed to the Nabateans downfall (p. 334). Further, the flash floods symptomatic of the region prompted the city water authorities to capture and store for use every drop of the rainwater.

Water Distribution

The water delivery was accomplished through a network of ceramic pipelines and open channels set into the inclined elevations of hills and canyon surfaces. Here is where the hydraulic skills excel. Reflecting an understanding of fluid dynamics, city engineers took into consideration the effect of such factors like the size, geometric slope, and interior surface roughness of the pipe to deliver a measured quantity of water at optimum speed. Open channels were integrated into the distribution line at critical points to quell the speed of water flow. "Analysis of the system indicates exploitation of all possible water resources using management techniques that balance reservoir storage capacity with continuous flow pipeline systems to maintain a constant water supply throughout the year" (Ortloff, 2005).

Setting 3: Design Inventiveness

The Nabateans design inventiveness theme shows at both, the architectural project scale and the urban plan scale. The rough, rocky landforms of Petra natural landscape have played a major role in painting the urban character of the city through indisputably indigenous Nabatean innovations with adaptations influenced by the Hellenic, Mesopotamian, and Egyptian precedents and, from106 AD, by the Roman development interventions.

Architectural Project Scale

The rock-cut architecture, including funerary structures, with chambers dug into the depth of the cliff is a hallmark of the Petra urban scene. This resulted in façade declared peculiarity of architectural production compared to free-standing structures. This phenomenon materialized clearly at a particular stretch of the main trail pathway (Wadi Musa) past the Treasury (Al Khazneh) in what is now known the Street of Facades. Here are several bands of tombs stacked at three of four levels on the face of ridge. Having diversity of geometric carvings in the façade, the entrance openings to the tomb burial chambers anchors the visual perception of the burial ensemble scene (Figure 04). The "Facadism" example repeats at a more majestic scale in the Royal Tombs site along the Al-Khubtha Trail, short distance from its convergence with the Main Trail at a point between the Theatre and the Nymphaeum (Figure 05).

The four abutting tomb structures align roughly in a south-north direction, facing west. As it was meant to be perceived, the burial ensemble declares the grandeur of the royalties interned in the alcoves behind. Here the burial façade size and treatment scales are worked out to bring about the visual effect at higher levels than those worked out at the Street of Facades burial site.

Figure 04. Street of Facades lines of tombs.

Credited image edited

Source: Gunther , 2014.

Figure 05. The Royal Tombs, four lined tomb structures.

Credited image edited

Source: Raddato, 2018.

In contrast to the practice of the rock-carved structures physically integrated into the cliffs, the sandstone block unit construction had a share in Petra's built environment design, and in the course, provided a flexibility for pragmatic development. The completion of the Great Temple complex located at the south bank of the Colonnaded Street in the city center attests to discretion afforded the designers and constructors for shaping the complex (Figure 06). Completed in the 1st century BC, the design, materials, and size of the project reflect the Nabateans program of growth and urbanization (Joukowsky, 2023) and their exposure to the Roman and other cultures of the time.

Figure 06. The Great Temple, a "brick and mortar" construction.

Source: Institute for Archaeology and the Ancient World, 2006.

Most buildings connect to the public realm at some external space anchored with the building entrance to provide, in addition to the circulatory function, a transitional external environment, or a courtyard. This building-city public space was normally used for celebratory gatherings, and in terms of treatment scale, ranges from the informal and geometrically irregular, as of that associated with the Treasury, to the formal and regular, as with that associated with the Great Temple.

The Treasury project located at the west end of the Siq's canyon displays the irregular type of outdoor spaces. Here, the space footprint is largely determined by the lines where the steep ridges meet the "ground" (Figure 07). At Qasr Al-Bint monument, the Temenos terrace linking the building with the Main Trail serves the transitional function between the building and the urban realm of the city as shown in the ensemble reconstruction scene in Figure 08. Here, the footprint of the temenos, and for sure its three-dimensional configurations, have a stark contrast with what we have seen for the Treasury outdoor space counterpart. This sequence of scale at the building, site, and city levels seems to have been used as a tradition in urban design.

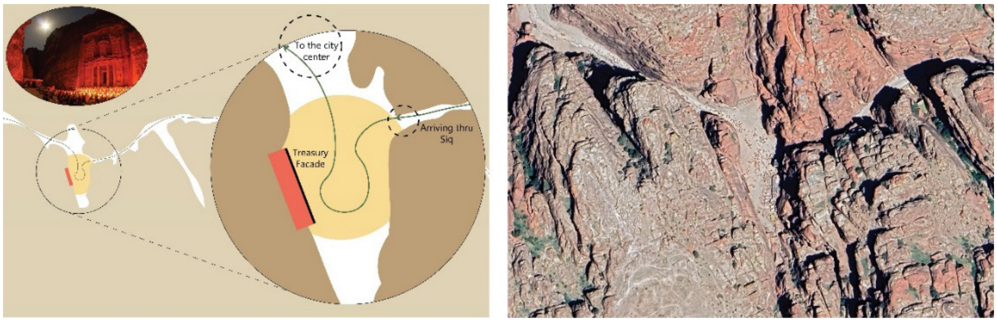

Figure 07. Informally shaped public space associated with the Treasury.

Image, left adapted from source image, right

Sources: Petra Satellite View, 2023; Sylvain, 2014.

Urban Plan Scale

The effect of the hilly, rugged landforms of the city's environs have had a hand in the development of the city layout through the years. The dynamic landscapes of valleys have influenced not only the urban fabric in terms of circulation, but also agriculture and rituals (Berenfeld, Dufton, and Rojas, 2016). This topographic characteristic must have been an omnipresent factor in the city planners' judgments as related to transport network and land use layout. What is now called the Main Trail (Wadi Mousa) between the Djin Blocks (East) and Qasr Al Bint (West) hugs the lowest contours of gorges and ravines and reigns as the spinal pathway for the city. Running for a winding length of about four kilometers with alternating plane and low navigable slopes explains the rising role of this throughfare in weaving urban circulation and land use patterns. This thoroughfare holds the largest collection of Petra's projects at its flanks including the Dam, Siq, Treasury (Al Khazneh), Street of Facades, Theatre, Nymphaeum, Colonnaded Street, and Great Temple. At desperate junctures along the thoroughfare, as many as eight trails branch out into valleys sloping to defined destinations. Thus, the circulation scheme of the city builds on clear hierarchy of movement elements at graduated scales of importance and respective spatial configurations (Figure 09).

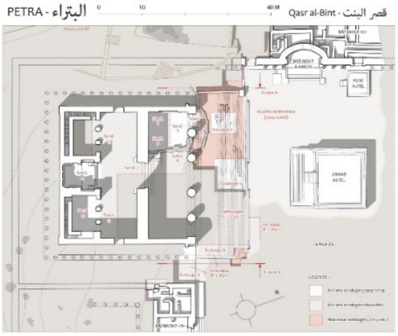

Figure 08. Qasr Al-Bint reconstructed plan with outdoor temenos.

Source: Fournet and Renel, 2019.

Figure 09. Map of Petra showing scale hierarchy of circulation

Sources: Petra Development & Tourism Region Authority; Proust, 2023.

The archeological sources suggest levels of growth or decline of the city development from one chronological period to the next, ensuing respective changes in the City's institutional, communal, commercial, and residential land uses. Several sources indicate the golden years of project construction and city expansion range from late 1st century BC through early AD 1st century (Kouki, 2012, p.38). Kouki further mentions "this period also witnessed the monumentalization of the city centre and produced the layout of the city much as it is known today." For example, a residential quarter existed around the city urban center from about the middle of the 2nd century BC through the Byzantine times, early in the AD 5th century (Bouchaud, Jacquat, and Martinoli, (2017).

Discussion and Concluding Matters

We have proposed the importance of understanding the thematic agency and associated spatial manifestations that are inherent in any heritage district, archaeological site, or urban landscape for facilitating informed urban development plans and projects. We have done the following: first, incorporated the concepts of thematic agency and spatial manifestations into the normalized construct of "setting;" second, appropriated for discussion three settings attuned to Petra's cultural themes and spatial development through time: engaging nature, water management; and design inventiveness; third, used the expanded concept of scale, as applicable, throughout the discussion of the three settings. This Section reflects on the study accommodations and limitations, conclusions, and implications and recommendations.

Accommodations and Limitations

- This paper accommodates only three cultural settings—each integrating a thematic agency and the associated spatial manifestations. Although preliminary investigation revealed several settings applicable to the city of Petra, we selected the settings based on the relevance and the number sufficient for informative feed. Settings such as international trade and religious life, although significant, were not entertained.
- As thematic agency and spatial manifestations were set as the framework of the discourse, scale and scalability played as an analytical tool to support the discussion, whenever appropriate. Scale has been used in its expanded interpretation to describe or differentiate magnitude, value, and levels. In this capacity, scale was set as an interpretive, expository tool rather than substantive domain of the discussion.
- The thematic and spatial milieus of Petra are, in principle, rich for supporting the objectives of the study. The references on Petra's history, culture, and development are numerous, but we have encountered some challenges in obtaining precise facts in terms of dates, and more importantly, in terms of societal events and trends, the latter representing the ingredients for weaving key themes. While there are plenty of maps, images, and other digital information available, the selected items needed adjustments and adaptations to suit the reference purpose.

Conclusions

Although the concepts of thematic agency and spatial manifestations of historic sites are not quite foreign terms in historic preservation, the study has provided a fresh look at their meanings individually, and more importantly, at the critical relationship between both within an umbrella of cultural setting. Normalizing the construct of cultural setting proved useful to refine the relationship of its components—the thematic agency and spatial manifestations. And, in the process, this kept the message to the reader (or user) at a pragmatically fathomable level. The workings of these dual concepts under the normalized cultural setting become more tangible when they are brought to bear on analysing a viable heritage site "in situ," per se. As the subject, Petra carried viable ingredients to support the study objectives, and by extension, represents heritage sites that can benefit from the results of this study for continued curation and preservation of heritage assets.

Bringing scale to bear on the discussion of this research proved useful in analysing conditions in certain contexts such as when comparing the levels of façade treatment of different buildings. At certain points of discussion, the use of scale related to size or extent. This, for example, materialized for Setting 3: Design Inventiveness where the discussion made a distinction between the architectural project scale and the urban plan scale.

Implications and Recommendations

The concepts of thematic agency and spatial manifestations accept further investigations and so is the construct of the cultural setting into which they coalesce. These theoretical domains will deliver good when applied to qualified heritage resources, typically beyond the scale of single structure of small site such as an archaeological complex, urban centre, or historic landscape. Work is needed to clarify how heritage programs would realign conservation policies and approaches to take advantage of cultural setting proposition.

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Mapping The Unseen | Scalar Explorations

Introduction

> All sites exist first as places. Before places become objects of urban planning and design, they exist in personal experience, hearsay, and collective memories. Standing between planners and designers and the sites on which they hope to act are socially embedded narratives. And, while these place narratives can be ignored, they cannot be wholly erased. Places are never empty.[1]

A city is a palimpsest of our experiences, attitudes, and collective vision. Cities are robust and durable artifacts of human activity and aspiration. The built or designed infrastructure of the city is not only a context for urban activities and functions; it can also express ideologies that facilitate social, economic, and cultural life. *Mapping the Unseen* is an exercise in learning to 'observe' the multi-dimensional experiences of the city constantly in a state of flux, revealing its fragmentary nature within its collective promise. It provides opportunities to create a new urban vision as architects, planners, and urban design students engage their evidence-based findings to develop new programmatic opportunities that connect to the structural, physical, and social context based on equity to meet the needs of today's diverse citizens.

Design is, in part based upon a deep structural analysis of existing site conditions, which leads to value judgments and design decisions. The spatial experience of architecture provides a critical ground for interpreting of the architectural 'program.' Thus, mapping as a generative tool with new forms of representation gives each student the agency to explore possibilities architecturally through formal and spatial design interventions that engage innovative programming to create urban places and spaces where equity, justice, and environmental stewardship prevail. Through student projects, this paper manifests how a new urban vision is developed through innovative programming that responds to grave concerns over affordability, densification, and climate change?

Theoretical Framework

"Cities are central to virtually every challenge we face – and essential to building a more inclusive, sustainable, and resilient future."[2] The call is to the makers of the city: educators, architects, planners, and urban design students, to challenge the existing norms of market forces as disruptions to historical patterns and orders, creating ruptures, scars, and traces that are evident today.

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[2] Guterres, Antonio. (2022). *United Nations Secretary-General*. UN News.

Manfredo Tafuri's assertion of a frontierless city: where sites and boundaries are forever shifting, brings into question - issues of equity: social and spatial justice, climate change, and carbon footprint; more than that, these forces play a pivotal role in transforming the city into an emergent global urban condition that begs the question: How can our cities be reformatted as multi-functional urban centers to respond to the needs of today's global citizens? How can innovative mapping and new representational techniques reveal characteristics of space as a means to explore and inform new architectural constructs? Why is adapting the existing city grid and infrastructure critical to promote new programs and public-private partnerships to tackle shelter, affordability, access and climate change?

Cartography, maps are symbolic representations of information - parts to whole relationships illustrating data in the most simplistic terms on both micro and macro scales. However, in the 20th c, artists, architects, and activists used mapping to open up all possibilities of discovery and vision. It is more than just a tactic for gathering information and data. Situationists used the technique of *derive* as a rapid passage through varied ambiances of the fragmentary nature of the city. *The Naked City* maps are potent attempts to connect out-of-context fragments of the city in new relationships. They are forced to create an explicit understanding of the city that offers instructions on operating, maneuvering, and living in it.[3] Buckminster Fuller developed a methodology to generate The Dymaxion Map through a series of projections suggesting an alternate vision of an interconnected world as Spaceship Earth that equips humanity with a better tool to address existential challenges and systems interventions. James Corner asserts that,

> "… mapping is not endless data accumulation but is rather better seen as a practice of relational reasoning that intelligently unfolds new realities out of existing constraints … that are crucial for the effective construal and construction of new worlds."[4]

Building upon these theoretical frameworks *Mapping the Unseen* seeks to investigate the city to reveal nuances around materiality, texture, light, scale, proportion, programming, enclosure, shading, permeability, accessibility, history, and demographics to give new meaning to a place through personal experience. It challenges the makers of the city: architects/planners, and students of urban design and architecture to unravel the complexity of cultural significance as embedded in the urban condition – part-to-whole relationships at overlapping scales of inquiry from the city, to the block, to the street, to the building detail to reformulate. Representational strategies also play a pivotal role in exploring new connections within the built environment, and mapping techniques continuously shape them. They are opportunities to raise questions within a new framework, thus creating a fertile ground for exploration in a contemporary setting for the architectural construct.

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[3] Schoonderbeek, M. 2017. *Mapping Experimentation in Architecture and Architectural Design*, A Theory of 'Design by Research.' Taylor and Francis e-book.

[4] Corner, James. 2011. *The Agency of Mapping: Speculation, Critique and Invention*. The Map Reader

James Corner's assertion that a map is a project in the making that can evoke design potential in a site was tested in the upper-level urban design studio. Building on the theoretical framework of cartography and contemporary discourse, students interrogated their sites by questioning the city and its physical, social, and cultural landscapes. Specifically: the public realm, infrastructural system, access to transportation, issues of equity, and spatial justice. These investigations document the visceral and experiential impressions of the urban context, allowing students to 'observe' and 'feel' the effects of design decisions on human behavior. New forms of representations capturing their observations and experiences of the site as a generative process give each student the agency to set into motion new opportunities and promises within the city.

Mapping | The Project

The pedagogical approach engages three specific interdisciplinary frameworks:

1. Investigating the City - gathering qualitative and quantitative data emphasizing historical and theoretical conceptions of contemporary urban space, particularly on observation of given realities through documentation, experimental and experiential mapping.
2. Diagramming and Visualization Tactics - Quantifying data as visceral engagement of observed data collected by engaging with materiality, imagery, ambiances, and cultural and social values.
3. Scalar Composite Mapping - Exploring new and innovative interdisciplinary representation techniques activating spatial analysis as both projective and performative that can inform the architectural construct in making engaging 2d and 3d physical media.

Figure 1 | Brainstorming - Mapping

Source | 5th year Focus Studio 2014

Through inquiry at varying scales, the goal is to develop a methodology for mapping as a creative and performative act to unravel the scarred ruptures in the city. The mapping process generates the artifact (s) not as an end goal but as a springboard for what will come next. In the creative act lies the potential for innovative practices expressed not in the invention of novel form but in the productive reformulation of what is already given. Unexpected solutions and effects may emerge by showing the world in renewed ways. Composite mapping tactics can reinterpret the questions to respond to the current context. This form of expression gives agency not just data collection but opportunities to reshape the worlds in which people live, as evidenced in the final projects. The studio pedagogy of *Mapping the Unseen* has grave potential to be applied to real-life scenarios by architect-planners to respond to the challenges cities are facing today: spatial equity, social justice, active and safe public realm, access to transport, and most importantly, a sustainable city as outlined by United Nations.

Case Study 1 | Public Space Comes Alive[5]

As asserted, the relationship of mapping to the given site directly impacts design outcomes, which are put to the test in the fifth-year focus studio. The assignment was in response to Atlanta Streets Alive's call to activate a 2 1/2 mile stretch for a community-building human-powered event that explores concepts such as tactical/ guerrilla urbanism to build a happier, healthier, and more sustainable Atlanta. The project had 2-parts:

a) Mapping as a generative tool to select a site for intervention;
b) Design intervention as Site Specific - DIY

The studio was split into two groups of eight each. Each group was to strategize to observe and analyze the site using an interdisciplinary theoretical framework and ethnographic research methodology: observations/mapping/interviews and other tactics to explore new readings of the site collectively and individually. The design challenge was to propose a site-specific DIY intervention using found materials fabricated in the school of architecture's wood shop and digital lab.

Group 1 | Bamboozlers | Claiming the Right to Public Space

Each member of the group mapped the site to unravel the physical, social, and cultural aspects of the site through various filters of investigation. The next step was to devise a strategy to organize their findings into a 3-d mapping construct to represent individual students' data as a color-coded framing model. Each frame of the analysis portrays a different category. Each category has a grid that provides maximum and minimum levels, thus leading to the most promising site. The site selected was at the corner of Boulevard and Ralph McGill. It is a private, green lot with a dirt trail with no grass. This trail is a "donkey path" created by locals cutting the corner along the hypotenuse, which was intriguing and showed the potential to highlight through an iconic urban installation.

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[5] Public Space | *Sites of Action(s)*, ARCH 5998F: Focus Studio 2014

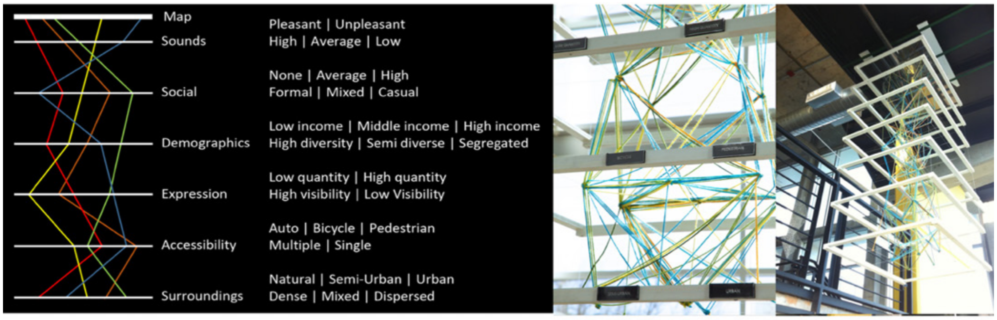

Figure 2 | Mapping manifested site opportunities and design strategy | Bamboozlers
Source | Public Space Comes Alive - 5th year Focus Studio 2014

The vision to accentuate the path as a symbolic threshold to mark the bike route along Boulevard was, in essence, pushing the boundary of the bikers - to test if they would notice such an installation and stop and interact with it. As is evident in the documentation, citizens of all ages did stop to pause and play with the structure – thus proving our hypothesis right.

Mapping directly impacted the design intervention of an iconic Bamboo installation. "Bamboozler," whose form, shape, color, materiality, texture, fabrication, and installation created an inviting gesture to an otherwise sketchy part of the route in front of a pawn shop was a spectacle in the public space as one speactator tweeted "I was bamboozled by the Bamboozlers!"

Figure 3 | Breaking Boundaries through design strategy | Bamboozlers
Source | Public Space Comes Alive - 5th year Focus Studio 2014

With a design-build intervention, students were in awe of their success – giving them the agency to believe in the power of architects as social agents of change.[6]

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[6] Public Space | *Sites of Action(s)* Student Testimony, ARCH 5998F Focus Studio 2014

Group 2 | Les Enfants de Rues | Claiming the Right to Public Space

Biking through the streets, this group divided the Atlanta Streets Alive route into seven zones delineating transition areas along the path. Each student analyzed a sector and then produced an experiential response to the site in conjunction with three keywords. These signifying words convey the student's sensory reaction. The site selected was the highest point with a view of downtown Atlanta. The performative aspects of biking, fluidity, and speed generated the composite mapping as a site-specific artifact in the making with sound and imaging in the studio space alcove. The artifact directly impacted the design, materiality, tectonics, fabrication, and assembly.

Figure 4 | Mapping manifested site opportunities and design strategy | Spectacle for all ages | Les Enfants de Rues

Source | Public Space Comes Alive - 5th year Focus Studio 2014

Mapping manifested site opportunities and design strategy, which is aptly described by student testimonies as is evident from the installation's images.

> "Life was unleashed - as the public biked and walked through it. To see the children climb and imagine what the space could be was an insightful experience. To see Boulevard transition from a buffer zone to a zone of action/meet and greet was a clear vision of how the collaboration of a designer's vision and the public's involvement can promote the evolution of an existing dead space."[7]

Figure 5 | Breaking Boundaries through design strategy | Les Enfants de Rues

Source | Public Space Comes Alive - 5th year Focus Studio 2014

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[7] Public Space | *Sites of Action(s)* Student Testimony, ARCH 5998F Focus Studio 2014

An excerpt from *Sampling the Public Space* by a student team sums it up:

> ”To understand how space operates, every instrument must be explored. The material used in the space had a significant presence, and shapes gave meaning to the experience. Sounds were sources of reference throughout the navigation of the public space. An encounter was more than an image or color; it was a matter - humanity proved to be very responsible and accountable for one another, changing my perception of the unseen and the unheard. The simplest conversation meant more than it had ever before. Every voice had a weight and could easily be distinguished in a crowd. At times, the wind seemed to carry one conversation to another side as if nature wanted us all to interact and be part of each other’s lives somehow. The space was alive, and every entity played a key role in composing this beautiful and thrilling experience.” [8]

The agency of mapping as a creative act was put to the test in this exercise, the scope of which, as a real-life project, stands testimony to James Corner’s assertion that a map is a project in the making that can evoke design potential in a site. These examples provide evidence of mapping the unseen to yield new imaginaries that can shape our experiences in the urban realm to break the social and cultural norms of architects as social agents of change.

Case Study 2 | Mapping the Unseen – Creating an Urban Vision [9]

Building on the 20th c theoretical framework, students in Urban Lab studio interrogated the Buckhead loop by questioning the urban fabric and the role of architecture within the city and its context. Students examined the evidence of forces of change along Peachtree and Lenox Roads through mapping techniques and image-making. The goal was to unravel the narrative of the Buckhead loop within the ½ mile radius of Buckhead and Lenox Marta Stations as opportunity zones for Transit-Oriented Communities engaging Density, Diversity, and Design.

In teams of two, students began investigating the Buckhead loop. Next, they zoomed in on a particular zone of interest to focus their analysis on by raising questions: is it disjunction or disparity found at all levels: social/political/cultural? Is it the issue of scale? Boundaries? Demographics? Land use? Public transit? Amenities? Street life? Access? They then set the site’s limits to a 1-mile radius to critically analyze and collect data through the following filters: historical memory, land uses, public spaces, social mix, cultural life, streets, transportation and access, and more. Collecting and analyzing data together with experiential-sensory aspects of the site, students used keywords, photography, graphics, images, digital mapping, and aural expressions as a strategy that led to discoveries.

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[8] Public Space | *Sites of Action(s)* Student Testimony, ARCH 5998F Focus Studio 2014

[9] *Urban Lab*, ARCH 4014; 2022

James Corner's assertion that,

> "… mapping is not endless data accumulation but is rather better seen as a practice of relational reasoning that intelligently unfolds new realities out of existing constraints."[10]

was manifested in the 2d and 3d artifacts presented by student teams. Marshall McLuhan's phrase *The Medium is the Message*[11] provided a strategic framework for new and speculative forms of representation to augment the mapping process. A compositional strategy had to be devised where materials, tools, and techniques were aligned to fabricate the artifact.

The mapping process generates the artifact(s) not as an end goal but as a springboard for what will come next. In the creative act lies the potential for creativity practices that are expressed not in the invention of novel form but in the productive reformulation of what is already given. By showing the world in new ways, unexpected solutions and effects may emerge.[12]

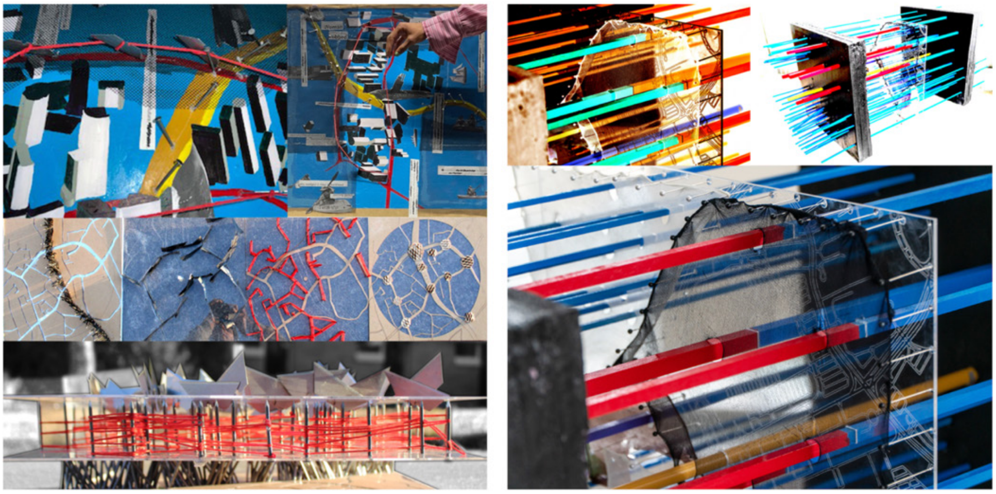

Figure 6 | Mapping manifested site opportunities

Source | 4th year Urban Lab Studio 2022

Mapping | Design Interventions

Mapping led to discoveries and opportunities for the final project Creating an urban vision. Each team had to develop a project brief outlining a program for TOD Transit-Oriented Communities engaging Density, Diversity, and Design within the Buckhead

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[10] Corner, James. 2011, The Map Reader, *The Agency of Mapping: Speculation, Critique and Invention.*

[11] McLuhan, Marshall. 1964, *Understanding Media*, McGraw-Hill.

[12] Corner, James. 2011, The Map Reader, *The Agency of Mapping: Speculation, Critique and Invention.*

loop. Each proposal was unique programmatically, from co-housing to artists' colonies to mixed-use, mixed-income housing with a public realm. A pedestrian-friendly walkable community where culture, arts, and economic opportunities promote sustainable and equitable urban growth engaging, Density, Diversity, and Design within the Buckhead loop.

Figure 7 | Mapping manifested site opportunities and design strategies

Source | 4th year Urban Lab Studio 2022

Unique projects that were the outcome of the methodology established created a new vision for a city that is historically an affluent community. Student project named 'Buckhead Fashion District.' won the competition sponsored by a local firm. Their abstract sums up the success of the studio,

> "Described as "swanky," "chic," "white & wealthy," by the backroom journal. Buckhead, as a city, has these high-end retail stores and nowhere to show off these designs. The city is set up to be the fashion hub of Atlanta. This project aims to establish more true public spaces, introduce affordable housing, create a fashion node for Buckhead, and update Lenox Square Mall by returning it to its roots and making it open air again."

Figure 8 | Creating an Urban Vision

Source | 4th year Urban Lab Studio 2022

Urban Lab 2023 tackled the issue of ‘Housing for the Missing Middle,’ in Buckhead, an affluent suburb of Atlanta. Tasked with the problem, students used mapping to analyze the issues facing the discrepancies in income, housing shortage, accessibility, social service, education, and so forth which was unravelled in the first module Mapping the Unseen which then led to precedent analysis for housing typology and Transit Oriented Development. Program is a direct outcome of each group analysis which then sets the framework for the final project, Urban vsison as is illustrated in the student project ‘Link.’

This studio has been extremely interesting and unique, as we were tasked with the understanding of architecture on the urban level. This meant that we must think not only of the spaces that we are designing, but also how the pedestrian interacts and experiences the space. As the project was a masterplanning of a block within Buckhead, Atlanta, we had to understand the effect on the existing infrastructure of the city: transit, roads, buildings, programs, cultures.

Throughout the semester our team utilized model-making as a way to analyze mutliple aspects of a given project in 3 dimensions. Our zoning model of the Buckhead Redefined area illustrated the stark contrast between the building typologies, as well as the unseen zones that were created. Our model for the Nakagin Capsule Tower was used as a physical method for testing the modular interchangability of the capsules. Magnets were fasted to the structural core and each of the individual pods as a way to show the simplicity of design and allow for viewers to interact with

Fig 9 | Creating an Urban Vision

Source | 4th year Urban Lab Studio 2023

Over the years student testimony attests to the studio pedagogy’s success on the urban level as been extremely interesting and unique to unraveling how architectural projects engage with the street section on a human scale. Public – Private explorations challenges architecture student to work at multiple scales to solve the city’s issues, , “… we must think not only of the spaces that we are designing but also how the pedestrian interacts and experiences the space in the 3rd dimension.”

Creating an urban vision as a masterplan with a focus on housing was an opportunity to develop a unique program within an existing context that students have to negotiate: transit, roads, buildings, programs, people, and culture,

> “… little by little, we understood what urban life was all about – we proposed a modern art museum as an anchor institution to pull people into Buckhead around the Lenox Mall area. Building programs with stratified Housing, including shopping, restaurants, public spaces, and plazas with robust street culture and experiences, will be incorporated. Our team utilized model-making to analyze multiple aspects of a given project in 3-dimensions, which led us to visualize a rather complicated field of design in a way that made it simple and effective. We can certainly walk away from this studio, realizing that architecture is about our experiences within space.”

Conclusion

The transformation of cities worldwide demands new strategies to respond to the needs of more diverse people than ever before. Composite mapping tactics at various scales can reinterpret the questions to manifest further readings of the current context. This form of expression gives agency, not just data collection but opportunities to *re-shaping of the worlds in which people live,*[13] as evidenced by the student projects at two different scales: public space activation and suburbia redevelopment.

The studio pedagogy of *Mapping the Unseen* has grave potential to be applied to real-life scenarios by architect-planners to respond to the challenges cities are facing today: spatial equity, social justice, active and safe public realm, access to transport, and most importantly, a sustainable city as outlined by United Nations Conference on transforming world's urban area,[14] that we as educators and professionals must incorporate in our teaching pedagogy and practice.

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Senses of scale: iconicity and instrumentality through the three scales of House 11a in Cannaregio

Introduction

Scale is usually responsible for establishing a dialogue with the user, the place, and the function of the project based on its proportions. Furthermore, *it is entrusted for* being able to establish a logic correspondence between the project and the physical world through its dimensions. Therefore, playing with scale can be a way of questioning some limitations imposed to architecture, such as its reference point and also its function – does architecture necessarily need to be attached to a user or a program? If it does not, how to detach architecture from this determinacy while still practicing architecture?

These are key points for Peter Eisenman's Cannaregio Town Square, designed in 1978 for Venice. In this project, the critique of the architectural dictates takes place largely through the incorporation of a previous work, House 11a, also from 1978, when scaled to three different sizes. In this paper, we discuss about how scale engages directly with our perception of the architectural object as something endowed with function and meaning. We start from the concepts of icon and instrument, which Eisenman would apply in his texts almost two decades later, in 1995.

Both concepts, icon and instrument, refer to Eisenman's nearly semiological analysis of architecture. With these concepts, one can understand an architectural element as a sign if we consider the properties of "iconicity" and "instrumentality" (Eisenman 2007a, p. 43), allied to the sign bipartition of signified and signifier. This way, this study proposes to analyze the role of scale in Cannaregio Town Square through a number of linguistic tools. This work also makes use of thoughts from Jacques Derrida on the relationship between linguistics and philosophy, in which we see some parallels with Eisenman's theories and projects. Therefore, at first, we will contextualize Eisenman's concerns that led to the projects discussed here, followed by the presentation of the works themselves, House 11a and it insertion in different scales in Cannaregio Town Square. After exposing the project concerns, we report our analysis tools and investigate the relationship between Eisenman's concepts and linguistic theories, culminating in some conclusions.

Here, we intend to apply the architect's concepts of "iconicity" and "instrumentaliy" to analyze his previous design for Cannaregio, in Venice. In such project, we already see some manifestations regarding its roles of what Eisenman would later call icon and instrument in architecture. Thus, this paper proposes to discuss how the relationship between our understanding of architecture and reality is affected by the indeterminacy of scale. Considering Cannaregio Town Square and the theories mobilized by it evoke the rupture of some conventions and certainties, we are more interested in the questions that arise from this project than trying to find or impose some answers.

Against representation: a humanist tradition

The projects shown here, House 11a and Cannaregio Town Square, are based on Eisenman's investigations about how to think about architecture without it being necessarily linked to programmatic needs and serving people's needs. This involves some points, such as of function, representation, proportion and scale directly, understood as limiting architecture as an autonomous discipline.

These projects operate as polar opposite critics to functionalism by proposing the subversion (in the case of House 11a) and the extinction (when the house is incorporated into the Cannaregio project) of their intended function for a user. In fact, these projects belong to a moment in Eisenman's career in which the architect understands funcionalism as an extension of the humanist tradition. That meant, then, that architecture, since the Renaissance, had been guided by anthropocentric precepts, keeping the design process centered on humanist ideals (Eisenman 1998a), such as function and form, dealing directly with notions such as beginning and end. So, since the advent of architecture as a result of construction regulated by a designer's thinking, the same procedures had been guiding building and reproducing external ideals.

By a humanist tradition, Eisenman means the maintenance of architecture as defined by the dialectical opposition between its internal arrangement and its formal articulation (the function-form relationship) endowed with an extrinsic meaning to it. His criticism focuses mainly on the adaptation of architecture to human proportions: "Architecture has traditionally been related to human scale. For five centuries man's bodily proportions have been a datum for architetcure." (Eisenman 1986, p.77), occupying the center of their relationship. Not only for proportional adequacy or for determination of a programmatic function, but also for the maintenance of some ideals, such as origin or end, or even presence as a physically real form of the architectural object: "The issues of presence and origin are central to the question of anthropocentrism." (Eisenman 1986, p.77). That is, the necessity of building a design/project relates to the fulfillment of a purpose, which is also taken as a starting point when stipulating its program.

Whether privileging one or the other, Eisenman understands that the design of the project was always based on the causal link between program and type. This statement is exposed for the first time in his text "Post-Functionalism", from 1976, in which the architect argues that the permanence of the cause-effect relationship between function and form (and vice versa) reproduces an "[…] idealist view of man's relationship to his object world." (Eisenman 1998a, p.236). According to Eisenman, architecture would only take place as mediation between the user and his immediate surroundings through its construction – therefore, architecture would be merely a representation of this ideal way of interaction. Both privileging function and form, the architectural object would arise from the search for the adequacy of an ideal to its user, both through its proportions (type) and through its needs (program).

According to Eisenman, other areas such as mathematics, music, literature, painting, etc., abstracted the leading role of man in in their modernist instances, which is seen as a break with the humanist ideology. They would be closer to being autonomous disciplines, something that modern architecture, in his view, was not capable of achieving. The aforementioned text is called "Post-Functionalism" precisely because the architect also points out in it that this causal relationship between program and type persists in modern functionalism, suggesting that one should think of an alternative, post-functionalist – and therefore post-humanist – approach. In other words, for Eisenman, functionalism would be a continuation of the humanist tradition by keeping man at the center, considering the practical purpose of constructions is prioritized (from the idealization of technology). This would perpetuate the position of architecture as a mere mediator, not thought through its conception itself. In this wise, the forms of functionalist architecture, in defense of industry and devoid of ornaments, would only be aesthetic and idealized manifestations of the moral impetus of transforming society and of this supposed new relationship between man and the world. However, its core would still be attached to the human body as a user:

> For functionalism, no matter what its pretense, continued the idealist ambition of creating architecture as a kind of ethically constituted form-giving. But because it clothed this idealist ambition in the radically stripped forms of technological production, it has seemed to represent a break with the pre-industrial past. (Eisenman 1998a, p.237).

Following this statement, if what was reproduced until Beaux-Arts dealt with the representation of the human figure through its proportions, functionalist architecture had only transferred its focus to mimesis, mirroring itself, this time, in the machine, but still at the service of its user. What Eisenman proposes with "Post-Functionalism" is "a displacement of man away from the center of his world. He is no longer viewed as an originating agent." and that "[architectural] Objects are seen as ideas independent of man." (Eisenman, 1998a, p.238). Considering architecture as something devoid of a utilitarian purpose, whether by wavering of its built form or by the indeterminacy of its function, would guarantee a rupture with its role of representation and mediation.

Only in "The end of the classical: The end of the beginning, the end of the end", from 1984, Eisenman would formulate in a more purposeful way how to design through other ways of thinking and producing architecture. Prior to that, some experiments had already put into practice Eisenman's criticism of the centrality of man and its positioning as an originating agent, whether in the criticism of the relationship of similarity (formal and proportional), or in the maintenance of this same relationship of similarity with its utility (relationship function-form). We will see how House 11a deals conceptually and formally with such criticism and how its replication at different scales in Cannaregio Town Square enhances its questioning.

Three scales

House 11a

House 11a was conceived two years after "Post-Functionalism", designed in 1978 for art and architecture historian and critic Kurt Forster, but never built. The proposal deals with the extinction of any possible centrality, both in the forms applied and in man as user.

Formally, the decentralization of the subject in this project is marked by the predominance of voids to the detriment of "full forms." That is, instead of using mostly squares and cubes – remarkably stable and perfect shapes – Eisenman withdraws their centers, creating what he called "el forms" (Eisenman 1982, p.54). These "el forms" were first used in House X (1975), adding up to a fragmented and perpetually incomplete architecture (Fig.01). Emptiness predominates, nullifying any mimesis with the human body, marked by the loss of what Einsenman (1982) understands as the archetype of the house as conceptually vertebrate. For him, houses are usually thought of as bearing a center, whether that be the fireplace or the stairs, in addition to the roof pitch that sometimes also establishes a symmetric axis, which would configure some kind of backbone:

> Most houses are conceptually vertebrate. […] The center expresses both the functional core (either as a place or as a route) and conceptual unity of a house. Here [in House X] the center is no longer a place nor route, it is essentially nothing. The vertebrate house is also mimetic; it mirrors man's upright, axial, condition. In an attempt to produce a conceptual distance between man and object, House X is non-vertebrate; to this extent it is non-mimetic. (Eisenman 1982, p.88).

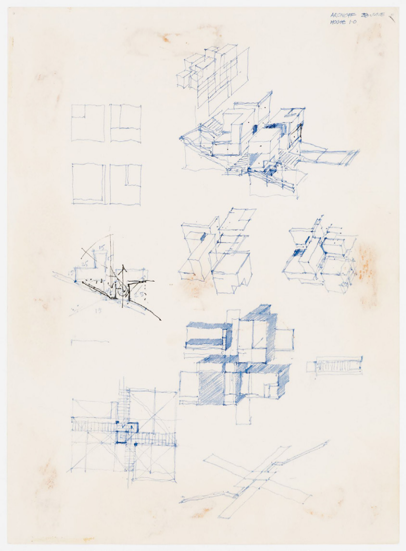

Fig. 01. Peter Eisenman, House X, Bloomfield Hills, Michigan: conceptual sketches. 28 June 1975. Blue and black ink on paper, 27.7 × 20.2 cm. DR1994:0138:066.

Source: Peter Eisenman fonds, Canadian Centre for Architecture © CCA.

House 11a, however, expands man's alienation beyond the decentralization of volumes. Its spatial arrangement seeks to dissolve the separation between interior and exterior, resorting to properties of topological geometry. Like a Möbius strip, the house unfolds almost from a single surface through the articulation of the "el forms", in a way that creates an uninterrupted continuity (Fig.02). This interaction between forms causes a deformation of both the purity and the stability of Euclidean geometry. Furthermore, they demonstrate the rupture with the certainties established by the Euclidean geometry, such as the notions of interior and exterior and, therefore, of perception of reality. For this reason, even when the user is inside the house, the effect is as if he were outside, positioned as an observer, not a resident. Or rather, it plays with the possibility of being an observer which is at the same time inside and outside, as the client's statement points out:

> As the client, I would like to remain a viewer of the house while inside of it. […] I would be a viewer who is inside, separate from what he is dealing with, which is the world short and simple on the outside, and at the same time, while I am inside and separated from it, I would be able to know about it, I would have the world present. I would like to be in this dual condition of the viewer who is both inside and outside of the house. (Forster 1978 cited in Weil [no date]).

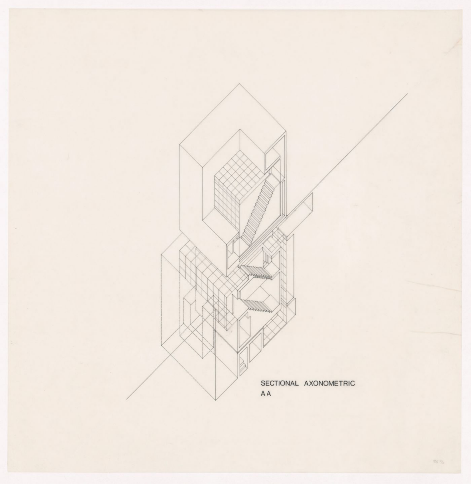

Fig. 02. Peter Eisenman, Sectional axonometric for House 11a, Palo Alto, California. 1978. Drawing in pen and ink with scraping (as erasures) on translucent paper, 53,6 × 53,5 cm. DR1994:0139:283.

Source: Peter Eisenman fonds, Canadian Centre for Architecture © CCA.

The formal distortion occurs simultaneously upwards and downwards on the ground surface, so that this same continuous surface reveals and hides (Fig.03). Thus, it engages with the perception of what we access as the truth or reality of objects: can we really access their totality?

> The resulting configuration [of the House 11a's topological sheets] appears to have an inside and an outside but in fact there is no real inside and no real outside, only two deformed membranes. (Eisenman 1978 cited in Weil [no date]).

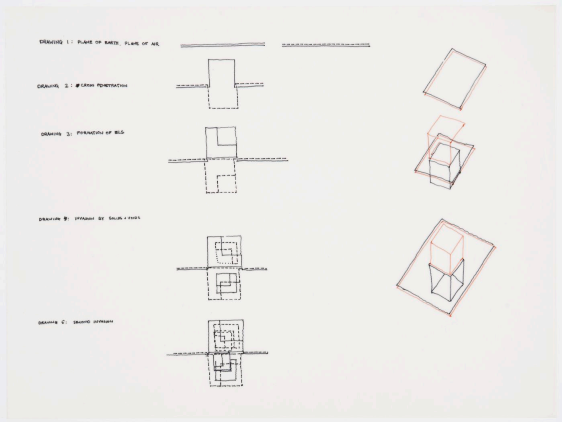

Fig. 03. Peter Eisenman, Conceptual sections and axonometrics with instructions for House 11a, Palo Alto, California. 1978. Ink on translucent paper, 22,8 x 30,5 cm. DR1994:0139:001.
Source: Peter Eisenman fonds, Canadian Centre for Architecture © CCA.

Cannaregio Town Square

Cannaregio Town Square was designed in the same year as House 11a, 1978, bringing to the urban fabric the concerns surfaced by House X and further elaborated in House 11a. It operates by incorporating elements of Venetian history and memory. The voids that were already *formal parts* of House X are explored in this project in a more abstract way, since the components used for its conception are not present pieces in the city, but events that actually or potentially happened in Venice. Consequently, they lack their physical condition. Some of them are Le Corbusier's never built Venice Hospital, the incorporation of also never built House 11a and the event of the imprisonment of Giordano Bruno by the Inquisition.

A small text stems from each of these events, composing the "Three texts for Venice": "Text one", "Text two" and "Text three." We will focus on "Text two", which deals specifically with the incorporation of the three scales of House 11a.

"Text two" presents two groups of objects. The first fits the existing context, but its objects are solid and lifeless blocks, "[…] their presence is nothing but an absence." (Eisenman 1980, p.9). The second group is the one that matters most to us: it is a series of objects that, instead of relating to the existing context, it dialogues with the voids arising from "Text one", from holes in the ground (or graves) that come from the structural grid of Venice Hospital (Fig.4).

This group of objects consists of six replicas of House 11a inserted into the mentioned graves. Each of these replicas, in fact, has two smaller versions of itself inside, with exactly the same shape (Fig.5). However, none of the three versions corresponds to a type or program of the architecture because they do not fit a usual scale or cannot be occupied: "The first object is smaller than a house, the second is the size of a house, the third is larger than a house." (Eisenman 1980, p.9). These three replicas are one inside the other, preventing any one of them from being occupied, while the smallest one, the only which is empty, is smaller than a house, prevented from offering shelter. The intermediate one, which has the size of a house, shelters its smaller version.

Fig. 04. Peter D. Eisenman, Architect (architectural firm), Presentation model including Cannaregio West and Le Corbusier's Venice Hospital. 1978. Gold and pink paint over wood and cardboard, 9 x 101 x 101 cm. DR1992:0009.

Source: Peter Eisenman fonds, Canadian Centre for Architecture © CCA.

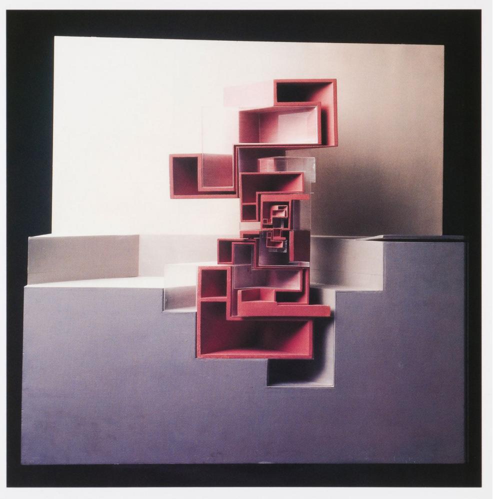

Fig. 05. Peter Eisenman, Competition entry for the International Seminary of Design, Cannaregio West, Venice: Sectional model of El structure. 1978. Grey, beige, and pink paint over wood with plexiglas, 101 x 101 x 27 cm. DR1992:0010.

Source: Peter Eisenman fonds, Canadian Centre for Architecture © CCA.

Allied to the indeterminacy of the scale, the three versions also carry the indeterminacy of their names and our perception of which is real and which would be a representation:

> Is it a house, or a tomb for itself, or for a model of itself, or for a real object? *If it is a mausoleum, then the first object, the five-foot "house" is no longer a model of something real, but a reality itself, no longer a model of something but something in itself.* (Eisenman 1980, p.9).

Which of the three sizes would the real object be? If one of them is *the real one*, would the smaller one be its model, that is, an ordinary representation, or would it also be a real object, an architecture in itself?

Iconicity and Instrumentality

What interests us in the use of these different scales in House 11a is the way in which their indeterminacy affects our perception of architecture and even its identification as a real object. Since it is not possible to define the use of these architectural objects by their program – the proportions of none of the "houses" correspond to those of the human body –, it is also impossible to categorize them into any type. There is no certainty as to what these objects can be called, which are confused with the miniature of a house, or a model, or a house itself, or a museum for this supposed house, a tomb for the house or for the model.

The play with our perception of reality is only allowed by the resources of determination and recognition of the objects around us. For this reason, one places a human scale on drawings and models: to be able to relate the dimension of the project to the physical space. The scale deals, therefore, with the meaning linked to the typology and its respective programs. Regarding the three versions of House 11a, it is only possible to try to fit each of them into a type – house, tomb, museum, mausoleum – based on the approximations of their scales, but through the relationship they establish with each other, and not with the user – since they do not correspond to human proportions.

It is important to notice, however, that all versions start from the "house", from House 11a, which still has the initial purpose of *being a house, even though it already contravenes some conventions*. Therefore, it carries in itself the essential function of architecture, which is sheltering and protecting its user. It seems impossible to get rid of this idea. Its subversion in the Cannaregio project takes place in the extinction of its primordial role precisely because of the *indeterminacy of the scale* and, consequently, the *indeterminacy of its name*. That is, what is incumbent upon the *idea* of housing and how this relates to the way we receive and appropriate it.

This topic touches upon what would be an *icon in* architecture, a categorization brought from semiotics whose nature can be described as the object's relationship with external reality. The linguist and semiotician Thomas A. Sabeok (2001 p.10) explains an icon as being "[…] a sign that is made to resemble, to simulate, or reproduce its referent in someway." It derives from the similarity between carriers of the same properties. According to Sabeok, *index is also a type of sign related to an external reality, but whose attributes deal with temporal and spatial frames:*

> *[…] refer[ring] to something or someone in terms of its existence or location in time and space, or in relation to something or someone else. (Sabeok 2001 p.10).*

An important third type of sign is *symbol*. The relationship established by symbols with its referent is done by conventions. That is, the link between the sign and what it means is not so direct, not made through similarity: the symbol carries a message stipulated by a social convention – an idea, such as a cross figure to stand the concept "christianity" (Sabeok 2001 p.11).

The iconic property would provide the object with an *a priori* condition interconnected to an entire imagery with other similar objects, carrying with it this common concept. In his text from 1995 called "Presentness and the being-only-once of architecture", Eisenman gives us the example of a wall: among other resemblances, such as spatial separation, a wall will always have a relationship of similarity with another wall under the idea of "element that supports a ceiling." In his words: "A wall in architecture is not merely holding something up, it also symbolizes the act of holding up." (Eisenman 2007, p.43).

This means that not every wall necessarily supports a ceiling, but the concept of "wall" will is commonly linked to this idea, what Eisenman (2007a, p.43) calls "iconicity." That is, the wall will always be linked to this *signified* – what Jacques Derrida (1967, p.412) understands as a "transcendental meaning" and a "metaphysical concept"[1]–, regardless of its materiality or its "effective" role. Thus, we could say that what Eisenman calls "iconicity" in architecture surpasses the limits of similarity imposed to icons and also faces some characteristic of symbols, reaching the *idea* of these objects.

However, the wall originally has the function of supporting, which carries with it something that Eisenman (2007a, p.43) defines as its "instrumentality." This is a unique condition of architecture: regardless of the program, it will never be able to be separated from its architectural convention, the meaning linked to its function. In architecture, the iconicity of an element will always be linked to its instrumentality because an architectural object is usually conceived to be built and occupied. It seems to be the essence of architecture and it clashes with the discussion that opened this paper: the rupture with the utilitarian role of representation and mediation played by architecture. Eisenman (2007a) points out that even an architectural design that would be impossible to build, such as Piranesi's Carceri series, continues to be imagined and interpreted as physical elements.

At this point, it is already possible to expose the relationship between the decentralization of the forms that make up House 11a with the intention of subverting what would be the transcendental meaning of architecture to shelter.

Decentralization had already been treated by Derrida (1967) as a way to interrupt a teleological conception of knowledge and discourse. That is, for Derrida, the existence of a center (in a given system or in the structure of a discourse) would always imply the connection and regulation of an origin to an end. The notion end is also

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[1] From the original: "signifié transcendantal" and "concept métaphysique" (Derrida 1967, p.412).

about searching for an unattainable ideal – as Eisenman points out in "Post-Functionalism". Let us remember that between the 1960s and 1980s (mainly through Deconstruction), many thinkers sought to break with the notion of universal truth. In Derrida's thought, this rupture would imply the extinction of the "centers" and opening up to different interpretations other than the sovereignty of a truth. Thus, decentralization, for Derrida (1967, p.427), seeks to overcome man and humanism by the rupture of the totalization of history, plenitude of knowledge and truth – again, implied in the rupture with concepts of origin and end. The philosopher demonstrates an example by the relationship between signifier and signified of a sign, in which the form, so to speak, always refers to a preponderant concept:

> For the meaning "sign" has always been understood and determined, in its sense, as a sign-of, a signifier referring to a signified, a signifier different from its signified.2 (Derrida 1967, p.412).

But Derrida recognizes that it is not possible to extinguish such predominance of the signified over the signifier simply by "erasing" the metaphysical meaning to which the sign is linked:

> […] we cannot announce any destructive proposition that has not already been seen slipping into form, into logic and into the implicit postulations of the very thing we would like to contest.[3] (Derrida 1967, p.412).

In other words, one can only question a discourse by using the tools and vocabulary of the *discourse itself.* The attack takes place through subversion, not through extinction.

It is at this moment that we understand the strength of Eisenman's attitude in incorporating a previous project, of a house – with all the notions embedded in its iconicity and its instrumentality *as a house* – that cannot be inhabited, nor even occupied because its dimensions do not allow it to perform its function. The house, as a sign, has both its signified corrupted, precisely because it does not correspond to its primordial idea, and its signifier, since it is not even possible to name each of the three scales because we are not able to assign them to a function. It is not just a case of categorizing it as a house or a museum, since the indeterminacy of the scale prevents one even from verifying which is the "original object", which is the true and real one among the three sizes arranged one inside the other. In this case, the corruption of the "house" as a sign is achieved purely through scale. The iconicity of the "house" remains, but shaken, since its instrumentality is rejected. Therefore, our conception of "home" and the reality of "home" are also shaken.

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[2] From the original: "Car la signification 'signe' a toujours été comprise et déterminée, dans son sens, comme signe-de, signifiant renvoyant à un signifié, signifiant différant de son signifié." (Derrida 1967, p.412).

[3] From the original: "[…] nous ne pouvons énoncer aucune proposition destructive qui n'ait déjà dû se glisser dans la forme, dans la logique et les postulations implicites de cela même qu'elle voudrait contester." (Derrida 1967, p.412).

Conclusions

Iconicity and instrumentality are two concepts applied by Peter Eisenman to understand certain properties of architecture. For a given object to be recognized *as architecture*, it necessarily carries these two properties. Therefore, the attempt to propose new approaches to the discourse of "architecture" cannot disregard the relationship between icon and instrument that define the architectural object. Otherwise, it would cease to be "architecture."

The procedure for this proposition – which does not nullify the existence of the usual conception of architecture, that is, offering shelter – operates through the subversion of the internal structures of its discourse. How to produce architecture that, at the same time, contradicts the demands of utility and similarity, imposed by what Eisenman (1998a; 1998b) considers to be remnants of a humanist tradition, without leaving the field *of architecture?* Questioning our ways of receiving it. And Eisenman did this by subverting the idea of architecture and the relationship it establishes with the *reality of the physical world* when it corrupts what is perhaps its icon and primordial instrument: the house.

House 11a was already trying to break with the precept of resemblance to man through formal manipulation, but even so, it maintained the fundamental relationship of dwelling and also of naming as "house." Its insertion in the Cannaregio Town Square leaps toward this transgression process from the moment in which the figure of the man as a reference point for its elaboration is completely erased. And this is only possible through manipulating the scale.

As there were three versions of the same house in three different proportions, one inside the other, man ceases to be the user – the point of origin of the project's conception as a measurement reference and also the one for whom architecture is intended. Architecture starts to shelter itself, because its scales refer only to *themselves,* giving the scale the meaning of "who is the project intended for?". We clearly perceive this definition when we think of a project aimed exclusively at children, for example. The space layout will take on distinct proportions from those designed for teenagers and adults.

What is questioned here is just the highlight of this reflection, or rather, this *self-reflection* of architecture. It is a theoretical formulation to think about other ways of conceiving and practicing architecture, without proposing the extinction of its ordinary way. The use of the three different scales of House 11a in Cannaregio presents itself as this exercise of showing alternative ways of conceiving architecture not restricted by the fulfillment of demands. It is a self-absorbed architecture to draw attention to the design act, an exercise of thinking about architecture. At this point, it would be possible to bring it closer to philosophy or art precisely because of the way it presents its critique. However, the concepts of iconicity and instrumentality show us that it seems to be impossible to understand architecture as art – in its tautological sense of being completely detached from a purpose – or as philosophy, since the "architecture" icon will always refer to something that acts and functions as shelter.

What can be done is just to to merely *play* with this conception with this conception by proposing, *as a reflection,* an architecture, or rather, a house that turns in on itself, that shelters itself. Maybe one could not even call it a "house", as its scale does not correspond to one, but departs from one. Its meaning is corrupted, but not completely erased, since, when it comes to architecture, this would be impossible. With that, the way we understand and perceive it also changes. That is, by the simple act of manipulating the scale, we are not able to enter this "house" or even define it under a name or a category. This is not quite simple, since it draws theory from different fields of knowledge and also questions architecture's ontological points. How do we receive it and also understand it? We are no longer certain of our reality: here, architecture no longer fulfills the role of mediator of our relationship with the world. We are thus faced with some senses (and distortions) of scale.

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Intervention of Human Scale in Evolving Contemporary Urban Public Spaces

Introduction

The concept of heterotopia, bridging virtual and physical spaces with human scales, plays a productive role in generating contemporary urban and architectural design strategies. Derived from Michel Foucault's inception of *heterotopia*, urban design theorist David Grahame Shane categorizes three urban elements: armature, enclave, and heterotopia (Shane, 2005). Among these elements, the emergence of heterotopia has always been favored by post-structuralists as a catalyst for creative contemporary urban design methods, from the certainty and uncertainty of Bernard Tschumi's Parc de la Villette to the nothingness of Diller Scofidio + Renfro and James Corner's High Line. This paper also presents the processes of one of our design projects involving urban scales as an exploration of these new urban design strategies.

In Charles and Ray Eames's short film "*Power of Ten*" released in 1977, through a zooming camera's lens, we experienced a sequence of visual transformations with scales from human being to planetary beings and back to atomic beings. A daily experience in a Chicago waterfront park was de-familiarized through systematic changes of scales in both space and time, from 100 million light years away of the limits of the observable universe to a proton of a carbon atom within a DNA molecule in a white blood cell (Horton, Z., 2021). The incremental increases of multiplication of 10 in the first half of the journey, and the inversion later, shifted our perceptions of visible physical phenomena, both ontologically and epistemologically. Once again, technological interventions enabled us to delight ourselves by seeing the world as a multitude of worlds.

As Friedrich Nietzsche wrote in *The Wanderer and His Shadow* in 1878, "*The press, the machine, the railway, the telegraph are premises whose thousand-year conclusion no one has yet dared to draw*", modernization and technological progress have been constantly changing our modality of experiences as well as the relationships to aesthetic. Ontological shift of physical scale of industrialization and the machine age also inspired Le Corbusier, and he looked on automobiles, airplanes, ocean liners and industrial products of civil engineering as the expressions of modernity.

In his seminal book “*Towards a New Architecture*” published in 1924, the sublime of ocean liners empowered by their transcending scales was translated into the poetics of modern architecture (Corbusier, 1924). The ramp, as an invention of his apparatus of new architecture was repeated almost in every of his projects, from Villa Savoye in France to the Carpenter Center at Harvard University. It changed the scale and speed of how we move our bodies in space, allowing us to experience a new kind spatial movement in modern architecture. Seven decades later, Rem Koolhaas’ “*Bigness or the Problem of Large*” envisioned the irreversible and radical increase of scale in buildings and cities driven by technological, economic, and political power of post-modern society at a global scale (Koolhaas, 1994). Bigness is a metaphor of architectural paradigm change in the context of the recent globalization. This theoretical stand was manifested in most OMA’s global practice, such as the Euralille in France, Seattle Central Library in the US, and the CCTV in China.

The ontological shift of virtual scale in the age of globalization has been supported by ubiquitous and ever-escalating progressions and applications of digital technologies. In the field of architecture and urban design, virtual scale has been both a heated debating concept and an evolving opportunity for ontological and epistemological movements in architecture. William Mitchell, in his “*e-topia*”, proclaimed that we were transforming from “Machine for Live in” to Computers for Live in, where radical scale set changes were emerging simultaneously: new global interdependencies; the network city extended; the end of rural isolation; displacement of place; juxtaposition between public and private spaces; decentralization and delocalization. However, without contemplating the arguments between digi-phile and digi-phobe, Mitchell advocated that the definitions of architecture and urban design must be expanded to encompass both virtual places and physical ones (Mitchell, 1999).

Heterotopia

The concept of heterotopia, bridging virtual and physical spaces with human scales, plays a productive role in generating contemporary urban and architectural design strategies.

The inception of heterotopia is coined with Michel Foucault’s *Of Other Spaces: Utopias and Heterotopias*, in which he argues that we are unfortunately still living with certain oppositional spatial practices such as private vs public, family vs social, cultural vs utilitarian, and space of leisure vs that of work. Foucault examines the set of relations that define the sites of spatial practices. He is interested in certain sites that can relate to all the other sites in such a way as to “suspect, neutralize, or invert the set of relations”. He further analyzes that the space perceived from a mirror is a utopia, a placeless place, and a site without a real space in society. However, a mirror is a real site, and it connects a specific space to other places, the virtual spaces, therefore, a mirror functions as a heterotopia (Foucault, 1984/1967).

Derived from Michel Foucault's definition of heterotopia, urban design theorist David Grahame Shane categorizes three urban elements on multiple scales: armature, enclave, and heterotopia. Among these elements, the interpretation of heterotopia has always been evolved as both a post-structuralist's debating subject and a catalyst for contemporary urban design methods (Shane, 2005).

Multiplicity of Human Scale

For urban designers and architects, if structuralists have established complex networks of sets of relationships, they have also enabled post-structuralists to "suspect, neutralize, or invert" these relationships (Foucault, 1984/1967). In Bernard Tschumi's Parc de la Villette, the experience of the *otherness* in the park was ambiguous. It reacted to, released from, and reconnected to the forces of the urban dynamics of the Paris city on different scales. Radically departed from both Frederick Law Olmsted and high modernists' approaches, the design deliberately liberated its fundamental and underlaying structural elements from a prescribed set of relationship: circulations as lines with the scale of pedestrian movements, follies as anchor points of activities with the scale of a pavilion, and park as open spaces with the scale of open landscape. The relationships between each layer were intentionally suspended to allow each system to act independently and generate unexpected spatial experiences. The autonomy of each layer also enacted itself as a site. The deconstruction of predictable and controllable design principles generated new relationships for these spatial organizational elements and formal systems. Each layer was formulating as both conditions and opportunities for movements and opportunities of human interactions in public spaces. The design encouraged the formations of ever-changing relationships between temporal participators and the permanent park elements, and it unfolded unexpected chances through time for programs and events. Simultaneously, through programs and events, the spatial and temporal experiences and activities constantly constructed and reconstructed new relationships to the site and established different sets of ever-changing relationships to the city. It became a host for diverse programs and events.

A heterotopia is a place at a real site that simultaneously connects to other places. These connected places are heterogenous that can also be real or virtual or both. "The heterotopia is capable of juxtaposing in a single real place several spaces, several sites that are in themselves incompatible "(Foucault, 1984/1967). Historically, a program and an event could always connect a place to spatial practices of a site in a city and beyond, both real and virtual, like in a *theater* as Foucault indicated. However, the notion of heterotopia addresses emerging and more challenging contemporary urban issues and conditions of heterogeneity, temporality, complexity, intensity, dynamics, mobility, and unpredictability. Critical postmodern urban design theories, from Aldo Rossi's *The Architecture of the City in* 1966 to Colin Rowe's *Collage City* in 1978, argued that design organizational forms, spaces, and programs could be independent and juxtaposed to each other. In Parc de la Villette, Bernard Tschumi developed a radical concept between program and event. In an interview by *Praxis 8,* Tschumi defined program as prescriptive and that "a program relies on repetition and habit"; in contrast, an event cannot be designed, and we can only design certain conditions for potential unknown events to occur. In other words, "An event occurs unexpectedly"

(Tschumi, 2006). Therefore, an event is not necessarily to be attached to a certain program, although an event and a program can relate to each other accidently, an event is a play of chance other than ad hoc, and it is event that evolves in time and space as part of being and becoming.

Temporal and Spatial Extensions of Human Scale

The concept of heterotopia unfolds possibilities to re-construct alternative relationships and scales between architecture as an autonomous discipline and social space as the domain of spatial practice. Undeniably, architecture needs to negotiate with social, political, and economic conditions to establish its own position. However, architecture could never be merely an outcome or direct product of the social practice determined by materialist's constraints. Striving for the freedom from socioeconomic constraints, "like conceptual art in the mid-1960s, architecture seemed to have gained autonomy by opposing the institutional framework. But in the process, it had become the institutional opposition, thus growing into the very thing it tried to oppose" (Tschumi, 1994).

Instead of imposing oppositional relationships to the socioeconomic constraints, the High Line park came into being along with unexpected events. As a heterotopic project, it was exemplified by its pluralistic scales through unprecedented processes. In 2001, when photographer Joel Steinfeld published his photograph of this decommissioned railroad, titled as A Railroad Artifact, the sublime of enduring forces of nature, oppressed by the city as a machine, that gradually reclaimed the site from the withdrawn infrastructure and embraced the surrendering rusted steel rails, suddenly changed how we looked at the site and its relationship to the city. The idea of the High line as an urban park was conceived through a sequence of events, and it was Friends of The High Line, a self-organized community group other than an established institution that preserved the original railroad (Davis, D.E. and Gray, S.F., 2019).

Inspired by the Promenade Plantee in Paris, this community group initiated the competition for the design of this elevated green linear park. The process of transforming it into a public park unfolded into a series of events, and in the end, the park became an event. The very idea of the design of the park was surprisingly as simple as to intensify the natural process of this rhizomic ruin and to re-connect it to everyday urbanisms of the city. As Elizbeth Diller reflected on the design process during her lecture at Harvard University Graduate School of Design invited by Scott Cohen in 2013, the sense of nothingness was really what the architects had conceived and constructed. By neutralizing the set of relationships between the High Line and the site, the programs, and the city events, it expanded its scale and evolved into a vital public domain of the city.

Scale of Collective Identity and Representation

The High Line connects its site to New York City through ever-changing linkages, both real and virtual, and at complex scales and speeds. As a passerby, you can just walk onto a section as a shortcut to your path and also a momentary escape from the busy streets; you can take a break from the daily duty by sitting at the rout-ledge of tall grass grooves, imagining a distant landscape from Manhattan's cityscape; you can simply sit on a step of the elevated amphitheater and watch the flow of cars through the looking glass; you can find a peaceful mind, surfing the smartphone, taking a phone call, or reading an open page, to refresh yourself at a site that connects to both public and private spaces through different physical and virtual linkages. Families find it relaxing to bring their kids to the elevated plazas; schoolteachers take advantage of the botanical diversity to arrange outdoor learning sessions in the grooves; teenagers enjoy the openness of space along the trail for adventures. The High Line is a real place as well as a virtual site. It acts as a network for public programs both within the site and to the city. As a heterotopia, it links many other sites beyond the scales of the site and the city, both real and virtual. The High Line represents one of Michel Foucault's favorite subjects – the boat: "the boat is a floating piece of space, a place without a place, that exists by itself, that is closed in on itself and at the same time is given over to the infinity of the sea" (Foucault, 1984/1967). The boat is the metaphor of heterotopia also the manifestation of "heterotopia par excellence", so does the High Line Park.

From Precedent to Project: The Urban Inhabitable Object

The design and realization of the Urban Inhabitable Object explored architectural scales in these three categories.

1 Multiplicity of Human Scale

In response to a call for a street prototype festival international design competition, we designed an inhabitable object involving complex and diverse dimensions on a human-centric scale. We explored multiple levels of human scales that allow different people to use or interact to it without either a specific program or any predetermined practical intent. The design form was reduced to a simple framework, however, to project a multitude of potentials, possibilities, and opportunities for public interactions on an urban scale. It is neither a shelter nor a building, therefore, as an abstract yet inhabitable object duo to its adaptable scale for people to act upon.

With this winning design proposal, we were commissioned by Downtown Denver Partnership to materialize it for a two-week prototyping festival in the summer. The current 16th Street Mall was opened in 1982 as one of American's well recognized urban design projects during the movement of *new urbanism* era. It was designed by Henri Cobb of Pei Cobb Freed and Partners in collaboration with OLIN landscape architect. The mall's public space is marked by a wide pedestrian promenade.

This central tree lined corridor with red-and-gray granite pavement also serves as an axis for stores of major businesses as well as points of tourists' attractions. The project site was at the most prominent section, but the challenge was to have minimal interference to the daily operations of the stores as well as the existing urban infrastructures. On the other hand, the installation must be able to invite the public to participate. The budget and materials were limited as a temporary structure for a two-week event only. In conclusion, a small project in the physical scale had to be magnified to be impactful on such a large urban scale site.

The bigness of a small project was celebrated through the notion of movement unfolding multiplicity of human scale in urban public space. Looking beyond conventional pragmatic constraints such as site context, form, program, materials and building tectonics, the design strategy was to search for the connections between movements on a human scale to urban mobility, of a different architectural domain inspired by Foucault's concept of *otherness*. Through exploring the notion of movement and mobility, the design developed opportunities to *suspect, neutralize, or invert* the set of relationships between human scaled body movements and urban mobilities.

There were different scales, modes, speeds, directions, and rhythms of movements and mobilities on-site. On a downtown district scale, free shuttle buses formed one continuous loop, circulating around the main streets on the fixed schedule. Bicycles were ubiquitous as a symbol of Denver's unique environment as well as healthy lifestyle. On a community scale, riding a bike was more convenient and efficient than shuttle buses and was easier parking than cars. Of course, on a neighborhood scale, strolling on foot was what the mall was designed for.

In response to different movements on site, a Cartesian coordination system was established. The overall design form was comprised of three bar-shaped linear elements that were placed along the pedestrian flow (X-axis) and divide the flow into four strands of movements: the middle two streams created congestions; the outer two streams could either slow down the speed or allow the movements to flow uninterruptedly. By elevating three-linear bars at different scales and heights, as differentiated topographic planes, that allow people to interact in different positions, the design further diversified movements along both the Y and Z axes. The geometric relationships between the three bars were intentionally randomized, resulting a system of disjunction. Through *neutralizing* these sets of spatial and functional relationships, we assumed that chances could find their own chances through their interplays.

Along the Z-direction, the design provided a range of elevated surfaces at different heights for people to engage: the height of a step, the height of a ledge, the height of a chair, the height of a stool, the height of a table, the height of a countertop. In public spaces, people could choose to sit on a step, sit on a ledge, sit on a chair, sit on a stool, and lean on a counter edge; people could freely step on a step, step on a ledge, step on a seating, and rest their feet on a table edge. Along the Y-direction, the narrow gaps between the bars could only fit one person to pass to interrupt or delay the flow along the X-direction; the depth of each bar's top surface was designed to be comfortable enough for people to sit temporarily but uncomfortably for a prolonged duration, as a way to discourage and interrupt the privatization of public space. These arrangements generated rhythms and patterns of diverse-scaled human activities and urban spatial movements (Fig. 1).

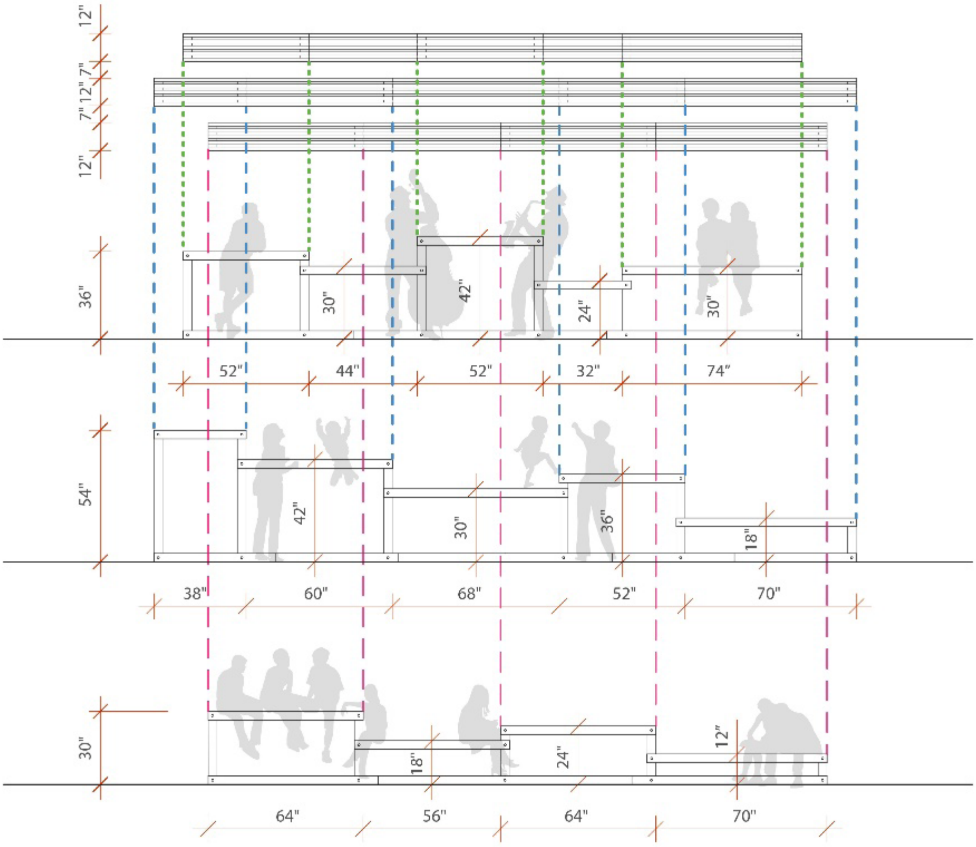

Fig. 01. Plan + Section.

Source: Tony Yue, author's design team.

As indicated in Tschumi's theory, a *program* is repetitive and somehow predictable and mostly controllable, but an *event* may never happen again and is unpredictable and uncontrollable. A predetermined set of relationship between table and bench could clearly define a specific program without being able to generate unpredictable multiplicity of events. Herman Hertzberger argues:" The secret of the habitability of the Amsterdam canal houses for example lies in the fact that one can work, live, or sleep anywhere; that spaces leave the individual quite free with regard to his inter- pretation of living. The greater variety of the old town is certainly not caused by more comprehensive or richer elements (those of the 20th century are more complex), but by a sequence of spaces which, although generally not much different one from another, allow individual interpretations because of their greater ter polyvalency" (Hertzberger, 1963). In the same way, by *suspecting, neutralizing, or inverting* the table-bench relationship, the multiplicity of human scale allowed people to "mismatch" all design elements without any predetermined correlational orders, which made these elements more adaptable to changes as well as inhabitable, creating opportunities for unforeseeable *events* to happen.

The design form was reductive and de-materialized as a set of abstract diagrams with intricate dimensions at specific human scales, however, during this two-week-long festival, media coverage was overwhelming: two kids climbed on two different tops of the *bars* and found comfortable positions for each of them to carry on a face-to face conversation; an athletic man lifted up his body with two hands holding on two horizontal frames that fitted his height, and swung his body like on a Pommel Horse; school kids jumped up and down on it as an extended territory to explore on the way back to home; people of different ages and physical conditions could always find different positions to rest upon comfortably. They could sit often on the lower bars with their backs leaning against the taller bars. Occasionally, someone could even be lying on it for a sun bath. For street performers, it could be an instant stage right in the center of a public space. For cyclists, both the riders and the bikes could find spots to rest upon. With the support of free-Wi-Fi infrastructure, this Inhabitable Object also became another hot-spot for passersby to make a stop and navigate in virtual places beyond physical scales. The scales of virtual and physical intersected at this location, and the acts and actions of people were momentary and ever-changing, constructing and generating movements, motions, programs, and events in both virtual and physical spaces, functions, programs, and micro-events on site were far beyond our scales of imagination (Fig. 02 & 03).

Fig. 02. On Site Photo.
Source: Nick Fish, author's design team.

Fig. 03. On Site Photo.
Source: Nick Fish, author's design team.

2 *Temporal and Spatial Extensions of Human Scale*

This Downtown Festival was an impactful event at both a physical place and virtual sites hosted by local social media. Surprisingly, after realizing that people had been overwhelmingly interacting with this prototype during these two weeks, the festival organization believed that it had become an inseparable feature of the 16th Street. They decided to preserve it as a permanent feature of the city, although it was built for a temporary festival. We were concerned about its durability and curious to see how well it could withstand so many daily activities in such creative ways.

Two years later, we were contacted by the director of Downtown Denver Partnership again and delighted to hear that this project had been performing well. To continue its service to the public as a permanent feature, some wood members would need to be replaced and the paint would be refurbished. Since this project was of the world of *otherness* and out of what the city had planned for, its cost of maintenance also became an exceptional item out of the city's budget. Supported by the Downtown Denver Partnership, we were asked to design images for social media and posted a call for public donations.

In order to produce an effective image for social media, multiple images at different scales from the real site and re-imagined sites were edited in digital media. The design of the poster was to project a real place and a sequence of real events related to this place into a virtual space, which could connect different temporal spaces from the past to the future. To compress spatial experiences into a 2-D image, the play of scales was an essential strategy in creating a visual narrative where different images at a variety of scales of time and space were articulated as a collage.

This fundraising process extended this project from a physical site to its presence of the future at social and virtual scales. Consequently, it enabled the project to be professional refurbished by a local contractor, and became a permanent urban feature, continuously operating on heterogenous scales in both physical and virtual spaces. The virtual presence of the project echoes what Foucault called the space reflected from a mirror, and it is unreal, like a utopia, but together with the mirror, they become real, as heterotopias (Foucault, 1984/1967).

3 Scales of Collective Identity and Representation

Three years after the event, the Downtown Denver Partnership informed us that our design had become an icon for the 16th street, and they were inviting us to provide additional design plans for placing more inhabitable objects in other significant areas of downtown public spaces. To continue invigorate downtown and improve quality of public spaces and public life, as a Downtown Denver Partnership's long-term objective, creating an evolving cultural identity for public space became a priority. Supported by the joint funding from local government and corporations, the new design initiative would support vibrant urban events and activities of the local community and beyond.

Although the initial design was never intended to be iconic to begin with, it went through an unexpected and unprecedented process. After three years' exposure to the public, its layered and looped lineal elements could be perceived as an abstract sign representing layered Rocky Mountains of Denver; the rainbow colors of the bands could also be interpreted not only as a connotation of social diversity but also as a supportive signification to current LGBT movement in Denver. From the complexity of human scale, through collective interactions and reflections, the design transcended its operational mechanism in a physical sense, functioning as a representation for both physical and virtual realities. As a design becomes collective reflections of heterogenous individuals, it embodies a multitude of meanings and beliefs that influence social identities on ideological and cultural scales (Fig. 04).

Fig. 04. Poster for Socal Media.
Source: Jiawen Qiao, Huiyu Pan, Nick Fish, author's design team.

Conclusion

Evolving urban scales have been shaping contemporary heterotopic realities in both virtual and physical domains. Perceptions of physical scale changes in our built environment, contemplated by Corbusier and Eames during the early 20th century, have been constantly reframed by both digital media and ecopolitical dynamics of the cities. However, human scale-based method is critical, meaningful, and instrumental in contemporary design practice. It posits the power, latent or blatant, to generate the multitude of relationships and opportunities that allow diverse individuals with freedom to create and re-create user-defined activities and interactions. An effective architectural project, as an intervention to public space, simultaneously constructs virtual and physical places. The multiplicity of architectural scale not only informs a human-centric site but also unfolds a new kind of "other place" – a heterotopia – that both contributes to the evolving authenticity of the site and transforms the immediate presence of the site internally.

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About changing our conceptual dialogue with architecture to change architecture and it’s situated involvment with our world

Introduction

In what follows, I will reflect on the importance of our conceptual dialogue with architecture. The reflection considers not only how we are in a conceptual dialogue with architecture that we are in the process of creating, but also how we conceptually relate to architecture that has already been thoroughly analyzed and described. In other words, the question that occupies the following reflection concerns not so much new, realized architecture or changes to already existing architecture, but whether a changed conceptual dialogue with architecture can contribute to our observing and understanding of aspects that we have not previously understood and been aware of. I am concerned with how a conceptual work as a *parallel creative activity* plays a role in the ambition to expand and enrich our understanding of, and learning from, architecture that has already been, or are in the process of being, created.

The claim is that it is decisive how we conceptually talk with architecture, as the concepts not only contribute to directing, but also creating attention. The reflection is motivated by climate changes and especially the biodiversity crisis and by the notion that it is crucial that we change our relationship with a nature that we– despite the best of intentions–are in the process of turning into a wasteland with our planning and architecture. There is simply a great deal that we have not paid attention to, and it is the thesis of the following reflection that the way we have historically conceptualized our world and its architecture is part of the problem. It is also the thesis that with attention to the trouble we can do something about it. But it requires reflection, a changed bodily engagement with a nature that is non-scalable (which is a crucial but often neglected fact; I will of course argue for this) *and* an active re-thinking of our conceptual dialogue with that nature, it’s life forms and our architecture. That’s the thesis I will try to motivate and examine.

Our body can do more than we know, our thought more than we are conscious of

Gilles Deleuze, in his presentation of Spinoza’s practical philosophy, points out that “the most famous theoretical theses of Spinoza is known by the name of *parallelism*; it does not consist merely in denying any real causality between the mind and the body, it disallows any primacy of the one over the other” (Deleuze 1988:18). For Spinoza, our bodies can do more than we know, just as thought can do more than we are conscious of. Deleuze stresses that it is “by one and the same movement that we shall manage, if possible, to capture the power of the body beyond the given conditions of our knowledge, and to capture the power of the mind beyond the given conditions of our consciousness" (Deleuze 1988:18). This awareness, for me, motivates a critique of Leonardo's *Vitruvian Man* and of Le Corbusiers *Modulor*, which both give the impression that the proper understanding of the human body is revealed where it is related geometric relations that are governed by a consciousness emphasizing the notion that proportionality is an underlying, essential truth of everything, thus not only of architecture, but also of nature. Rather than working with one overarching truth about bodies, our architecture and nature, controlled by consciousness, I am interested in the possibility of allowing different attentions to unfold in the investigation of unknown aspects of nature–and of architecture–by relating *on the one hand* to the power of a body beyond our prior knowledge of it and *on the other* to a parallel creative thinking with concepts that transcends already conscious conditions.

In other words, I agree with Elizabeth Grosz where she points out that in the past "it was through largely epistemological considerations that ontological hypotheses or claims have been directed and evaluated. If we know what there is, it makes sense that we come to what is through what we know" (Grosz 2017:3). It is my opinion that this approach very well characterizes traditional architectural theory, which has rather been concerned with setting standards for architecture in accordance with what we already know, than to facilitate an investigation of what we do not yet know. By reading Alberti's treatises I understand that he tries to establish a norm for art and architecture I can confirm with my consciousness, and it is–as already stated–my opinion that I am taught similar lessons when I relate to Leonardo's *Vitruvian Man* and to Le Corbusier's much later *Modulor*. But it is also my experience, in Grosz's words, that today with the biodiversity crisis it's impossible to neglect "that there are things that we do not know", and that it is crucial that we know how to change our tradition-bound attentions. We are heading towards an awareness that "what things are, how they connect with each other, what relations exist between them may be beyond our capacities for knowing at any moment in history" (Grosz 2017:3). However, this does not mean that we give up creating knowledge, but that "new forms of knowledge may be developed, new paradigms can emerge that may address what exists quite differently, even, perhaps, in incommensurable terms" (Grosz 2017:3).

It is part of my thesis that concepts of scale, which name relations with an emphasis on measure–and which thereby differ decisively from the size-independent proportional relations, which have been emphasized by a tradition which still imagined that ontology could be identified with an epistemology–can contribute to conceptually determining how architecture is embedded in an ontology, in a nature, that can't be identified with any epistemology. In the words of Bruno Latour, it is crucial that we do not subordinate scale concepts an unchanging meta-concept, since as concepts they are related to what we create experimentally with attention to more than we are aware of beforehand: "Scale is what is produced, not what you should have as your own metalanguage to describe it. Scale is the most variable thing to analyze–it is in the hands of actors because they constantly move scale" (Latour 2008:129). Philippe Boudon has similarly pointed out, that "scale does not exist" (Boudon 2009). Scale is what we produce when we relate–and name–different relations and are aware that "it matters what relations relate relations" in the words of Donna Haraway (Haraway 2016:35). Boudon: “If scale does not exist, there must exist scales instead” (Boudon 2009). It is Boudon’s and Latour’s understanding that the way we with our architecture give measure to a world, that has no measure in itself and–as I have already stated and which will soon become clear–is non-scalable, depends on choices. And the choices of measurement relates to and are motivated by what we find relevant for the realization of our endeavours. The relevance of measurement is no longer a graduated ruler, but its relevance. It is a central point for Boudons Architecturologie that unlike geometry architecture has measures, which is why architecture is not scalable geometry; we give with our architecture measures to a non-scalable world which has no measure in itself and is much more than we will ever know (Boudon 2019).

It is my opinion that Latour’s and Boudon’s consideration are in dialogue with what Louis Kahn pointed out, where he expressed that “a great building must begin with the unmeasurable, must go through measurable means when it is being designed and in the end must be unmeasurable” (Kahn 1991). The architect must let her intuition, which belongs to what we cannot know in advance, involve ‘measurable means’, i.e. relationships we find relevant and physically necessary and can name with concepts of scale, in order to thereby realize what in the end is more than we can determine and measure. To conclude the mosaic of quotes from Grosz’s inspiring reflection, I can approvingly emphasize with her that “while I do not consider what follows to be a critique of epistemology, I aim to bypass epistemological questions in favour of a focus on an ontology sensitive to and engaged with the realities of space and time, of events and becomings, not just things and their knowable, determinable relations” (Grosz 2017:4). Concepts of scale are created in an ontology, a nature, which remains more than we know of, but which we must give measure and inhabit wisely, which is a possibility precisely because we ourselves at any time are able to sense and think beyond given limits of consciousness. It is in that horizon that concepts of scale are necessary and can make sense also in the analysis of architecture from cultural history, which has not previously been analyzed with that understanding: Through a conceptual work we can learn something new from history that can have an impact on what we create tomorrow.

Nature isn’t scalable

We have, Anna Tsing states, in modernity identified scaling and large-scale business with progress: “Scalability was progress” (Tsing 2012:514). Tsing exemplifies her claim with reference to the fact that capitalist realism, with its prioritization of profit and ever accelerating effectiveness, has had as an ideal to create plantations of one fast-growing type of trees or chicken farms, where the production of chickens and eggs can be both scaled up and made ever more efficient. But it is not about bigger trees and bigger chickens and eggs. It’s about many trees of the same, fast-growing variety and many, many chickens and eggs in XL-farms. The ‘problem’ is that “scalability is not an ordinary feature of nature” (Tsing 2015:38). That fact sets certain limitations for growth capitalism cannot ignore, but these limits have apparently only been a further motivation for the creation of ever more efficient and bigger monocultures. We have moved from small to XL to semi-cite Rem Koolhaas; in planning of *Grand Paris* we have to change to a bigger scale in order to create bigger structures according to the Dutch architects *MVRDV*. If there are limits to growth, we have found other growth opportunities. Progress must not be limited by physical restraints.

It is only in an abstract universe–in the world of drawings or computers–that we can zoom and thus arbitrarily enlarge and shrink what we are working with without changing anything other than the size of it. In the abstract world everything is scalable by will. The problem that manifests itself with architectural theory, and thus with the concepts we value when we talk about architecture, is that the possibility of scaling up and down, linked to the work with the drawing material, has been of decisive importance for what has been elevated to *the norm* for architecture. Or put another way: The idea that proportions should be in dialogue with the essence of architecture, as is characteristic of Alberti's architectural theory, which indicates that small (a room), large (a house) and XL (a city) should be equally proportioned, has promoted the idea that everything essential can be decided on the drawing board–or in the computer–and that what you draw can then be easily scaled up and realized. When Alberti demands that a building or a city must be finished on the drawing board without anything being changed afterwards, it is not because he is not aware that the drawing must be realized as a building or a city on a different scale, but because size and measure to him is almost irrelevant; Alberti did pay some attention to the size of the human body. More on that.

When Galileo in Venice, 150 years after Alberti's treatise on architecture, found out that a cube that is 10 in each side weighs not 10 but a thousand times more than a cube made of the same materials that is 1 in each side, he was put under house arrest. For Galileo, this was an explanation for why there are no scaled-up giants: their weight would mean that they would have to be constructed–and proportioned–quite differently from the *Vitruvian Man*, so that, for example, they would be able to support their own bodily weight with their legs. But for contemporary rulers it was unacceptable that everything in the physical world changes with size. The experience that "scalability is not an ordinary feature of nature" (Tsing) was unacceptable, because the abstraction–with an emphasis on proportions–tells us that size makes no difference and that the two cubes are identical (1:1:1=10:10:10=100:100:100….), despite their size. This proportional 'fact' has–apparenetly–made it easy to control everything, including architecture with our rational consciousness, and it should therefore not be challenged. We like being in control with our consciousness. Or we seem to become maladjusted when our bodies and thoughts tell us there is something we cannot control with our consciousness. And, what the heck, it was just the physical world and its inert matter that wasn't right and scalable; that we could change with our houses and cities, created in accordance with ideal principles of proportions for everyone to learn what truth and beauty are in essence.

It sounds perhaps like a caricature but is a relatively solid representation of what has been a prevailing attitude towards what we have perceived as 'inert matter' even in recent times. For Alberti architecture was a concern of the mind and "it is quite possible", he wrote, "to project whole forms in the mind without any recourse to the material" (Alberti 1988:7). According to the anthropologist Tim Ingold, Alberti's normative architectural thinking is exemplary of the *hylomorphism* that–rooted in the thinking of Plato and Aristotle–has characterized the Western World for the past two Millenia. Ingold emphasizes that the *hylemorphism* is characterized by "an ontological claim, namely that things are constituted in the rational and rule-governed transposition of preconceived form onto inert substance" (Ingold 2010:93).

The question is whether Galileo's realization that everything changes with size in the physical world has become even more difficult to accept today, when scaling–monocultural largesse–has become the very definition of progress, as Tsing puts it. In addition, the entry of the computer into the field of architecture has contributed to the fact that scaling has become automated. As Michael Tavel Clark and David Wittenberg point out, "CAD tends to privilege architecture freed from its site-contextual considerations" which means "a strange, virtual subversion of Galileo's founding insight that engineering must obey the physical constraints on scale determined by the properties of materials" (Clarke and Wittenberg 2017:16). It is my opinion that this characterizes *MVRDV*'s planning theory and is what Koolhaas sought to thematize, with his considerations of *S,M,L,XL*, but still without paying attention to the fact that the physical nature cannot be scaled. And that lack of attention to nature has, if I may say so, been fatal. It's crucial in architectures contribution to making our world a wasteland.

Points of life – man/architecture/earth system

It is, it seems to me, with attention to the issues listed here and to the fact that they are important for the biodiversity crisis, that Latour–with inspired reference to Tsing–insists that we in every field of knowledge and thus also in fields of knowledge with significance for architecture, acknowledges that many of the problems we face are fostered by upscaling and monocultures. We must recognize that the problems relate to the fact that we have consciously and radically repressed everything that we both in thought and in body experience that we have very limited knowledge of. If we think about it, we know and feel that. And If we actually are about giving up the identification of progress with monocultures and plantations/farms/megacities, it is because we are becoming aware that this way of planning are not only exterminating biodiversity, but also that sorts of life forms develop in these 'capitalist ruins' which is difficult to adapt to: "The uniformity of crowding of the chickens in effect constitutes a natural laboratory for viruses that produces new and virulent forms. The viruses bred under such condition spread far beyond the chicken farm, potentially infecting humans around the world. Large-scale ecological simplification, then, invite 'feral proliferations' that end up ripling through the entire landscape mosaic" (Tsing 2019:189).

We are connected globally. The Corona virus testifies to that. But we do not live in a world where the local is to be understood as a small dot in the global as cartographic scalability (Google Earth^{TM}) and much planning has given us the impression of. We shall be 'relocalicing the global', as Latour states with what he calls a *resert procedure* for modernity (Latour 2016). I'll return to Latour's 'reset procedures'. Latour: "It cannot be said that the small or the short lie within the large or the long, in the sense that the largest or the longest contain them but with just 'fewer details'" (Latour 2017: 94). The local is a reality of its own, where many different life forms meet, and some of them extends beyond, while other move down below, around of, up above or even into that 'point of life' we focus on, which can for example be a specific tree that isn't scalable. The world we live in is characterized by what Haraway calls "symbiogenesis among lively arts" (Haraway 2016:58-98).

For Latour "one might almost posit as a rule: good artists do not believe in zoom effects" (Latour 2017:94). And one can point out that it is time for that critique of zoom effects to spread among others, including architects, where the critique must be helped along by a renewed dialogue between concepts and drawings, as for example takes place with the *Terra Forma*-project, created in dialogue between a historian of science, Frédérique Aït-Touati, and two architects, Alexandra Arènes and Axelle Grégoire. With a book, the project has presented a series of models (concepts and drawings) that can help us "describing our territory–only, the right way round" (Latour 2021: 69-77), as Latour has called for in his insistence that we must describe the world of life forms starting from something local, alive, non-scalable. With Anna Tsing, one can say that the *Terra Forma*-project has understood that "it is time to turn attention to the non-scalable, not only as objects for description but also as incitement to theory" (Tsing 2015:38).

One of the models in the *Terra Forma* book is called 'point of life': "This model is an attempt to represent the world from an animate body, a living point or 'point of life' (a powerful formulation by Emanuele Coccia), in order to try to sketch a map of active body-spaces" (Aït-Touati 2022:55). When *Terra Forma* mentions a tree as an example of a 'point of life', I think again of Anna Tsing's work and–which I will return to below–of Sverre Fehn's *Nordic Pavilion* in *Giardini* in Venice. Fehn, who was a student of Kahn's, has with his pavilion given measures to a local field around life points, trees. It's indeed worth conceptualizing what Fehn has created to help create attention, and maybe *Terra Forma* can help us in that endeavour? A bit more on Fehn's pavilion in the conclusion of this article.

In *Terra Forma* they write that "one of our best examples of a living being that is anchored in the ground is a tree. (…) If we draw a tree according to [our] guidelines, it will not be miniature, nor a legend, nor a symbol, nor an object, but a point of life: a singular way of unfolding things as they are, in space, with the world around them" (Aït-Touati 2022:58). With Tsing's attention to life that develops in 'capitalist ruins', i.e. around trees in a plantation of monoculture, one experiences that the trees are points for symbiogenetic life that is not planned by man. But if we want to learn about life, which arises and develops in the ruins we ourselves have created, we must consider how we can map and describe this life, which requires work with structures and systems, but in such a way that we let the structures, we map, be informed by sensory experiences: "In contrast to the French tradition, we are interested in structures accessible to the senses. (…) 'Structures' is our analytical word for the form in the world that catches the eye, begs for attention in a phenomenological sense, but also points to longer trajectories. Like the morphologies of trees, which show us historical growth patterns, the structures we identify are signs of landscape-making, a historical process. Landscape structures show history rather than opposing it" (Tsing 2019:188).

If one wants to think further in the field of architecture with this attention, it involves expanding the attention from the duad: 'architecture/man' to the triad: 'architecture/man/earth system', as Jörg Gleiter (Gleiter 2022:75) recently has advocated for under the influence of the biodiversity crisis. Rather than considering whether there is a proportional concordance between the human body and the building in accordance with universal principles and which we can put on a mathematic formula, one examines–with the involvement of a body that is more than we know–whether we can sense and think relationships that involve more than we had prior been conscious of. Now we investigate what relates to a unique local environment composed of specific and non-scalable life forms–and that we cannot put down to a mathematic formula. We are by purpose for the first time dealing with a local *critical zone* of coexisting life forms were we ourselves exist. We are not outside–there is no outside–but inside this world. Another of Latour's procedures for a *reset of modernity*, "Without the world or within" (Latour 2016), criticizes the perspectival tradition, which has given us the impression that a true gaze looks into the world as if from a place outside, which by its formalized attitude has hindered the understanding that we live in a world of life forms (an 'earth system') with which we–from the inside–have to involve ourselves compositionally.

It is my experience that the attention to this changing of our attention to prioritize the non-scalable earth system–and which is at the same time a localization and an attention to 'symbiogenesis among living forms'–has been in the making for a long time. But it is also my experience that this attention continuously has had to struggle with–and consciously thematize–notions rooted in the Renaissance with (among others) Alberti and in later philosophical aesthetics with (among others) Immanuel Kant. We are continuously forced to deal with the possibility that powerful and skilled persons by reference to tradition can make use of what Haraway has called a 'god trick' (Haraway 1988: 581) from which everything seemingly can be controlled, planned and scaled. It is my experience that these considerations are relevant in relation to the planning of *Lynetteholmen* in Copenhagen; the island seems conceived in a world where only human needs: money, count. I will not argue this further in this context. But I want to point out that the name 'the god trick', suggests that it is an attitude, borne of an alliance with a higher power: market economy, perhaps. And it is by this trick we trough cultural history have been able to imagine that man is the measure of all things, as Alberti–with reference to considerations from antiquity–expressed it in his treatise on perspectival painting: "Since the human figure, of all [objects], is the best known to man, perhaps Protagoras, in saying that man is the model and measure of all thing, meant precisely this: that the incidentals of all [objects] are correctly measured by man's [own] incidentals" (Alberti 2011:18). It is this anthropocentrism that still characterizes Le Corbusiers *Modulor* and as such has dominated the conceptualization of architecture from antiquity to today. For Haraway and her 'situationism' it's about insisting on "the embodied nature of all vision and so reclaim the sensory system that has been used to signify a leap out of the marked body and into a conquering gaze from nowhere" (Haraway 1988:581).

According to Gleiter, anthropocentrism was still thematized and critizized within the duadic horizon: architecture/man by the modernism-critical architectural theory after the Second World War (Gleiter 2022: 59-71). It is only recently that we have become aware that architecture must be thematized with attention also to a non-scalable earth system of which both man and architecture are involved parts. With the duadic privileging of *anthropos*, we are dealing with a kind of blind spot–our own position: nowhere–which has limited the criticism of the hegemony of the proportion theory which–the criticism of proportion theory–has actually been present both in, for example, Vilhelm Wancher's criticism of his contemporarie's reception of antique architecture in the early 20th Century and in Steen Eiler Rasmussen's later criticism of the theorist Le Corbusier.

Staying in control instead of staying with the trouble

Both Vilhelm Wanscher and Steen Eiler Rasmussen were very skilled at developing our experience of architecture with a parallel creative, conceptual work. They were aware that concepts both directs and create attention. With Wanscher, the conceptual work was even linked to the ambition to establish a norm for the experience of architecture as art. In his youth work *Den æstetiske opfattelse af kunst* (*The aesthetic perception of art*, 1906) he states at the outset–and as a presentation of his endeavor with the text–that his ambition is "to gain certainty that the impression the artworks make on us is the right one." (Wanscher 1963:12). With reference to Kant's philosophical aesthetics, Wanscher points out that "there are other values in art than the artistic ones, which can perhaps be determined personally or historically or theologically" and which could be studied separately. But Wanscher is only interested in conceptualizing "the actual art values; a difference which already Imm. Kant emphasized" (Wanscher 1963:8).

Wanscher is interested in what "is best achieved by studying art practically, just as you would learn any other language" (Wanscher 1963:12). In other words, it is in the dialogue between, on the one hand, a perceiving human being who pays conceptual attention to his sensory experiences, and on the other physical and practical architecture, that Wanscher seeks to conceptualize and articulate the right aesthetic perception of art. Bearing in mind what I stated with Spinoza/Deleuze above, which concerns attention to the fact that the body can do more than we know and thought more than we are conscious of, it is my opinion that *with consciousness* Wanscher seeks to determine the right way of sensing art and architecture. Wanscher is–as already stated–rather interested in articulating a norm than to facilitate an investigation of what we do not yet know. It's therefore my impression that Wancher's attention can be characterized as a 'correlationism', in accordance with Queitin Meillassoux's characterization of Kantian philosophy: "The central notion of modern philosophy since Kant seems to be that of *correlation*. By 'correlation' we mean the idea according to which we only ever have access to the correlation between thinking and being, and never to either term considred apart from the other" (Meillassoux 2008:5). For Wanscher, we are able by this correlation to consciously identify and articulate with concepts the true aesthetic experience of various works of art and architecture. It is my opinion that Wanscher would not actually be dissatisfied with being characterized as a correlating subject, as Timothy Morton–following Meillassoux's characterization–describes the subject working in modern philosophy since Kant: "Correlationism means that there are things in themselves (as Kant would put it), but that they aren't 'realized' until they are correlated by a correlator, in the same way a conductor might 'realize' a piece of music by conducting it. (…) The similarieties between all the 'deciders' is that they are all human. (…) Strong correlationsim is anthropocentric: Any attempt to include nonhumans is ruled out in advance. The correlator has all the power" (Morton 2017: 9).

Wanscher criticizes the architects of his day for not being aware of the true aesthetic effects of ancient architecture. He points out that "we ourselves carry out aesthetic work when we look at a building" (Wanscher 1963:22). And he states that this is something we have to develop and train, but which the architects of his time do not seem to have understood: "For instead of developing their powers of observation and sense of beauty by immediate studies of the buildings, they place the main emphasis on measuring them geometrically correctly, without regard to the natural optical effects" (Wanscher 1963:22). In Wanscher's words "we forget– what the Italians never forgot, because they were far too influenced by the ancient traditions for that–that a building belongs to the terrain and the space and above all must fill its place in this in a harmonious and balanced way." (Wanscher 1963:22). It is characteristic of Wanscher's aesthetic experience–and the reason why I call him a correlationist interested only in the correspondence between human perception and nature–that he pays attention to nature and thus to what man has not created, but at the same time states: "'Love of nature; a very vague, not to say misleading, concept. You should rather say love for perspective" (Wanscher 1963:76). Wanscher believes that the task of culture is to give form to what is in itself indeterminate and to conceptually confirm this formgiving with an emphasis on the perspective, which has *anthropos* as its focal point. There is an attention to affirm what is more than we can control with mathematical formula, proportioning and the aesthetics of the beautiful, but in the same breath there is an insistence on correlating what we thereby experience with our senses. We stay in full control from a specific *point of view*. We stay a conscious subject and are in full control of our senses instead of staying witht the trouble.

With Jean Francois Lyotard's considerations about Kant's aesthetics and especially the aesthetics of the sublime, one can–with relevance also for Wancher's ambition– point out that Kant and Wanscher are aware of something which turns away from consciousness and which cannot immediately be correlated with forms of rational cognition. They are aware that there are *points of life*, that are not dependent on man. But it's also obvious that both Kant and Wanscher nevertheless seek to control this with a reflexive dialogue with our senses, reestablishing conscious control from a central *point of view*. Lyotard has pointed out that art, following the conceptualization linked to Kant's aesthetics of the sublime, also challenges this correlationism and as such requires a different conceptual dialogue between what we sense and what we think than the one Kant himself payed attention to. In the essay 'After the sublime, the state of Aesthetics', Lyotard asks: 'The paradox of art 'after the sublime' is that it turns towards a thing which does not turn towards the mind. (…) The Thing is not waiting to be destined, it is not waiting for anything, it does not call on the mind. How can the mind situate itself, get in touch with something that withdraws from any relationship?" (Lyotard 1991:142). For me, Wanschers answers this question by insisting on the nowhere that characterizes the conquering gaze of perspective. And this is what Haraway (and others) challenges by making us aware that we bodily experience something, which is *not* controled by our consciousness, and that we must engage with this by an active thinking that precesily acknowledges other attentions than we are conscious of.

For me, we are thus in dialogue with a very central challenge if we want to move from the duad of architecture/man to the triad of architecture/man/earth system, as Gleiter points out. I have already referred to two of Latour's procedures for *reseting modernity*–his insistence that we localize the global, and his critique of the perspective that gives us the impression that we can occupy a position outside the world–and will now highlight *a third reset procedure*, which particularly relates to the conceptual work and which Latour refers to as "Sharing responsibility: Farewell to the sublime" (Latour 1996). For Latour, it seems clear that *both* our visual procedures–which situate our bodies–*and* our thinking and philosophy–which Kant and Wanscher works with–must be at work, since these two fields can *either* cooperate to confirm that we are in conscious and correlative control outside the world (Kant/Wanscher) *or*–with a *parallelism* (Spinoza/Deleuze)–help us move beyond conceited control *from* an abstract point outside where everything is scalable and *into* a non-scalable nature in order to situate what we give measure and compose with nature's unmeasurable qualities.

Conclusion

It is not sufficient to let the human body be the model and measure of everything, as Alberti imagined it (Alberti 2011:18). According to Alberti, everything material should be manipulated and thus adapted to our bodily measures. With Tsing, Latour and others I have argued that nature cannot be scaled, as everything changes with size. We must give measures–scales–to the architecture we create with an understanding *both* of the non-scalable nature *and* of qualities we cannot measure but sense and which we involve in our compositions, such as the play of light and shadow.

Le Corbusier understood that "light and shadow reveal form" and spoke of "the inexpressible space, the apotheosis of plastic emotion" (Le Corbusier 2004:32). One senses what he expresses by experiencing his architecture. But at the same time, Le Corbusier was concerned with putting the forms of architecture–and of the human body–on a mathematical formula, which could testify that the relation between architecture and man rested in rational, mathematical proportions controlled by conciousness. He was fascinated by mathematical thinking and by geometry, and sought to give the impression that every measure in, for example, the *Unité D'habition* (1952) in Marseille, was determined by his system of proportions, the *Modulor*. But it is a misleading guidance, as Steen Eiler Rasmussen has pointed out: The giant columns that support *Unité D'habitation* are not given measure according to the human body, but according to the building they have to suport (Rasmussen 1962:119).

Rasmussen, like Wanscher–to whom Rasmussen refers in the 'personal notes' that are included in the Danish edition of *Experiencing Architecture* (Ramussen 1957:241)–is on the track that measures other than the ones related the human body must be involved when we give measures to a world of diverse life forms with our architecture. But like Wanscher Rasmussen does not let this observation challenge the duad: architecture/man, which–if Gleiter is to be followed–has been the horizon of architectural theory until quite recently. Both Wanscher and Rasmussen are on the track of attentions, which are relevant if we want to land on earth among other forms of life than humans with our architecture. But their conceptualizations contributes limiting and demarcating rather than expanding and facilitating in relation to that challenge.

It is in this extension that I want to end my reflection with considerations related to Fehn's *Nordic Pavilion* in Venice, which is built around points of life: trees. As the philosopher Arnfinn Bø-Ryg has pointed out, Fehn's pavilion can be considered as an 'art of measuring' insofar as the pavilion, built around points of life that cannot be scaled, provides measures for materials in order to create a field, a space, around the trees with a speciel feeling of light: By virtue of the dimensioning of, among other things, the transverse concrete beams in the roof the sharp, harsh Italian light is filtered and creates in the pavilion the shadowless nordic light that Fehn often spoke of. Bø-Rygg relates in his conceptualizing dialogue with Fehn's pavilion to Martin Heidegger's considerations about dwelling, and writes: "Heidegger calls the space between the earth and sky (or heaven) the 'dimension'. All forms of art and architecture are a means to measure this between, the dimension. To dwell poetically, to create art, is to take measure. 'Is there a measure on earth?' Hölderlin asks. To which he answers: 'There is none.' (…) To measure the dimension is then to dwell in the open, in what Hölderlin calls 'the Unknown'" (Bø-Rygg 2013:232).

It is against this background that Bø-Rygg emphasizes that there is a difference between the architecture that Alberti promoted and which seems to have no real dialogue with the world and nature in which man dwells, and Fehn's architecture, and I will end this text with a longer quote from Bø-Rygg's text: "To make a poem, to take a measure in this way, to scale the dimension, still means designing a building that is essentially 'right'. Alberti defined beauty in this way: that the harmony of all parts in relation to one another, and its part in relation to each other and the whole, must be so that nothing can either be added or taken away, without ruining the wholde. (….) In this way, Fehn's pavilion is surely classical. But what is right in his pavilion is not the harmony between parts or the porportions alone: What Fehn did was to scale the materials, the space, the light, and the shadow to each other. (…) The classical in Fehn's building is just as unexpected as it is inventive" (Bø-Ryg 2013:233).

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Missing opportunities and lost values in urban space: Reclaiming resilience

Introduction

Agricultural landscape and urban fabric have been intertwined in İstanbul for centuries. The city, a self-reliant and resilient whole (Barthel,S., Sörlin,S., & Ljungkvist,J. 2010), with its water sources and fertile agrarian fields, has lost its agricultural areas on the city's outskirts and within the urban fabric due to rapid and mass urbanization and population growth. Can we compensate for such losses within a new framework in a dynamic and developing environment? My primary purpose in this paper is to narrate the social and physical transformation of an area in the city between 1970 and 2022 through various representation tools such as maps, now and then photographs, and drawings; to discuss existing and lost values and resilience opportunities to mitigate negative consequences of urban development and global effects in the context of livability.

Can this neighborhood, which has lost its character and productive landscape as a sustainable and accessible environment with vehicles and low-profile structures lining its streets, be re-gained? While the disruption of sustainable continuity is linked with physical and social deterioration, can the city's social-ecological memory be restored? Can the negative consequences of the wrong decisions that caused all these losses be compensated? Besides presenting observational and research findings about the transformation of the urban space, I also briefly discuss resilience in traditional and contemporary senses within the context.

Livability is generally associated with sustainability and is used to evaluate the environmental and spatiotemporal quality of urban space. We know that the concept of livability varies from society to society or culture to culture and only partially coincides with the idea of sustainability. (Wiryomartono, B.2020). The characteristics of a livable community widely include a sense of safety, good public schools, well-paying jobs, access to food, parks, green spaces, spatial features, cultural amenities, and walkability.(Rakow, D:A., et.al.2020:9)

Nevertheless, when looking at the case through the question of how an urban space should be or the lens of quality of life, one can agree on some of the commonly acknowledged characteristics of a livable environment. We do not have social research on the environmental or spatial satisfaction of the neighborhood inhabitants in question or an objective study on whether the environment is a livable urban space. However, when the spatial features and clues about life in the 70s and before are evaluated, we see that some elements shown as the characteristics of the livable environment exist in this place. For example, the balanced ratio between the green and built environment, a pedestrian-centered living and spatial organization, easy access to unprocessed food and integration of agriculture into urban space, a vivid street life, a mix-use environment, the proximity of activity areas in a wide variety, the urban environment within the natural setting where water and soil are multi-way fertile that allows work and recreation to be intertwined, a symbiotic urban space where animals, plants, and people live together – an environment where the human scale is at the center (low-rise constructions, proximity of environmental elements), easy access to clean drinking water, accessible health, and education services and having a strong Gestalt quality.

As I stated, this paper aims not to bring out a romantic approach that carries a nostalgic longing and lament for the missed opportunities in an existing urban environment. The study, on the contrary, is an attempt to "remember" what is valuable in the long term and to question whether an urban environment that has lost many values; witnessed the negative consequences of seemingly inaccurate planning & design decisions and implementations still has the potential to become a human and nature-oriented place again in the changing scale, conjuncture, and context. A narrative based on revisiting the site and past personal experiences, now and then pictures, photographs, and maps are the primary tools for remembering and representing the urban space.

Urban Form

The place lies in the middle of a major settlement on the Asian side of Istanbul. It is a neighborhood with a modest scale where middle-class families mostly live(Fig.1); the primary transportation network passes through; two important landmarks, two complexes designed by architect Sinan, situated at both ends of the main transportation axe. On both sides of the cobblestone paved road, 2-3 story buildings lined with shops at the ground level and houses on the upper level. Behind the buildings on both sides along the main road stretched the gardens with fruit trees and the urban gardens adjacent, namely bostans, a typical spatial quality peculiar to the old urban fabric in Istanbul, which played an essential role in the city's resilience. Beyond the private gardens, the organic street layout, frequently seen in medieval and traditional settlements, expands and becomes square in some places, widening, which is another element contributing to the main characteristics of the place.

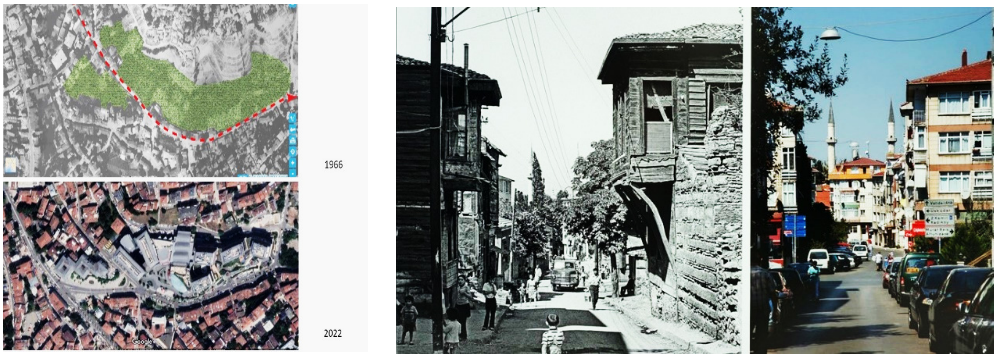

Fig. 01. Now and than maps and photograhs of the neighbourhood
Source: https://sehirharitasi.ibb.gov.tr/ and Photos by Reha Günay.

Environmental, architectural and human scale

The modest scale of buildings with the hip roof not exceeding 2-3 floors, roads, trees, and other plants and animals interacted with the human scale, contributing to a responsive environment. Almost all urban functions, from housing to education and recreation, were within walking distance, allowing people to move into the urban space in a series of uninterrupted experiences. In the neighborhood where wooden structures were the majority, it was possible to see brick masonry buildings and modern low-rise buildings here and there.

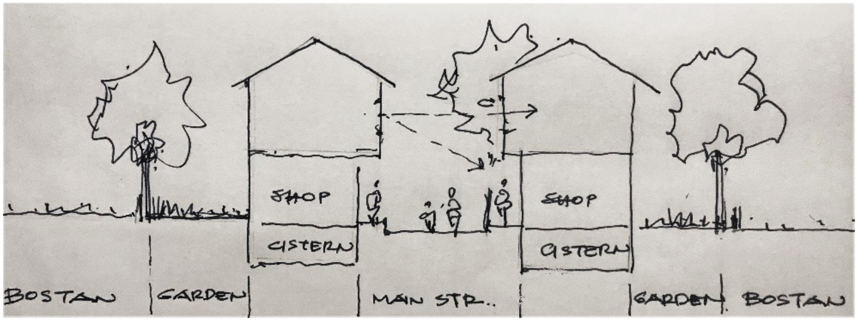

Fig. 02. The typical section reveals the modest scale of the environment

A green element was unintentionally included in every perspective: a tree or a garden. The low-rise structures, including schools and other public buildings, allowed the built environment and nature to coexist proportionally. The vertical and horizontal perceptible dimensions of urban space and architectures, their human-scale nature, simple spatial organization, and street layout laid the foundations for the, arguably in a particular perspective, humane socio-spatial relationships. (see Fig.02)

Street Life, movement, the sensory experience &activity

The street was a place for communication, learning, and teaching, where men, women, and children of all ages lived together and interacted. At street level, the mix-use space consisted of rows of buildings on both sides, including grocery stores, greengrocers, two tailors, two butchers, a hardware store, a bakery, and other shops. The women who watched the street through the window of their flat could chat from window to window thanks to the scale of the street and the proximity. Life had a distinct rhythm that varied according to days, weeks, months, and seasons.

The cultural, natural, and economic values within the existing urban pattern that have significance in the city's "social-ecological memory" are indisputable. The shuttering sounds of shops in the mornings, the sounds of roosters, the increasing and decreasing footsteps of those who go to work and school, the sounds of people and conversations heard in the calming space during the day, the sound of a radio that is on from a distance, the talks of the shopkeepers and vendors, the calls to prayer from the minarets, the sounds of bells coming from the churches nearby, the sounds of children returning home from school on foot, the footsteps of the workers returning in the evening, the smell of food and bread that surrounds the place, the people, the plants, animals and the buildings along with a small number of cars and carts, different smells brought by the weather, the scent of flowers, the smell of the sea from time to time, created a strong sense of place where the rhythm of life and the rhythm of nature coincided on the same interface. The tobacco factory and warehouses on the waterfront, educational and shopping facilities, and the town hall were some workplaces close to the settlement that provided main employment opportunities.

Green space and water culture

Until the end of the 70s, urban gardens (bostans) were scattered among the built environment, the rooted water culture based on sensory experiences, elements, and traditions such as cisterns of the houses collecting the rainwater, wells, fountains on the streets, creeks, pools and the sea and fisheries, large green backyards, and animal husbandry extending into the city made a significant contribution to daily life by shortening the distance between food sources and living areas in the city. The superposition of Pervititch Insurence maps with the satellite map reveals agricultural areas lost in the intervening years (Fig. 2).

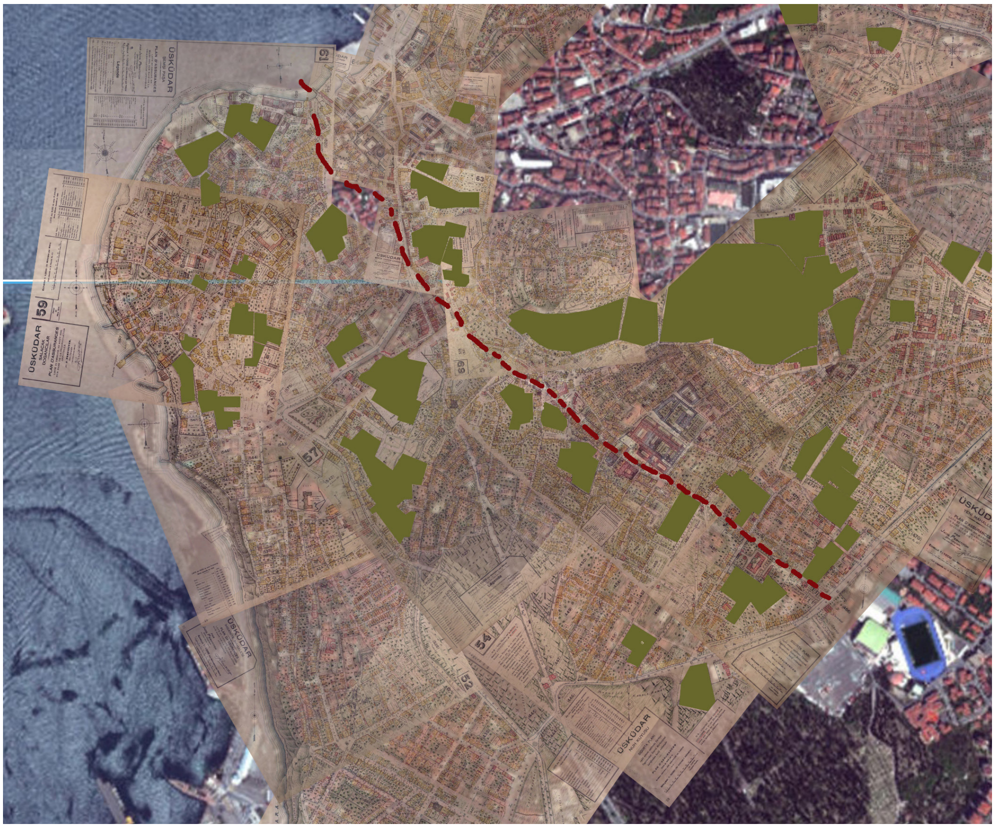

Fig. 03. Superposed maps reveal the productive green areas lost.

Source: https://archives.saltresearch.org/handle/123456789/1872 (Jack Pervititch maps) and https://sehirharitasi.ibb.gov.tr/ (satellite map)

Pervititch Insurance maps prepared between 1920-45 and aerial photographs up to the 70s show that green spaces dominate the urban environment so powerfully that the image of the place reflects a character between urban and rural. The extensive gardens of the houses, the gardens that followed them, the groves, the vast meadows, the green slopes, the plots emptied of wooden buildings and old buildings, and the large cemeteries constituted these green spaces. The only park in the modern sense was designed in the early 20th century in town. There were extensive promenades and many sandy beaches on the Bosphorus's shores and the Marmara Sea. Fishing, swimming, and fruit picking were among the natural hobbies of many people. Access to clean drinking water was not a problem in the urban space due to the fountains on almost every corner that lasted from the Ottoman Period until recently.

Integration to disruption

From the Byzantine and Ottoman periods to the early Republican era, Istanbul, which was a resilient and self-sufficient city with its agricultural activities and water culture integrated with the built environment, lost this feature to a great extent by losing its agricultural areas in consequence of planning decisions, unplanned implementations, intensive development, migration, and global effects. The same negativities occurred in the urban pattern in question, one of the central districts of the city. Since the decision-makers who emulated modern cities couldn't develop original solutions peculiar to the rooted resilient nature of the town. Consequently, the socio-ecological structure of the urban space and the memory that contains valuable knowledge on an integrated urban life has also been lost. The last green areas on the city's outskirts are the only chance to be evaluated for integrating agricultural activities into urban life. The opportunity to gain this feature for the town, as is, seems very difficult in the central locations. Yet for long years, the city of Istanbul has carried the economic burden of the whole country in the Republican era so far, which still needs to be alleviated with the inclusion of broader planning decisions.

Proximity, similarity, and simplicity of the buildings created a strong sense of Gestalt (Norberg-Schulz, C., 2000), which is weakened by the construction of new roads, large-scale structures, and the loss of productive green areas and integration.

Ecosystems are constantly evolving… with slow and fast changes at small and large scales…As a heuristic or guiding concept, resilience refers to the ability of an ecosystem to withstand and absorb change to prevailing environmental conditions and, following these change-induced events, to return to a recognizable steady state…in which the system retains most of its structures, functions, and feedbacks… (Lister, N-M,L., 2016: 312,313)

Resilience, in its narrower perspective, means" bouncing back" to a normal state. In this case, the change in the urban space deviates from its routes of adaptive cycle -and shifts to another direction which necessitates strong collaboration between research and policies to be developed aiming at long-term sustainability (ibid). Reclaiming resilience requires getting back first to the normal adaptive cycle. It needs intentional and comprehensive effort.

Conclusion

In this paper, I briefly share the story of the transformation of a specific urban pattern I experienced through narratives, maps, and now and then photographs. The urban environment in question has lost the positive qualities it has previously sheltered, such as agricultural areas and urban textures with distinct characters, due to various reasons such as migration and displacement, global effects, and dense urban development. Besides tangible values, the urban memory's consistency and cultural continuity are severely damaged.

Today, Istanbul, which has ceased to be a city with precise form and edges that could be defined, has become a megacity with blurry edges. The period when the city was described as resilient was mainly a Holosenic era when the city's borders and production areas were more evident and static. In the 20th century, technology, industrialization, and urbanization did not develop as rapidly as in the West, which unintentionally ensured the preservation of the rural elements of resilience for a while that existed in the city's genes. Although Modernism entered urban life in the 50s with new boulevards and multi-story buildings, these implementations were on such a scale as insufficient to eliminate the city's rural features. The acceleration of migration from the rural environments to the city in the 70s resulted in replacements, the addition of new people, roads, coastal roads, and means of transportation for the town. In this period, the rural-urban character of the city disappeared along with the urban textures shaping it. The city's macro-scale social, economic, and cultural change has led to micro-scale cell changes. Over time, the city has been filled with anonymous images, ordinary residential buildings, and new and accelerated commercial activities and mobility. The disappearance of the agricultural areas of the city, which are the memory depots, and the deterioration of the urban texture have led to ruptures between the qualities of the old and new patterns. Authenticity has given way to superficial artificiality. Aside from the memories, the documents that reveal this situation are comparative photographs and maps, in which this is most evident. While the urban population continues to live with various difficulties within the overwhelming scale of the city, consisting of new and multiple textures, changing scale, and urban identity. Considering that socio-economic relations are established more centered on trade and consumption than production and the change in urban space with no comparison, fully retrospective solutions appear unrealistic. The question: "Is there a possibility for the city, or at least for the certain urban fragments, to regain a resilient nature within the new dynamic context?" seems more realistic, which will be the central theme for further research.

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Scale and the Senses

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Architectural scale from inside-out: Learning body awareness through figure drawing

Introduction

Among other methods, architecture students learn architectural scale through observation and figure drawing. Throughout history, architecture has been intertwined with our understanding of the human body and its proportions. The primary purpose of architecture is to support humans, so architecture and the human body are intricately connected on many levels. The master Leonardo da Vinci (1452 - 1419) has long been admired as one of the best artists and inventors whose work demonstrates the connections between bodies and his creations. With no classical education (as he was largely self-taught), da Vinci relied mainly on the power of his observations. His extensive studies of human anatomy lead the Renaissance master to an understanding of proportions and the notion of scale in his creative work (Suh, 2005). Upon close examination, his architectural design works reveal a keen awareness of scale and proportion rooted in his microcosm studies of the human body. Furthermore, his study of the human body entered an ontological dimension, resulting in the divine quality of his work. Leonardo da Vinci's ideal man is prime evidence of his realization of the scale from microcosm to macrocosm; the Vitruvian Man is inscribed in geometries of square and circle to portray a divine connection between the human proportion and the Universe. Many artists and architects of the past, such as Michelangelo, Palladio, Le Corbusier, and Carlo Scarpa, to name a few, spent part of their lives mastering human anatomy and proportions to advance their architectural design. The intent of their studies was not for more than just anthropometry; the awareness of the human body and architecture is indispensable.

Le Corbusier developed Le Modulor based on a human proportion study that he later applied to many projects. The Marseille block is the direct result of this study. Each apartment block consists of small rooms; the ceiling height is based on the Modular's raised arm height of 226 cm, and the rest of the design is based on his Modulor rules (Rassmussen, 1993). Furthermore, researching Alvaro Siza's design process through a series of initial sketches, Siza often accurately depicted figure drawings associated with his architectural explorations. The evidence illustrates Siza's constant awareness of human scale in conjunction with his architectural design. The fundamental understanding of human anatomy and proportion is essential to art, architecture, and design. For example, in Carlo Scarpa's architectural drawings, elements of architecture actively respond to human gestures; therefore, the human body is the primary component of his design decisions. Human figures not only function to indicate scale in architectural drawings, but they also motivate Scarpa's design decisions (Anderson, 2002). Technology, materials, and design conditions constantly change, affecting the idea of scale in architecture, but the awareness of the body as an essence in architecture and design remains vital. To highlight the necessity of bodily awareness in the field of architecture and how our understanding of the body's dimensions contributes to the sense of scale in architectural design, Professor Pierre Von Meiss cites the quote by Auguste Rodin in his book, *Elements of Architecture:*

> Harmony in living bodies is a result of the counterbalancing of shifting masses: the Cathedral is built from the example of living bodies. Its concordances, its equilibriums are exactly in the order of nature, they originate in general laws. The great masters who raised these marvelous monuments were men of science, and they were able to apply it, because they had drawn from its natural, primitive sources, and because it remained alive in them. (Rodin, cited in Meiss, 2013, p. 66)

From the quote, Rodin stresses the value of keen observations of the great masters who drew and distilled their inspiration from nature, and primitive sources. Visiting the Rodin Museum in Paris, one may sense the quality and quantity of Rodin's works that he captured from nature. The intensive study of human bodies was crucial to his creative process. Developing a comprehensive insight into our bodily dimensions and proportion is a way to learn about architectural scale from the inside out. In contemporary architectural education, scale figures can be conveniently integrated into drawings. Facilitated by digital and graphic software, students can easily add scale figures to their drawings without further understanding the relationship between architecture and humans beyond simply indicating scale in architectural drawings (Fig.01). However, this convenient method of cutting and pasting scale figures into drawing has lost an ontological dimension between architecture and humans, as Marco Frascari argues.

Fig. 01. Cut and pasted scale figures.
Source: author.

This essay argues the importance of developing a sense of architectural scale through figure drawing to inform and influence the design process. As an active practitioner in observational drawing and through first-hand experience teaching architectural design courses, the author speculates that if architectural students learn figure drawing, it will strengthen their sense of scale in the design process. A semester-long experimentation begins by integrating figure-drawing practice into the sophomore studio design pedagogy. Then the author analyzes the finding in relation to the existing theoretical perspectives. Furthermore, the investigation discusses the altruistic dimension of learning figure drawing for architectural purposes. In conclusion, the essay suggests a pedagogy on strengthening a sense of scale in the architectural design process based on the resulting evidence.

Architecture and the human body

The fascination and quest to understand our bodies have a long history that dates back centuries. One of the most significant discoveries in art and design that amplified the importance of anthropometry and ontology of humans was during the Renaissance era and onward. During the Renaissance, the knowledge of the body became fruitful in many fields, including architecture. With close examination, many artists and architects of the past advanced their creativity in art and design through intensive study of the human body.

In the architectural representation context, scale figures in a drawing help viewers associate the human body dimension with spaces, buildings, and the surrounding environment. Depicting human figures in architectural drawings is indispensable, as Marco Frascari argues. It helps architects understand the dimensions and scale of the proposed project while also integrating and constructing human facts and architectural dimensions. It is a method of accepting a body as a means to compose the architectural world (Frascari, 1987). On the contrary, Anderson argues that this declaration only partially applies to the contemporary practice of architectural representation since many architects utilize numerical and metric graphics to inform a sense of scale in their architectural drawings. According to Anderson, ‘human figures seem to promote an intuitive understanding of scale.’ (2002).

However, both scholars indicate other valuable aspects of learning human figures to strengthen a sense of scale beyond architectural representation. Both authors argue that, in contemporary practice, human figures incorporated in drawings have little to do with the buildings or spaces depicted. They are generic and less narrative just to indicate scale. Representing human figures is merely a form of communication pasted on the scene with no ontological dimension. In order to strengthen an anthropomorphic practice, an awareness of the human body as an integral part and its essential role in the architectural design process and representation is necessary (Frascari, 1987). Therefore, architecture should accommodate the human body through an intimate understanding and study.

Although human figures promote an understanding of scale in architecture, learning figure drawing in architecture has an additional benefit. If the primary purpose of depicting figures in drawings is to inform the scale and dimension of a project, it would be beneficial for students to further establish a keen awareness of the human body as an integral part of design processes rather than purely for representation. Historically, architecture was spiritually and symbolically linked to the human body, proportion, and form (Anderson, 2002). Western architects applied male and female human proportions during the Renaissance and sixteenth centuries to compose various architectural elements such as columns or the arrangement of entire building facades. Shifting to the twentieth-century practice of architecture, some eminent architects apply knowledge of the body to inform and create spatial quality and their architecture. For example, Carlo Scarpa studied and utilized human gestures as direct agents to inform his architectural composition and develop responsive spatial quality. Studying human bodies strengthens our awareness of the architectural scale for representation and communication. It is an integral part of the design process in which awareness of the body and architectural space inform one another.

In 1977, Kent C. Bloomer and Charles W. Moore argued in their book Body, Memory, and Architecture that the profession focused on a set of prescribed technical goals and quantifiable elements rather than being responsive to fundamental human desires, feelings, and the whole architectural experience. Much research has been done since the book was published regarding the relationship between the human body and architecture, particularly recent research on neuroscience and architecture. The significance and affinity between the human body and architecture in the book are relevant to this article. Both authors believe an essential sense of three-dimensionality emerges within the bodily experience, which leads to our understanding of spatial feeling in our building experience. The human body is a three-dimensional possession we can use to understand and experience architectural form (1977). Our bodies become a doorway of our perception through which we experience the surrounding environment. We touch objects to feel their textures and temperature. The sense of touch, or the haptic sense, is a perceptual system that informs various bodily sensations, such as pressure, warmth, and cold. At the same time, we also haptically sense our bodies' motion through the feeling of muscles and joint movements or kinesthesis. Our body is in a constant mode of interaction with the surrounding environment. We subconsciously use our bodies to communicate and measure up and justify buildings' dimensions and scale as we experience them. Our bodies are in the center, as Pallasmaa indicated:

> I confront the city with my body; my legs measure the length of the arcade and the width of the square; my gaze unconsciously projects my body onto the facade of the cathedral, where it roams over the moldings and contours, sensing the size of recesses and projections (Pallasmaa, 2012, p. 43).

Figure 2 is a result and an interweaving representation between awareness of scale in architectural space and a method of depicting space in a two-dimensional representation. By depicting human figures in the painting, the image presents the drawer's awareness and relationship between the human scale/body and architectural spaces and their elements. Yet, during this process of in-situ watercolor sketching, the painter consciously projects an awareness of the body into the observed spaces to establish an understanding of scale through their own body. The artist constantly and virtually measures and transfers three-dimensional reality onto the two-dimensional surface of the paper. The process is a feedback loop of a strengthening sense of scale when the painter uses human figures to portray their awareness of scale. At the same time, the painting provides information on whether the spatial observation is accurate, judging through scale figures in the painting---the message in the painting further steps into the spatial feeling and the atmosphere, the connection between body and architecture. Through the contemplative act of in-situ painting, an embodied experience emerges with a wholeness of spatial scale and body intertwined. The spatial awareness of scale is strengthened by using the body as a doorway to articulate the experiential environment.

Fig. 02. Bodies and space.

Source: author.

Pedagogy

Throughout modern architectural pedagogy, it has been unfortunate for many architecture and design schools to gradually remove or never even include figure drawing in their curricula. With a close examination of various US undergraduate architecture program curricula[1], many schools excluded the study of human anatomy from their curricula. With the required acquisition of a large body of knowledge and technical skills with only four or five years of study, there is little room to accommodate studying the human dimensions and body that may not seem directly related to architecture. Moreover, wouldn't it be more direct to teach architecture students to draw a plan, section, elevation, perspective, and axonometric drawings? What would be the benefits of teaching the students figure drawing? No particular scale rules can apply to all architectural situations since the conditions and design circumstances constantly change. Alternatively, computer-aided design technology has gradually become an integral part of the equation regarding the study of architectural scale. In most universities, a figure drawing course will be offered through an art program. Most likely, architecture students will be able to enroll in the course as an elective course. However, due to the density of required architectural courses, most students have little time to take a figure drawing course to advance their understanding of human bodies and their dimensions.

Nevertheless, no one can deny the breathtaking effect of the Gothic cathedral spaces and proportions that portray the power of God emerged from a simple realization of the basic scale of the human body. Whether human figures are included in the representation and communication of architectural design, the awareness of human bodies and spaces should always be considered from the beginning of the design process. Understanding human bodies is the root of our comprehension of scale in architecture. Therefore, a brief introduction to human anatomy and scale in architectural curricula could benefit students' design ability and strengthen their sense of scale.

Why figure drawing in architecture education?

In early 1980, the dean of Cooper Union's School of Architecture, John Hejduk, commissioned an artist and educator, Professor Sue Ferguson Gussow, to teach freehand drawing to architecture students. Hejduk expressed this to his colleague, the painter Robert Slutzky, when he stated, "I want someone who can teach the figure." For nearly four decades, Professor Gussow continued teaching figure drawing to architecture students, despite many questioning the value of this practice. Gussow's argument emanates from the body, which she calls the "body of knowledge...[that] becomes knowledge of (the) body" (Gussow, 2008). Alex T. Anderson argues that beyond the basic functions of human figures to provide a clear scale indication in architectural drawings, they also provide a sense of scale that cannot be replaced

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[1] The author examines the US architecture schools' curriculum based on the Design Intelligence ranking for undergraduate programs of the top 20 architecture schools, there were only a few that mentioned freehand drawing courses, such as Cornell University and the University of Notre Dame, but none specifically mentioned figure drawing in their curricula.

by mathematical graphic scale. Additionally, they also offer a functional and characteristic sense of a building when properly depicted (Anderson, 2002).

The concept of measurement and scale in architectural design begins with the proportions and dimensions of human anatomy. For example, the standard units of building materials, such as timber, brick, and many others, are based on human body dimensions. The measuring unit in America, the British Imperial system, refers to the human body. Therefore intuitively, knowing our body dimensions is the beginning of learning architectural scale. Figure drawing is an effective form of learning architectural scale. „Drawing entails another form of measurement," Gussow went on, „from the vast panorama of what the eye perceives, one needs to isolate, translate, and transcribe an image and proportion it to fit the two-dimensional confines of a finite sheet of paper." (2008, p. 15).

Translating a three-dimensional body form onto a two-dimensional surface through drawing is another method of learning about scale. For example, depicting a six-foot body on the 4"x 6" sketchbook requires complex skill and an understanding of scale. While each body element is scaled to the measure of the page, the process is the exercise of learning space concerning scale. Translating three-dimensional reality onto a two-dimensional surface through drawing is another form of measuring and learning about scale. The way one draws reflects the way one thinks. Freehand drawing is part of learning to think spatially when freedom and constraints are intertwined. (Fig.03) exhibits an experiment by the author on shifting and changing the scale of human figures on a two-dimensional surface of the paper. Moreover, the skill gained from the exercise of transforming a three-dimensional form onto a sheet of paper will be beneficial for students to strengthen a sense of scale in architectural design.

Fig. 03. Figure drawing and scale.
Source: author.

Eventually, students will use computational tools to create and produce their drawings as they progress to the upper levels of their study. However, the figure drawing and observational exercises will fortify their insights and scale awareness. As a result, students will establish a firm foundation before shifting their method of drawing to computer-aided tools.

Body diversity and drawing for compassion in design

The architectural design task is to respond to the need of others—architects design spaces and architecture to support others to the best of their ability. To fully understand the needs of others, architects must consider themselves from the clients' viewpoints. In other words, they altruistically imagine themselves as a client, then design the building for him/herself. With this benevolence of thought, compassion in the design process is seeded (Robinson & Pallasmaa, 2015). In contemporary design education, initiating such an altruistic viewpoint in the young generation is vital, and figure drawing could be a doorway to developing compassion for others. Engaging our observation of a place and people through freehand drawing brings us closer to the place and the person. Popowsky argues that a person who has spent a decade observing and sketching how people sit on chairs and benches will likely be able to design a good chair and bench for sitting. (Popowsky, 2019). If we have studied/drawn many people, we are more likely to develop compassion toward each individual. This feeling is the seed of body inclusivity and compassion in design when an emphatic thought originates from the beginning of a design process.

Historically, the study of human form and dimension has been based on ‚male Grego-Roman forms,' which limited and narrowed the perception and idea of beauty in human form. However, attention to human figure diversity is gaining momentum in the current era, particularly in art. For example, a group of artists formed a project called Figure on Diversity, which concentrates on traditional skills of representing the human form. Unlike the traditional approach, the project provokes awareness and celebrates the beauty of human bodies with assortment. With a similar approach, architectural education can implement the idea of body diversity in design. Introducing students to various body types and forms through figure drawing will empower their understanding and compassion for other human beings. As Steinhart (2004) argues in his book, Undressed Art, learning to draw figures requires much observation. The opportunity to observe various types and differences in bodies from various ages and genders enables practitioners to look deeply. This intense observation is linked to developing a human connection. Consequently, the process is a gateway to developing compassion.

Implications

Based on the constraints of the existing curriculum where the author teaches, it excludes ergonomic study and figure drawing from foundational levels. Therefore integrating figure drawing and human anatomy into regular drawing or studio courses is in the experimental stage. By not adding extra courses to the already dense curriculum, the subject could be integrated into any introductory design course, ideally in the program's first year (Meiss, 2013). With the circumstances in mind, the author selected a student from a second-year studio course who showed interest in figure drawing and asked the student to practice figure drawing in parallel with studio design development routinely.

The author began by introducing a figure drawing book, Drawing from Life by George Bridgeman, as a reference to the student and asking him to spend ten to fifteen minutes practicing figure drawing at the beginning of each studio session. The introduction to figure drawing began with the author introducing an essential human proportion and scale to the student by demonstrating a method of figure drawing and using 7.5 human proportions as the focus of the practice. The author also introduced the human skeleton, which would help the student apprehend the human structure. After a few weeks of practice, the student had developed a better understanding and gained confidence in his figure-drawing skills. In addition to regular practice, the author gives input regarding the student's drawings by further demonstrating the method in more detail (Fig.04).

Fig. 04. Figure drawing and proportion studies.

Source: Sophomore student's drawing after George Bridgman.

With this experiment, the author hoped to see if the routine practice of figure drawing would strengthen the student's sense of scale in the design process and representation compared to students who regularly use digital tools as the primary method of designing and representation. (Fig.05) showcases the work of the

student. Through repetitive figure drawing practice, the drawing demonstrates that the student could discern the notion of scale and proportion of space in conjunction with the human dimension and bodies during a design process, as evidenced in his section drawing.

In addition to understanding the scale of the building in relation to bodies for communication and representation, the expression of building occupation or human actions can help to explain the effect the building has on occupants and how people shape their environment (Anderson, 2002).

Based on the author's experimentation and observation, the notion of scale not only exists via depicting human figures in a drawing. It is rooted in an awareness of scale through a comparative measure of the student's body and the architectural spaces he designed via his figure drawing. The following quote is the testimony of the student responding to the question, What are the benefits of figure drawing practice in conjunction with an architectural design course?

> Growing more familiar with the proportions of the human figure has proven extremely helpful in informing the proportions of designed space. Being able to sense the scale necessary for certain actions or activities allows me to understand and create much more effective spaces, with less effort spent. In understanding the rhythm and balance found in the body, one can much more easily understand those found in the built environment[2.]

The span of this figure drawing practice in architectural curriculum experiment was an entire semester which is four months long. The practice could be continued if the student selects to do so. Based on the author's direct experience, routine practice of figure drawing for 15-20 minutes in each studio session throughout the semester will be more effective than a few assignments at the beginning or the end of the semester as these skills are strengthened through routine practice.

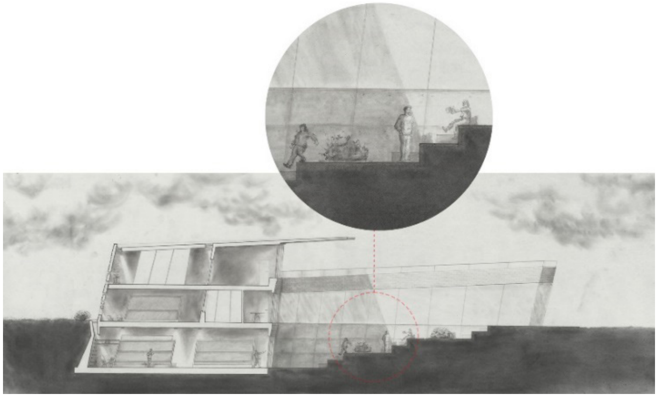

Fig. 05. Figure drawing and scale in architectural spaces.
Source: Sophomore student's drawing.

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[2] This quotation respresents the student's statement regarding the benefits of learning figure drawing to support his architectural studies and how the skills and knowledge gained from this experiment strengthened his sense of scale in the architectural design process. The student wrote the testimony a month after completing a semester of figure-drawing practice. He has continued practicing figure drawing and incorporating the skills and knowledge into this design process as he progresses in his education.

Conclusion

Developing a sense of scale is essential in architectural design. Awareness of human proportion and scale is a vital part of this equation. The impactful method to comprehend human proportion and scale is by learning to draw human figures, yet this awareness further empowers architects to step into an ontological dimension of architecture. The practice of figure drawing is a doorway to developing compassion for others, and that is the heart of architectural design, the concern for others' well-being through creating meaningful architecture. In architectural pedagogy, a sense of scale through figure drawing should be established at the early stage of student learning. The first-year curriculum is ideal for integrating and introducing students to the topic. As they progress through the school curriculum, they will begin to see the benefit of figure drawing practice and how it can enrich their sense of scale in architectural design. Although most students will gradually adopt computational tools to aid their design process and production, they may no longer create drawings by hand. However, there is an unbounded and subtle connection between this transition. The awareness of human proportions and dimensions established during their formative years of learning will remain in them. It is a foundation that students must establish before advancing to the next level of their education.

The images accompanying this article embody the author's argument that learning to draw figures could strengthen architects' and students' sense of scale. While the article is scholarly, it also resulted from the author's direct experience as an architect and educator who actively engages in drawing, architecture, and teaching. Through first-hand experience, how the practice of figure drawing empowers the author's confidence in the design and a sense of scale is the immediate motivation for developing this article, with the hope that this effort will aid architectural students in the digital age.

For further investigation, this experiment should be conducted at the freshman level of study before students acquire any architectural knowledge and compare whether figure drawing and human proportion studies will amplify students' sense of scale when engaging with architectural design. A longer term of study would be helpful with short practices over an entire school year. It is also worth considering drawing from cast or live models rather than from reference images. This approach enables students to practice transforming a three-dimensional form onto a two-dimensional paper surface and changing scale. While this experimental study with one student may not be enough to draw a solid conclusion, it does provide some positive findings on what figure drawing could offer students in architecture foundation courses.

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Shifting the Architectural Body: Designing Sensory Ecologies Across Scales

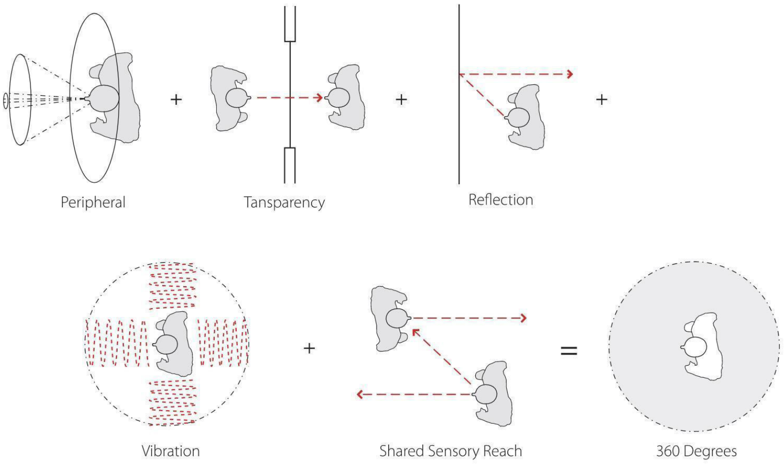

Fig. 01. Deafspace Diagrams.
Source: Hansel Bauman, 2010.

Introduction

The design of accessible and inclusive spaces for Deaf communities calls for a thoughtful understanding of various "assets of deafness" (Hendren, 2020, p. 115). In "What Can a Body do?," Sara Hendron writes that "DeafSpace isn't a plea to 'make room' for deafness. It's an unapologetic and joyous expression of the integrity and beauty of deaf experience" (Ibid.). In this article, she describes the implementation of the *Deafspace Design Guidelines,* written in 2010 by Hansel Bauman Architects at Gallaudet University. (Fig. 01) Gallaudet, founded in 1864, is a school where deaf students mostly communicate through English and American Sign Language or ASL. Hansel Bauman Architects describes that "the Deaf community is a diverse one in which many people inhabit a rich sensory world with a heightened visual-tactile means of spatial orientation and visual language" (Bauman, 2010, p. 10). During Hendren's visit to the school, she noticed this "heightened visual-tactile" environment describing "how deafness produces a distinct sensory ecology" (Hendren, 2020, p. 114). The environment might include the reverberation of a tabletop or floor to call another person's attention, the organization of furniture to see all the gestures of all participants in a room, the lighting and surface color of space to reduce visual fatigue and distraction, the extra-wide hallways that allow for continuous movement and sustained conversations, and wayfinding to scan for barriers and changes in direction. These considerations call for empathy, attention, and design research for different types of users rather than the ideal singular user type. Instead of addressing an imagined ideal such as the *Vitruvian Man* or Le Corbusier's *Modulor Man*, this paper shifts the focus to other bodies critical to making spaces work better for all people. (Fig. 02) In an essay titled "Human, All Too Human," Federica Buzzi argues that "the ideal normative body of the Modulor Man has more to do with the schemes of domination of a given society, than with an objective statistic of physical average. To various degrees, this norm is harmful for all the bodies: although favoring some over others, it generally introduces a restricted notion of what accounts as human." (Buzzi, 2017)

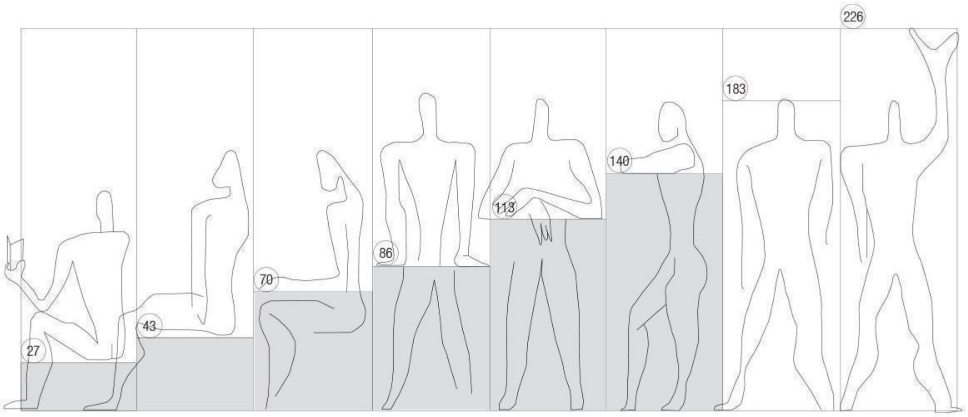

Fig. 02. Modulor Man.
Source: Studio 27, 2015.[1]

These standards limit the ability for architecture to resonate and represent those who make up everyone else, including most female, non-binary, disabled, and non-European groups. Studio 27, an architectural firm that has worked on multiple projects with the Gallaudet community, depicts a more pluralistic scenario with images of different types of bodies directly contrasting the *Modulor Man*. (Fig. 03)

There is an urgency for traditional curricula and design pedagogies to expand and adjust to respond to these more inclusive perspectives. With this in mind, the authors of this paper developed a seven-week architectural studio project for sophomores to consider the lived experiences and "distinct sensory ecologies" of the anticipated users of a new proposed community center located in the Allston/Brighton neighborhood of Boston near the existing Horace Mann School for the Deaf and Hard of Hearing.

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[1] StudioTwentySevenArchitecture. *Fragment 04: Gallaudet University.* [online] Available at: https://www.studio27arch.com/casestudy/fragment-04-gallaudet-university/ [Accessed 1 Jun. 2023].

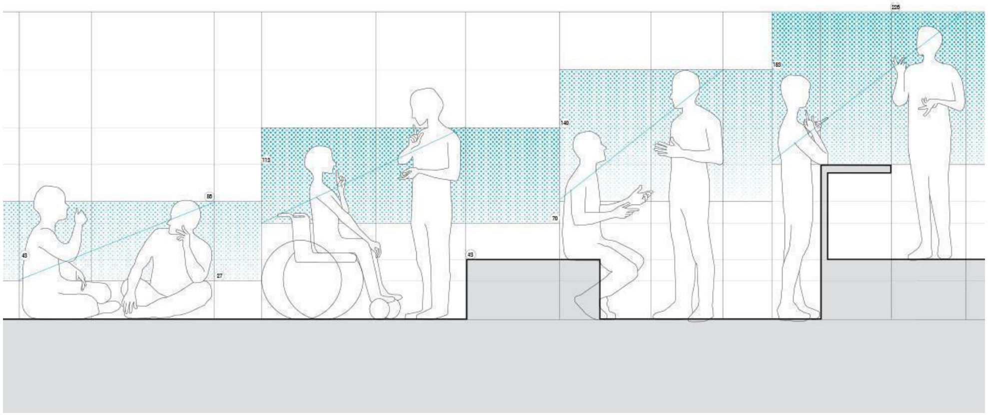

Fig. 03. DeafSpace Modular.
Source: Studio 27, 2015.[2]

Case Study: Community Center for the Horace Mann School for the Deaf and Hard of Hearing

The Horace Mann School is an accredited dual language program with instructional fluency in American Sign Language and English. The new community center anticipates welcoming the Deaf community as users of the building. Envisioned as an inclusive neighborhood hub, the proposed community center will offer a range of programs, including affordable K-6, middle school, and teen afterschool and evening programs, as well as summer programs, short-term classes for adults and seniors, and larger gathering opportunities for athletics, meetings, art shows, and other community needs. Recently, the Mayor of Boston Michelle Wu initiated an ongoing discussion and review of a future vision for a new facility to house the Horace Mann School. In 2019, the City of Boston commissioned a full-scale external engineering review of the existing 1975 facility and in early 2022, she outlined a future vision for the Horace Mann School. [3]

The sophomore studio inserts itself into this moment of transition to speculate on what a community center might look like when considered alongside and in support of the future Horace Mann School for the Deaf and Hard of Hearing. The academic project began with talks from principals at MASS Design Group, and Machado Silvetti Architects, who are collaborating on designing a temporary educational building environment in Charlestown to house the Horace Mann community while a permanent building begins planning. Students were introduced to contemporary ongoing research into the architecture of deafness and the historical context and legacy of the state institutions such as The Governor Baxter School for the Deaf

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[2] StudioTwentySevenArchitecture. *Fragment 04: Gallaudet University.* [online] Available at: https://www.studio27arch.com/casestudy/fragment-04-gallaudet-university/ [Accessed 1 Jun. 2023].

[3] BLW Engineering (2019). *Jackson Mann Engineering Report*. [online] *Boston Public Schools*. Available at: https://www.bostonpublicschools.org/cms/lib/MA01906464/Centricity/Domain/1901/Jackson_Mann%20Engineering%20Report.pdf [Accessed 1 Jun. 2023].

in Falmouth, Maine, and the Wyoming School for the Deaf in Casper, Wyoming. The student cohort later heard from the Co-Directors of the Human Experience Lab at Perkins & Will, who shared their expertise in environmental psychology and the intersections between human behavior and design. These real-world discussions, research, and education facility design invites students to reimagine the architecture of a community center to amplify the lived experience and sensory experiences of all its expected users. The project brief embraces the community center's evolving identity and inclusive mission as a mixed-use hub, with public spaces and services that consider those who have been historically marginalized and unconsidered by building designers.

Methodology: Sensory Ecologies

Sensory ecologies refer to the interplay between environmental stimuli and human perception, encompassing modalities across scales. These ecologies interact to create unique experiences that shape our understanding of space, from the body-scale of intimate experiences to the macro-scale of spatial connections. Sensory ecologies are critical aspects of designing with the Deaf and Hard of Hearing communities and recognizes the importance of user-centered design in the design process, particularly for deaf individuals, in order to facilitate clear communication, community building, and promote a sense of belonging. These Deafspace principles can be applied across scales, from designing individual rooms to wayfinding throughout buildings. The five design principles include:

1. **Space and Proximity** shows understanding of spatial distances, enclosures, arrangements, and visual connections to support basic communication needs.
2. **Sensory Reach** aids deaf individuals in utilizing vibration, tactile, and social cues to perceive their environment. This guideline supports wayfinding, view corridors, and connections to extend sensory understanding.
3. **Mobility and Proximity** guidelines enable signed conversations while users are walking safely. Designing spaces for clear pathways and circulation, with carefully considered intersections and thresholds, is essential.
4. **Light and Color** facilitate visually centered communication. A thoughtful palette of colors and textures helps to contrast with human skin, well-controlled light helps to show facial expression, and the use of natural lights indicates the changes in the day to provide a sense of time.
5. **Acoustics** support minimal background noise with clever room adjacencies so Deaf users will not be distracted if they have hearing aids.

These principles consider user-centered and inclusive experience at multiple scales in the design process.

Student Project Examples

This paper describes four student projects from a sophomore studio that reference the *Deafspace Design Guidelines* mentioned above. These projects explore both the body-scale through interior studies emphasizing isolated moments through precedents and physical fragment models, and the macro-scale utilizing sectional drawings and annotations depicting circulation, way-finding, spatial awareness, and connections to the environment.

Circulation and Movement

In Alim Bayram's project, he delved into the relationship between movement and circulation using fragment design models. (Bayram, 2022) The primary objective was to create a space seamlessly integrated with its surroundings while promoting people's flow through the site. Alim broke up the site into smaller zones, examining how movement could be enhanced within each one. He explored open courtyards, narrow passages, spacious halls, all interconnected by a network of pathways, each with distinct ambiance and circulation patterns. The design models synthesized architectural elements at the scale of the body such as stairs and corridors. (Fig. 03) By utilizing fragment design models, Alim optimized the flow and movement of people through the space, resulting in a cohesive and practical design. [4]

Fig. 04. Circulation and Movement, Fragment Study.
Source: Alim Bayram. Concept Development.

Thresholds and Moments of Arrival

Sarah Carpenter explored the relationship between threshold and aperture, investigating how the manipulation of these architectural elements could create unique spatial experiences within the built environment. (Carpenter, 2022) To begin, Sarah researched the theoretical and practical aspects of threshold and aperture in architecture, analyzing the Skaden School for the Deaf by Sverre Fehn in Sweden. (Fig. 05) Using this knowledge as a foundation, Sarah began experimenting with a series of fragment models that focused on the relationship between interior and exterior spaces or using light and shadow to create visual interest. (Fig. 04) By

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[4] From *Deafspace Design Guidelines*, Chapter 3.1 Pathways & Flow, 3.2 Ramps & Stairs, 4.2 Solar Control - Daylight & Shade, written in 2010 by Gallaudet University and Hansel Bauman

manipulating these elements, she was able to create spaces that were both visually exciting, functionally effective, and experientially impactful.[5]

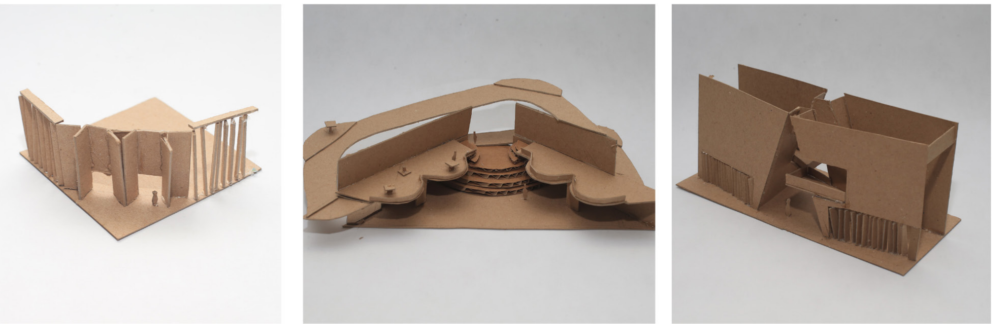

Fig. 05. Threshold Conditions, Fragment Study.
Source: Sarah Carpenter. Concept Development.

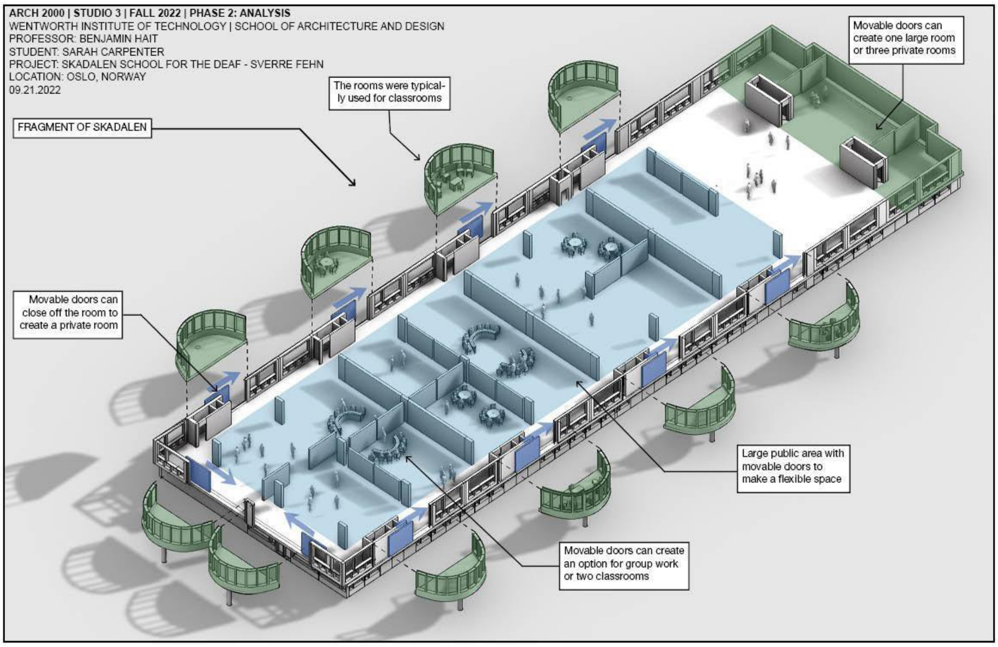

Fig. 06. Analysis of interior and exterior threshold conditions in the Skaden School for the Deaf.
Source: Sarah Carpenter. Precedent Research.

Conversation Eddies

Student Nathaniel Clement created intimate moments along a path that promoted connection and ease of communication between inhabitants. (Clement, 2022) He first developed fragment models looking at how users could quickly move aside and have a deeper conversation in a widened space. He identified movement and nodes as separate elements and integrated these ideas into subsequent models. (Fig. 06)

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[5] From *Deafspace Design Guidelines*, 1.1 Degrees of Enclosure, 2.3 Spatial Awareness and 3.3 Thresholds, written in 2010 by Gallaudet University and Hansel Bauman

Fig. 07. Conversation Eddies, Fragment Study.
Source: Nathaniel Clement. Concept Development Guideline Study.

He advanced the merging of these spaces in his precedent investigation of Hellerup School by Arkitema Architects in Denmark, where he studied how stairs, seating, and gathering could be seamlessly combined while distinctly coded into one space. (Fig. 07) His analytical methods of diagramming in plan and axonometric drawings sharpened his strategies in designing the Community Center. He identified these zones throughout his scheme through tones and color that contrasted with human skin so that signing and facial expression could be clearly seen. These resulted in “conversation eddies” or spaces along a path that could expand to become spaces of gathering, communication, and connection for varied-sized groups. [6] (Fig. 08)

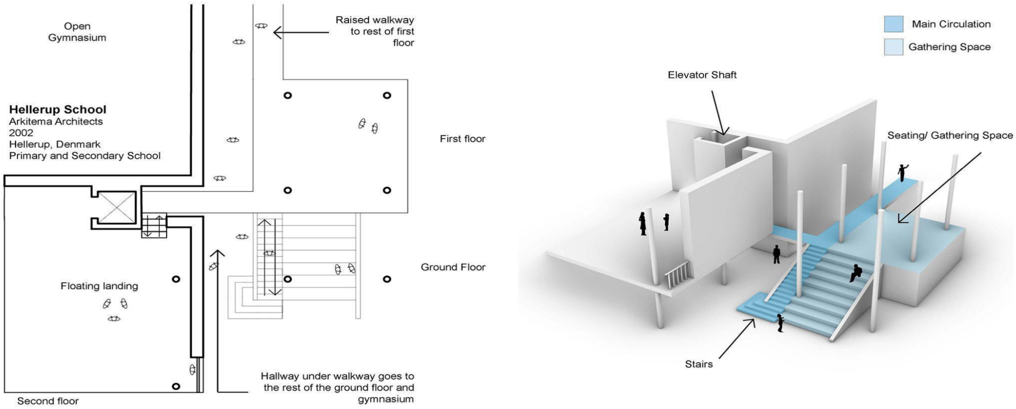

Fig. 08. Analysis of Circulation and Gathering Spaces in Hellerup School in Denmark.
Source: Nathaniel Clement. Precedent and Guidelines Research.

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[6] From *Deafspace Design Guidelines,* Chapters 1.3 Collective Space-Promoting Connection, 3.1 Pathways & Flow, and Chapter 4.1.2 Color Eddies, written in 2010 by Gallaudet University and Hansel Bauman.

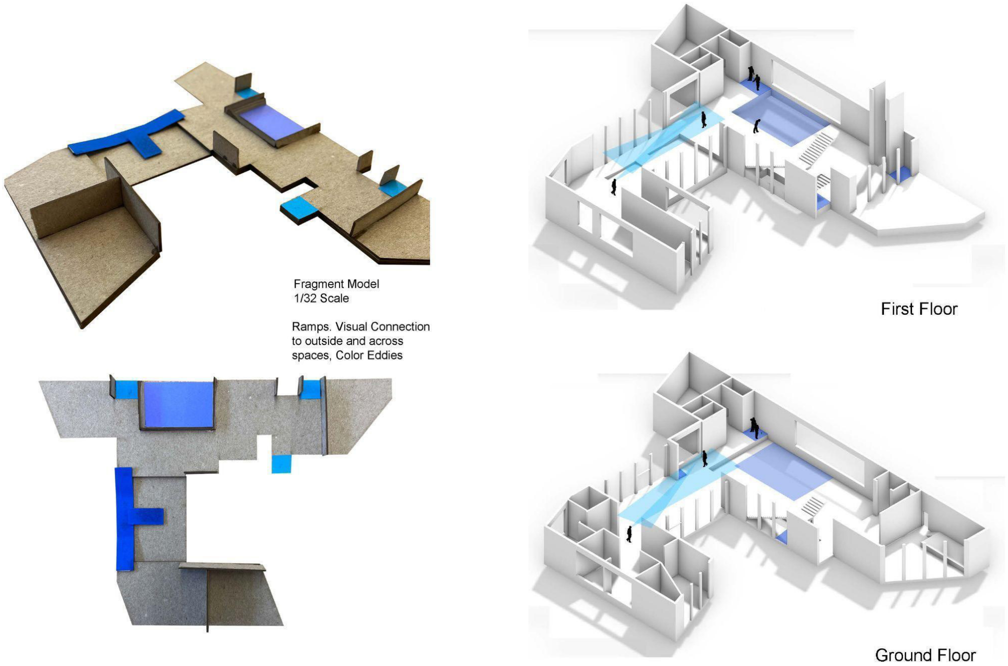

Fig. 09. Conversation eddies explored in model and axonometric drawings.
Source: Nathaniel Clement. Community Center.

Visual and Spatial Connections

In Colin Sainato’s project, spatial orientation and connections were critical concepts. (Sainato, 2022) He intended for individuals inhabiting the space to have visual cues to see and connect with others in an expansive vertical area. In his study of Gallaudet University by Studio 27, he observed that the center atrium allowed for a clear view between floors. The glass allowed for visibility yet permitted minimal acoustic distraction while helping one feel a part of a shared public space. (Fig. 09) He translated lessons from Gallaudet’s spatial and visual connections into his final design of the Community Center, where he brought natural light into the central space and to each floor. He created visibility and spatial connections in the interior of the building both vertically across floors and horizontally across the ample main space. (Fig. 10) He also used the full floor-to-ceiling windows to create engagement with the exterior of the building, with balconies that extend the inside-out and the outside-in, providing a sense of time. Finally, he developed an inviting space at the ground level and entry that considers how users use vision as a primary means of way-finding. He opened the space, with interior spatial arrangement so users could see what may lie ahead, pause, communicate with friends, and see potential barriers, before they move further into the building.

Fig. 10. Analysis of Connections and spatial awareness of STM Gallaudet University by Studio 27.
Source: Colin Sainato. Precedent Study.

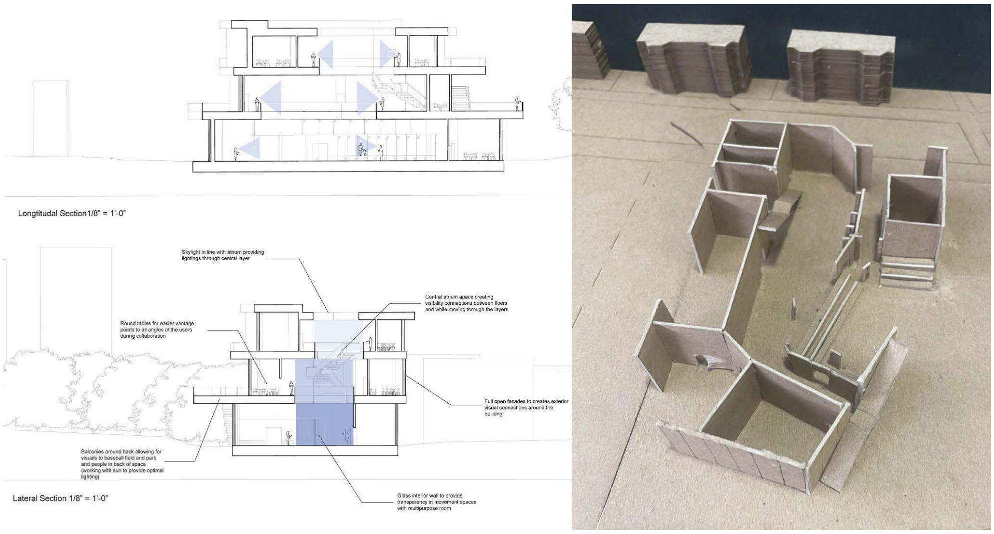

Fig. 11. Final Section and Ground Floor of Community Center.
Source: Colin Sainato. Central Gatherings and Layers.

Conclusions: Inclusivity and Intersectionality

The methodology in this studio project encourages students to thoughtfully consider the human body to produce an architecture of inclusiveness. The topic area provides opportunities to listen empathetically and learn from the Deaf and hard-of-hearing community. With these criteria in mind, students worked at multiple scales: the body, the space it occupies, the design of circulation, and wayfinding through a sequence of spaces. By starting at the scale of the body, the studio could produce learning outcomes that considered different types- of abled- and disabled bodies and produce through iteratively designing spatial conditions and movement sequences that actively engage with the parameters of accessibility. ADA was not relegated to a perfunctory checklist of dimensional criteria but rather a social and cultural driver of access and catalyst of architectural thought toward inclusive space-making. Oscillating between these varied scales, students worked both from the inside-out, advancing their understanding of sensory ecologies of Deaf spaces, and the outside-in, synthesizing the context and community around the designated site.

It is clear that incorporating Deafspace principles such as space and proximity, sensory reach, mobility, light and color, and acoustic, can have significant benefits for all users, not just those who are deaf or hard of hearing. By prioritizing sensory experience and multi-scalar design methods, architects can create spaces that are more inclusive, functional, and accessible, while promoting a sense of community and belonging.

Deafspace principles also have the potential to create connections between various design disciplines, particularly interior design and landscape architecture. In interior design, visual cues such as contrasting colors and patterns, solar and electric lighting design, and interior sequences and furniture design can aid in wayfinding and promoting spatial awareness and inclusivity for Deaf individuals. In landscape architecture, utilizing Deafspace principles can enhance the sensory experience of outdoor spaces. By prioritizing tactile and olfactory elements such as plants and textures, designers can create spaces that engage multiple sensory modalities and promote connection with the natural world.

In summary, this paper seeks to contribute to design studio pedagogy and discourse at the intersection of inclusionary design, disability justice, and the centering of the lived experiences of historically marginalized perspectives and voices. The topic of disability has a fundamental architectural dimension that has been under-examined by the discipline. It affords and requires engaging with and learning from the rich experiences of disabled people historically marginalized from the status quo. Within this context, the same fundamental ambition remains to design an improved built environment for those who use it, with broader underlying aspirations for diverse collective life and a more inclusive and multi-scalar approach to developing sensory ecologies for the Deaf.

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Ambiance and Scale in 5-Microenvironments: A Design-Build Focus Studio

Introduction

The role of digital tools for design representation gradually has become more integrated with full-scale fabrication. There is no reason why the education of architecture would only be limited to design and representation and not embrace construction. With the availability of digital software and hardware, in particular 3D applications in combination with laser cutters, 3D printers, CNC routers, and traditional wood shop, unlimited opportunities are available to explore ‘design thinking’ and ‘visual grammar’ along with execution of full-scale physical construct. The concern of safety in construction, as well as duration of completion within a semester’s time is now more realistic than before. The objective of this paper is to demonstrate the design, representation, and construction of 5-solar powered functional pods by undergraduate students (3 to 4 students in each group) in an elective design studio within a 12-weeks’ time frame.

This studio demonstrated the entirety of a design process from conception to execution using both manual and digital methods to embrace the notions of three-dimensional design thinking, visualization of details, graphic motif, composition of space-form-material-light, use of proper digital tools, calculated budget, and methods of full-scale construction.

Design and construction of a Mini Pod with specified ambiance and function for human use being the main project the studio also asked for construction of a number of artifacts that complements the final Pod and creates a new ambience of the created environment.

Considering the fact that architecture is as much a science as an art, this paper aims at linking and visually applying both arts and science in a full-scale construction of microenvironment (functional pod).

The paper highlights the “Sensory Pod” (one of the 5) designed and constructed by the studio in its entirety, from perception to execution. The concept was to design an ambiance to reduce stress levels through the simulation of five senses, touch, vision, hearing, smell, and taste.

It is to be noted that the scope of the studio was limited only to design and construction and not on follow-up evaluation of its use or effectiveness.

Focus Studio and Design-Build

The Fifth-Year Focus Studios are intended to introduce the student to design research and its application, while adhering to creativity, critical thinking, processes of making, and constructability……All qualified fifth year students have the option to select a studio critic who will broaden their area of interest in a subject-based studio.

DIY vs. Structured Learning in a Design-Build Studio

The effective education comes from experience, be it in architecture or in other professional fields. To define active interactive learning, it can be said that it is a condition in which the course of learning is controlled by the learner. Such conditions may result from the user's action as well as reaction to the environment the learner is dealing with. It has been proven by experiment that people find it easier to learn and remember knowledge visually, and that information stays in that person's memory longer if it is obtained by the learner actively reaching out for and manipulating it rather than fed passively.

DIY is an abbreviation of "do-it-yourself" from 1950s. In architecture it primarily means an activity of construction done by oneself, as a non-specialist or by a person without relevant professional qualifications. While a DIY is the foundation of getting ready to disseminate that knowledge, a design-build formal teaching must be a structured learning and not a random one that leaves room for uncertainty. To test the extents and limitations in a possible design-build studio offering, a 6' cubic garden pod powered by solar energy was solely constructed by the author before creating structured content for this studio (figure 1).

Figure 1: A cubic garden pod powered by solar energy solely constructed by one person, the author of this paper.

Source: Author

Subject of this Focus Studio

This course focuses on creating an ambiance through the design and construction of a functional personal pod that uses sun and wind energy for its primary function. Creating artifacts using motifs of art and applied graphics to create the desired ambience for the pod was an optional task of this studio. The main goal of this course was to explore the link between art and science for creating micro-living environment (figure 2). The four main components of this studio were:

- Arts and Science in Architecture
- Ambiance and Scale
- Functional Microenvironment (self-sustained and solar powered)
- Design process and design-build

Art and Science in Architecture

The Arts of Design-Build

One of the objectives of this studio was to investigate the relationships between art, science and design-build. The basic questions along this inquiry included;

- Defining co-relationship between art, graphics, visual design principles, and architecture
- Defining Art, Science, and Architecture
- Elements and Principles of Visual Design
- Applied Visual Graphics (Geometry and Pattern)
- Texture: Visual and Tactile
- Surface exploration with graphic pattern and texture

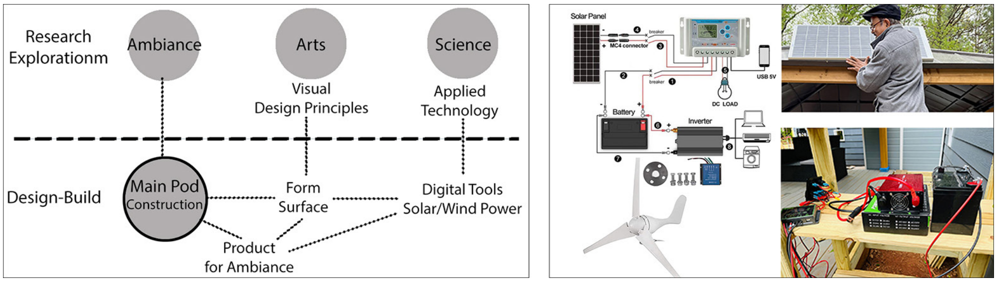

Figure 2: Diagram illustrating arts and science of design-build (left half) and demonstration of 12-volt solar power system components by the instructor.

Source: Author

Art is defined as a highly diverse range of human activities engaged in creating visual, auditory, or performed artifacts, artworks, that express the author's imaginative or technical skill, and are intended to be appreciated for their beauty or emotional power. "Art can employ skill and imagination to produce objects, performances, convey insights and experiences, and construct new environments and spaces."

As an act of art this studio project looked at surface as its canvas to integrate various elements and principles of visual arts to create graphics, texture and pattern.

Students were asked to define "Surface" in physical entities and in architecture. Research and documentation of main categories of surfaces with their physical, visual, and sensual characteristics were to be investigated.

The task was to design, draw, and represent various types of surfaces using principles of visual composition in a 4'x4' surface. This surface could be a single plane, tiled, or modular. The design and construction were intended to express one or more of these visual design principles of Progression, Movement, Gradation, Radiation, Rotation, Anomaly, Contrast, Concentration, Hierarchy, and Focus.

Various combinations of Graphical, Textural, Modular, Porous/Perforated, and Translucent surfaces were to be explored for this segment of studio.

The Science of Design-Build (Applied Science, Technology and Net-Zero)

Science is the pursuit and application of knowledge and understanding of the natural and social world following a systematic methodology based on evidence. Modern science is typically divided into three major branches that consist of the natural sc iences (e.g., biology, chemistry, and physics), the social sciences (e.g., economi cs, psychology, and sociology), and the formal sciences (e.g., logic, mathematics, and theoretical computer science), Disciplines that use existing scientific knowledge for practical purposes, such as engineering and medicine, are described as applied sciences.

The technology of energy to run appliances or to control an environmental condition is considered as applied science. To be off-grid and net zero, both solar and wind power are effective sources of applied science through 12-volt systems. While solar system does not need any special considerations (except exposure to sunlight) the wind power system would highly be dependent on velocity of prevailing wind at the location of the wind turbine.

For off-grid power supply the first consideration was the voltage of the power supply based on the function and need. If the purpose is to illuminate the interior space, illuminate reading need, on-screen projection from laptop, recharge a phone, power a laptop, output audio/ music through Bluetooth then a low-voltage power system would be good enough to power individual pods. Since 12v systems are good for many DIY power supplies such as RVs/motorhomes/vans, Camper trailers, Small cabin or tiny home it makes the system versatile and adaptable and safe to work with. For landscape lighting 12 volt is a standard system and various options of LED lights, cable, connectors are readily available to purchase.

The Design-Build Studio

Process

The studio started with the intention of linking proposed construction and creation of ambiance. Additional product design to enhance the intended ambiance was suggested.

Design considerations included a) Volumetric space based on function and ergonomics, b) Interaction with sun, wind, and air through surface articulation, c) Understanding arts and science of micro-environment, and d) Integration of power to run the function of the pod.

Similarly, construction considerations included a) Light-weightiness, b). Cost effectiveness, c) Ease of assembly-disassembly, and d) Quality of surfaces and finishes.

The studio content included five basic premises: a) Research, b) Observation, c) Analysis, d) Synthesis, and d) construction. It starts with the investigation and definition of Ambiance. The purpose was to investigate the relationship of the proposed construction and the quality of Ambiance intended to be created by that construction. Additional product design could be introduced to enhance the intended ambiance. Students were asked to investigate these following items.

- What is Ambience?
- Types of visual and sensory ambience
- Elements of ambiance in drawing, physical model, and 3D rendering
- Purpose and objective of the pod
- Design proposal in orthographic drawing, physical model, and 3D rendering
- Physical objects to be designed and constructed to create ambience, such as artwork, painting, sculpture, wall tile, lighting fixture, dinnerware, time device,

Defining and explaining Ambiance was the beginning of the studio. All 18 students were asked to propose two ideas of proposed structure through scale-drawings, 3d renderings, and physical scale models. Out of 18 proposals 5 are finally selected by votes (figure 3). Then teams of 3 to 4 members were assigned to each proposal for development and full-scale construction.

Surface

Next, students are asked to individually research on “Surface” and its visual and textural qualities. Investigating materials, methods, and techniques to create unique surfaces with texture, pattern, color, and applied graphics was the goal. Graphical, textural, modular, porous/perforated, and translucent surface panels were to be created in panels of tiles by each student.

Structure, Envelope, and Assembly

To understand the primary structure the students were asked to construct a 25% reduced sized physical model to understand the stability and details. Materials of interior, accommodation of battery, wiring, and other systems were also investigated through this model. It was noticeable that most groups were thinking of using unnecessarily heavy material based on their Revit model rather than optimizing the structure. Then they were asked to construct the basic enclosure/envelope in full-scale using low-cost insulation boards to get a good sense of optimized space volume and functional need.

Construction Cost and Funding

Budget was an important consideration which could become a hindrance for design iterations and experimentation. Each group had to research materials and supplies in context to their specific pod design. Each pod started with a construction budget of US $700 primarily for material and equipment. Each group was asked to create a detailed list of itemized materials with web links for purchase options. Based on the accumulated list the instructor raised the limit to $1,000 each requiring a total of $5,000 to construct 5 pods. Consequently, the instructor was successful in securing the total funding from two different sources: about 70% from the competitive Annual Dean’s Research Grant and the rest 30% from the Design Communication Association.

Figure 3: Top 5 pod proposals selected for construction based on concept, function, and cost.
Source: Author

Summary of Constructed 5 Pods and Features of their Microenvironments

Re-Focus (Cost US $ 920)*:* Re-focus is intended to be used for studying and other work-related actions. It is an ambiance pod that puts the user into a focused state by nature of its enclosed layout. The entirety of the pod is only three feet by four feet at its base, stretching up to 7 foot six inches at its tallest on the roller casters.

The Plex Pod (Cost US $ 1247)*:* The main feature is a collapsible structure that allows contraction and expansion of the design. This allows for a difference in size based on the number of users and ease of transportation. The construction is made of dowels and different types of 3d printed connectors.

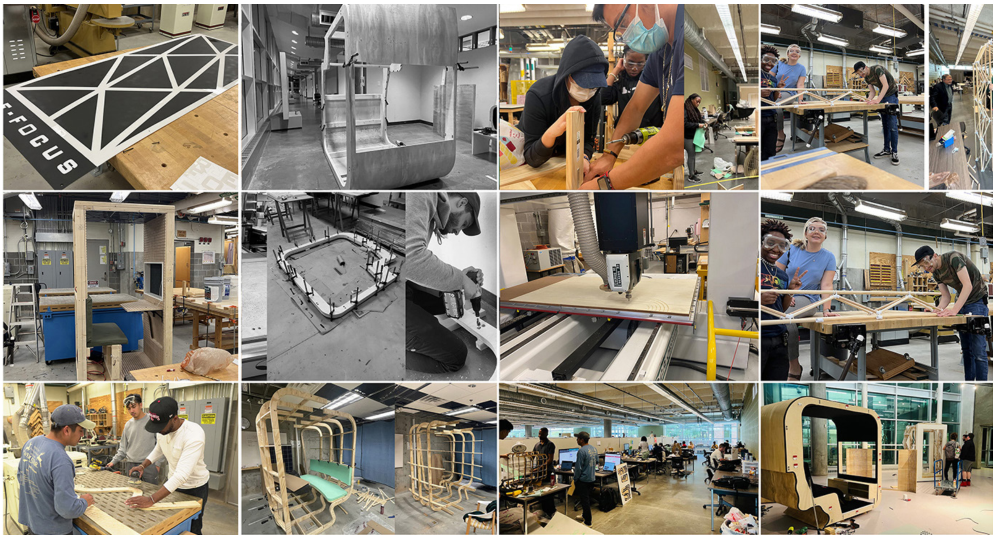

Figure 4: Construction phase illustrating techniques and methods of construction by five groups. Source:Author

FILTR. a sensory pod (Cost US $ 884.93)*:* The purpose of the Sensory Pod (figure 6) is to provide personalized comfort through aimed sensory stimulation. The design incorporated a projector that will have a chosen audio and video, according to people's mood. Textures to experience vary of feelings through touch, and a scents diffuser to go along with the desired ambiance.

The Zen Pod (US $ 744): The Zen Pod reconnects one's mind, soul, and body. Zen is defined by the state of calm attentiveness in which one's actions are guided by intuition, like meditation and yoga. The form is an enclosed diamond shape that represents direction. The direction to take within oneself.

The Work in Progress Pod (Cost US $ 1100): The concept of the Work In Progress Pod is drawn from a desire to meet the needs of students to disconnect from the surrounding environment to enable them to develop a higher level of focus. While the purpose of the pod is to spur a higher of focus the overall function of the pod is an adaptable space that allows inhabitants to be flexible enough to engage in a variety of activities.

Explanation of "FILTR. a Sensory Pod"

Statement by students:

> The purpose of the Sensory Pod is to provide personalized comfort through aimed sensory stimulation. In our design, we incorporated a projector that will have a chosen audio, according to people's mood, and at the same time will be showing a video or series of images, and this brings us to the second sensory, vision. Studies show that the mind reacts to what it sees, based on a level of physical association. With our design, we want to offer people the ability to choose the video and sound to be displayed on a translucent screen that will be projected to the outside for the exterior audience to experience a bit of the interior ambiance. For olfactory sense, is written in history as being directly connected to the memory function of the brain. One's smell is connected to their memory and can be used to influence emotion. Our design provides a diffuser that personalizes the ambiance, which scent could recreate memories or create new ones at the time that visual and audio are being displayed. Touch therapy can have psychological effects on participants. Touching or being touched specifically relates to increased dopamine release. Human-to-human contact has its effects, so how can materiality be used to generate personalized stimulation? Our sensory pod offers different textures to experience different feelings. By combining specific sensory experiences, a mood can be curated for the users of the pod. This concept is commonly used to describe the combination of audio, visual, and tactile stimuli. We will be applying this concept to use olfactory stimulus to achieve gustatory reactions. The pod uses materiality and technology to offer modes of relaxation for the user. In the pod, there is a cavity that houses a projector aimed at an acrylic screen. This acts as a window to create interaction between the inside and outside of the pod.

Framework of Design Concept

The initial proposal started with defining and correlating ambiance and five senses for a space that would relieve stress and can be used for a variety of functions. Transformation of that sensory concept was suggested through the following methods of material use, technology adaptation, space modulation and designed artifacts.

Touch: Wood roller seating for upper, middle, and lower back to relieve muscles.

Vision: Translucent screen that shows the movement of color according to music vibration. Screen to show ambience/mood inside of the pod reflected to the exterior.

Hearing: Music can be played according to people's mood and vibrations will be reflected in colors on the translucent screen.

Smell: Plants with calming scents to be placed near or around translucent screen to provide relaxing ambience while colors play a role in the plants according to type of music.

Taste: Space and fixtures for dining, to keep the ambience calm.

Figure 5: Ambiance, five senses, and features of ambiance.

Source:Author

Perception and Visualization

The project started with a detailed proposal explaining the purpose, function, and construction methods through drawings, 3D renderings, exploded axonometric and a detailed scale model in 3" = 1'-0". Next, students were asked to investigate materials, methods, and techniques to create unique surfaces with texture, pattern, color, and applied graphics.

Figure 6: The Sensory Pod proposal with orthographic drawings and a detailed physical model

Source:Author

Scale, Material, Structure, Envelope, Assembly

To understand the scale and structure the students were asked to construct a 25% (3” = 1’-0”) reduced sized physical model to understand the structural stability and close-up details. Materials for interior, accommodation for electrical wiring, and other systems were also investigated through this model (figure 7 top row).

For the main structure the two primary profile sides were CNC cut from 2 layers of ¾” plywood and glued together for strength. Then horizontal bracings or studs were then connected with adjustable anchor bolts for easy assembly and disassembly. The organic wrapping envelope using ½” plywood was achieved by scoring and making grooves on the inner side and formed by hot water, glue, and clamps. Once formed in shape and left for a day the shell became stiffened and permanent. This allowed the organic wrapping to be constructed in modules for easy assembly (figure 7 bottom row).

Figure 7 (top row): The development of full-scale construction for structure, envelope, and assembly was based on a 25% reduced scale (3” =1’-0” scale) physical model.

Figure 7 (bottom row): Construction techniques include CNC milled main frame, anchor bolt for horizontal bracing, and scored and grooved plywood for undulated wrapping form.

Source: Author

For exterior finished panels aluminum composite material (ACM) left over from a construction site was used because of its lightweight and sturdiness. A perforated pattern was cut using CNC router. To attach these exterior panels Z-clips were used for easy assembly and achieve clean surface at the exposed area (figure 7 bottom row).

The final pod was equipped with an audiovisual system allowing to use digital devices to charge and project images and videos in its integrated screen that are viewable from both inside and outside (figure 7 and 10). Students were asked to produce a visual logbook illustrating every studio session’s progress as part of the final documentation.

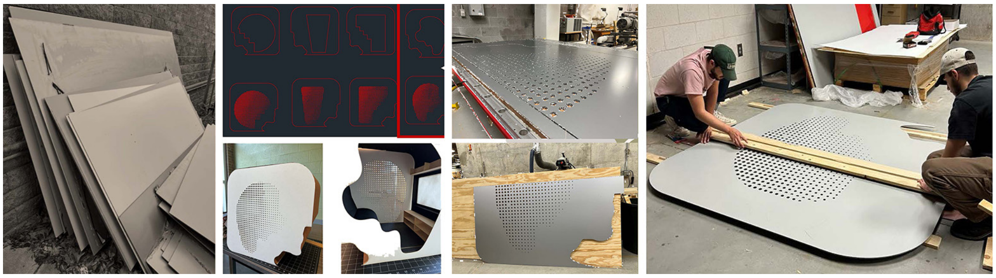

Figure 8: Exterior finished panels from recycled aluminum composite material.

Source Author

Figure 9: Final review showing assembly process and use of the pod by visitors during the curated exhibition.

Source:Author

Observation

In general students are interested in construction and design-build. But they do not necessarily had either the knowledge or the patience to construct a well-crafted construction. For most students' investigation and research were not expected in a design-build studio. The biggest challenge was to motivate students to explore options of unique material, texture, surface and quality of finishes. The sense of scale for initial selection of fixtures was not inspiring.

Some groups were interested in informing the instructor in every step of the work progress, making the communication open to both sides. One such communication on technology test and material cost is sited below.

> "Professor Uddin, Attached is a file we have been using to identify the materials we need and where to find it, each of them have the links. We are planning on starting the real scale model tomorrow, we will work on a more detailed version of the 25% reduced scale model, and we are all in agreement on structure, finishes, and function of the Pod. Also, we tried the projector yesterday and it works perfectly with laptops, androids and iPhones."

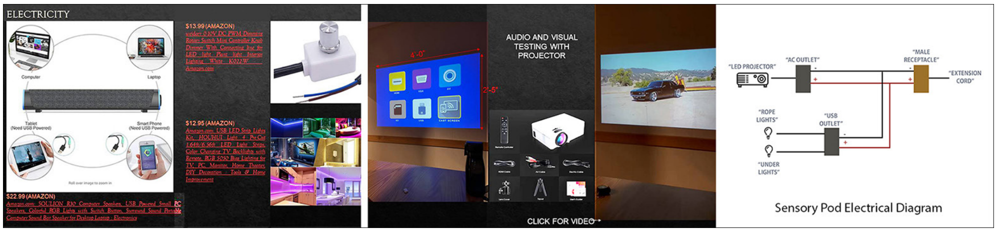

Figure 10: Video-audio test to check projection distance.

Source: Author and Student Andrea

Budget is an important consideration which could become a hindrance for design iterations and experimentation. One group ordered the wrong type of boards incurring additional expenses that the school had to deal with after the semester was over.

In a professional accredited architecture program, a design-build studio must have a balance between investigation, representation, and actual construction.

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Modularity as an enabler of scalability in industrialised building platforms

Introduction

The productivity of the construction industry has lagged behind other sectors for decades, hindered by the linear and fragmented processes of traditional building activities (Aitchison *et al*., 2018). Among the main causes of such fragmentation is the one-off project-based approach of traditional construction that isolates the design and the construction phases (Vrijhoef and Koskela, 2000). The lack of integration across the building value chain accounts for critical decisions being left to be resolved on-site. This results in inaccuracies, delays, rework, increased waste, cost, low productivity, and a lack of continuity of the processes for reusability in future projects (Rocha *et al.*, 2022).

In this context, industrialised building (IB) offers promising opportunities for productivity gain through technical process-related approaches. IB is defined as an approach that incorporates prefabricated building production while adhering to the organisational, technological, supply chain and market-related issues towards continuous improvement of products and processes (Lessing, 2006). Since the early 2000s, companies have developed new production approaches for increased efficiency and process innovations including IB principles such as the one of 'product platforms' (Lessing, 2006, Lidelöw *et al*., 2015). Originating in the manufacturing industry, a product platform is defined as the collection of common assets (i.e., components, processes, knowledge, people and relationships) that are shared by a set of products (Robertson and Ulrich, 1998, p. 20). In IB, product platforms allow differentiated production and assembly of standardised building components while supporting continuous improvement of recurring processes (Lidelöw *et al*., 2015).

Two distinct views exist within the product platform approach of IB companies: product and process-orientation (Lessing and Brege, 2015, Maxwell, 2018). It has been argued that IB companies' product platform approaches are predominantly product-oriented, prioritising product development and production quality over process improvements and product variability, resulting in limited product offerings (Maxwell, 2016). Furthermore, product platform literature in IB has largely emphasised modularity for standardised product development, and less so for process modularity (Veenstra *et al*., 2006, Lessing and Stehn, 2019).

This study aims to bridge this gap by examining the concept of process modularity in IB platforms. Specifically, it investigates how work processes can be structured as modules for reusability in IB projects. Through the analysis of a case study, this research captures data and documents work processes across the design-to-assembly value chain of a 'live' IB project— a timber-built prefabricated multi-family residential building development in Australia. By analysing empirical data, this paper presents a view of process modularity within IB platform thinking. It is expected that this work may contribute to IB by informing future strategies for leveraging process knowledge across multiple projects, enabling higher productivity, scalability and product variability in building delivery.

Theoretical background

Industrialised building

IB refers to an approach to building that relies on advanced process considerations supported by standardised components and prefabrication (Crowley, 1998). Recent studies recognise IB as a concept that involves integrating technical and process-related factors, including design, planning, logistics, production technology and product quality into a long-term strategy to provide desirable customer offerings (Lessing and Stehn, 2019). Lessing (2006) introduced the necessity for integrating several constructs to characterise industrialised house-building (IHB) (synonymous with industrialised building), where prefabrication is just one of the constructs, but not sufficient alone to define IB. Lessing's conceptual framework for IHB emphasises eight areas, including planning and process control, developed technical systems, off-site manufacture of building parts, long-term relations, logistics integration, customer focus, use of information and communication technology (ICT) tools, and reuse of experience. These constructs require integration and reinforcement by continuous improvement of solutions (the ninth area) in order to support the industrialisation of house-building beyond single projects. During the early-2000s, renewed interest in industrialisation saw increased investment by a number of companies in Japan, Europe, the USA and the UK, translating in the development of new approaches for IB. Of major significance is the Swedish construction industry, where housing companies have sought effective ways for project delivery based on process innovations and product platforms (Lidelöw *et al*., 2015).

In Australia, the adoption of IB is not widespread. A lack of understanding of the IB systems, limitations in the building industry supply chain to support the establishment of off-site production at scale, and a traditional approach to house design and construction have been identified as hindrances to its holistic adoption (Khalfan and Maqsood, 2014). Currently, a small segment of the housing market involves prefabrication or off-site manufacturing (OSM), representing only 3% of Australia's $150 billion construction industry (Blismas and Wakefield, 2009). Reviewing the current state of IB implementation in the global construction sector, particularly in the Swedish IB industry, provides a valuable reference for the adaptation of product platforms in the specific context of the Australian IB industry, to achieve higher productivity, quality, and flexibility in customer offerings.

Product platforms

A product platform is a method of sharing components and production processes, allowing companies to launch differentiated products efficiently through a flexible, responsive and resource-efficient production system (Meyer and Lehnerd, 1997, Robertson and Ulrich, 1998). By using this method, companies develop 'product families' (groups of related products) to satisfy a variety of market niches, whilst also maintaining economies of scale and scope in their manufacturing processes (Simpson *et al*., 2006). Meyer and Lehnerd (1997, p. 7) define a product platform as "a set of common components, modules, or parts from which a stream of derivative products can be efficiently created and launched". Platform-based product development allows companies to derive modular product families by adding, removing, or substituting one or more modules or by scaling them in one or more dimensions to target specific market segments (Meyer and Lehnerd, 1997).

In the early 2000s, a renewed emphasis on IB resulted in several house-building companies adopting the product platform approach to facilitate continuous improvement of both products and processes (Jansson, 2013). According to Lessing (2019), this approach allows IB companies to balance between the level of predefinition and the level of project-specific solutions to target suitable market segments for their product offerings. Within IB companies' product platform approach, the literature highlights two dominant views: product and process-orientation (Lessing and Brege, 2015, Maxwell, 2018). Product-orientation offers an alternative to the traditional one-off project-oriented approach in building construction. It involves utilising a platform or pre-developed structure to design and produce repeated products (Lessing, 2015). To ensure efficiency, product-oriented IB offers a specific range of products, aimed at specific customer segments. While this approach limits the scope of product variability, it allows predefining production methods, technical solutions, and subsystems, resulting in an efficient end-product configuration (Johnsson, 2013). In contrast, process-orientation primarily focuses on reusing work packages on separate building projects on a recurring basis (Lessing and Stehn, 2019). The value of this approach lies in achieving stable and continuous processes, which can be improved based on performance measurements and experience from previous iterations (Meiling *et al*., 2014). Process-orientation involves integrating design, planning, and production with the supply chain to achieve increased customisation in product offerings. The opportunity presents greater flexibility in handling parallel projects, leading to long-term benefits in speed, quality, cost efficiency, and safety (Jansson *et al*., 2008).

Modularity

Within the product platform literature, modularity is an important concept and a key enabler for customisation (Hvam *et al*., 2008). Modularity refers to the structure of a product or process that is comprised by smaller subsystems (modules or chunks) that can be developed independently, yet can function together as a whole (Rocha and Koskela, 2020). In manufacturing, modularity often involves the repetitive use of a single set of interchangeable units, which are assembled together for the development of differentiated end-products (Ulrich, 1995). Bonev (2015) argues that modularity contributes to an organisation internally through standardisation while having high external variety towards the market. From this perspective, many companies in manufacturing have focused on product modularity, through a product platform approach to derive product families for satisfying a variety of market niches, while maintaining shortened lead times, and reduced costs (Meyer and Lehnerd, 1997).

While modularity has been extensively researched and applied to define manufactured products (Ulrich, 1995), the one-off nature of most projects has limited its impacts in the construction industry (Vrijhoef and Koskela, 2000). In the context of IB, modularity is often understood from a product viewpoint, where a building is assembled using a unique set of standardised components (physical parts, sub-assemblies or modules), with limited opportunity for variation. By contrast, a process viewpoint would recognise a set of predefined activities or work packages as process modules (i.e., workflows, collaborative decisions among stakeholders, design and planning methods, etc.), across the building value chain (Rocha and Kemmer, 2018). In theory, these process modules could be reconfigured for reuse on differentiated building projects, facilitating scalability and customisation. However, there is a research gap in characterising and structuring IB work processes as reusable modules to improve both product variety and process efficiency.

Process modularity

Process modularity in construction refers to the management and control of production methods (Voordijk *et al.*, 2006). The value of a modular process becomes evident when a system expands to a magnitude where achieving integrated design and production becomes challenging due to the interdependence between physical components (Rocha and Koskela, 2020). According to Björnfot and Stehn (2007), process standardisation is the core of modularity. Reijers and Mendling (2008) assert that modular process design can benefit from scalability, which refers to the ability to enhance both production growth and product diversity through the reuse of process modules. Therefore, efficient product delivery depends not only on a high degree of product predefinition but also on predefined processes. From this perspective, IB companies applying such processes require different structures in comparison to traditional building companies in order to effectively utilise well-developed processes with defined value chains, repetitive operations and technical solutions, and experience feedback (Johnsson and Meiling, 2009).

In this context, Lessing (2006) presents the concept of product development and continuous improvements of IB platforms (Fig.01). Lessing structures these development streams into technical and process platforms that must be developed and managed simultaneously. Technical platforms are proposed to configure engineering solutions, establish standards, and develop interfaces and systems suitable for effective production, transportation, and assembly of building components. Process platforms include instructions and guidelines regarding production processes. This involves a systematic collection and organisation of process modules concerning workflows, collaboration, logistics, information handling systems, design and planning methods among others.

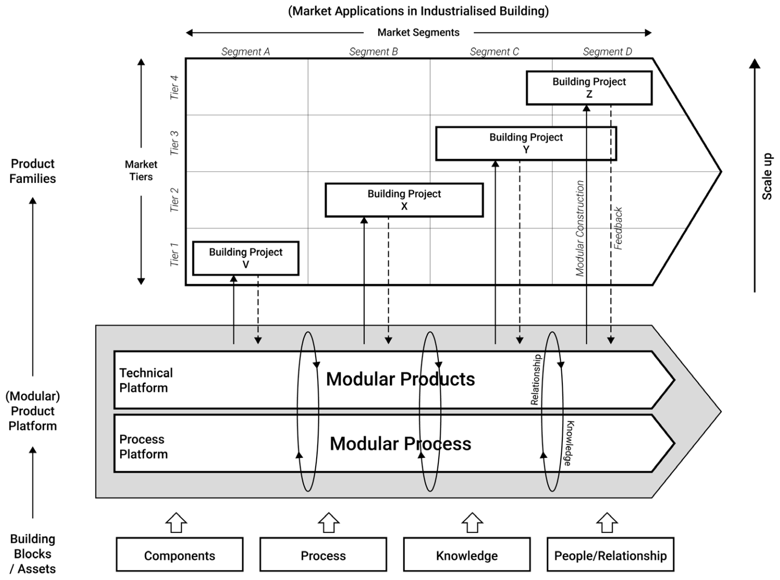


Fig. 01. Enabling scalability through modularity in technical and process platforms in IB.
Adapted from Meyer and Lehnerd (1997) and Lessing (2006).

In this platform approach, buildings are still produced as projects, while effectively scaling between differentiated market tiers. At the end of each project, learnings from executed projects are systematically reviewed to serve as input for further improvement of the overall platform strategy. Product platforms for IB hold the potential to benefit from aligned process modularity in structuring work processes as a means of project support. In this context, the definition and characterisation of process modules is an issue yet to be resolved. Starting from the product platform definition by Meyer and Lehnerd (1997) through to its introduction in IB by Lessing (2006), this research explores the concept of process modularity in IB platforms covering the entire building value chain, including design development, manufacturing, and assembly.

Methods

This study examines modularity in the building processes as an enabler of scalability, specifically in relation to scaling up the production of differentiated end-products through IB platforms. By undertaking case study research, this paper engages in the observation and documentation of data to critically analyse the processes involved in the design, manufacturing and assembly of a prefabricated multi-residential apartment project in Australia. This research methodology provides qualitative methods to understand how companies manage, develop, and operate their processes, technology, and relationships (Yin, 2003).

More specifically, the 'live' IB project involves the development of a 14-unit apartment building, comprising a three-storey and single-basement structure. The project is led by a developer (DE) in Australia, aiming to implement an IB strategy to increase the efficiency of their building delivery process. The platform strategy of the company is in development, which presents an opportunity to investigate how entire building processes can be structured as reusable modules within a platform-based system. In this project the DE has engaged a team of stakeholders for a period of two years (2022-24), covering five specific stages: 1) design development, 2) planning permit, 3) production and manufacturing, 4) logistics and assembly, and 5) completion. At present, the first two stages are complete and the developed design has been locked at an 80% level to obtain the required town planning permits. Throughout the design development and planning permit stages, the work processes have been documented by observing actions and collaboration between stakeholders during regular coordination meetings and team workshops. These meetings have been a crucial source of data to describe stakeholder relationships and processes concerning design decisions, component configuration, interface, material knowledge, supply chain logistics, quality, compliance, regulations, production process and technology among others. This paper analyses observations documented in 15 coordination meetings over a 9-month period (June 2022-March 2023). The documents exchanged during these meetings, including design drawings, compliance reports, developed drawings, and tender documents, have also been documented and assessed to determine the sequence and level of work progress. By collecting and analysing this empirical data, this study explores factors involved in a platform-based approach to structuring process modules for reusability in future IB projects.

Results

This section presents a synthesis of the information gathered from the case study project. During the coordination meetings, a number of stakeholders performed a range of activities within the stage: 1) design development and 2) planning permits. The stakeholders collaborating in this project are listed in Table 01. These stakeholders can be clustered as primary and secondary consultants:

Table 01. List of stakeholders

Primary Consultants	Secondary Consultants
Developer (DE)	Landscape Architect (LA)
Architect & Interior Designer (AR)	Sustainability Management Expert (SM)
Civil/Structural Engineer (SE)	Traffic Engineer (TE)
Prefab Building Manufacturer (PR)	Geotechnical Engineer (GE)
MEP/Building Services Engineer (ME)	Tree Management Expert (TM)
Fire Engineer (FE)	Quantity Surveyor (QS)
Acoustic Engineer (AC)	Market Surveyor (MS)
	Land Surveyor (LS)
	Town Planner (TP)
	Building Surveyor (BS)
	Builder (BU)
	Fit-out Team (FT)

While the primary stakeholders are the main design and technical decision makers, they frequently had to rely on the information and support provided by the secondary consultants. As a result, one defining characteristic of these activities was their level of interdependence between consultants. Tasks performed by one consultant team often served as prerequisites for the progress of other teams, while also supporting future execution. For instance, the development of the ESD report provided support (predecessor) for the MEP team's preparation of initial drawings and concept design report of building services. This collaboration allowed for necessary modifications to be made to the MEP system, ultimately contributing to the architectural layout development by the Architect (successor). Another important activity towards the end of the design development stage involved integrating architectural elements, prefab structures, and building services into a single BIM model. The Architect was primarily responsible for this integration, receiving support from the other two teams. The collaboration among these stakeholders resulted in the consolidation of the design development at an 80% level. As a result, the finalisation of the tender documentation was achieved in February 2023, and prospective builders were invited to participate in the tendering procedure.

In this research, these dynamic relationships between the work processes and dependencies of the stakeholders are meticulously documented. This is to structure these processes as modules to bring efficiency to the case company's management of similar future projects through the reuse of such modules on a platform-based approach. Figure 02 & 03 illustrates the dependency of the stakeholders who performed a range of activities across several months as part of the design development and planning permit stages. Based on the interrelationships between the chronological activities observed across these two stages of the case study project, this research has clustered these work processes in 14 work packages –

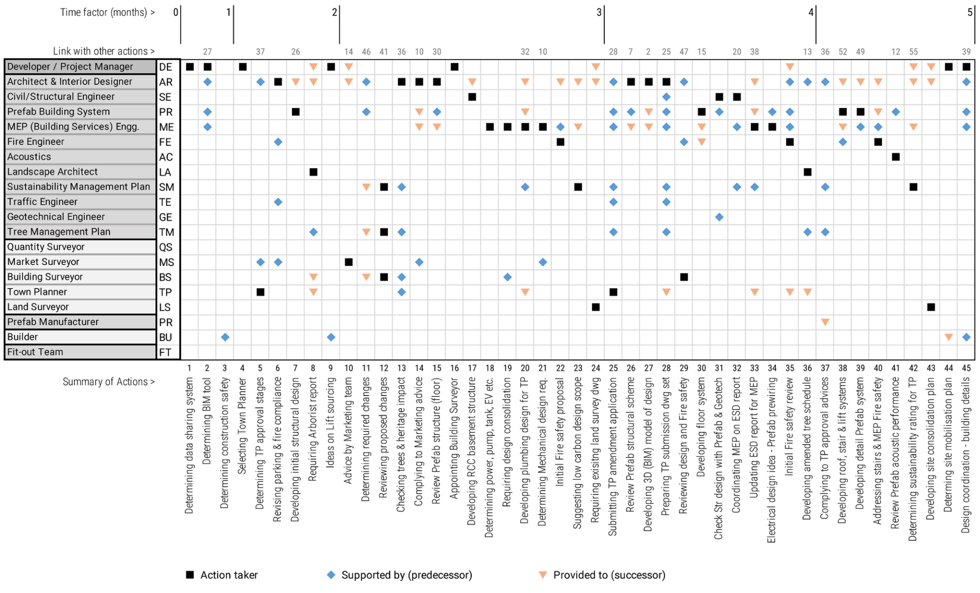


Fig. 02. Dependency of work processes in the case study project (month 1-5)

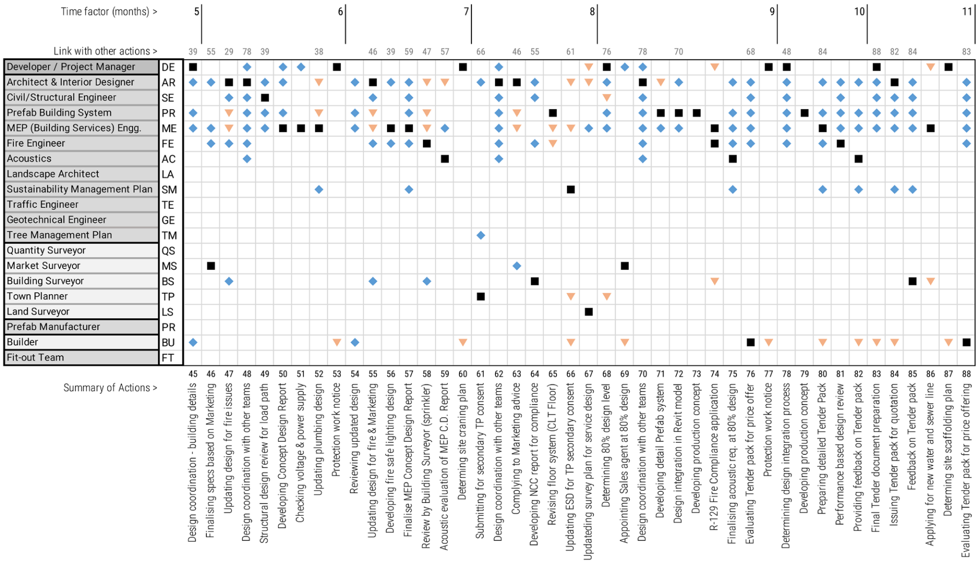
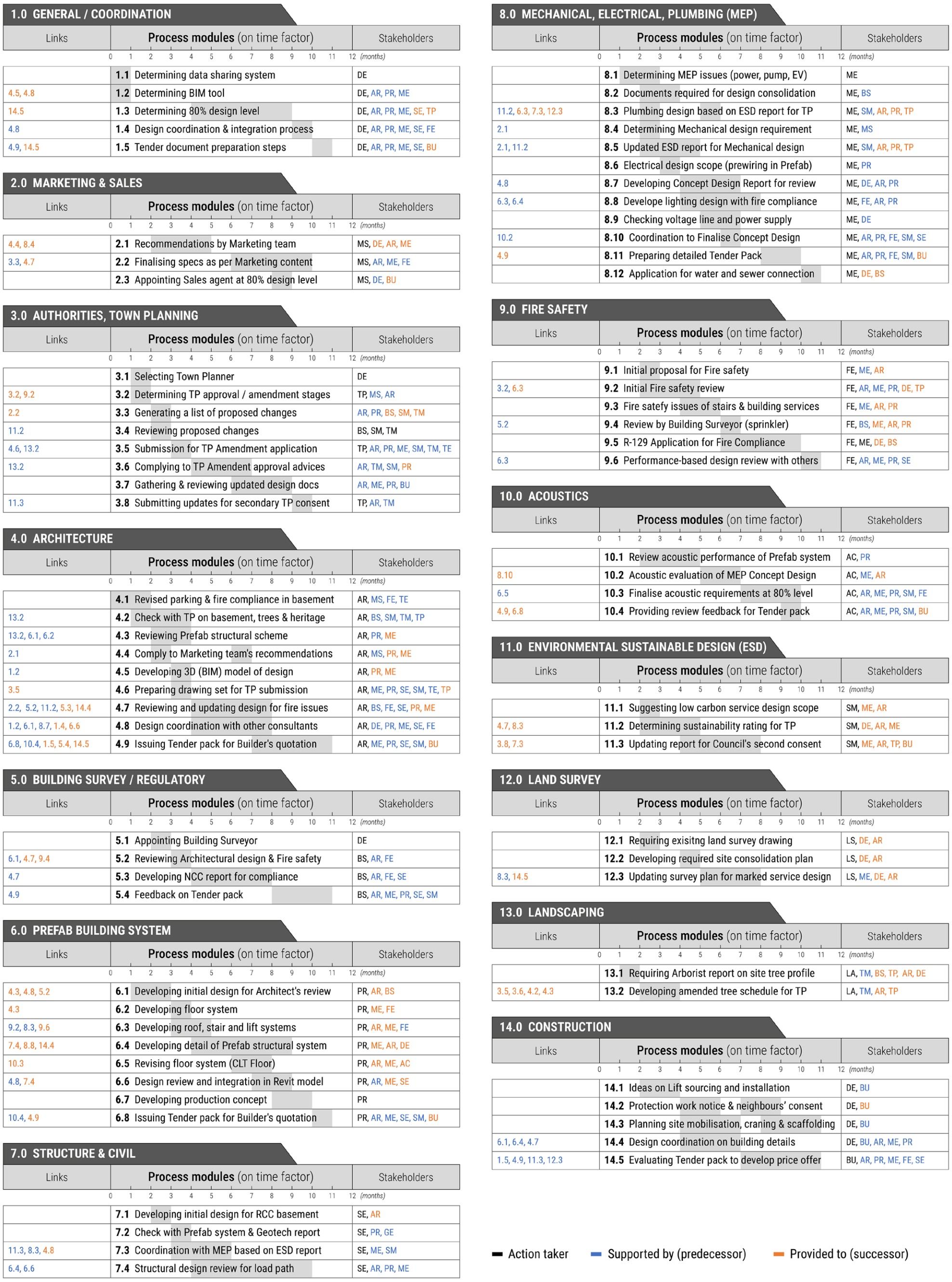


Fig. 03. Dependency of work processes in the case study project (month 6-11)

1) General/Coordination, 2) Marketing and Sales, 3) Authorities and Town Planning, 4) Architecture, 5) Building Survey/Regulatory, 6) Prefab Building System, 7) Structure and Civil, 8) Mechanical, Electrical, Plumbing (MEP), 9) Fire Safety, 10) Acoustics, 11) Environmental Sustainable Design (ESD), 12) Land Survey, 13) Landscaping, and 14) Construction. By organising closely related activities or actions within specific packages, these work processes are structured as modules. The grouping of activities within these packages is determined by the typology of professional activities and the dependency constraints between them. The time sequence further aids in ordering these modules. This method contributes to the development of a concept of process modularity for the case study project. While the current project does not directly implement these modules as a platform-based approach, they serve as essential ingredients for future platform module development. In future, as these modules are applied across multiple projects, the professional boundaries between work packages may become less distinct, resulting in enhanced integration between work processes, improved collaboration between project teams and increased efficiency within future IB projects.

As illustrated in Figure 04, these modules consist of a set of closely related actions that are frequently performed within the same time frame. These process modules (along with their action links) enable the efficient execution of interdependent activities, allowing for greater control and coordination of work activities. It is worth noting that the linked actions belong to other work packages, indicating that when one action or activity takes place, it is supported by relevant actions from other clusters, and often contributes to the execution of a future action. Moreover, the modular structure of the work packages identifies the stakeholders who perform the process either as action-takers, predecessors or successors. Figure 04 further suggests that the Planning, Architecture, Prefab, and MEP work packages consist of the highest number of process modules. These four clusters collaborate primarily through the common module of preparing documents for Town Planning permit.



1.0 GENERAL / COORDINATION

Links	Process modules (on time factor)	Stakeholders
	1.1 Determining data sharing system	DE
4.5, 4.8	**1.2** Determining BIM tool	DE, AR, PR, ME
14.5	**1.3** Determining 80% design level	DE, AR, PR, ME, SE, TP
4.8	**1.4** Design coordination & integration process	DE, AR, PR, ME, SE, FE
4.9, 14.5	**1.5** Tender document preparation steps	DE, AR, PR, ME, SE, BU

2.0 MARKETING & SALES

Links	Process modules (on time factor)	Stakeholders
4.4, 8.4	**2.1** Recommendations by Marketing team	MS, DE, AR, ME
3.3, 4.7	**2.2** Finalising specs as per Marketing content	MS, AR, ME, FE
	2.3 Appointing Sales agent at 80% design level	MS, DE, BU

3.0 AUTHORITIES, TOWN PLANNING

Links	Process modules (on time factor)	Stakeholders
	3.1 Selecting Town Planner	DE
3.2, 9.2	**3.2** Determining TP approval / amendment stages	TP, MS, AR
2.2	**3.3** Generating a list of proposed changes	AR, PR, BS, SM, TM
11.2	**3.4** Reviewing proposed changes	BS, SM, TM
4.6, 13.2	**3.5** Submission for TP Amendment application	TP, AR, PR, ME, SM, TM, TE
13.2	**3.6** Complying to TP Amendent approval advices	AR, TM, SM, PR
	3.7 Gathering & reviewing updated design docs	AR, ME, PR, BU
11.3	**3.8** Submitting updates for secondary TP consent	TP, AR, TM

4.0 ARCHITECTURE

Links	Process modules (on time factor)	Stakeholders
	4.1 Revised parking & fire compliance in basement	AR, MS, FE, TE
13.2	**4.2** Check with TP on basement, trees & heritage	AR, BS, SM, TM, TP
13.2, 6.1, 6.2	**4.3** Reviewing Prefab structural scheme	AR, PR, ME
2.1	**4.4** Comply to Marketing team's recommendations	AR, MS, PR, ME
1.2	**4.5** Developing 3D (BIM) model of design	AR, PR, ME
3.5	**4.6** Preparing drawing set for TP submission	AR, ME, PR, SE, SM, TE, TP
2.2, 5.2, 11.2, 5.3, 14.4	**4.7** Reviewing and updating design for fire issues	AR, BS, FE, SE, PR, ME
1.2, 6.1, 8.7, 1.4, 6.6	**4.8** Design coordination with other consultants	AR, DE, PR, ME, SE, FE
6.8, 10.4, 1.5, 5.4, 14.5	**4.9** Issuing Tender pack for Builder's quotation	AR, ME, PR, SE, SM, BU

5.0 BUILDING SURVEY / REGULATORY

Links	Process modules (on time factor)	Stakeholders
	5.1 Appointing Building Surveyor	DE
6.1, 4.7, 9.4	**5.2** Reviewing Architectural design & Fire safety	BS, AR, FE
4.7	**5.3** Developing NCC report for compliance	BS, AR, FE, SE
4.9	**5.4** Feedback on Tender pack	BS, AR, ME, PR, SE, SM

6.0 PREFAB BUILDING SYSTEM

Links	Process modules (on time factor)	Stakeholders
4.3, 4.8, 5.2	**6.1** Developing initial design for Architect's review	PR, AR, BS
4.3	**6.2** Developing floor system	PR, ME, FE
9.2, 8.3, 9.6	**6.3** Developing roof, stair and lift systems	PR, AR, ME, FE
7.4, 8.8, 14.4	**6.4** Developing detail of Prefab structural system	PR, ME, AR, DE
10.3	**6.5** Revising floor system (CLT Floor)	PR, AR, ME, AC
4.8, 7.4	**6.6** Design review and integration in Revit model	PR, AR, ME, SE
	6.7 Developing production concept	PR
10.4, 4.9	**6.8** Issuing Tender pack for Builder's quotation	PR, AR, ME, SE, SM, BU

7.0 STRUCTURE & CIVIL

Links	Process modules (on time factor)	Stakeholders
	7.1 Developing initial design for RCC basement	SE, AR
	7.2 Check with Prefab system & Geotech report	SE, PR, GE
11.3, 8.3, 4.8	**7.3** Coordination with MEP based on ESD report	SE, ME, SM
6.4, 6.6	**7.4** Structural design review for load path	SE, AR, PR, ME

8.0 MECHANICAL, ELECTRICAL, PLUMBING (MEP)

Links	Process modules (on time factor)	Stakeholders
	8.1 Determining MEP issues (power, pump, EV)	ME
	8.2 Documents required for design consolidation	ME, BS
11.2, 6.3, 7.3, 12.3	**8.3** Plumbing design based on ESD report for TP	ME, SM, AR, PR, TP
2.1	**8.4** Determining Mechanical design requirement	ME, MS
2.1, 11.2	**8.5** Updated ESD report for Mechanical design	ME, SM, AR, PR, TP
	8.6 Electrical design scope (prewiring in Prefab)	ME, PR
4.8	**8.7** Developing Concept Design Report for review	ME, DE, AR, PR
6.3, 6.4	**8.8** Develope lighting design with fire compliance	ME, FE, AR, PR
	8.9 Checking voltage line and power supply	ME, DE
10.2	**8.10** Coordination to Finalise Concept Design	ME, AR, PR, FE, SM, SE
4.9	**8.11** Preparing detailed Tender Pack	ME, AR, PR, FE, SM, BU
	8.12 Application for water and sewer connection	ME, DE, BS

9.0 FIRE SAFETY

Links	Process modules (on time factor)	Stakeholders
	9.1 Initial proposal for Fire safety	FE, ME, AR
3.2, 6.3	**9.2** Initial Fire safety review	FE, AR, ME, PR, DE, TP
	9.3 Fire satefy issues of stairs & building services	FE, ME, AR, PR
5.2	**9.4** Review by Building Surveyor (sprinkler)	FE, BS, ME, AR, PR
	9.5 R-129 Application for Fire Compliance	FE, ME, DE, BS
6.3	**9.6** Performance-based design review with others	FE, AR, ME, PR, SE

10.0 ACOUSTICS

Links	Process modules (on time factor)	Stakeholders
	10.1 Review acoustic performance of Prefab system	AC, PR
8.10	**10.2** Acoustic evaluation of MEP Concept Design	AC, ME, AR
6.5	**10.3** Finalise acoustic requirements at 80% level	AC, AR, ME, PR, SM, FE
4.9, 6.8	**10.4** Providing review feedback for Tender pack	AC, AR, ME, PR, SM, BU

11.0 ENVIRONMENTAL SUSTAINABLE DESIGN (ESD)

Links	Process modules (on time factor)	Stakeholders
	11.1 Suggesting low carbon service design scope	SM, ME, AR
4.7, 8.3	**11.2** Determining sustainability rating for TP	SM, DE, AR, ME
3.8, 7.3	**11.3** Updating report for Council's second consent	SM, ME, AR, TP, BU

12.0 LAND SURVEY

Links	Process modules (on time factor)	Stakeholders
	12.1 Requiring exisitng land survey drawing	LS, DE, AR
	12.2 Developing required site consolidation plan	LS, DE, AR
8.3, 14.5	**12.3** Updating survey plan for marked service design	LS, ME, DE, AR

13.0 LANDSCAPING

Links	Process modules (on time factor)	Stakeholders
	13.1 Requiring Arborist report on site tree profile	LA, TM, BS, TP, AR, DE
3.5, 3.6, 4.2, 4.3	**13.2** Developing amended tree schedule for TP	LA, TM, AR, TP

14.0 CONSTRUCTION

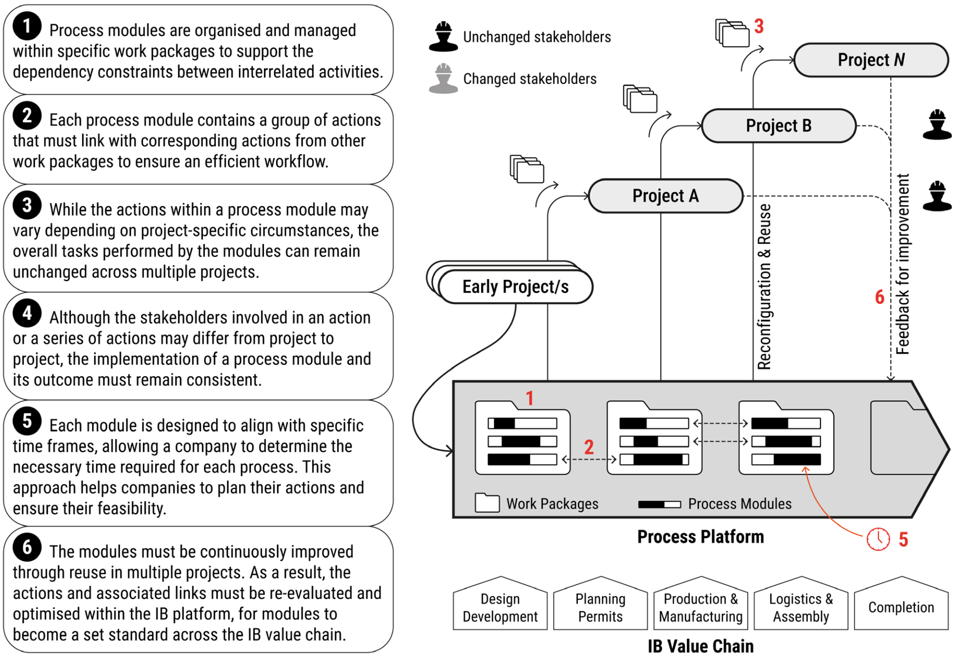
Links	Process modules (on time factor)	Stakeholders
	14.1 Ideas on Lift sourcing and installation	DE, BU
	14.2 Protection work notice & neighbours' consent	DE, BU
	14.3 Planning site mobilisation, craning & scaffolding	DE, BU
6.1, 6.4, 4.7	**14.4** Design coordination on building details	DE, BU, AR, ME, PR
1.5, 4.9, 11.3, 12.3	**14.5** Evaluating Tender pack to develop price offer	BU, AR, PR, ME, FE, SE

▬ Action taker ▬ Supported by (predecessor) ▬ Provided to (successor)

Fig. 04. Developing process modules within IB work packages.

More intricate relationships between work packages, such as General, Architecture, Building Survey, Prefab, MEP, Acoustics, and Construction, can be observed within the common module of preparing and reviewing a detailed Tender Package. Supporting modules from other clusters, such as Marketing, Structure/Civil, Fire Safety, ESD, Land Survey, and Landscaping also contribute to the overall design development and planning permit stages, leading to the execution of the Tender Package development. Therefore, identifying and grouping corresponding actions can allow for optimised project planning and execution, reducing development time and costs while improving collaboration and overall project success.

While this research project is yet to reach the production and manufacturing, logistics and assembly, and completion stages, it is expected that activities involved in these stages can be similarly structured as process modules within the specific work packages for future reusability. The results of this paper align with Lessing's (2006) platform concept in IB that emphasised the way structured process modules can facilitate the development of process platforms that holistically contribute to increased productivity and product variability in IB. Based on the above analysis, preliminary guidelines (Fig.05) are proposed as a means to develop process modules:



❶ Process modules are organised and managed within specific work packages to support the dependency constraints between interrelated activities.

❷ Each process module contains a group of actions that must link with corresponding actions from other work packages to ensure an efficient workflow.

❸ While the actions within a process module may vary depending on project-specific circumstances, the overall tasks performed by the modules can remain unchanged across multiple projects.

❹ Although the stakeholders involved in an action or a series of actions may differ from project to project, the implementation of a process module and its outcome must remain consistent.

❺ Each module is designed to align with specific time frames, allowing a company to determine the necessary time required for each process. This approach helps companies to plan their actions and ensure their feasibility.

❻ The modules must be continuously improved through reuse in multiple projects. As a result, the actions and associated links must be re-evaluated and optimised within the IB platform, for modules to become a set standard across the IB value chain.

Fig. 05. Guidelines to develop process modules

Recent studies focusing on process-orientation in IB primarily highlight the significance of production-related aspects that enable the transfer of knowledge from executed projects to product platforms (Lessing, 2006, Jansson, 2013). However, a relatively unexplored area pertains to the novelty of structuring processes in modular forms for reconfiguration, re-use and refinement. From the examination of work processes in this applied research project, the concept and guidelines presented in this paper offer a structure to explore process modularity in future IB projects.

Conclusion

This study outlines the potential benefits of a platform approach in IB when a distinction is made between product and process-orientation. It is argued that IB companies' product platform approaches are predominantly product-oriented, prioritising standardised and repetitive product development, limiting focus to process orientation, while tending to oversee the potential benefits of developing and reusing standardised building processes. The concept of process modularity is discussed in this context, with Lessing's (2006) platform model, serving as a basis for structuring process modules for scalability and reusability in various IB projects.

The paper focuses on developing an explicit definition of process modules and how they can be structured as a platform-based approach. To achieve this goal the work processes across the design development and planning permit stages of an applied research project in Australia have been analysed as a case study. Australia is experiencing increased interest in IB, but the application of product platforms, from a process-orientation, is not fully explored. The research presents guidelines for organising interdependent activities in specific work packages as process modules that can then be reused in future IB projects. The proposed guidelines advocate for an approach where modules can be reconfigured when implemented across multiple projects, leading to increased efficiency, scalability and variability in IB delivery.

While still in development, this research provides initial insights into the potential of process modularity in IB production and the subsequent ability to achieve economies of scale across wider market segments. Nevertheless, there exists a research gap in the understanding of methods and guidelines for implementing process modules within the organisational structure of companies. To address this issue, further research will focus on how these process modules can be practically applied in future IB projects to increase scalability in product offerings.

Acknowledgements

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Significance of Symbolism in Envisioning Architectural Scale Through the Comparison Between Two Living Chola Temples and Their Relationship Between Cultural Psychology and Architectural Sublime

1. Introduction

A narrative is an abstract concept. It is incumbent not only on the mind of the creator but also on the perspective of the consumer of the narrative. The construction's conceptual reach and spiritual dimension lend sublimity to its architecture. The two statements that geometric principles form the basis for architectural construction and others, and that narrative exists in architectural constructs and others, therefore, seem contradictory. Structure and size in any construction depend upon its functions. Similarly, each component's size within the construction also depends on its utility. The proportion of each component to the whole is determined by scale.

Through the comparison of two great living Chola temples, namely the Brihadeeswara at Thanjavur and the Gangaikonda Cholapuram temple, this paper proposes to show how the sublime and abstract narratives in architecture remain unaffected by scale.

2. Background and Context

The relationship between culture, narrative, and architecture is well documented. Architects use a predetermined scale to determine the size of the components of constructions and create a narrative by structuring inner spaces to drive perception. Architects create space within a construction with not only functionality in mind but also the perspective of the observer Coates (2012) contends that architects prioritize meaning (narrative) over performance. Religious architectural constructions are places to experience the sacred and worship the Lord. They also serve the local community. Faith develops over time, and symbolism is a manifestation of faith.

The foundation for any place of worship lies in tradition. It offers *oases of peace, prosperity, and justice*. A geometrical design called the *vastu-purusha-mandala* forms the basis of Hindu temple design. Common architectural elements in Hindu temples include (i) the sanctum (*garbhagriha* literally 'womb-house'), which is the place where the main deity resides, (ii) the *pradakshina* path, usually a circumambulatory path along which devotees walk paying homage to the deity, (iii) the antheral, a space to maintain a respectful distance from the deity, and (iv) the mandapa, an open space for devotees. A dome tops the sanctum in most Hindu temples, called the *vimana* or *shikhara*. An Islamic mosque has similar spaces in the Sahn or courtyard, the Hauz, or a water body within the courtyard; the *mihrab*, which is a niche indicating the direction of Mecca concerning the mosque, mimber, or a dais for the preacher; a minaret, or tower; and a *Qubba,* or dome· A church comprises the nave, or a place for public gatherings, a baptismal fount or water body, the altar and tabernacle that symbolize the steadfastness of the church, and the crucifix, or the main deity· Most churches also have a steeple or tower

This discussion indicates that most places of worship are structurally similar, consisting primarily of a sanctum, a tower, and an open space for devotees.

3 Problem Statement

Does a religious construction's grandeur, narrative, and sublimity diminish if built on a smaller scale?

4 Research design and methods

We first highlight the differences in the construction of the two temples. Next, we show the relationship between culture, faith, and symbolism. Finally, we conclude that the grandeur and sublimity of the Gangaikonda temple result from its symbolism. The Gangaikonda is sublime, even though it is smaller than the Brihadeeswara temple.

5 Literature Review

5.1 Aesthetics in Architecture

Aesthetics refers to beauty and taste. The term originates from the Greek *aisthetikos,* which means sensitive or sentient. It refers to perception and sense· Aesthetics investigates how people perceive and approach their surroundings. The articulation of sensory impressions gives meaning to the narrative· The difference between architecture and other art forms is that the need for functionality restricts the creation of architecture. Naz et al. (2017) show that color impacts the senses while light impacts the feeling of spaciousness. Therefore, a well-lit room or space may seem larger than one with diminished illumination. Illumination also impacts the senses. Spatial features evoke an emotional response· There exists a relationship between open physical spaces and perceived spaces· Specific forms convey specific meanings —perception of spatial texture results from earlier experience with material, weight, shape, and resistance· A construction's appeal to the common eye combines several factors: shape, size, color, functionality, contrast, symmetry, alignment, culture, context, and more. The combined effect of these factors on each containing element and the building contributes to the aesthetic appeal of the construction· Aesthetics in architecture is, therefore, a combined effect of the multiple elements and sub-elements of the structure.

5.2 Sublimity in Architecture

The word sublime has many meanings. Its connotation has evolved to mean lofty, grand, exalted, outstanding (morally, intellectually, or both), awe-inspiring, high quality, supreme, or utter It means different things, from immensity to suaveness, gracefulness, and urbaneness. Immensity is physical as well as phonemic. The word may be used to mean enormous, overwhelming, or awe-inspiring. This paper uses the words grandeur, sanctity, and awe-inspiring spirituality.

Ancient architecture separated utility from art. Construction was focused on functionality. Art entered construction only when grandeur was required Thinley et al. contend that physical architectural features do not contribute to sublimity or spiritualism. Instead, sublimity and grandeur come from the conceptual reach of a construction Sublimity is *the echo of the greatness of the spirit.* It is an experience of the pervasive imagination of the writer By extension, therefore, a sublimity in architecture is the perception of the creator's imagination that is pervasive in the structure. Sublimity, therefore, is a psychological rather than a physical concept and is perceived rather than created.

5.3 How Architecture is Perceived

Architectural perception is the collective perception of architecture and its history. Cultural history comprises a significant part of history or architecture, if not the whole. It includes all factors contributing to its creation Objects in architecture are not just physical but also relate to the object's psychological perception, including the circumstances leading up to its creation Perception is the process of selecting and organizing sensory input in a way that gives it meaning. It originates from knowledge. Information is gathered from the environment through the senses, which gives meaning to that information Perception thus includes the past as well as the present environment. In addition, it includes the perception of legends passed down through generations, i.e., cultural history.

5.4 Role of Cultural Psychology in Perception of Architecture

The eye perceives the environment around us, whereas the other four senses collect information about the space and store it in memory, and the brain recalls this information when it encounters a similar environment, which is the process of psychological cognition The process may be executed consciously or unconsciously. The psychological cognition of a large group creates culture, and culture influences the individual psychological process The current environment and the recollection of material, texture, sound, and smell from previous experiences with similar environments influence the perception of an object Rapoport A. (1969), in Cultural Context in Architecture, describes architecture as *a profession rooted in culture*. Architecture and culture are interdependent. Cultural heritage is a collection of a community's systems, values, norms, ideologies, and beliefs. While these elements refer to the intangible aspects of culture, symbols, technologies, and objects, such as buildings, constitute tangible proof of that culture Greely (1995), in The Cultural Construction of Religion, contends that religion's imaginative or abstract aspect is necessary to understand any religion.

When people congregate at a place of worship, they create customs and rituals. For instance, the service at a church creates a sublime mood or sacred environment. The preacher requests that attendees focus on a symbolic object, such as the altar or a candle. The hymns and discourses lead the attendees through different levels of sublimity These customs comprise religion, and the building in which they are executed symbolizes that ritual. Thus, when one visits a place of worship such as a church, one experiences the sublime atmosphere resulting from centuries of custom, rituals, and legends. Cultural psychology, therefore, plays a significant role in the perception of the sublime.

5.5 Discussion through a comparison of the Brihadeeswara and Gangaikonda temples

Summing up the above research, architectural constructions reflect society's culture and its interaction with the structure. It includes society's social, political, economic, and other aspects. Ettehad et al. confirm this observation in *The Role of Culture in Promoting Architectural Identity*.

Mapping this conclusion to religious architecture in general and the Chola temples in particular, one may conclude that sublimity or grandeur in architecture comes from its aesthetic appeal and the collective cultural and historical perception. We now delve into comparing the two selected temples, namely, the Thanjavur Brihadeeswara temple and the Gangaikonda Cholapuram temple, to show how aesthetics, symbolism, and cultural psychology invoke sublimity and grandeur.

5.6 Background of the Chola Temples

The dates or duration of the Chola dynasty's rule are not well established, but most literature agrees that they ruled between the ninth century to the thirteenth century C.E. (850–1279 CE). Vijayalaya (850 - 871 CE) is the earliest known Chola ruler, followed by Aditya I (871-907), Parantaka I (907 - 953 CE), and Rajaraja I (985 CE–1014 CE). The Chola rule peaked during the reign of Rajaraja I, who also built the first of 80 Chola temples at Thanjavur, followed by the Gangaikonda temple built by his son Rajendra I. The Tanjore temple is one of the finest constructions of the Cholas, and the Gangaikonda temple is its miniature image. The Chola temples are known for their grandeur, art, symbolism, architecture, and the practice of Shivaism. The reason for selecting the Tanjore and Gangaikonda temples for this research is that they are identical except for a few distinctions, like the scale of construction.

6 Similarities and Differences in the Gangaikonda Chola Puram and Brihadeeswara Temples

6.1 Differences in Legend

The bigger temple was built following a dream in which Lord Shiva directed Emperor Rajaraja Chola to do so. Locals believe that the temple commemorates the Chola rule in south India. The temple at Gangaikondacholapuram (the place of the Chola who conquered the Ganges) celebrates Emperor Rajendra I's victory over several regions en-route to the Ganges in east India. Following the victory, Rajendra I assumed the name Gangaikonda Cholan according to tradition. He then set up his capital in Gangaikonda, and the village came to be called Gangaikonda (conqueror of the Ganges) Chola Puram (place).

Even though the Gangaikonda is constructed on a lower scale, the grandeur and aesthetics of both temples are similar.

6.2 Structural Comparison of Gangaikonda and Brihadeeswara Temples

The two temples are identical except for three points of distinction, of which only one is structural. Unlike the temple at Tanjore, the Gangaikonda temple (Ref. Fig. 01, Fig. 02) is concave in shape and constructed on a smaller scale compared to the Brihadeeswara temple. The tower of the Gangaikonda is smaller than that of the Brihadeeswara temple by three meters. Locals believe this was done as a mark of respect for the bigger temple· Finally, the larger temple has two enclosures,s compared to a single enclosure (*prakara*) with a gateway on the east for the smaller Gangaikonda temple·

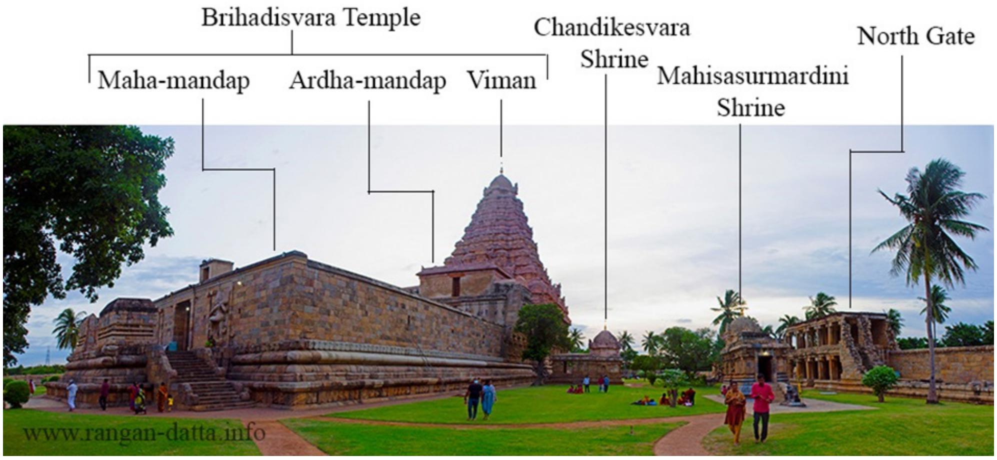

Fig. 01- Panoramic view of Brihadeshwara Temple, Gangaikonda Cholapuram (view from the northeast).

Source: personal archive of the author.

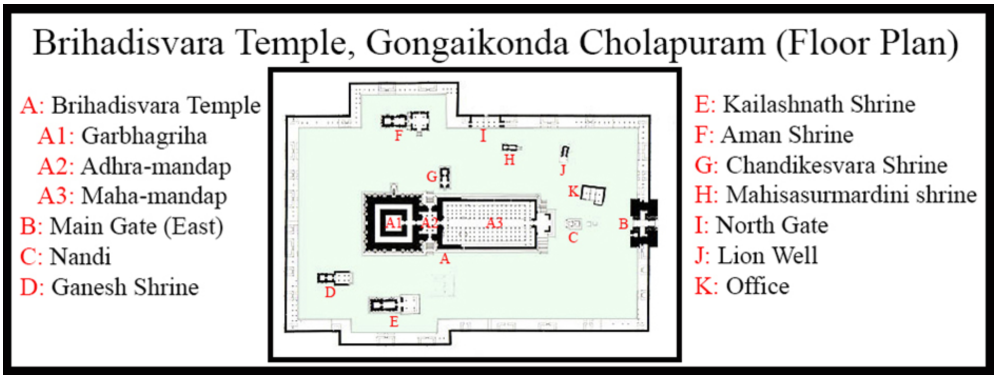

Fig 02- Floor plan of Brihadeshwara Temple, Brihadeshwara Temple, Gangaikonda Cholapuram

Source: personal archive of the author.

The Cholaveshwaram temple has an area of 340x110 feet compared to the massive 790x400 feet of the Tanjore temple, which is more than double the size of the smaller temple. Both temples are shaped like pyramids, with a hemispherical dome at the top above the *garbhagriha*, or central shrine. The Gangaikonda temple has eight stages in its vimana, compared to the thirteen stages of the Tanjore temple· The tower of the Gangaikonda temple is a vertical square rising 35 feet above the *adhisthanam,* or base· There are two horizontal bands and a cornice. Each band has five bays, one in each direction. There are carvings of Shaiva, Shakta, and Vaishnava traditions, Hindu mythological legends, and other mythical creatures on each side of the tower. In contrast, the tower of the Brihadeeswara temple (Ref. Figs. 03 and 04) at Tanjavur has a total height of 217 feet.

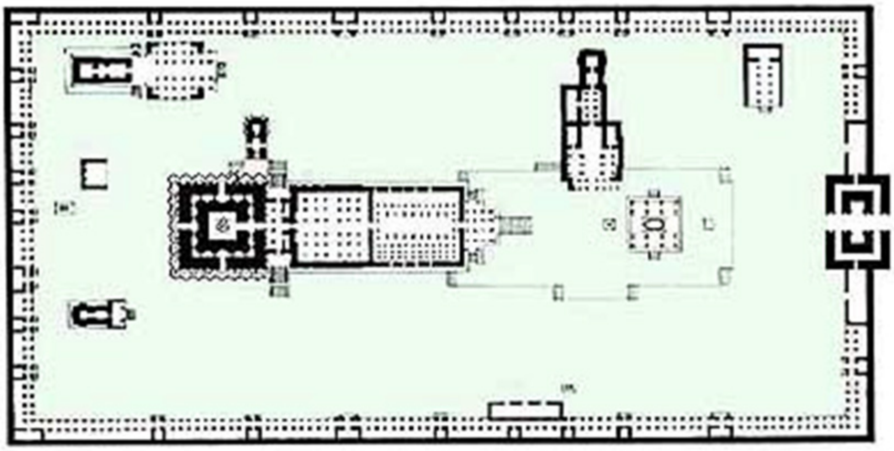

Fig 03- Plan of the Brihadishwara Temple, Thanjavur (“The History of Architecture in India” by Ch. Tadgell)

Source: personal archive of the author

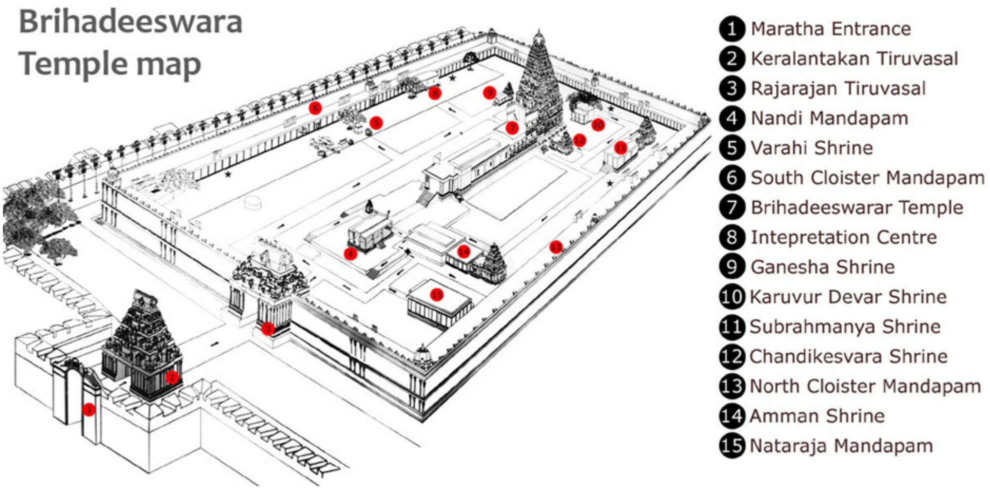

Fig 04- Brihadeeswara Temple top view map

Source: personal archive of the author

A *mukhamandapa,* or front porch, precedes the *garbhagriha* at both temples. Both temples have secondary shrines within the *mukhamandapa*. In addition, both temples have smaller shrines north and south of the main shrine, presumably indicative of an existing superstition or local belief. These shrines, believed to have housed *lingas*, are now known as the north and south Kailasa (the abode of Lord Shiva). Both shrines are identical in construction.

Table of differences between the Gangaikonda and Brihadeeswara Temples

Parameter	Brihadeeswara Thanjavur	Brihadeeswara Gangaikonda
Built By	Rajaraja Chola I	Rajendra Chola I
Legend and reason for the construction	Built following a dream in which Lord Shiva directed Emperor Rajaraja Chola to build the temple It established the rule of the Chola dynasty.	Celebrates the victory of Rajendra I over several regions en-route to the Ganges
Overall Size	Larger than Gangaikonda (212 ft or 64.8 meters)	Smaller than Thanjavur. Courtyard area 560 feet (170m) x 320ft (98m). Sanctum – 100 sqft (9.3 sqm).
Semantic Meaning	Brihat (big) + Iswara (Lord) The temple of the great lord (Shiva according to legend)	Gangai (Ganges) Konda Chola (Conqueror) Puram (Place) The place of the Chola who conquered the Ganges.
Shape	Angular	Concave
Height	The tower is taller by 3 meters	The tower is shorter by 3 meters
Enclosures	Two enclosures	One enclosure
Area	790x400 feet	340x110 feet
Vimana	1. Is 217 feet in height 2. Has 13 stages	1. Is 35 feet in height 2. Has 8 stages 3. Has 2 horizontal bands with 5 bays each 4. Has a cornice
Nandi Statue	Is larger	Is smaller
Beliefs	The sentiments and religious beliefs surrounding both temples are similar. Both temples are dedicated to Lord Shiva. Both were epicenters of socio-economic activities.	

Both shrines have a front porch and entry halls. Both have a temple dedicated to Caṇḍikeśvara, the guarding steward deity of Lord Shiva. To the southeast of both temples is a shrine dedicated to Lord Ganapathy, the older son of Lord Shiva. Both these shrines are dated back to the thirteenth century (Nagaswamy in The statue of Nandi guards the entrance at both temples. However, the one at Gangaikonda is proportionately smaller than the one at the Thanjavur temple. Whether the Nandi at Gangaikonda Cholapuram is composite and has the same legendary magical powers of growth as that at the Tanjore Brihadeeswara temple is uncertain.

6.3 Beliefs Surrounding Thanjavur and Gangaikonda Temples

The reign of Rajaraja Chola, and presumably the Thanjavur temple, established Chola rule. It legitimized the Chola rule. Both Thanjavur and Gangaikonda were epicenters of socio-economic activity, albeit ruled by different Cholas. Paintings and sculptures of various Hindu gods and goddesses adorn the walls of both temples.

The main deities at the Brihadeeswarar temples are the *lingams* of Lord Shiva. Both are called Peruvudaiyar, and the temples are often called Peruvudaiyar Kovil. The sculptures that adorn the walls of Brihadeeshwara temples at both Thanjavur and Gangaikondacholapuram, for the most part, depict Lord Shiva in various forms. The frescoes that adorn the walls indicate religious ideology, while paintings of dancing maidens and musicians allude to the existence of social culture. Emperor Rajaraja I took the title of Shivapada Shekhara (the one who bows his head at the feet of Shiva). These findings are indicative of the fact that both temples had common beliefs, religions, and customs.

7 Discussion

Pichard (1994) argues that the two temples are not structurally identical. He contends that Emporer Rajendra I expanded upon the architecture of the existing temple, which explains the few but significant architectural differences. Brown, P. (1959) contends that while the temple at Thanjavur is exemplary of Chola art, the Gangaikonda temple has an independent grandeur. Both temples were, however, built with spiritual intent Pichard, 1994 in ·

These contentions and the preceding discussion indicate that the similarities between the Gangaikondacholapuram temple and the Thanjavur Brihadeeswara temple outnumber the differences. The most significant point of difference is that the Cholapuram temple is smaller in scale than the Thanjavur temple. The question, then, is whether the size of the construction affects its impact on the viewer. The exploration of aesthetics, sublimity, and the evocation of awe by a construction determines this.

Aesthetics in architecture, and presumably in other fields too, is the combined effect of the material, its placement, the color scheme, and other elements of the building on the senses. Therefore, each individual perceives a building or its containing elements differently. The experience of an atheist in the Thanjavur or Gangaikonda temple may, for instance, be very different from that of a religious person. Regular visitors reverently view the place of worship, unlike occasional locals or tourists, who may view it with detachment. When people visit temples regularly, customs and rituals are created· As a result, people began viewing the place of worship as sacred. Aesthetics in religious constructions may therefore be described as a combination of the different perceptions of the building.

Sublimity is a psychological concept. Sublimity is perceived. The literature review in the relevant section supports this contention. Sublimity, for this paper, has three aspects: grandeur, sanctity, and awe-inspiring. Sanctity comes from the regular performances of cultures and rituals in the spaces within the building. Grandeur comes from the art and artifacts within the construction· The Science of Awe (2018) relates awe to spirituality and culture. Awe is a psychological phenomenon that occurs when the senses are overwhelmed by vastness or the need to adapt the senses· In religious places, therefore, the feeling of sublimity is evoked by grandeur, sanctity, and awe. Symbolism is a by-product of culture and customs·

8 Conclusion

This discussion concludes that any construction's sublimity, grandeur, and awe come from the perception of aesthetics, the evocation of awe, and sanctity (in the case of religious constructions). Awe is driven not merely by size or vastness but also by the legends, culture, and symbolism surrounding the construction.

In the examples selected for this paper, it was found that both the Brihadeeswara temples at Thanjavur and Gangaikondacholapuram had their independent legends. While both were built by the same clan or dynasty, each was created for a different reason. Shaivism was practiced at both temples. Both Rajaraja Chola and Rajendra I followed a conquest policy. However, there were subtle differences in their administrative practices.

Rajaraja I established the power of the navy and initiated a practice of local self-government. He was a pious ruler who accepted other religions like Buddhism and Vihara along with Shaivism. While Rajaraja was both a conqueror and a pious man who believed in religion, his son Rajendra, I, was more politically minded. He was also a philanthropist, giving education grants.

These observations and findings show that the effect of symbolism, culture, and legend on the sublimity of an architectural construction is stronger than the effect of its scale or size.

9 Implications and contributions to knowledge

This study presents a different perspective on scale in architecture. The importance of scale in architecture cannot be denied from a construction perspective. Most architects, however, focus more on the quantifiable aspect of scale rather than its sublime aspect. Earlier research has alluded to elaboration rather than a larger scale in architecture as the sublime aspect of monumental scale· Monumental scale is an unwarranted increase in construction size to accommodate public gatherings. A vision scale is described as *the size of an object seen regarding the objects around it*· Papapericleous, A., talks of vision as an image generated by the fusion of all five senses and visibility, which results from what the eye sees combined with the other knowledge surrounding the structure.

These arguments prove the contention in this thesis that scale in architecture is not merely a measurable, geometric, or mathematical concept but rather the combined effect of the perception of the proportions in the architectural construction, the culture and legend surrounding it, and the perception of individuals through all five human senses. Architects must therefore consider the abstract aspects of scale and the measurable elements. In other words, the impact of culture, period, human vision and perception, and symbolism are important architectural constructs.

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I truly acknowledge the language Tamil and its culture, from which I got the passion for researching this project, and I drew my inspiration by reading about the Great Raja Raja Cholan (985 C.E. to 1014 C.E.), the emperor of south India.

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Architectural scale models: Methodologies for studying daylight qualities

Introduction

Light has no scale. That is the traditional view upon light. That is is also why an architectural scale model can be used to investigate daylight and space (Mary Guzowski, 2018). The architectural model can be produced in a variety of scales - and daylight will follow and show the correct amount and distribution of light in relation to the space, provided that the model has the right proportions, apertures, form, orientation, surface character and reflectance. The scale model has been an architectural tool probably for as long as the discussion of architectural design has existed (Anne Kathrine Frandsen, 2005). Although the scale model has been and is still widely used in architectural practice, it is limited by the human scale when it comes to investigating the daylight qualities and the human experience and perception of the light in a space.

The scale model is commonly used in architectural design processes either to represent a final project or as an outlining tool during initial processes. It is useful for understanding the spatial experience as a whole. At the same time, the scale model can influence a project in an unforeseen positive direction.

In addition to spatial understanding, the scale model can serve as a tool for investigating the distribution of daylight and how this affects the experience of the space. Daylight changes how the space and its atmosphere are experienced depending on the geometric shape of the space and the apertures. (Nanet Mathiasen, 2006).

This study examines the methodologies that can be used to represent daylight and its spatial qualities. Therfore a comparative study of three forms of representtation: *The observation of daylight in a scale model; a photographic registration of daylight in a scale model; and a simulation of luminance levels and distribution.*

The qualities of daylight are studied in a specific space. The space is one of three spaces in a pavilion to be built in 1:1 scale in the inner city of Copenhagen.[1] The geometry of the space will be determined by the project. This paper discusses a selection of the project's preliminary studies.

The study seeks to answer the following questions:

- *What daylight qualities can be depicted by the different types of representation?*
- *How can the qualities of daylight be interpreted?*

The different methodologies for representing the perceived daylight in the space are examined in a comparative study in which the ability of these methodologies is observed.

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[1] The pavilion will be in place from July to October.

Below is a description of the theories of Anders Liljefors and Sophus Frandsen. This is followed by a presentation of the representations of daylight applied, including observing daylight in a scale model, photographic registration of daylight in a scale model; and simulation of luminance levels and distribution. Each constituting the different types of representation. Subsequently, there are descriptions and analyses of the perceived daylight qualities as they relate to the various types of representation.

Theory for describing the quality of daylight

The theoretical point of departure for the studies comprises Anders Liljefors' seven variables for describing daylight quality and Sophus Frandsen's categorisation of spatial shadows. The parameters of the three types of representation are examined on this basis.

Anders Liljefors[2]

In his book *Seende och Ljusstråling, Anders Liljefors describes daylight from two different approaches by examining the physical and the visual properties of daylight (*Anders Liljefors, 1997). He differentiates between light that can be *measured as physical luminosity, and the light that is perceived, which is a description of the visual conditions concerning the nature and presence of light (*Anders Liljefors, 1997). This study focuses on describing light that is visually perceived.

Liljefors defines seven variables that are used to describe how light in a space is perceived: *level of lightness, spatial distribution of brightness, shadows, reflections, glare, colour of light, and colours (*Anders Liljefors, 1997).

The *level of lightness* describes the space's general light conditions from light to dark, a description of the light's inherent variation, degree of intensity and contrast. The perceived level of lightness is affected by the level of lightness to which the eye adapts. This means that a space which is initially experienced as bright can subsequently have the effect of being experienced as dark.

The *spatial distribution* of brightness describes the sources of light in a space and how this light is distributed within it, i.e. where is it bright and where is it dark.

Shadows describes the location and demarcation of shadows and whether they are sharply or diffusely defined; the intensity of brightness or darkness in the shadow and the degree of variation between darkness and brightness within it. Liljefors differentiates between attached shadow and cast shadow and describes the types and characteristics of the shadows themselves.

Reflections are defined by the nature of the surface and are produced by shiny and glossy surfaces. Reflections are affected by the direction from which they are perceived, which is why they change as the observer moves around in a space and will be perceived as dynamically variable.

Glare arises when the contrast is perceived to be too great for the eye to spontaneously adapt to it. Glare is not unpleasant per se, but will eventually be tiresome and will always lead to undesirable brightness contrasts.

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[2] Anders Liljefors, architect and professor emeritus, KTH Royal Institute of Technology.

The *colour of light* defines the shade of colour associated with the light that is affected by and observable in the interplay between the surfaces in a space and the objects within it, meaning that the colour temperature is not exclusively defined by the colour of the illuminant. Often, daylight is perceived as colourless, but with a tendency to be warm, neutral or cold. When moving from one space to another, the experienced colour of light will be affected in the same way as the level of light, depending on a previous adaptation.

The *colour* defines the colour of the surfaces illuminated by the light in question. It is affected by the reflective properties of the surface and by the light's properties and must be kept separate from the colour of light.

In addition to these seven variables, Liljefors defines luminance as a visual concept to define the luminous radiation from a surface in a defined direction. Luminance is a photometric value measured in candela per square metre (cd/m²). The value is affected by the illuminance of the surface, the angle of the surface and the surface's reflective properties. The measured value cannot in itself describe any visual properties of the light (Anders Liljefors, 1997).

Sophus Frandsen[3]

Sophus Frandsen has developed a categorisation of shadows defined according to size, location within a space and illumination intensity (Sophus Frandsen, 1985). He describes the shadows within a space and the shadows cast by objects, respectively. He divides the shadows cast by objects into types of shadows from 0 to 10. These describe in minute detail the shadows cast by objects according to their shading. He groups the shadows within a space into four categories: *large spatial shadows*, *large attached shadows, small attached shadows*, and *small shadows cast by details and textures* (Sophus Frandsen, 1985).

The *four shadows* categorise the types of shadows experienced within a space. The large spatial shadows and attached shadows are defined as being larger than human scale, and the small, attached shadows and shadows cast by details and textures as being smaller than human scale. The large spatial shadows and attached shadows describe the shadows within the space, the shadows which the body moves through and occupies. The large spatial shadows are defined by the geometry of the space, whereas the large attached shadows are defined by furnishings and sizeable elements within the space. The shadows cast by objects, details and textures relate to the illumination of things, objects and surface textures (Sophus Frandsen, 1985).

Methodologies for representing daylight

This study is part of a comprehensive research project which investigates the poetic and sustainable potential of daylight. The project will result in a pavilion, in 1:1 scale, to be built in July 2023. The pavilion is designed to enable a walk through a series of three spaces. The corridor has no apertures and its surfaces are black. As a result, the corridor contrasts with the three spaces, all of which will represent different types of daylight: sunlight, light from the sky and reflected light. To delimit the scope of

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[3] Sophus Frandsen Architect and Docent at the daylight laboratory at the royal danish academi of Architecture.

this study, this paper describes only one of the three spaces: *the space with light from the sky*. Light from the sky can be characterised as the primary source of light, as it is always present in a space, albeit less perceptible in direct sunlight as sunlight's intensity outshines the sky's characteristic spatial distribution of brightness (Marie-Claude Dubois, 2019).

As the pavilion will be located in Copenhagen, Denmark, it is under a Nordic sky. Nordic light is characterised by its profusion of diffuse light from the sky and the relatively low altitude of the sun (Nanet Mathiasen, 2006). It is under these light conditions that the spaces in the pavillion are going to be perceived and experienced.

Geometric dimensions of the space

The floor plan of the pavilion is shaped by the public square's existing architecture. The space for this study, measures 3.8 x 3. 8 metres and its volume is 5 metres tall (See Fig. 01). The aperture is a skylight, placed in the corner along the north-west wall, measuring 1 x 1 m. From the skylight, the aperture slopes down and opens out as a funnel of light into the space, with plane dimensions of 1.4 x 1.4 m. The shape of the bottom edge of the funnel is defined by the path of the sun in that the sun wanders around inside the funnel but never shines directly into space (See Fig. 01).

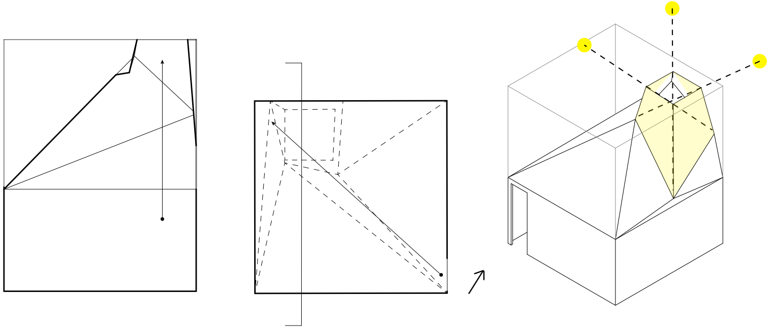

Fig. 01. Section and plan of the space in the Pavilion. The arrows define frem where the studies have been made. Isometric shows how the funnel is shaped by the path of the sun.

Source: Own illustration.

Daylight laboratory

The studies were carried out at the Royal Danish Academy's daylight laboratory, where it is possible to reproduce the light from the sky and sunlight of any location in the world (Ebbe Christensen, 1976). The floor space is 20 m² and windowless, and all the walls have mirrors. A white canvas is suspended below the ceiling covering the electrical sources of light, which evens out the illumination. The sun is a parabolic concave mirror that rotates around the object on a rail, held in place by a chain, to reproduce the sun's daily zenith passage on the 21st in a specific month (Ebbe Christensen,1976).

Study parameters

This study uses three different types of representation. The methodologies are simple and intuitive to use. They are typically applied in the initial development stage of a project.

The daylight studies were conducted using the following types of representation:

- Observation of daylight in a scale model;
- Photographic registration of daylight in a scale model;
- Simulation of luminance levels, distribution and contrast conditions

All studies were conducted at the daylight laboratory under identical light conditions and settings from the same fixed viewpoints in terms of observation, registration and simulation.

All the studies were carried out in the daylight laboratory under an artificial sky set for the following time periods: 21 June and 21 September, at 9.00 am, 12.00 noon and 3.00 pm in combined sunlight and light from the sky, as well as light from the sky only.

Observation of daylight in a scale model

The scale model is made on a scale of 1:10 in wood-pulp board, which is why all of the model's surfaces are the same, i.e., equally bright and matt. The model is considered to be a spatial object that is studied from several angles, focusing on interior spatial conditions. It is large enough for its interior daylight conditions to be visible from an observation opening without allowing false light to enter the space (David Egan, 2001).

Fig. 02. Photography of the scale model in the daylight laboratory at the Royal Danish Academy. *Source: Own Photograph.*

Photographic registration of daylight in a scale model

The same scale model is used to register daylight through series of model photographs. The registrations were photographed using a wide-angle 26 mm f 1.6 lens. The placement of the camera represents the eye level of a standing person, i.e. 160 cm. All registrations in the model photographs were taken from the same position to provide a comparative basis.

The photographic representations are a series of photos of the aperture and the appereances of daylight in the space (Louise Grønlund, 2015). The aperture is used to represent the experience of seeing the aperture from below gazing up towards the ceiling, i.e., a representation of the aperture's geometric shape. (See Fig. 03) The photograph of the appereances of light is used to represent the experience of the effects of the light, i.e. the visual, qualitative properties within the space. Seen from the arrival through the doorway, looking towards the north-west corner where the aperture is placed (See Fig. 03).

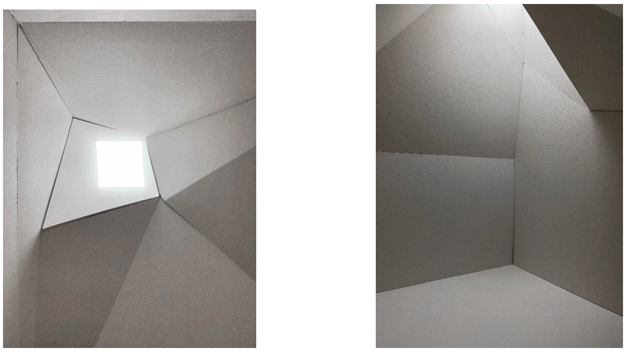

Fig. 03. Photography in the scale model of the aperture (left) and the appearances of daylight (right).
Source: Own Photographs.

Simulation of luminance levels and distribution

The simulation of luminance levels, distribution and contrast conditions is also a series of appereances of light and apertures that were carried out in the same manner as above (See Fig. 04). The series is calculated in the 'Fusion Optix' program and measures the volume of daylight reflected by the surfaces in the space. The measurements were taken in both direct sunlight and direct light from the sky. The luminance measurements represent the level of lightness, spatial distribution of brightness and contrast conditions, as defined by cd/m² (Marie-Claude Dubois, 2019). For interpreting the luminance calculations, the white and yellow colours indicate the highest level of lightness, whereas turquoise and black indicate the lowest. Thus, the luminance calculations act as a diagram in which the colours indicate the spatial distribution of daylight.

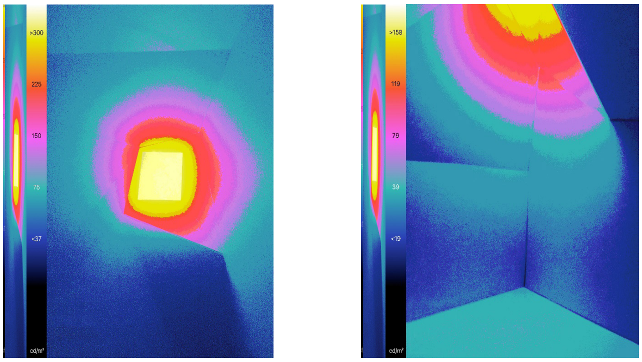

Fig. 04. Simulation of luminance levels and distribution of the aperture (left) and the appearances of light (right).
Source: Own Simulations.

Studies and observations

Concepts for describing daylight

In the following, the daylight in the space is defined according to Liljefors' seven concepts for describing the effect of daylight and Frandsen's four types of shadow.

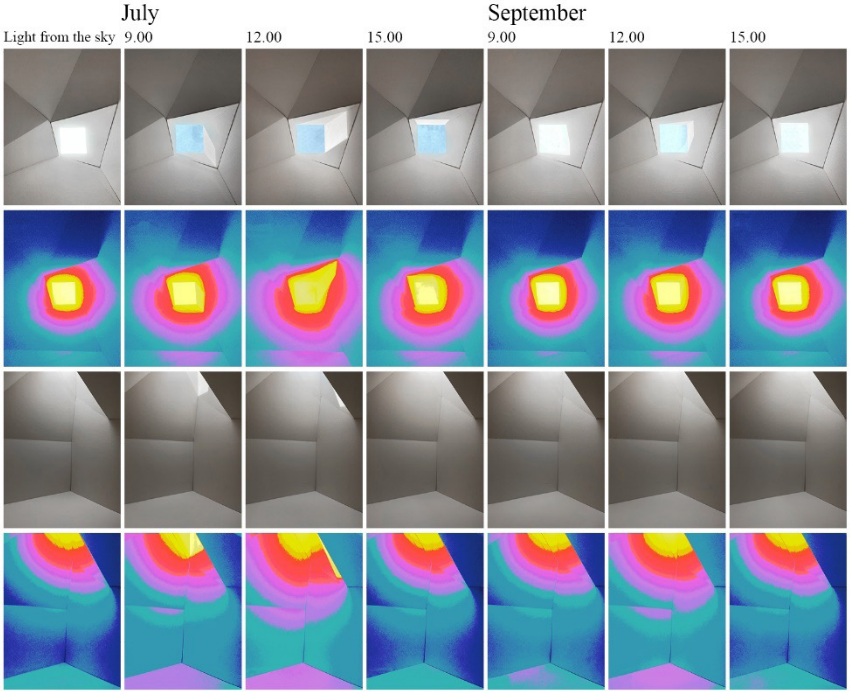

Fig. 05. Series of photographic registration of daylight and simulations of luminance levels and distribution in the scale model.

Source: Own photographs and simulations.

Level of lightness

Observations of daylight in the scale model describe an experience of the soft, diffuse light from the sky emanating from the funnel. The space is experienced as bright, with darker shades but not contrasts. The space has a high level of light without total darkness. The differences in level of lightness are created by the ceiling's intersecting surfaces, with each surface having its own shade of emanated light.

Subtle shadow differences outline the space, and distinct demarcations of light are produced solely by the geometric forms.

The photographic registration generally depicts a varying level of lightness in the space. There are subtle differences between light and dark, and the varying intensity of light is experienced almost as contrasts, as opposed to the observations in the scale model.

The simulation of the luminance values underpins the general experience of the space as bright, with no black areas. It can be observed in the simulations that the space is evenly illuminated and that small areas are brightly illuminated, at the same time that a small number of surfaces are much darker. The level of lightness varies during the day and year, as is seen in the tables alongside the luminance simulations where the values, indicated by colour, vary.

Spatial distribution of brightness

The scale-model observations depictes the top of the funnel to be perceived as the brightest spot in the space during periods when it is illuminated by sunlight. The other ceiling surfaces, illuminated solely by reflected light, cause the funnel to appear even brighter. The brightness is evenly distributed from the funnel down into the space until it meets the edges of the ceiling where contrasts arise.

The photographic registrations depict widely varying levels of brightness in the space. The contrast between the bright funnel and the dark ceiling is experienced as quite dramatic. The level of brightness in the funnel and on the floor directly beneath the aperture is quite high.

Very dark surfaces are seen in the top right corner of the photo by the appereances of light on the surfaces that are not illuminated by direct light. As these surfaces slope up and away from the aperture, they are cut off from a large volume of reflected light. The same experience is depicted in the photograph of the aperture in which the same sloping surfaces at the top of the photo appear quite dark.

The simulation of the luminance values shows that the spatial distribution of brightness in the space is even and with varying intensities, which is also true of the observation and model photograph. The space is constantly brightest in the funnel, at the top of the photo of the appereances of light. By contrast, the ceiling surface facing away from the aperture is the darkest, which is also experienced in the observation of the model and the model photographs. This correlation does not change. Depending on the time of year and day, the brightness in the space changes, as indicated by the distribution of colours in the photograph. The bright yellow colours can be seen extending further upwards in the space in mid-morning and the afternoon, and they are most dominant in the middle of the day, i.e. the very brightest at midday. The photo of light from the sky indicates the lowest level of spatial brightness (See Fig. 05).

The brightness varies from bright to darker vertically downwards through the space, with a sudden change in volume of light from the point where the angle of the ceiling changes. There is a clear correlation between the spatial distribution of brightness in the luminance photograph and the experienced spatial distribution of brightness in the model photo.

Shadows

Soft, diffuse shadows are observed in the scale model, and the only distinctly delimited shadow is cast where the wall meets the funnel in a dramatic shift in geometric shape. In perceiving the space as a single interconnected geometric shape, no cast shadows are experienced in the space. However, the geometric dimensions cast their own shadows where surfaces intersect at the aperture of the funnel.

The photographic representations depict the wide variety of shadow effects in the space. The shadows' brightness is high on surfaces around the aperture, where they are diffuse and nuanced. The ceiling's angled surfaces cast the darkest shadows in the space. They are solely illuminated by reflected light, which is why they are experienced as dark and keenly demarcated monotone shadows but in the photograph characterised by more highly defined contrasts. The shadows accentuate the geometric shapes in the space, the intersecting surfaces forming the funnel, and the varying illuminated areas in the space.

The simulation of the luminance in the space attests to the dark shadows cast in the transition from funnel to ceiling. Here, a sharper contrast than in the photographic representation is depicted. An almost black surface is produced in the area that shapes the aperture.

The shadows in the ceiling are blurred in the luminance simulation in the top left corner, where a pale shadow is visible in the photographic representation. Consequently, pale shadows cannot always be detected in the luminance simulation.

Reflections

The scale model's wood-pulp surface forms a bright, matt surface which explains why the photographic representations depict a diffuse reflection of the light – uniformly from all surfaces. This explains why it is not relevant to describe the light's reflections on the basis of the scale model.

Glare

In the observation of the scale model, no glare is experienced from the matt surface, the eye can adjust to the light to a greater degree than the camera can, and what is experienced in the model photograph as glare or over-illumination is experienced in the observation of the model as wide differences in the spatial level of brightness.

In the representation of the aperture in the light from the sky, the photograph is over-illuminated where the transition from aperture to opening creates sharp contrasts. Glare is also experienced at the top of the photograph of the light in the space in all photographs where the contrast between the dark ceiling and the brightest aperture is produced. The photograph is over-illuminated and completely white.

Glare is usually something to be avoided, but as this space has no other function than to create an experience of daylight, a mild degree of glare is not necessarily a unpleassant experience, if it emphazizes a specific atmosphere of light in the space.

The reason that the daylight in the funnel in the model photograph is experienced as glare is because it is being experienced in relation to the darkness in the space. As the measurements are not relative, the luminance photograph will not register the daylight in the funnel as glare. The photograph continues to depict a scaled level of lightness without any sudden transitions in the colour scheme.

Colour of light

The observations and registrations of the colour of light in both the scale model and the model photographs are not directly relevant, as the artificially-produced sky has specific illuminants that define the colour of the light. This means that it is not relevant for the studies to examine the colour of light.

Colour

The studies were made in the wood-pulp scale model, which is why the model does not have a representative surface. The colour and surface of the wood-pulp panels affect the colour of the surface, which is why it is not relevant to describe the colour of the surface on the basis of the scale model.

Large spatial shadows

In observing the scale model, the large spatial shadows are clearly experienced where the funnel intersects with the ceiling surfaces and where it casts a attached shadow. In addition, spatial shadows arise where the surfaces of the celing intersect, and where the floor meets the walls. The spatial shadows depict the space.

The registration depicts the shades of the many angled surfaces, and their points of intersection are even more distinct than in the observation. The edge of the funnel casts deep shadows where the ceiling meets the walls. As the space is dominated by diffuse light from the sky and the reflecting and relatively weaker light, the spatial shadows appear throughout the space as soft, which is why they are not experienced as well-defined and contrasting.

The luminance measurements show how the light is evenly distributed in a scaled intensity, and that the only defined shadow is cast against the darker ceiling. In the version of the aperture, shadows other than the one cast by the funnel into the space are visible to only a minor extent. The small shifts between the surfaces are so pale that no differences are produced in the simulation. However, we see multiple shadows cast in the version of the appereances of light where the geometric differences are greater and therefore cast darker shadows.

Large and small attached shadow

As the space of the scale model does not contain objects, it is not relevant to describe large attached shadows.

Small detailed and textural shadows

The surfaces of the scale model are atypical in terms of scale and materials for the space, which is why it is not relevant to describe shadows cast by details and textures.

Summary

The first question of this study examines the specific daylight qualities that can be depicted by the different types of representation.

The observations of the scale model assist in understanding how daylight is present in the space and influenced by the eye's ability to adapt to the light in the space. To supplement this, the model photograph works to register the variation studies. The luminance study supplements the depiction of the model photograph, as it can depict whether the space is sufficiently bright and where undesirable dark areas are produced. A solid basis for preparing an aperture to achieve a specifically preferred effect is established in the interplay between the three methodologies.

The observation in the model is particularly intuitive to interpret, but it is difficult to compare or to see the differences between any variations over time. The model photographs are legible and contributes to the comparative studies. At the same time, it can be difficult to determine the scale of the photographs, especially given that they are devoid of objects and surface materials. The three methodologies are interpreted according to the concepts of Liljefors and Frandsen to ensure a systematic process.

This leads to the study's second question, dealing with how the qualities of daylight can be interpreted according to the concepts of Liljefors and Frandsen.

By applying Anders Liljefors' seven variables to describe daylight quality and Sophus Frandsen's categorisation of spatial shadows, the types of representation can provide information on the large spatial shadows as well as on the level of lightness and spatial level of brightness in the space. However, the small shadows cast by small objects and textures, as well as colour and reflection, cannot be described using the concepts, as daylight is heavily influenced by the geometric shapes and surfaces of the space and the model's materials and surfaces are atypical.

Consequently, the representation of light in the model is incomplete, which is why the methods are recommended as part of the outline process for forming an impression of the experience.

Discussion

The representation of the experience of daylight is informed by the three methodologies, all of which contribute to different types of information, which is why the methodologies supplement one another.

The observation creates an experience for the oberserver and enables a dynamic experience, as the peripheral field of vision perceives a wider field. However, the subjective observation in itself establishes a deficient basis for comparison and description. The model photograph is informative and communicative, and the series of photographs lays the basis for comparing and analysing the appereance of daylight. At the same time, the experience created by the observation differs from the representation contributed by the model photograph. The photographs also depict a higher degree of contrasts and darker shadows.

The simulation of the luminance distribution indicates how the intensity of daylight is evenly scaled from the aperture down into the funnel and how it is evenly distributed in the rest of the space. This information is also communicated in the model photograph. However, the luminance simulation imparts knowledge that cannot be interpreted or analysed in the other types of representation, i.e. quantitative information about the value of the light that is not relative or influenced by adaptations. The evaluation of the level of lightness in the observation of the model and the model photograph is described in relative terms, as the eye adapt according to the brightest and darkest areas. On the other hand, the luminance value, seen in isolation, is comparable to other spatial geometrics.

As a result, the model photograph and the luminance photograph form a point of departure for a comparative study of these two methodologies, as they are registered in the same way. This comparison shows that the model photograph has more nuances within the shadows than the luminance photograph, where diffuse shadows disappear in the weaker reflected daylight.

Conclusion

The three types of representation inform the study about the daylight in the scale model, and the observation is affected by the eye's ability to adapt to the light from the sky, by contrast with the camera. The photographic representation and the luminance simulation render the comparative study possible through the series of photographs.

Daylight is heavily influenced by the surroundings, geometric factors and surfaces in the space, which is why this study, done in a scale model made of wood-pulp board without representative surfaces, is unable to provide information about colour, the reflections of light, or shadows cast by small objects and textures in the space. At the same time, the colour of light is influenced by the daylight laboratory's light from the sky, which is why it is not relevant to describe this in this study either.

The model can make use of the three selected types of representation to describe the large spatial shadows and the level and spatial distribution of light in the space, but the concepts associated with materiality and surface and with the shadows cast by the small objects and textures cannot be described in this scale model. Therefore, we can extract that daylight has no scale, but that the quality of daylight has a scale. We can experience, observe and register perceived daylight in the space of the scale model, but when we are to describe the experience and to characterise daylight's qualities, this is not clearly seen in the model due to its scale and the detailling of surfaces.

Knowledge from this method brings an awareness on the difference between the scale model 1:10 and the space in 1:1. This will be unfolded at the presentation at the conference where it is possible to visit and experience the pavilion in Copenhagen.

The experience of daylight is linked to a scale because human beings have a scale. Therefore, one can extract - that daylight is without scale, but that the perceived quality of daylight has a scale.

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Scale and Representation

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Anthropic units in Baroque Architecture, the *Gallery of the Palazzo Spada* and the roman palm

Introduction

Historically, measurement units have been linked to bodily proportions. From the ancient cubit based on the length between the elbow and the middle finger used by the Sumerians and the ancient Egyptians, to the foot still in use in a minority of nations today, human-based systems of units allowed for straight forward representations of scale. No tools were needed to apprehend the surrounding environment. The dimensions were quite literally incorporated within humans, in the Latin *corpus*, the body. Measurements were consequences of a palpable reality linked to a close material universe. After the French Revolution, the Age of Enlightenment looked for a unified way of measuring lengths and weights. During the 1875 *General Conference on Weights and Measures,* seventeen states adopted the international system of units (Moreau, 1953) which brought the question of scale to an astronomical division with its primary measurement of length, the meter, determined by a subdivision of the earth perimeter along the Paris meridian. The search for a unified unit has also caused a standardization of our perception of measurements (Lugli, 2019). The physicality of our relationship to scale has tailed off.

Considering the determining role of measurement and scale in architectural design, questioning the shift from a unit of measurement based on the body (and apprehensible on a human scale) to a unit based on a fraction of the earth seems necessary. As an extension, understanding the impact of historical dimensional systems on compositional logics constitutes a telling way of reinvestigating references from architecture history. Why is a precise understanding of the link between scale and measurement necessary to apprehend composition in its proportions? We will study Baroque architecture as it offers many avenues to explore the singular relationship that links body and scale to proportions, space and representation.

The aim is to reinvestigate the link between body and composition through a drawing-based analysis of a case study which makes use of anthropic units of measurement, directly linking architecture to human proportions. This analysis will focus on Borromini's Gallery of the Palazzo Spada (Fig.01) with the aim of capturing, through the re-drawing of original documents, the impact of the Roman palm and its resulting drawing scales on the proportional logics, the geometric lines, and the design process. The gallery has been studied through multiple lenses as one of Baroque's most emblematic anamorphosis. We will shed a new light on it, by offering a reading of this historical Baroque building through the architect's tools, research in history by copying, by re-drawing, as a way to understand.

Fig. 01. View of the Galleria del Palazzo Spada from the courtyard.
Source: The authors, November 2022.

Learning through copying and Baroque representation

A Renaissance Heritage & Copying as a Teaching Resource

In the western world, the Renaissance marked a passage from builder architect to design architect. Ever since, buildings have been conceptualized through drawings and composition has started on paper. Representation techniques have become the heart of the architectural practice as they constitute the architect's ability to generate forms (Evans, 1997). Throughout modern history, copying was used to share knowledge in diverse fields and manners. The imitatio naturae, the drawing after nature, was notably used to illustrate 18th century encyclopedias (Datson & Galison, 2012).

During the Renaissance, the reproduction of representations served as a teaching methodology. Visual arts were taught through the copy of Masters' drawings. During that same era, the architecture curriculum also involved copying as a learning tool. As the current was considered the pinnacle of arts, the imitatio auctorum, the redrawing of man-made objects, became an essential teaching resource (Fransen, Reinhart 2019). The practice of copying, coupled with the democratization of printing, rendered the junction of theoretical writings and graphic representations possible, linking, from then on, drawing to research in architecture.

Even though redrawing in architecture has, since the Renaissance onwards, been used in higher education, it is only in recent years that the heritage of copying has been explored as a research tool in our field.

The Practice of Copying as Knowledge Production

Recent works in anthropology, art history and applied arts have focused on the practice of copying as a relevant methodology in research (Lucas, 2019; Fransen, Reinhart 2019). The act of redrawing conveys different forms of knowledge and grants access to new perspectives on the original works. The copies of existing works produce a part of newness due in part to choices operated by the drafter. Whether it be the decisions in elements to reproduce, in layouts, in methods or in how the resulting drawings are presented, each choice alters the final works. The act of reproducing each specific quality in a drawing implies its prior analysis. The modes of projection, the view point, the quality of the lines (Lucas, 2019), or the drawing scale, need to be understood in order to be relayed. The copies are not meant to be exact, the researcher is not a forger, the reproduction of each quality of an original drawing carries out knowledge. These qualities are key elements in the design of the architectural project and their mobilization through the reproduction of representations renders the use of re-drawing as a heuristic device for research in architecture history possible. The reproduced works become objects of discussion, their relationship with the original work gives way to a new dialogue, they allow us to re-examine a newly acquired knowledge. It is in search of this knowledge, in understanding projection as a process of design, that our study relies on copying. As making exact copies is not of interest to us, we will, from now on, use the term *re-presentation* to address our work.

The knowledge which can be discovered through *re-presentation* is rooted in a specific analytical device, namely abduction reasoning. The principle of the *indicial paradigm* describes a research methodology specific to disciplines that do not claim to achieve universality (Ginzburg, 1980; Peirce, 2017). This method is based on a science of clues that, like police investigations, explain identified phenomena by the formulation of successive hypotheses containing ‘an irreducible margin of uncertainty’ (Ginzburg, 1980). Reasoning by abduction takes on its meaning in architectural research thanks to the iterative process of design, which is materialized by the production of graphic representations (Genard, 2017). It is through the process of trial and error in drawing and modeling that the architect designs and solves their buildings. It is the link between retro-conception and projective acts that our research aims to demonstrate in regards to its methodological objectives. If there is indeed a production of knowledge from the act of drawing, it would be possible to access it by mobilizing the same medium, by producing re-presentations. This is where the analysis of architecture through the reproduction of graphic documents takes on its full meaning. Going back to iterative the traces of the architectural project will allow us to rediscover the projective processes of our case study.

These preoccupations will be addressed by discussing Baroque architecture through *re-presentation*. It is by mobilizing the tools of the architect, for a research specific to the field, that we aim to deepen our understanding of the *Galleria del Palazzo Spada.*

The Baroque Representation Shift, Perspective Plays and Anamorphosis

The Baroque is a pivotal moment for architectural representation's evolution, the Renaissance progresses in terms of geometric projections were mastered and started being played with. The use of anamorphoses and *trompe l'oeil* perspectives testify to how representation techniques and composition were intertwined. Buildings such as the *Scala Regia* (1663) by Bernini or our case study, the *Gallery of Palazzo Spada* (1632) by Francesco Borromini blur the lines between drawing and architecture of the embodied world.

The particular case of Baroque anamorphosis highlights our interest in analyzing Baroque architecture through *re-presentation.* It is through the act of drafting that the design process takes place. Canonical representations, plans, sections, elevations from the spectrum through which buildings are imagined. The drawing conventions thus have a significant influence on spatialities (Lucas, 2019). Dimensions suddenly go through a shrinking specter, measurements are reduced to fragments of what they represent. An understanding of the tools, the units and the scales used is needed to apprehend a building's composition. These notions allow us to situate the importance of representational practices not only as design tools for the architect, but also as a methodological basis for understanding our case study.

Borromini's Gallery of the Palazzo Spada and the Roman Palm

During the Italian Baroque measurement units varied from one locality to another. The Roman palm, an anthropic unit based on the width of the human palm, was used by Borromini and his draughtsman Francesco Righi in design. Grasping the richness of the compositional logics of Baroque architecture without considering or analyzing the link between measurement and body seems difficult. This specific case study introduces a double complexity through its twofold relationship to corporality and the human scale. To understand these two parameters we propose to analyze the gallery through two complementary approaches. First, the analysis of the building as designed highlights the incorporation of the human observer, of their proportions as the starting point in the geometrical process. Second, the building as perceived, with its projected regularity, allows us to approach the impact of the Roman palm on the composition. The relationship between physicality and unit of measurement present in Baroque architecture is here exalted by the accelerated perspective which positions the body at the center of the projective device, integrating physiological properties within the design process.

Our research hypothesis is that a precise understanding of a unit of measure and its relationship to the body is necessary for an analysis through drawing. The practice of copying's purpose is to reveal dimensions of the project and its design that have not been explored through other specters so far. First, we will examine original drawings through their re-presentation. Then, we'll compare our findings to the building by making use of a survey. Finally, we will confront both the project as designed and the building as surveyed to the building as perceived, projected by the accelerated perspective.

Re-presentation and Roman Palm

The two archival documents at our disposal are a plan (Fig.03) and a so-called pseudo-perspective drawing (Fig.02) dating back to 1652/1653, around the years of the gallery's construction. Before diving into our renditions of Borromini and Righi's drawings, a few observations can be made. Measurements in fractions and multiples of Roman palm are annotated on both drawings and graduated lines allow us to take the drawing's scale into consideration. We can already notice the space between the framing columns at the front of the colonnade (14 palms) is divided by two at the end of the gallery (7 palms). These measurements can be found on both drawings, hinting at the nature of the *pseudo-perspective* which is in fact an elevation. The accelerated perspective introduces vanishing lines in both plan and facade drawings. The representation allows us to go back to the geometric lines, towards a supposed vanishing point, we will start by drawing the elevation as it allows us to analyze the project as a whole.

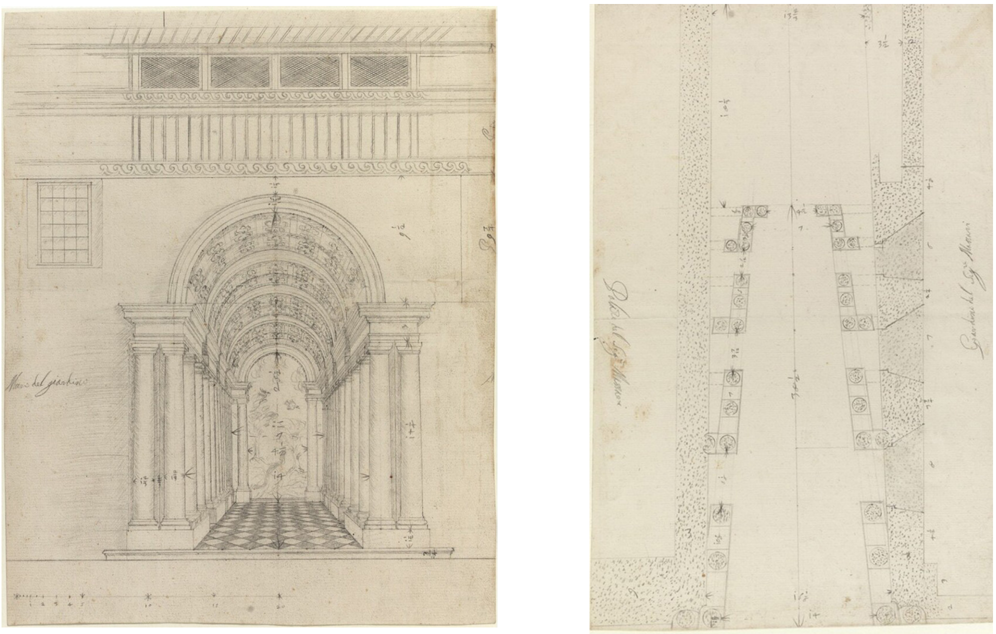

Fig. 02. Pseudo-perspective elevation of Galleria del Palazzo Spada, Francesco Borromini, Francesco Righi, 1652/1653. Fig. 03. Pseudo-perspective plan of Galleria del Palazzo Spada, Francesco Borromini, Francesco Righi, 1652/1653.

Source: Collection of the Albertina Museum, Vienna .

<u>1. The Pseudo-Perspective Elevation, Towards a Vanishing Point?</u>

When starting the re-presentation, the bar scale is the first mark reproduced. It serves as a ruler, as our first guide for reporting all proportions and measurements using a compass. At first glance, the drawings suggest the accelerated perspective was designed according to classical conical projections, meaning all lines in the depth should converge towards a singular vanishing point which would serve as our second guide in the re-presentation. This point should be situated on a horizon line, at the height of the ideal observer. However, in the elevation this vanishing point cannot be found precisely. Indeed, when drafting 6 lines of flight (in red) we can see they converge towards a vanishing zone but not a singular point (Fig.04). The discrepancy is most noticeable when comparing the lines from the floor and those at the top of the pedestal. This divergence could, however, be explained by drawing imprecision, which is why we attempt to verify our observation by looking for the horizon line.

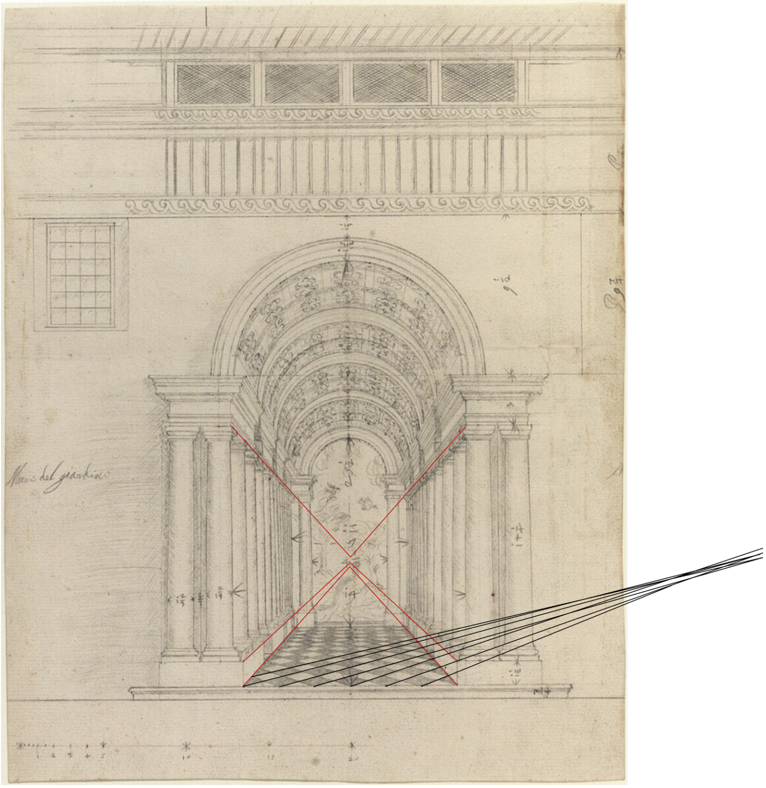

Fig. 04. Galleria del Palazzo Spada, Francesco Borromini, Francesco Righi, multiple vanishing points and no singular horizon line.

Source: The Authors

We search for it by following the floor grid, in accordance with the rules of quadrature (Fig.04). When doing so we notice the lines (in black) not only do not converge precisely towards two symmetrical points but are also situated approximately 1,5 palms above the vanishing zone, confirming the elevation was not drawn according to conical perspective rules. If all the lines of flight vanished towards a singular point in space, the elevation, as a canonical projection should indeed conserve this singular vanishing point on a horizon line. (Fig.05) As a precise vanishing point cannot be found in this drawing, our only drafting guides are the bar scale and the annotated measurements.

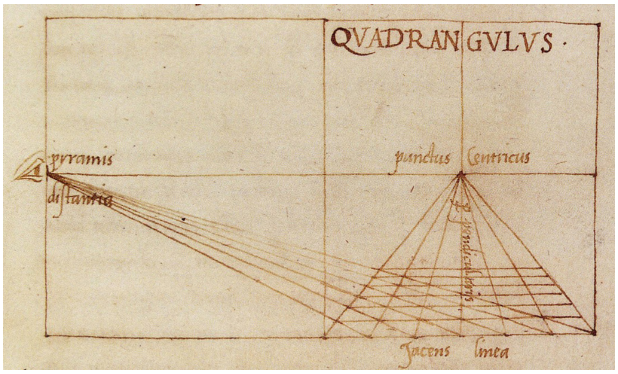

Fig. 05. Leon Battista Alberti, on quadratura, 1448.

Source: Biblioteca Statale Lucca

<u>*2. The Pseudo-Perspective Elevation, Proportionate Shrinking in Roman Palm.*</u>

As we concluded the vanishing point is only approximated in this first drawing, our hypothesis that emerged from the re-presentation drawing (Fig.06) is the following. Borromini and Righi's elevation was designed according to a proportionate shrinkage stemming from the plan's dimensions, from heights related to Doric composition and potentially by reporting heights from a missing section.

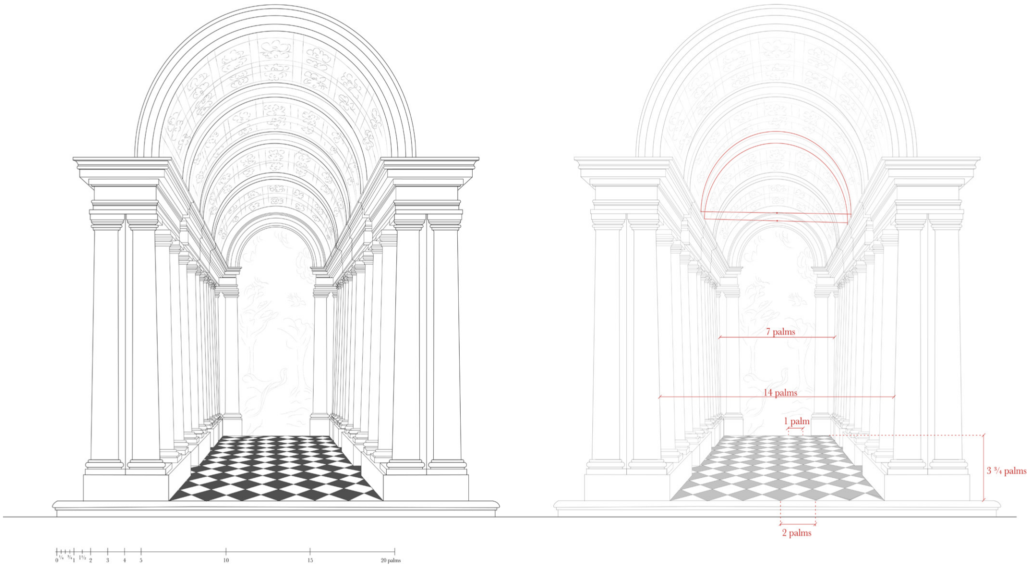

Fig. 06. Galleria del Palazzo Spada, Elevation re-presentation and annotations

Source: The Authors

Our elevation was drawn starting from the forefront colonnade. Measurements from the original drawing allowed us to draw this foreground, considering it as the accelerated perspective's projection plan, meaning it would constitute the illusion's undeformed true size. The main width measurement of 14 palms, an even number that could fit in between the existing surrounding walls, might have guided the order's heights which maintain Doric proportions. Our second main width measurement then comes into play. The background colonnade, with the external width of 7 palms is then drafted by dividing all the foreground measures by two. It was drawn at a height of 3 palms and 3/4 from the foreground columns' bottom of the pedestal. As we know, Borromini burnt number of documents before his death (Fallacara G., Parisi N., 2004) we cannot be sure of how all heights were determined. We can, non the less, surmise this placement is related to a potential lost section drawing that set an ideal observer height, resulting in the floor and vaulted ceiling's specific inclines. This supposition also stems from how the rest of our re-presentation was drawn.

3. The Pseudo-Perspective Elevation, Column Placement and Distorted Arches

After drawing both the foreground and background columns, vanishing lines are outlined by connecting the two parts. The vault's arches are effortlessly reproduced by drawing a series of horizontal lines following the annotated measures. We do, however, notice each series of two half-circles, which compose an arch comes from a translation of the center on the vertical axis resulting in a true half-circle and a slightly raised one. As the accelerated perspective stretches the arches in the depth, a geometrically exact vault (according to a conical perspective) in elevation would be composed of two arches, with one center each, on two parallel diameters. This distortion is noticeable when comparing the arches' thicknesses on the central vertical axis and those on the cornices. The distortion suggests two things, first it confirms the elevation wasn't drawn as a perfect perspective. Second, it questions once again the projection of heights through a lost section. As we will see later when analyzing the gallery as built, the arches' distortion was solved by implementing a succession of vaults framed by front facing arches supported by groups of three columns. The first rows of columns, supporting the arches can be sketched by following the arches trajectories. When attempting to delineate the remaining columns, we soon notice the elevation's annotations do not suffice.

4. The Pseudo-Perspective Elevation, Checkered Floor and Depth Perception

We turn our interest to the checkered floor and divide the foreground in six segments measuring at two palms each. The floor's end is divided in six one palm increments, allowing us to recreate the diagonal checkered pattern. In quadratura, these floor division would serve as depth guides for anamorphosis, and would thus help us in finding the remaining columns positions. In Borromini and Righi's drawing, however, the columns' bases are not placed on the squares' vertices. The floor's patten doesn't serve as a guide, it role seems to be rooted in emphasizing depth perception in the drawing. We count ten squares in depth, without even considering the accelerated perspective's role in shrinking each square, we realize the floor cannot match real measurements as the gallery's plan measures at 38,5 palms and a non-distorted checkered floor would only reach 20 palms. Our only guide in redrawing the remaining columns is the projection of vertical lines from the columns' positions in plan.

5. The *Pseudo-Perspective* Plan, Round Columns Against Anamorphosis Rules

The plan's re-presentation is a more straight forward endeavor. By following the annotated measurements, the directional strokes, the dashed lines and some bold dots marking various proportions, a plan is reproduced. Once again the vanishing lines connect the 14-palm wide opening between the front columns to its 7-palm counterpart at the end of the gallery. In opposition to the elevation, a singular vanishing point can be found 36 palms away from the end of the gallery. (Fig.07)

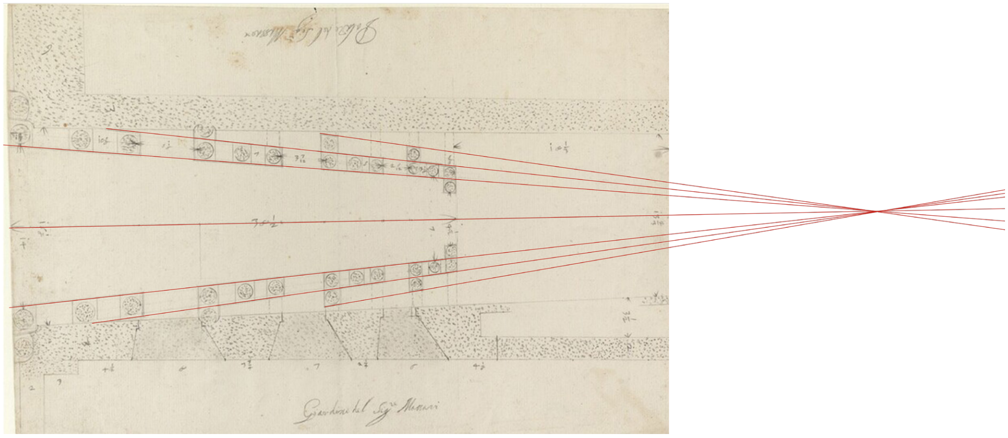

Fig. 07. Galleria del Palazzo Spada, Francesco Borromini, Francesco Righi, singular vanishing point in plan

Source: The Authors

The columns become of interest in this drawing too, they reveal the gap between anamorphosis's geometric implications and the realities of projects meant to be built. In order to truly follow the anamorphosis's perspectival deformations, the columns' section would be elliptical. These ellipses' major axes would conserve the current columns diminishing diameters. The ellipses' minor axes would shrink more drastically, flattening the columns towards the end of the gallery. As the columns support the arches and vaults, we can argue the elliptical columns' absence is due to constructive realities.

The re-presentation brings geometrical inaccuracies to light. Annotated measurements serve as clues in understanding how the accelerated perspective original drawings were constructed. We will now compare our findings stemming from the gallery's drawings to the gallery as built in order to appreciate the coherence between the project and its materialization. This will then lead us to an analysis of the building's composition as perceived.

A Re-Reading of the Gallery Through the Survey

Considering the architectural project through its drawing and its copy allows us to apprehend with more subtlety some of its compositional dimensions, but also to bring out a non-visible part of the genealogy of design. While this approach enriches our view of the drawn object, it does not fully take into account its material dimension. Between the drawn object and the constructed architectural object, there remains a gap that needs to be qualified.

Whether for reasons of execution on site or simply for reasons inherent to the project itself, the confrontation of the study by the copy of the survey is essential to measure the richness and the coherence of the project. In the continuation, our interest in an observation of the object as built is to show the possible compositional ambiguities that the drawing reveals. These ambiguities do not disqualify the project, but rather reveal certain subtleties that the history of art fails to grasp.

In this particular case, the challenge is to provide a more complete view of the Galleria del Palazzo Spada. In addition to the singularity of its integration between two courtyards of the Palace, it presents an anamorphic feature that increases the perceived length of the gallery. While the dimensional and executional coherence between the drawing and the built object has been highlighted in Adriana Capriotti and Augusto Roca De Amicis' study, La Prospettiva di Palazzo Spada (Capriotti, Roca De Amicis, 2022) the perspective projection as such remains rarely discussed.

The accelerated perspective of the constructed building is often represented by a limited number of vanishing points. It is interesting to note that the design drawings and the re-drawing work show more, indicating the absence of a constructed conical projection. This perspective approximation, present from the beginning of the project, seems to manifest itself also in the built object. In total, the survey reveals almost ten perspectival lines, which makes it possible to exclude the existence of a geometric design using the "Perspectiva artificialis", even if it was already used by numerous artists and architects since the 15th century.

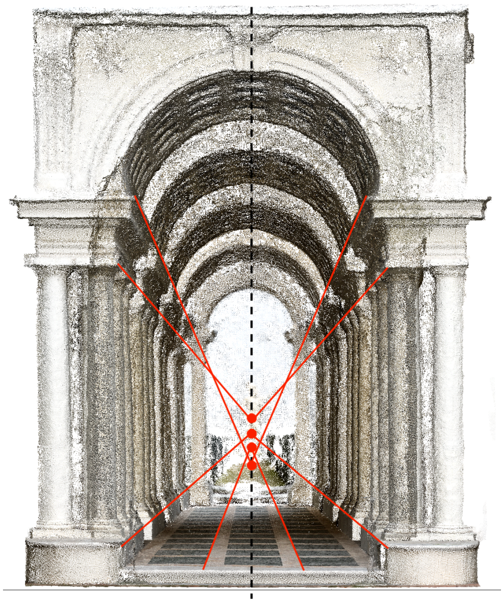

Fig. 08. Galleria del Palazzo Spada elevation from a photogrametric survey, multiple vanishing points.

Source: The Authors, November 2022

The comparison of the drawing with the survey (Fig.08) not only confirms the coherence of the project (designed and built) but also suggests that Borromini would have favored the principle of perceptual shrinking to the detriment of a geometrical construction of accelerated perspective. This can be explained by the need to integrate the gallery project into an existing building, one of the wings of the Palace. This constraint could have led Borromini to favor an adaptation of the pre-existing composition of the building to the mathematical accuracy of a constructed perspective.

The Gallery as Perceived

The survey allows us to draw a plan and a section of the gallery and its direct surroundings as built. The accelerated perspective is inherently linked to human perception as it plays on our depth perception through conical vision. In order to analyse the buildings' proportions we must project the perceived space. To do so, we would need to situate an ideal observer. Re-presentation revealed the multiple vanishing points contained in the gallery which were confirmed by the survey. As the vanishing points do not align on a singular horizon line, there exists multiple possible view points. We need to take all those factors into account in order to project the space as perceived. This allows the illusion to be operative not from a single point of view but from a viewing area, or even from multiple locations.

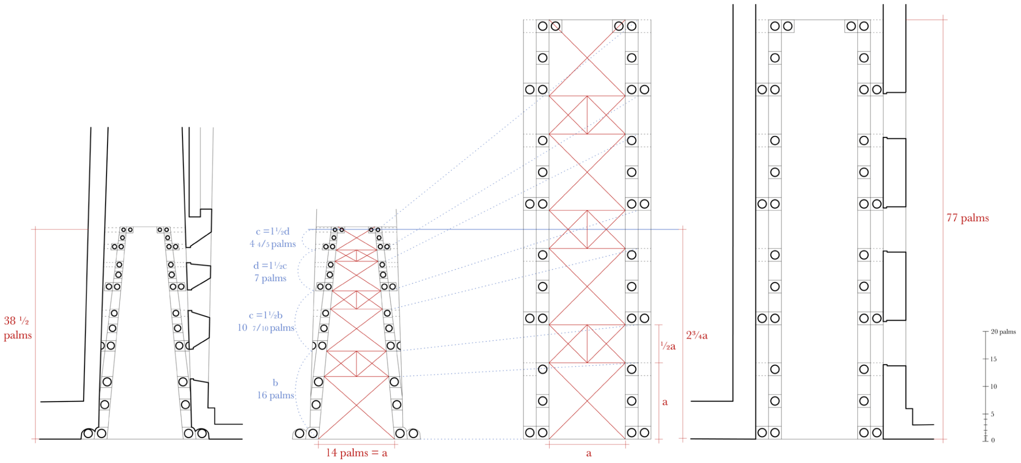

Fig. 09. Galleria del Palazzo Spada re-presentation plan, annotated plan and the gallery as perceived.
Source: The Authors

To reconstruct its undistorted version from conical perspective implies identifying a single point of observation and a single vanishing point. If this approach seems relevant, it would require us to correct the project towards a conical projection contradicting the building's design. We thus consider the gallery's arithmetical shrinkage rule as our basis for the projected space. By reversing this rule and by extrapolating measurements from the undeformed true width of 14 palms, we project a hypothesis of the perceived object (Fig.09). We observe a gallery of 77 palms in length, twice as long as the 38,5 palm deep accelerated perspective Galleria del Palazzo Spada.

Conclusion

The initial intuition pushed us to approach the analysis of the gallery through the palm and its anthropic relationship to measurement. This singular unit finally proved to be essential in understanding the arithmetic rules which guided the accelerated perspective's design. Even in the epistemic context of Baroque design, where conical perspective projection is known and mastered, this project's design seems to voluntarily not resort to it. This surprising approach suggests the use of arithmetical reduction principles which echo the anamorphoses of theater sets.

Analyzing the gallery on the basis of the Roman palm's dimensional system thus attests to the need to consider the unit of measurement of design as a key to its understanding. This was only made possible by a detailed analysis of the period drawings through their re-presentation. In this adbuctive research approach, a series of iterative observations were made through re-presentation. They allowed us to question the influence of geometrical projective devices through drawing and their influences on the project and its material embodiment.

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Conceptualising Object Lighting Across Multiple Scales and Media

Introduction

This paper presents findings in conceptualising object lighting across multiple scales, developed for a workshop, experimenting with directed LED spotlights in full scale 1:1 as well as in 1:10 and 1:20 scale models. The experiment set out to test whether conceptualised directed LED spotlight is perceived similarly at different scales in physical models with special interest in the smaller scale 1:20. Our focus was the perceived qualities of light distribution, shadows, light temperature (colour), balance, and intensity.

We combined analogue and digital representation, using photographed 360° panoramas of the architectural scale models for evaluation in virtual reality (VR). The didactive method used was based on hands-on experiments applying and evaluating object lighting for exhibitions. The method is qualitative and focus on human perception of light and light qualities.

The aim was to introduce fast and iterative workflows for experimenting with scaled directed lighting in spatial design with (often existing) scale models to supplement digital design tools.

Background

Light is a prerequisite for visual perception. Architects and designers are focused on the atmosphere and experience of space and objects in space and therefore light quality is an important aspect of spatial design (Garnslandt & Hofmann, 1992). In our teaching we consider both light source, object and context, and perceiver including evaluation medium.

Object lighting for retail, exhibition fairs and museums require a broad range of lighting knowledge including legislation and regulations (Olsson, 2019). Often museum exhibits are fragile and sensitive towards light exposure and require light protection limiting intensity, ultraviolet radiation and infrared radiation. This can be achieved with LED luminaires with low-damage spectrums ensuring long-term, conservation-compliant art displays. In this study we only considered the perceived qualities of light as a starting point for conceptualising object lighting for exhibitions using scale models.

Our spatial design master students have different backgrounds including various international architecture and design educations. Many students have not previously received dedicated lighting training. The presented didactive method for conceptualising object lighting for exhibitions require basic lighting knowledge, therefore we propose a three-part workshop setup where each part can be taught independently (Kreutzberg & Mose, 2021b).

First an initial general introduction to lighting through lectures and observations and experiments in 1:1, then specific exercises with LED lighting in scale models (Kreutzberg & Mose, 2021a) and finally digital modelling with IES lighting files.

In this paper we present the experiments and findings that defined some of the exercises included in the second workshop, working with directed LED spotlights in 1:1, as well as in 1:10 and 1:20 scale models and their representations.

Methods

An exhibition scenario was established with four lighting variations in three different scales. The smaller scale model scenarios were qualitatively evaluated and directly compared to the 1:1 physical reference by viewing series of perspective photographs or 360° panoramas captured inside the scale models as well as in the 1:1 setting and displayed on smartphones/tablets or in VR head mounted displays (HMD) to balance contrast and compensate for brightness eye adaption, (Fig. 05).

Exhibition scenario

The illuminated object in this experiment was a 43 cm white gypsum replicate of a Venus torso (see weblinks). The human body is a well-known object we can understand without explanation and is well suited for lighting studies. The torso was centered on a podium placed 12,5 cm from a wall as backdrop and 110 cm left from a floor-to-ceiling window (100 cm with curtains drawn) reaching a total hight of 145 cm (Fig. 01). In this study the colour of light was evaluated on white surfaces only.

Fig. 01. A. Exhibition object. B. Daylight setting, C. Mixed LED light setting.
Source: Authors.

Lighting scenarios

Both daylight and general lighting can contribute towards the illumination of displayed objects, as can light from directed spotlights. Sculptures generally require directed light in combination with diffuse light to best reveal three-dimensional quality, materiality, and surface structure.

We are aware of cultural and geographic differences in perception of light colour qualities and the use of cold, neutral and warm white light (Durmus, 2022). We define warm white with a colour temperature of less than 3500 K, neutral white with a colour temperature between 3500 K and 5000 K and cold white with a colour temperature of more than 5000 K. In the Nordic region neutral white light is often perceived as cold.

For this study we recreated four representative lighting scenarios in 1:1, from a larger series of scenarios used in teaching fundamental lighting design (Fig. 02):

A Diffuse cold daylight
B Warm white spot and diffuse cold daylight
C Warm white spot and neutral white wall wash (vertical lighting)
D Warm white spot and neutral white spot and neutral white wall wash

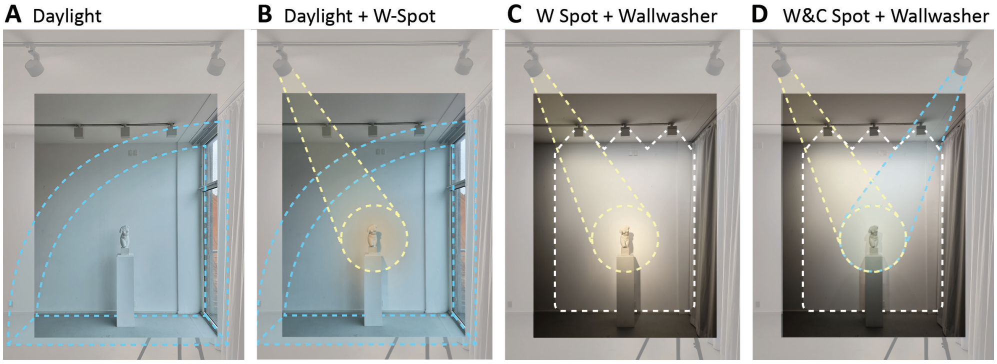

Fig. 02. Lighting scenarios A, B, C & D

Source: Authors

Three different LED light luminaires were used in combination with and without daylight (Table 01)[1,2] (see weblinks). ERCO spotlights use high quality LEDs and are widely used in museum lighting.

Table 01. Light sources 1:1

1:1	Luminous flux	CCT	Manufacturer part number
ERCO Parscan Spotlight (Warm white)	1042 lm	2700K	25999.000
ERCO Parscan Spotlight (Neutral white)	1042 lm	4000K	25999.000
ERCO Pantrac Lens Wallwash (Warm white)	694 lm	3000K	77766.000

Source: Authors.

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[1] Luminous flux is the total amount of light emitted from a light source and is meassured in the unit lumen (lm).

[2] Correlated color temperature (CCT) is a one-dimensional metric that aims to quantify the perceived visual quality of nominal white light sources.

The two ERCO Parscan spotlights of different colour temperatures defined an illuminated oval of 110 cm width on the back wall in scenario B, C and D. The ERCO Pantrac wall washer used in scenario C and D created reflected vertical back light to tone down shadows for a less dramatic scenario (Fig. 03).

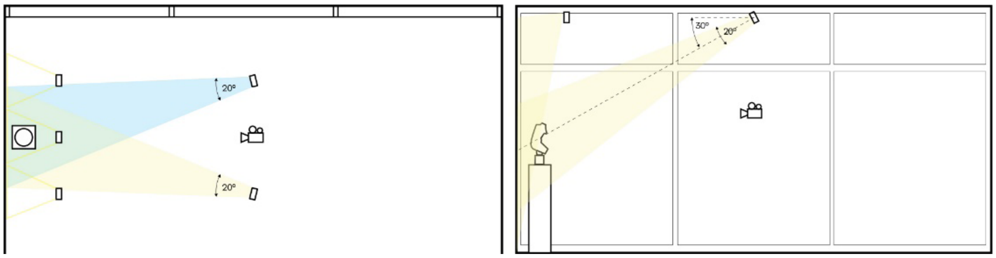

Fig. 03. Lighting setup. Plan left, Section right
Source: Authors

Shadow shapes and intensity were photographic registered and approximate colour temperatures were measured with a Sekonic C7000 spectrometer in front of the exhibition object and in the shadows in all four lighting scenarios to indicate the effect of light mixing (see weblinks) (Fig. 04).

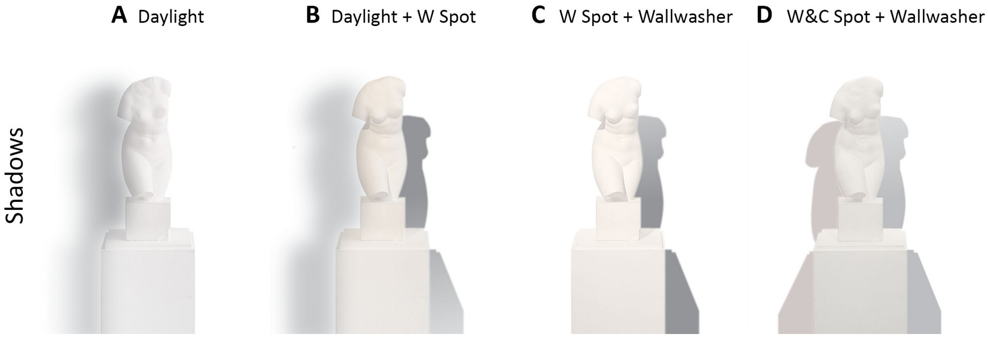

Fig. 04. Shadows
Source: Authors

Scales

There is a long tradition of using physical scale models for dayligt and shadow studies, since daylight is perceived precise at any scale without having a reference for size. And the scale models are still legitimate in evaluating the perceived qualities of day light compared to digital simulations (Bertram, 2012). Artificial light on the other hand is not perceived as scale less and vary in intensity depending on the distance to the illuminated object or area. In this study we experimented with and compared scaled LED lights.

The four lighting scenarios were established in three scales: A 1:1 studio equipped with ERCO luminaires for reference, a 1:10 detailed scale model and a 1:20 rough scale model both equipped with scaled LED lights.

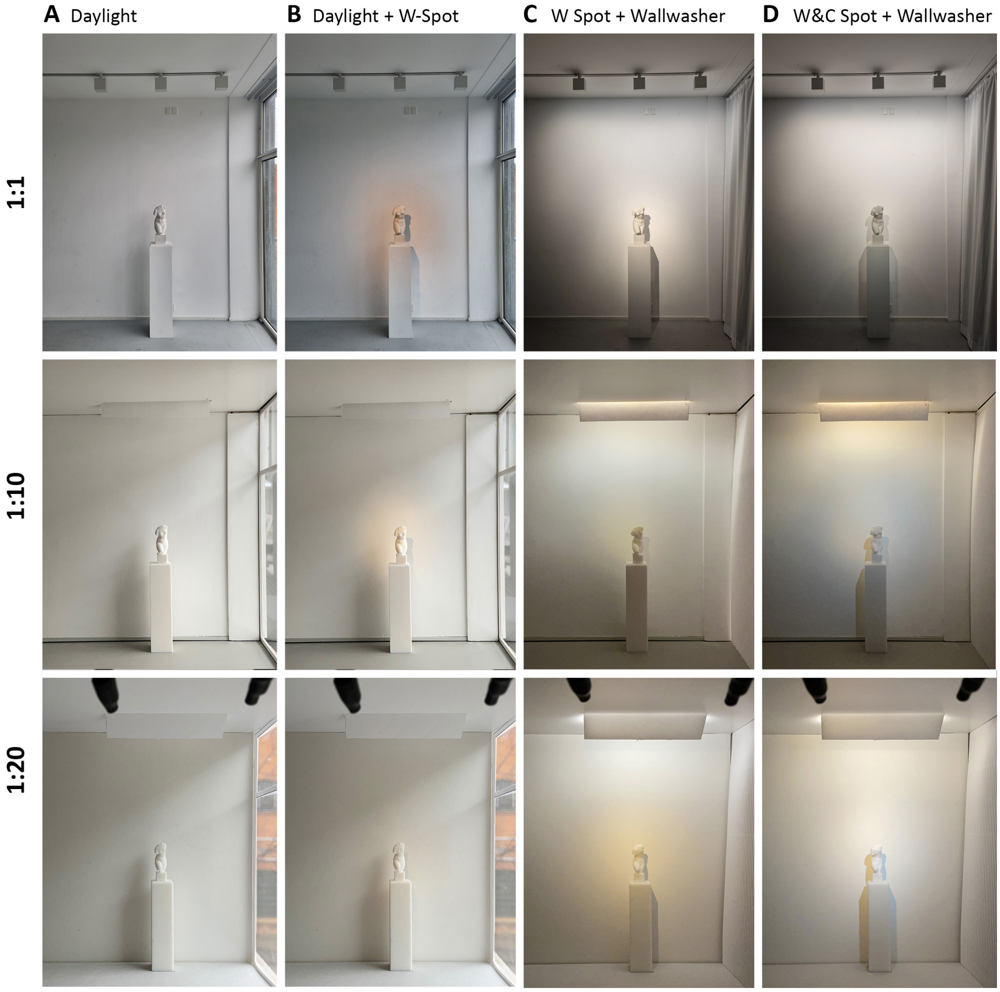

Fig. 05. Lighting scenarios A, B, C & D.
Source: Authors.

The 1:20 scale model size is widely used by students for daylight assessment and final presentations but has not to our knowledge been tested for sketching conceptual interior LED lighting design.

For the scale models we constructed spotlights by assembling round 5mm UHB LEDs with convex fronts and wires with heat shrink tubes and power glue. The LEDs were powered with CR2032 Lithium coin cell batteries. T5 LED tube lights were used as wallwashers and mounted on top of configurable cardboard ceilings with slits for vertical reflected lighting in the 1:20 as well as the 1:10 scale model (Fig.05-06) (Table 02) (see weblinks).

Fig. 06. Lighting parts
Source: Authors.

Table 02. Light sources 1:10 & 1:20

1:10 & 1:20 model	Luminous flux	CCT	Manufacturer part number
5mm UHB LED (Warm white)	1,61 lm*	3000K	OSM54K5111A
5mm UHB LED (Neutral white)	1,61 lm*	5500K	LRR5UW5C200G
LED T5 (Neutral white)	340 lm	4200K	LST5442
* Converted from mcd			

Source: Authors.

The gypsum Venus torso was scanned with an Artec Space Spider 3D scanner and the 3D mesh was refined and prepared for 3D printing in Rhino v6. The 1:10 and 1:20 models were printed with warm white 1,75 mm PLA filament on a Prusa i3 MK3S 3D printer (see weblinks).

Representation media

We photographed 360° panoramas of all four scenarios from a visitor's point of view in scales 1:1, 1:10 and 1:20 as well as supplemental perspective photography with smartphones. The Theta Z1 360 camera (see weblinks) used to capture 360° panoramas was placed on stands in different heights to achieve a correct scaled eye height eqivalent to 160 cm at the lens centre (Leyrer et al., 2011). The stands were designed to leave minimal visible footprint in the 360° panorama after the automatic stitching (Kreutzberg & Bülow, 2019). The 1:10 stand was crafted in wood and the 1:20 stand was 3D printed (Fig. 07).

Fig. 07. ThetaZ1 camera stands 1:10 – 1:20 and 360° panorama from 1:1 exhibition scenario.
Source: Authors.

The Theta Z1 camera is small and easily fit into scale models of sizes 1:10 and 1:20. The camera was operated remotely by a wifi connected smartphone.

For capturing the mixed light scenarios with optimal colour balance, test series with White Balance settings from 2700K to 4000K in steps of 100K was shot at all scales.

Perception methods

The perception of space is bodily grounded, we estimate heights and lengths as well as the distribution of light in space from our own body height and eye height, standing as well as seated (Corujeira & Oakley, 2013).

We used the photographed 360° panoramas of all four scenarios in all scales and compared the perception of the lighting scenarios from their equivalent position in all scales in VR and on screen in VR single view.

We specifically evaluated the perceived quality of light distribution, shadows, light temperature (colour), balance, and intensity.

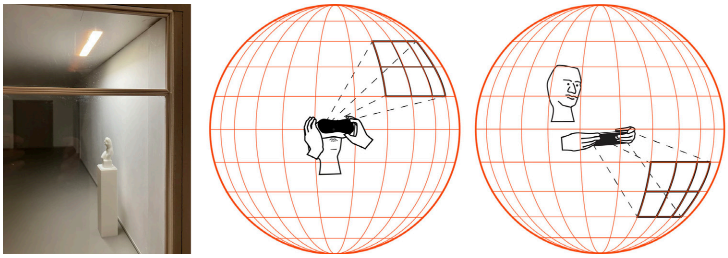

Fig. 08 Direct view, VR view and VR single view.

Source: Authors.

We evaluated direct view through windows of the scale models when possible. Perspective photographs were evaluated on smartphone and computer screen, and 360° panoramas were evaluated with smartphone VR with or without optional Homido Clip-on HMD (Fig. 08) (see weblinks).

Findings and Discussion

The experiment set out to test whether conceptualised directed LED spotlights are perceived identically at different scales in physical models with special interest in the smaller scale 1:20. The aim was to introduce fast and iterative workflows for experimenting with scaled directed lighting in spatial design with (often existing) scale models to supplement digital design tools.

Our focus was the perceived qualities of light distribution, shadows, light temperature (colour), balance, and intensity.We did not consider glare from a glass exhibition case since it was not part of the set up.

Light distribution

Several experiments with different approaches were made to create the scaled LED spotlights. 3D printed casings and soldering wires was the initial setup but using heat-shrink tubing in combination with power glue was easier to manage and much quicker to adjust in an iterative test process. Varying the ⌀ size of spotlight cones was achieved with either adjusting the length of the tube by moving the UHB LED further in or out of the tube or heat-shrinking the tube edge to a smaller ⌀ size (Fig.09).

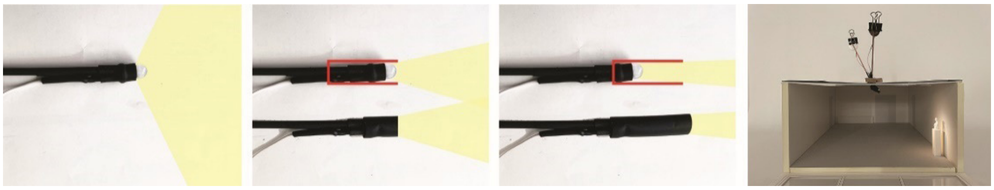

Fig. 09. Adjusting light distribution

Source: Authors.

Adjusting the direction of the ceiling mounted spotlights inside both scale models were managed by rotating the heavy copper wire, but proved to be difficult to evaluate due to limited visual access through the windows in the scenarios with occluded daylight. A solution was to connect a live broadcast from a smartphone or the Theta camera.

Shadows

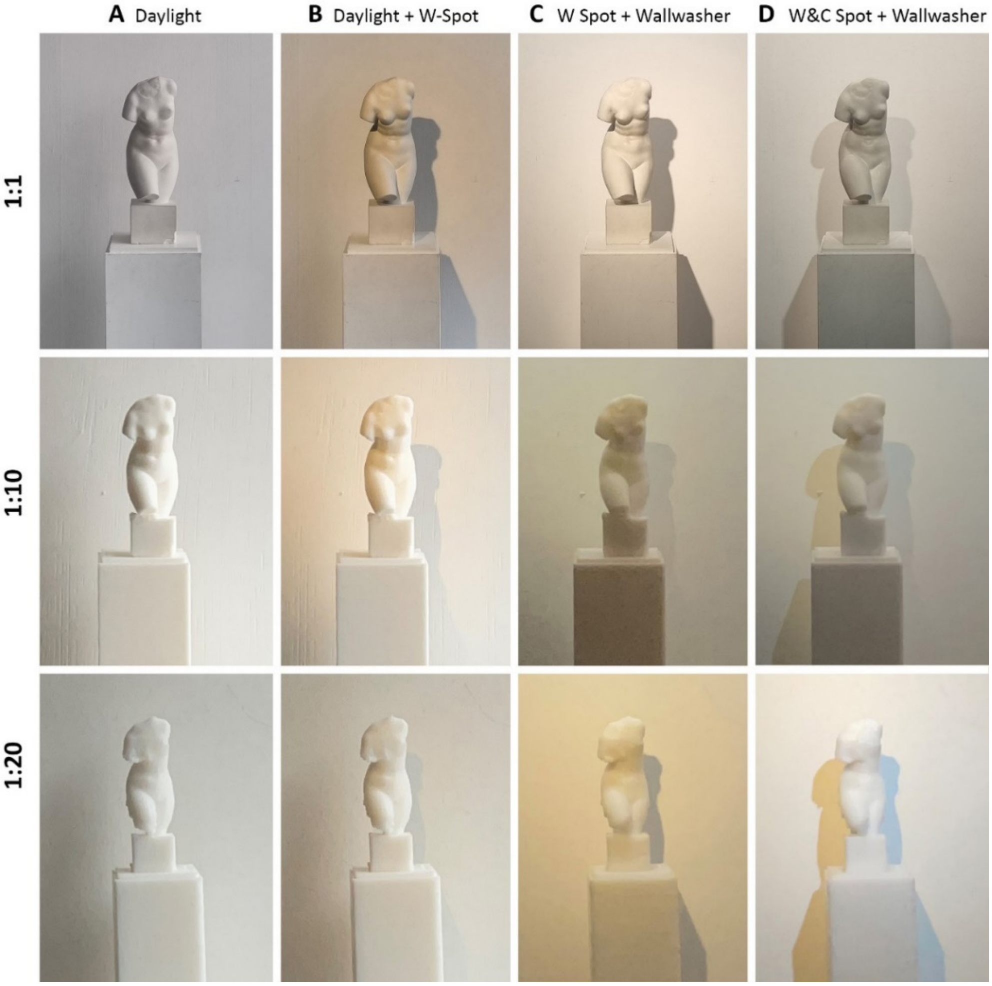

Fig.10 Shadows in three scales.
Source: Authors

In scenario A the shadow from the diffuse daylight was very soft and subtle and was scaled to 1:10 and 1:20 with no perceived difference (Fig. 10).

In scenario B combining daylight with a warm white spotlight the daylight shadow was colored by the warm spotlight. The spotlight shadow was crisp and distinct and slightly colored by the cooler daylight. In the scale models the daylight dimmed the spotlight shadows more than in the 1:1 setup.

In scenario C combining a warm white spotlight with a neutral white wall washer the spotlight shadow was also crisp and distinct and was slightly dimmed by the wall washer. In the 1:10 scale model the wall washer dimmed the spotlight shadow more than in the1:20 scale model and in the 1:1 setup.

In scenario D the shadow from the warm white spot occluded from the warm white light is lit by the neutral white spot and therefore shifts the perceived shadow colour towards a cooler blue & purple whereas the shadow from the neutral white spot occluded from the neutral white light is lit by the warm white spot shifting the perceived shadow colour towards a warmer orange and red (Baxandall, 1995). The neutral white wall washer contributed to dimming of shadows as in scenario C.

Light temperature/colour

The light temperatures and colours of the Warm White and Neutral White ERCO Parscan LED spotlights (2700 K & 4000 K) used in the 1:1 lighting scenario were visually matched within acceptable range with the UHB LEDs (3000 K & 5500 K).

The T5 LED tube lights with a colour temperature of 4200 K used in the scale models were perceived as cold compared to the ERCO Pantrac wall washer with a warm white 3000 K colour temperature. The light colour was adjusted by mounting colored filtering paper over the cut ceiling slids.

Intensity

Contrast is a very important factor in perceiving brightness and balance of lighting. The eyes can adapt to different light levels as can the camera with exposure value settings (Reeves, 2009). It is in the contrast we perceive the difference of varying light intensities. The UHB LEDs used as spotlights only have a Luminous flux of 1,61 lm which made it necessary to establish relatively dim lighting scenarios.

Balance

Working with the mixed lighting scenario B including daylight was challenging because of the big difference in brightness between daylight compared to the UHB LEDs. Several dimming and shading solutions were therefore tested and evaluated, most effective was moving the scale model further into the room and away from the daylight contributing window to lower the daylight intensity.

The mixed lighting scenarios C & D simulating spotlights and wall washer were challenged with very different luminance levels of the LEDs (Table 02). The T5 tube LED representing the wall washer having a luminance of 340 lm, more than 200 times the 1,61 lm of the UHB spotlights. Dimming was achieved by placing the T5 tube at varying distances next to the cutaway in the ceiling only allowing reflected light from a mounted reflector flap. Stacking layers of paper or cloth over the cutaway also contributed to dimming as well as to color correction of the light.

Perception

Initial assessments as well as iterative changes of light distribution and light balance in the 1:10 and 1:20 scale models were done in real-time from the smart phone 360 display when connected to the Theta Z1 camera placed inside the models. Connecting a tablet to the camera instead of a smart phone provided a larger screen for monitoring alowing more people to view and evaluate at the same time. The captured 360 panoramas were viewed with clip-on VR glasses for a more spatial experience of the scenarios. When comparing the lighting scenarios for evaluating their resemblance in this experiment perspective images were used captured with a remotely controlled smartphone (Fig.04 & 09).

Conclusion

Comparing the 1:1 exhibition lighting scenario with the scale models showed slight differences in perceived qualities of all parameters evaluated; light distribution, shadows, light temperature/colour, intensity and balance, but taking into account the quick and iterative workflow with often existing scale models we found the perceived qualities of directed LED light in both the 1:10 and the 1:20 scale model to be adequate as a starting point for conceptualising object lighting design.

The smaller 1:20 scale model proved to perform very well with the relatively dim UHB LEDs because of the short distances between emitting lights and lit objects. In the mixed light scenarios dimming of diffuse daylight and wallwasher were easily manageable whereas the larger 1:10 model required more dimming of diffuse daylight and wallwasher to achieve a balanced lighting.

It is crucial to note the importance of having balanced lighting when evaluating the perceived quality of light distribution and intensity in scale models, especially when combining several light sources with different luminous flux. For this a 1:1 reference mock-up is ideal support in choosing and modifying the scaled light sources, although not always accessible for students.

The proposed lighting parts can easily be introduced and fabricated during a workshop as starting point for individual student projects with object lighting.

Demonstrating a larger variety of mixed lighting experiments in scale models for students would didacticly benefit from flexible adjustment of light intensity, temperature and colour achievable when connected with a programmable electronic prototyping platform like Arduino (see weblinks), this could also inspire to work with more advanced dynamic lighting designs.

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How AI challenges architectural design

Understanding AI from a historical perspective

We would like to start our reflexion on AI by considering the long history of techniques in order to underline that AI has its roots in a continuous evolution coming from antiquity. Thus, we first mark the fact that the mathematization of the world is not a recent process but rather a long, slow and continuous phenomenon. We first consider the works of Villars de Honnecourt, an artist from the 13th century, who lived in the northern France, and who wrote a portfolio containing about 250 drawings on architectural designs. The sheet 40, from the folio 20, shows a man measuring the height of a building with the help of a measuring tool, shaped in a rectangular triangle. Tools and measurement go with human activities. During the same period, Raymond Lulle (1233 env. -1316), a Catalan philosopher and theologian, paved the way of the universal logic and try to show how combinatorial operations can simulate reasoning (Weibel, 2018). The abstraction becomes the support of the understanding and the thinking. Five centuries later, Jacques de Vaucanson (1709-1782), inventor and mechanical engineer, constructed several famous automata called the Flute Player, the Digesting Duck, and the Tambourine Player. These machines are experiments in automation and demonstrate the possibilities of autonomy. Automation and autonomy are still today controversial concepts that feed the debates on the risks of technologies. Jacques de Vaucanson participated in the industrial revolution by contributing to the development of machine tools and, for a long time, technological progress was linked to social challenges and claims. At the end of the 19th century, Charles Babbage (1791-1871) and Ada Lovelace (1815-1852), both with a passion for mathematics, developed the Analatical Engine and the Difference Engine, which are the beginnings of the electronic and computational machines we know today. A strong relationship established between the hardware, i.e. the physical components that perform the computation, and the software that constitutes the program and defines the sequences of operations.

The cybernetic moment

Following this long evolution of techniques, cybernetics was born in the 1940s and constitutes an acceleration in the digitization process of our activities. Logic, algebra, recursion, iteration, network geometry, topology and geometrical-fractal on the one hand, and regulation, feedback, behavior, control, cognition, machines and artificial animals on the other, are all topics that animate scientific communities and that will constitute the vast field of information and communication sciences and techniques. It is in this fertile and transdisciplinary context that the term cybernetics was born. It was proposed by Norbert Wiener (1894-1964) on the occasion of the publication of his book Cybernetics : or Control and Communication in the Animal and the Machine (Wiener, 1948). Cybernetics is concerned with the understanding of phenomena, both natural and artificial, and involves the study of communication and control processes in living beings and machines.

By the 1950s, Cybernetic was based on two distinct approaches (Cardon et al., 2018). The first is called Symbolic and is based on the development of expert systems, which seeks to reproduce specialized reasoning. Expert systems are programs designed to simulate decision making by a machine and based on explicit rules and symbolic representation of the world. The second approach, called Connexionist, implied probability and statistics and sought to achieve intelligence through learning. At the moment, Warren McCulloch (1898-1976), Walter Pitts (1923-1969) and later Franck Rosenblatt (1928-1971) worked on the Perceptron, which is considered to be the first artificial neuron. The machine learnt new skills by trial and error with the help of an artificial neural network, it is a classification algorithm that makes its prediction based on a mathematical regression function. If machine learning (ML) algorithms constitute the family of the artificial intelligence, some other processes are evolved.

Thus for instance, L-systems, shape grammar, cellular automata, evolutionary and genetic algorithms, all these mechanisms represent generative processes that have been the subject of researches in the field of architectural design for many years. The recent development of big data and the increase of the computing capacities has allowed the democratization of these techniques. Today, ML libraries and online AI systems are readily available to designers and are transforming the design processes and postures.

Recent developments

Several recent publications examine the creative potential (Campo & Leach, 2022; Leach, 2021) of AI, its risks and limitations. Sociopolitical and ethical issues are discussed (Crawford, 2021), as well as aesthetic implications for the cultural domain (Manovich, 2018; Manovich & Arielli, 2022).

Limiting our considerations to the initial design phase, we consider two distinct tooling strategies.

Online AI systems

For a few years and increasingly in recent months, several online AI systems have been available. They make AI easily accessible. Two kind of services are proposed. The first ones offer accessible interfaces and allow to easily generate representations and contents from an already learned model. Examples include text-to-image, text-to-video or image animation platforms[1] and the popular chatbot ChatGPT. The second is ML libraries accessible via APIs and hosted on powerful server farms. For example, Tensorflow is offered by Google and can be run online with google colab, or ML.net is offered by Microsoft. While these services involve coding, some

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[1] Midjourney, Dall-e, Dream studio, RunwayML

nocode platforms[2] allow us to train models and use them in our own application. This workflow has been directly experimented in the architectural domain (Steinfeld et al., 2019). Finally some open-source Graphical User Interfaces allow us to locally interact and customize an AI model[3] with our own images collection.

ML directly accessible from the digital design environment (DDE)

Some ML libraries are available directly from the software used by the designer, they become plug-ins or stand-alone processes whose results are imported into the DDE. This promising avenue has been explored by Salamanca (Salamanca et al., 2023). The workflow begins with a parametric model, from which a data set is generated and evaluated; a variational autoencoders (VAE) is trained; then geometries are generated from the latent space and the solutions space is explored and visualized from the DDE. Other strategies focus, for example, on 3D models generation, through voxel discretization, using a machine learning Procedural Content Generation (PCGML) algorithm (Koh, 2022), or attempt to transform images generated by a GAN algorithm into 3D models, using inverse perspective techniques (Chando Kim & Huang, 2022).

Introducing AI in the curiculum

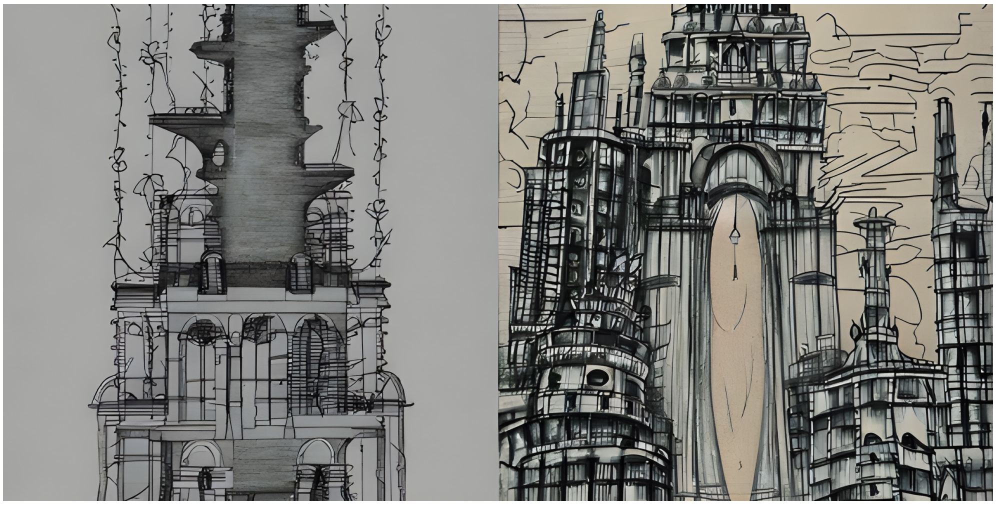

Figure 1. Alexandre Martineau, Bachelor 3 : a drawing like tim burton with a tower like rem koolhaas

If the information about text2image techniques are known to a public of experts, it is only during the year 2020 that the applications accessible to the general public have made their appearance. Dall-e, Midjourney at first, then Stable Diffusion and many other variations allowed everyone to test and start to make an opinion. It is perhaps really with “Theatre d Opera Spatial” composed by Jason Allen with Midjourney that the power and the quality of the images that can be generated by artificial intelligence could be measured. This work, presented at the Colorado State Fair Fine Art Competition in August 2022, won first prize creating a wake of consternation but

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[2] Lobe.ai, Teachable Machine

[3] Stable diffusion and Automatic1111 for instance

also admiration. Allen never hid the fact that he had worked with Midjourney, artists cried out for the loss of their art, or more exactly of the market that could feed them, by soulless machines so cultural.

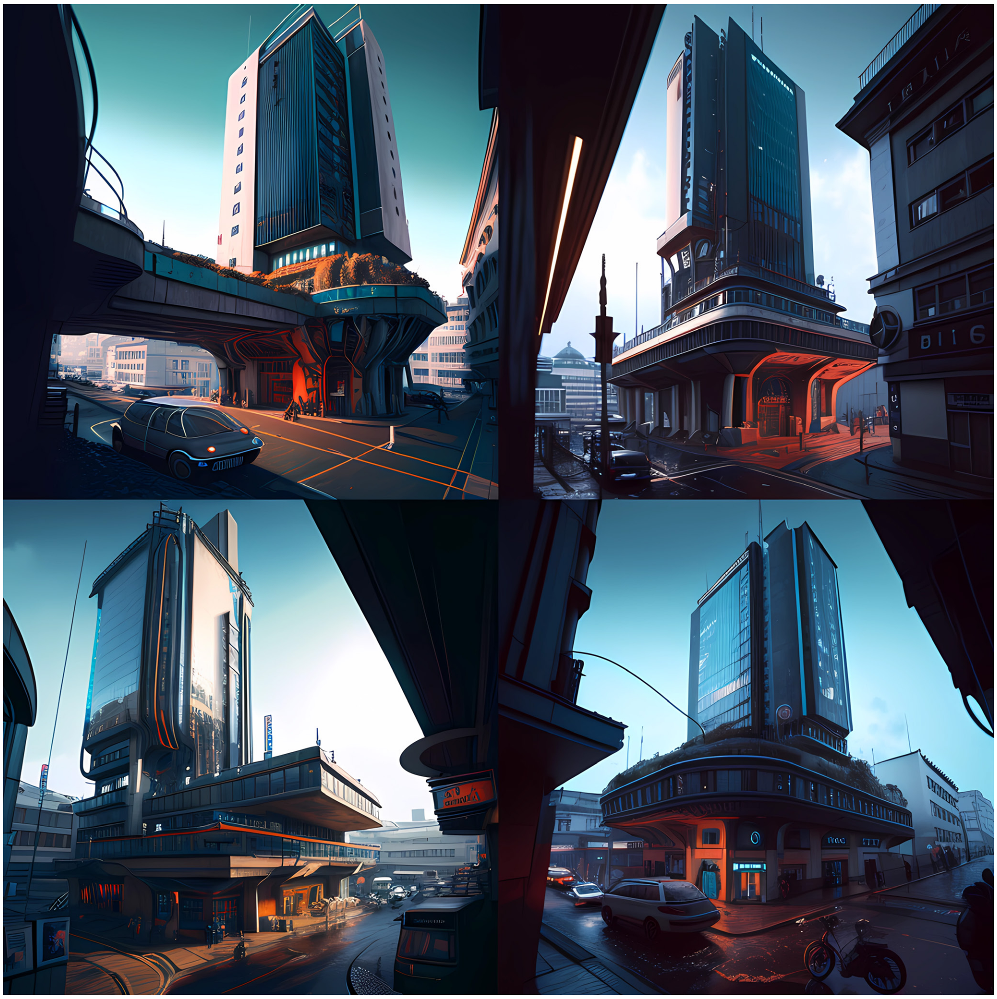

Figure 2. Ewen Cloirec, Master1, transfiguration os Nantes' iconic tower, prompt: Tour de Bretagne like cyberpunk city

The revolt of the artists and well a concern about their market, because, it is now understood that the quality of the artist does not depend on his talent to realize, but on his way of imagining the process of engendering. Big names such as Anish Kapoor or Richard Serra or many more, do not make their works themselves, they are made by competent technical teams. In the field of architecture, the question is more subtle. The image in the project is only an intermediate stage, it is not the result of the realization but what allows to make it emerge, to maintain the coherence of the proposal and finally to communicate the project. Since the advent of digital technology available on a large scale at the turn of the century, the architect's line is no longer a distinctive, identifying sign, as it once was with personalities such as Mies

Van der Rohe, Le Corbusier, Aldo Rossi or Sant Ellia for example. At the pedagogical level, the image is the proof of the research. It is the proof of the search for visual references and the proof of a graphic exploration of hypotheses. The first activity has been undermined by the evolution of the Internet. With an infinite number of images available, the construction of references, or the link between what one finds and the question one is developing, is already disrupted. It is not uncommon for teachers to receive a plethora of references that are not properly characterized. The graphic exploration then becomes problematic in and of itself. The lack of graphic solutions to represent such or such elements (a human, a tree, a piece of furniture) sometimes prevents doing so.

The possibility of creating convincing images very quickly with Dall-E or Midjourney would provide the opportunity to have both reference for inspiration and aesthetic solutions for developing projects. Rather than being faced with student productions that would risk hiding their origin on the side of Artificial Intelligence, we believe it would be more pedagogical to officially introduce this process as an additional conceptual tool available to future architects. For this purpose, specific courses are proposed with a progression protocol such as the one presented below.

The program is designed as a step-by-step process that starts with a basic prompt enabling the combination of two different worlds. For instance, one could create a dog niche in the style of Zaha Hadid. As the process continues, more complex definitions are introduced, drawing on references that can be stylistic, programmatic, or thematic. The final stage requires participants to specify their project, aligning the sketches they have already produced with the results generated by the AI.

Figure 3. Arpi Mangasaryan, Nantes flooded, eploratory work

The instructions are as follow.

You will use an AI engine to develop a project following the following criteria: Create a project in the style of a reference architecture, but with a twist. For example, a dog niche in the style of Zaha Hadid or the Tower of Babel in the style of Le Corbusier.

- *Create a contemporary urban scene that includes ecological challenges.*
- *Create a futuristic or retro-futuristic scene that may include flying cars or roads like in Metropolis, take the scene and make it comic book-style.*
- *Create a rural scene in the style of a known painter.*
- *Create a terrifying image referencing a known pictorial work or style (such as Zdzisław Beksiński or Hans Ruedi Giger).*
- *An architecture that combines two architectural styles or movements.*
- *An architecture that combines different types of materials referencing specific styles.*

An exploration of your project by showing what you have imagined and how you can reexamine them using AI.

Two platforms are recommended in this exercise :

- https://huggingface.co/spaces/stabilityai/stable-diffusion or/and https://www.photoroom.com/backgrounds

They are free, easy to access unlike Dall-E or Midjourney.

Figure 4. Noémie Brunet, master 1, mixing styles, prompt: Farnsworth house with modernisme and postmodernism

Results among several groups of students

Many surprising examples have been created by students along the recurring tests we've made along the semester. Understanding how to create a prompt was quick, but it took more time to develop prompts that effectively capture the ideas and expectations presented in the text. Students were able to complete the initial six questions and iterate through an average of 4 to 10 images in just a few hours. However, difficulties arose when attempting to recreate their projects through descriptive language. It was challenging for students to find the appropriate words, analogies, and references to accurately convey their project. It is clear that the challenge is not due to the limitations of text-to-image technology, but rather the students' ability to articulate their ideas effectively.

Figure 5. Marion Dolo, Master 2, a Doll House Gaudi Style

Figure 6 - Goullo Djenab Bah, Master 1, prompt: Futuristic city made out of bamboo and mud

Discussion

We are currently pondering over how the emergence of text-to-image platforms, and soon text-to-3D platforms, will impact the pedagogy in architecture. We have the option to disregard them as a mere byproduct, or we can proactively anticipate the changes they may bring.

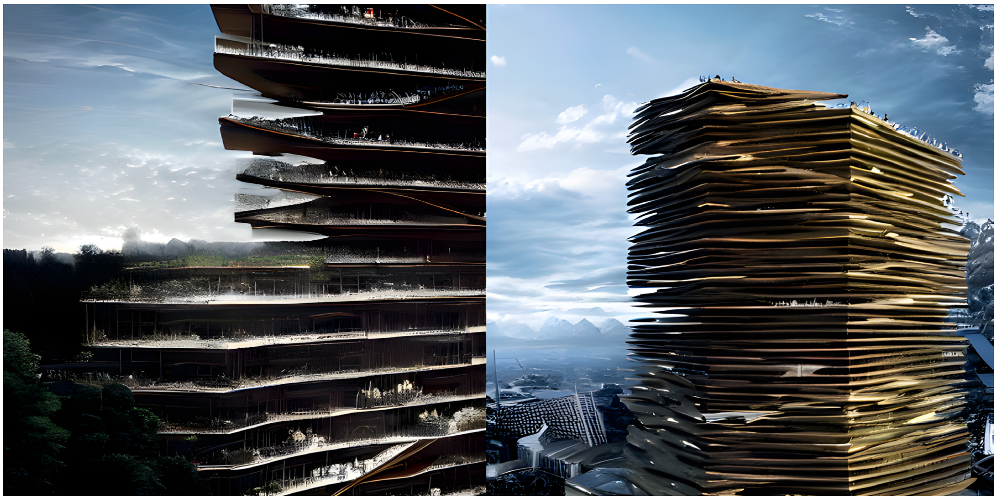

Figure 7. Margot Gesnoit master 2, Kengo Kuma meet Peter Zumthor to build the new and futuristic Babel Tower in an apocalyptic atmosphere

Following this, it has been interesting to see how ChatGPT, the other game changer, provides answers on the impact of Text2Image platforms for architects. The chat-machine has been a bit guided to generate a pro and con answer and therefore listed *improved engagement, time-saving, flexibility and accessibility.* It is noteworthy that the criticisms primarily revolve around the unreliability of the information. GhatGPT points out *Accuracy*, l*ack of creativity, over-reliance* and the *cost, some text2image AI tools may come with a cost, which can be a barrier to adoption for some educators.* When asking what expertise shall not be replaced by text2image AI tools, the chatbot enumerates *technical knowledge, communication skills and adaptability.* When comes the question of using AI in the curriculum, ChatGPT gives an ecumenical answer: *"It is important to note that the use of text2image AI tools should be integrated into the curriculum in a way that enhances students' learning and does not replace traditional forms of learning and visualization. Text2image AI tools should be used to supplement and enhance traditional forms of learning, rather than replace them entirely"*.

In early 2023, we saw an increasing number of platforms emerging, such as Dall-e2, Stable Diffusion, and Mid Journey, which have become some of the most popular ones. Additionally, there are other platforms such as Leonardo, NightCafé, Maze Guru, Deep Dream Generator, DeepAI, ArtBreeder, and Patterned, which are also gaining attention among users. Many students are concerned and repeatedly ask whether AI will replace them. This is a question that arises with every technological advancement and is not limited to those in the field of architecture. However, it is not people who are at risk, but rather certain tasks that they perform, especially those that do not add any significant value. This means that expertise will need to shift towards the two ends of production - focusing on input data and evaluating the output data. Experts will need to determine what is necessary to address a particular problem and qualify the responses obtained.

1_ Usine de voiture

2_ Usine de voiture

3_ Usine de voiture

1_ Station essence

2_ Station essence

3_ Station essence

Figure 8 - Loïs Gorin, Master1, explorations with Gaudi's style

Conclusion

Figure 9. Trying to design a Le Corbusier's style project : prompt : designing a villa in Le Corbusier style architecture using the 5 points of modernity and mimicking villa Savoy

One of the main challenges that students face is effectively describing their architecture projects in precise and evocative language, in order to ensure that the AI-generated proposals accurately reflect their creative vision. Should they begin by outlining the style, proportions, environment, or instead focus on the finer structural or aesthetic details, or take a more metaphorical approach? To address this issue, an experiment was conducted that tasked students with designing an alternative history project in the style of Le Corbusier, specifically a villa that adheres to the five principles of modern architecture. Numerous attempts were made, but the results were quite disappointing as they fell short of incorporating the elements of modernity. Ultimately, ChatGPT was tasked with creating the prompt, which it did by incorporating the key characteristics of the modernist movement: The working prompt gives:

> *Create a realistic image of a villa in the style of Le Corbusier, a famous Swiss-French architect known for his modernist designs. The villa should be two stories tall and have a flat roof with a terrace. The facade should be made of reinforced concrete and incorporate large windows with steel frames. Incorporate elements from Le Corbusier's style, such as: Pilotis: Use columns or pilotis to lift the house off the ground, creating an open space beneath the house. Free plan: Create an open interior with a free-flowing floor plan, which allows for flexibility in how the space is used. Ribbon windows: Use continuous horizontal bands of windows, providing ample light and an unobstructed view of the outside. Roof terrace: Incorporate a flat roof with a terrace that provides an outdoor space for relaxation or entertaining. White color: Use white paint on the facade to reflect sunlight and create a clean, modern aesthetic. Functionalism: Emphasize functionality in the design, with a focus on providing a comfortable living space with minimal ornamentation. Overall, the villa should showcase Le Corbusier's signature style of modernism, with a focus on functionality, open space, and natural light.*

Over the past few decades, the digitization of architectural plans and the subsequent adoption of BIM, have brought significant changes to the daily workings of architectural agencies. With the introduction of AI, a new phase of transformation has emerged, but this development is not comparable to previous ones. Unlike previous digital tools, AI does not merely modify or enhance existing production methods but has the potential to revolutionize the very modes of creation themselves. Therefore, we are prompted to engage in a more complex and nuanced reflection on the potential consequences of AI's implementation.

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Designing and experiencing spaces together – A low-cost VR multiplayer approach in teaching

Introduction

There is an increasing interest in using Virtual Reality (VR) in architectural academic teaching. Head Mounted Displays (HMD) enable users to dive into the virtual 3D model of a building. This way, clients and planners get a better understanding of a project than only using 2D plans. However, the main challenge is to create a VR environment for design purposes without having to be an expert in programming. The process should be simple enough to be manageable in the design process, but detailed enough to deeply engage the user. Users should be able to get a realistic sense of the scale and size of spaces. According to Eller (2020), there are several techniques and systems to improve this so-called immersion:

- Headphones to create a realistic acoustic environment
- VR Treadmill or similar devices to enable intuitive movement in VR
- Variable height of view in VR and a wide field of view to create a natural visual perception
- Adding realistic materials and additional visual effects to create an authentic model
- Adding objects to allow size comparison, e.g., cars, furniture or people (such as NPCs or avatars of other VR users)

There are many obstacles concerning the implementation of these technologies and systems. The offered solutions are expensive and extensive programming skills as well as complex model conversions are required to create one’s own solution. Therefore, the use of VR in the early design phase is not appealing for small companies and students – at least until now. To solve this issue, the authors of this paper have recently examined tools for low-cost VR systems using the Google Cardboard® system, which works together with an ordinary smartphone as an HMD. To improve the feeling of immersion, the original motion system provided by Google Cardboard® was replaced by devices developed by the researchers. The main aim was to replace a button on the HMD by translating the steps in the real world into the virtual world. Based on a wired solution with microswitches mounted on shoes (Dokonal, Knight, and Dengg 2016) a so called “Movement Box” with acceleration sensors and a bluetooth connection to the HMD was developed (Dokonal et al. 2021). A workflow for integrating a design model into the VR environment was formulated which can be used by architects without advanced programming and scripting skills.

Additionally, tools to alter the model in the VR environment were developed by the authors. With this toolset, a user is able to move walls and ceilings of a building model in VR and therefore change the desing and experience these changes in VR. A big disadvantage remains that only one user can dive into the VR environment. Therefore, when working in a group, the HMD needs to be passed around to discuss issues and design changes. If users could experience the vitual space simultaneously, they could collectively develop a more credible and faster understanding of the dimension than one person alone (Davila Delgado et al. 2020). Experiencing other users in the same virtual space in the form of their human-size avatar will also help to get a better feeling of the scale of the model and of the impact of design changes. In a multiplayer game, players experience the same virtual environment at the same time and see each other or their virtual avatars. This way, players interact with each other in the virtual environment and get deeply involved in the simulated environment.

This paper presents a new approach which uses the functionalities of a multiplayer game to create a collaborative VR design environment. This is achieved by using the game engine Unity and the network library Photon Fusion and combining them with the procedure mentioned above to create a VR application. The resulting multiplayer environment enables multiple users to view and alter the 3D model of a building design in VR. Since the users are connected via a server-based application, there is no need to be at the same physical location to join the VR design environment. This approach offers advantages in various applications, e.g. in teaching (design critiques) but also in practice (presentation with a customer, joint discussion of a design, etc.) (Sopher, Casakin, and Gero 2022). In November 2022 and March 2023, architecture and civil engineering students tested and refined the VR multiplayer approach in course of a workshop. The presented approach enables students to use multiplayer VR experiences in the design process.

Multiplayer basics

Multiplayer games involve two or more players who compete with each other in a shared game environment. This paper's focus is on VR multiplayer games, where players can each join the virtual world with their own device. To enable a multiplayer session, the game data must be exchanged between the individual devices via some sort of network transport. There are several libraries and frameworks for the game engine Unity, which handle the data exchange and enable the development of multiplayer games:

- Unity Transport
  This Unity package comprises a low-level networking library. It is the basis for Netcode for GameObjects and Netcode but can also be used for a custom multiplayer solution. (Unity 2022)
- Netcode for GameObjects
- This is a high-level networking library, which enables the development of multiplayer games without deeper knowledge about low-level protocols and networking frameworks. (Unity 2023a)

- Fish-Networking (Fish-Net)
  This is an open-source networking solution developed by an independent game developer. It has a feature-rich structure that allows a wide range of custom networking structures. At the same time, a high-level API also makes it possible to get started quickly without diving deeper in the matter. (First Gear Games 2023)
- RakNet 4
  RakNet is an open source, cross-platform C++ game networking engine. There exist several Unity packages developed by the community. It is used by Unity's biggest and most successful multiplayer game, Rust. (Jenkinssoftware 2023)
- Mirror
  Mirror is an open-source high-level networking library for Unity. It is based on the former UNET multiplayer networking library and still relies on the low-level Unity transport. It provides a wide range of template scripts to make coding easier. (vis2k 2023)
- Photon Fusion
  This is a high-performance state transfer Netcode SDK for Unity developed and maintained by Exit Games. The free trial allows 20 users at a time, 60 GB traffic per month and is only allowed for development purposes. (Exit Games 2023)

To implement a multiplayer game, it must be decided how the network will be structured. The so-called network topology defines how the devices relate to each other. The game can run on a dedicated server or one client can host a game, where the other clients could join. The second topology has the advantage that no dedicated server has to be maintained and updated with new models from the students. (Unity 2023b)

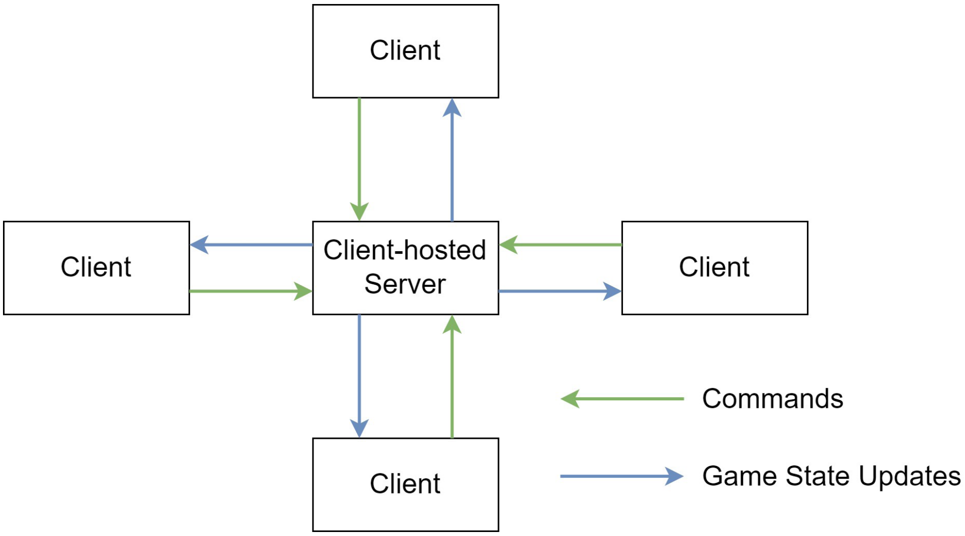

Figure 1 Choosen Multiplayer Topology

(Source: Personal Collection)

In this paper, Photon Fusion is chosen to create a VR multiplayer template project, where one client hosts the game, allowing the other players to join. The advantages of the Photon Fusion SDK are an easy to integrate network library, a good documentation, many out of the box sample projects and a wide variety of "How to" guides online. Because Photon Fusion is not open source, usage is only possible to a limited extent. This results from the disadvantage of this solution, that the game data is transferred between the devices via a server hosted by Photon.

To create user interactions in a multiplayer game, input data and the state of objects in the game have to be exchanged between the server and the clients. With the chosen approach (see Figure 1Fehler! Verweisquelle konnte nicht gefunden werden.), the clients have to send their input data to one client-hosted server. Based on the input, the server makes authorative decisions and publishes them at frequent intervals to the clients. These authorative decisions are functions which control the interaction with an object and must be implemented on the server. In addition, functions performing the interaction have to be implemented on the client side.

Workflow to create VR multiplayer

Hoon and Kehoe (Hoon and Kehoe 2003) showed the advantages of game engines in the architectural design process. Furthermore, they convinced their students of the prowess of a game engine in an elective course. With the game engine Unity, something similar can be achieved. Earlier, the authors of this paper organized workshops with students to create single player VR experiences. To go one step further, a VR multiplayer approach was developed based on the knowledge gained in these workshops.

To reduce the effort needed to set up an Unity project correctly, a template project was developed. This template project holds a minimalistic example of a floor inside a building, where the users can move the walls. Hereby, the students get a working VR multiplayer project at hand and can alter the existing project based on their own ideas. The first step is to export the 3D building model in the FBX file format. This can be done with the authoring software the students are using to create their architectural model (e.g., Rhinoceros, SketchUp, ArchiCAD, Revit etc.). The FBX file can then be imported in the Unity template project. There, the multiplayer functionalities and other game engine features can be added. In the last step, the VR application needs to be built within the game engine. A similar approach was developed by Bille et al. (2014).

Coursework

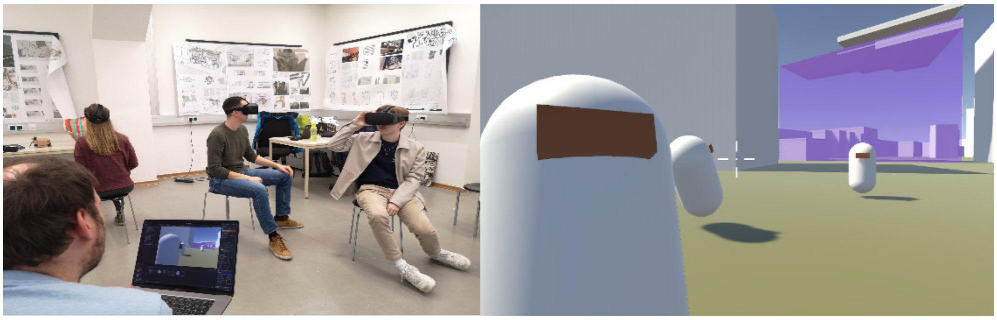

Figure 2 Students using the Project "Youth Center Graz" in the Workshop
(Source: Personal Collecton)

In March 2023 and November 2022, two elective courses were organised, in which the students experienced how the game engine Unity supports them in collaborative modelling. Therefore, the developed multiplayer approach was presented to students in a small workshop with 5 groups. The groups had each 4 participants mixed from the disciplines computer science, civil engineering and architecture. Most of them had no prior knowledge working with Unity and only basic programming skills. Their goal was to create a VR multiplayer experience based on one of their own architectural projects. After choosing a project, they integrated in a first step their own 3D model in the provided Unity template project. In a second step, the students developed further interaction methods for their projects. With the guidance of the supervisors, it was possible to implement the ideas of the students. The following three exemplary projects stood out:

- Project „Youth Centre Graz“: In this project, a gap in the inner-city area of Graz, Austria is to be closed. The first draft only dealt with the volume of the building. In the VR multiplayer environment, the height of the building can be changed.
- Project „Max-Becker area Cologne“: This project deals with the urban restructuring of the Max-Becker area in Cologne, Germany. The chosen quarter is located in the centre of the area and has an area of approximately 100 m x 160 m. In a first design phase, it is desirable to determine the building volumes. To support this task inside the VR multiplayer environment, a user can place volumes and wall elements on a fixed grid. In addition, the storey height can be changed by extruding the placed objects.
- Project „Market place pavilion“: In this project a pavilion on an inner-city market place needs to be designed. The initial sketch consists of a canopy that provides shadows and individual cube structures that support the canopy and are used to store things for the weekly market. The following interaction options have been added to the VR environment:
  - the position of the sun can be changed
  - the cube structures can be moved around beneath the canopy
  - individual shading elements can be removed from the canopy

At the end of the workshops the students tested their projects by providing each student with the built application and presenting the interaction options live in the VR environment to the other groups (see Figure 2).

Evaluation

After the workshop, we asked all students by handing out a feedback questionnaire, how they experienced the VR multiplayer approach. This led to the following findings:

First, the students estimated the time required for the individual activities in the workshop (see Figure 3). Most of the time was used to program new interaction methods.

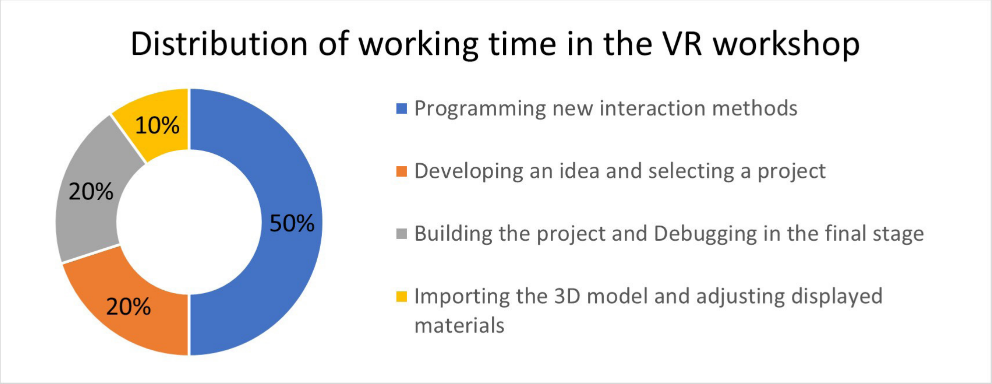

Figure 3 Students' assessment of the distribution of working time

(Source: Personal Collection)

Second, we asked the students to rate the benefits of VR and multiplayer for the tasks "design critique", "customer presentation" and "collaborative design". Furthermore, they should explain how the given approach affects their assessment. The feedback shows that the students think of the VR environment mostly as a insightful way to present a design to other people, e.g. customers. They also identified struggles when working in the VR environment with the given approach:

- The architects have little experience with VR and can therefore only poorly assess the programming effort or the possibilities of what can and cannot be implemented.
- Since CAD software already has extensive functions for implementation and visualization, there is no direct added value in using VR and multiplayer. The challenge is to provide features in the VR environment that do not exist in traditional CAD software to make VR more beneficial.

Third, the students should describe their biggest challenge in the workshop. All of them mentioned that they had major problems with understanding how new functionalities in the multiplayer environment could be implemented. As previous workshops already showed, it is easy for the students to implement new functionalities in a single player Unity project. In a single player project, one can simply use a function which regularly updates the game to collect the user input and then add feedback based on this user input, like opening a door. In a multiplayer game, the level of complexity rises drastically because of remote procedure calls. To implement a new interaction, a function has to be implemented which collects the input of the local player and sends it to the server. Subsequently a function for the server has to written, which checks if any input from remote players or the local player is at stake. Based on this input the actual feedback (e.g., make a door swing open) has to be implemented on the server. Finally, all clients have to be notified, that the door should also be opened in the games running on them.

Conclusion / Future Research

The students had difficulties adapting the multiplayer Unity project for their use case. To create new functionalities that also work with the multiplayer approach, students need a deeper understanding of the multiplayer network topology and remote procedure calls. It is nearly impossible to set up this understanding within a five-day workshop. At least with some help of the supervisors, applications useful for the design process can be programmed. Nevertheless, the students recognized the potential of the VR multiplayer approach and their interest to continue working on the topic was drawn.

Providing the developed functionalities in further workshops will help to further improve the workflow and reduce the effort for the implementation of individual projects. Then, the focus is more on testing the VR multiplayer environment in the early planning phase. Collaborative modelling of a building can be achieved with the given approach, even if not all participants are in the same physical location. Also, the visualisation of the avatars of other planners makes the model livelier and allows a better feeling of space due to size comparisons and the virtual experience of one's own comfortable talking distance inside the planned building.

In future research, the effort to adapt the template project for one's own project needs to be reduced. The aim should be, that architectural students could use this VR techniques without the need of a deeper knowledge of the game engine Unity and without advanced programming skills. Furthermore, the focus should be placed on an open-source approach, which has no limitation on the commercial usage.

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An exploration of 3D scanning as a medium to record spatial memory and form an inhabitable archive through space and time.

Introduction

This paper explores a process to archive spatial memory; from recording by 3D scanning, decluttering, sorting and finally representing and communicating information. It builds upon a background and theoretical framing, vital foundation to place it contextually and socially. In the dual character of the paper, foundation and case study of the proposed system are equally important, contributing on different levels of the same topic.

The background is based on how technical apparatuses are a non-distinctive part of contemporary human life. They define the means and limitations of recording and representing information, and by extension affect how memory is sustained through time. They are instruments which make information readable and graspable and in some cases represented as an image. These images, or by using Flusser’s more descriptive term, technical images (Flusser 2011, 23), are affecting our memory of past events and define how culture is sustained through time, as if our memory of space is also affected by the means of which we record it.

Similarly to Stiegler’s theory on the evolution of prosthesis, smartphones are the extension of hands (Stiegler 1998, 50); an a-live medium of recording, and source of retrieving information, forming a technical life increasingly available. Not that long ago in 2020, another generation of smartphones was introduced by Apple with an integrated LiDAR scanner (Apple, 2020). This 3D scanner can be therefore available to capture real time spatial data and it is considered as part of the archival medium genealogy. These mediums have an incorporated selection of the physical characteristics that are recorded and they define different perspectives of historical data. Specifically, 3D scanning, in the form of Point Clouds (PCLs), consists of two basic types of information: position and color, which after performing some basic operations are expressed as computational geometry and texture respectively (Fernandez-Diaz et al., 2007). These features are directly linked to time as they are affected by lightning conditions, reflections and all other parameters which affect the visual appearance of space (Figure 01).

Fig. 01. Visualizations from two 3D scans of the same space with different lightning conditions.
Source: Image from author.

In contrast to historical ortho-recording, where the past was connected with a delayed present and future, real-time recording, storing and transmitting is possible through “post-orthographic electronic surfaces" or interfaces, where our actions are enmeshed in “so-called real time” (May, pp. 33-34). Highly complex networks are communicated into a system of signals, where gestures (tapping, sliding, even looking) are translated into technical actions with momentarily response through interfaces.

Can we use this real-time depiction of post-orthographic surfaces as a dynamic tool for recording and organizing spatial memory through media traditionally used to represent space? In this exploration, by archiving temporal geometry on the cloud, all scale and time associations are dissolved, transforming it to an electro-topological entity. Physical space and time are signals, indicating the origin of recording. By creating the means of communication with this archive, one finds the oxymoron of re-setting time and scale in this case as signals; controls to allow retrieval and decluttering of information. Extended Reality (XR) is used as a medium to represent spatio-temporal information and by definition this information is related to its physical origin and it’s attached to physical space. Human experience is enhanced by the ability to explore and inhabit past spatial configurations of objects through an interface.

Part of the wider research is the creation of an interactive network of spatial information. In this context, spaces may create new electro-topological associations in a wider network, highlighting the importance of tool-based fusion, level of accessibility and experience. It's important to note that the technical aspects of the proposed research are beyond the scope of this paper, but it aims to provoke rethinking of assumptions based on space and time, outlining qualities of organizing and visualizing 3D data.

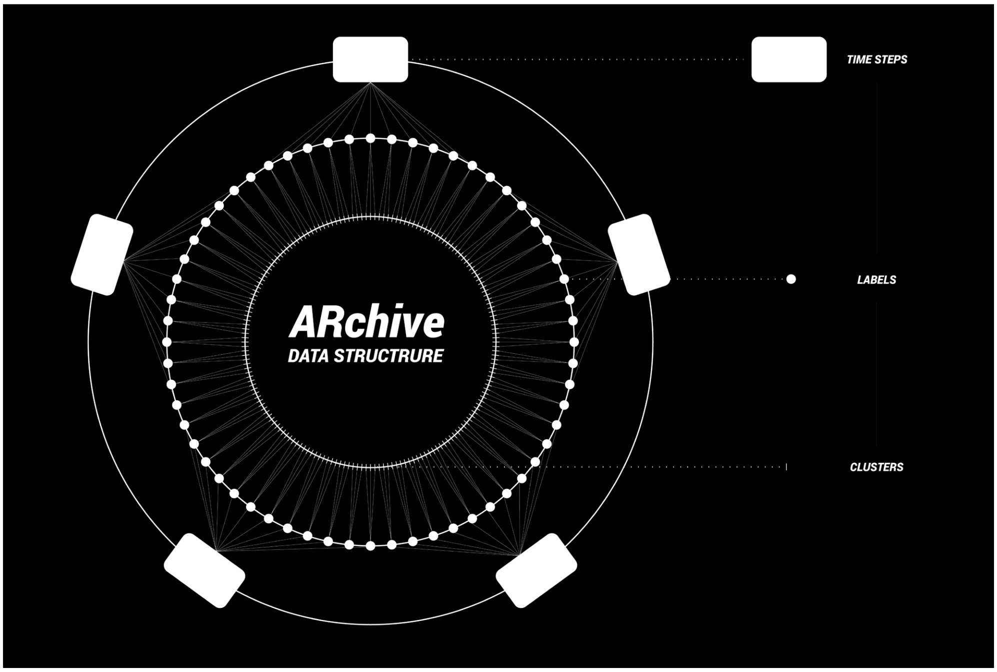

Fig. 02. 3D Data Structure: The information of the archival point clouds, XYZ and RGB, is organized based on time step, label (object definition) and cluster (individual objects).
Source: Image from author.

Background and theoretical framing

All knowledge, including technical knowledge, is filtered through the experiences and perspectives of the individual acquiring it and as Derrida explains, "ideal Objectivity is not fully constituted" or in other words, in order for information to be sustained through time it must be able to be incarnated in a transmissible form and be organized in a way to be readable and graspable (Derrida, 1989, p. 89). Additionally, constitutional systems, cultural erasure and power dynamics are shaping what information is preserved and how it is remembered, as dominant cultural narratives marginalize or erase alternative perspectives.

The compilation of a certain amount of information in one platform forms an archive, which is inherently directed to the medium of recording. Moving beyond a traditional definition of the terms, archive and medium are both different ways to describe the same system (Terrone, 34). What appears to be merely a passive repository of historical records, may in fact be a dynamic, and always incomplete entity which includes the act of recording and the means of communicating with the stored information. In parallel, the medium is used to materialize memory; historically humans have used different mediums to preserve and retrieve information. From the stone age, these mediums include a range from primitive drawings, language/ text, image and moving image, and the most relevant to this paper, 3D scanning and volumetric capture. The first two orthographic techniques embed a delay in the process of connecting thought and memory to materiality. Although every medium includes a delay in recording, it is highly relative to phenomenological time and human speed of perception (Ernst, 11). From twitter messages, to instant public sharing of photos, media culture seems to be obsessed with accelerating the perception of the present, or instead composing it anew.

The real-time transmission of information can take several representation forms such as sound and moving images. An example, experimenting by connecting cinema with LiDAR technology, is Volumetric Cinema by Current (Current, 2019). Narrative based visual content includes the third dimension, while space is constructed through the views of the user, in real time. 3D scanning has been also used extensively to more static ways of recording historical artifacts. Museums have attempted to replicate artifacts with 3D scanning. An example of that, is the British Museum, which has created a digital account to store and share 3D models on Sketchfab, an online 3D assets archive (The British Museum, 2014).

This increasing ability to digitalise our environment and behavior in real-time is generating vast amounts of data which can be decluttered, stored and create meaning, by caring cultural load. Artificial intelligence (AI), as a powerful human technological extension, is trained with this data, generating synthetic memory which in contrast to human memory, can be transferred and analyzed. Refik Anadol, a media artist, has extensively worked with data narratives, manipulating artificial memory as a tool to explore machinic alternate realities. His work is also highly related to the archival character of data, with an example of the project “Archive Dreaming” where a Machine Learning (ML) algorithm processed documents to create an immersive media installation through searching and sorting functionalities (Anadol, 2017). In the case of 3D scanning, PCLs represent spatial qualities through points in Euclidean space, with no formal structure or discretisation, but only the information of position and color. While humans conceive semantics by intuition, machines have been structured in a way to be trained and understand spatial semantics. Namely, scene understanding is the conceptualisation of a spatial representation as a way to get information on its contents and structure. It has matured through the years in 2D formats, such as image, but includes significant complexity when adding the third dimension (Singer and Asari, 2021, p. 97495). In parallel with the integration of LiDAR scanners in iPhones, Apple has also released RoomPlan, a library and API with scene understanding pre-made functionality, allowing non-specialist developers to create tools for parametric representation of physical space (Apple, 2022). This parametric representation allows access to semantic and dimensional information, such as types of furniture. Additionally, there are multiple Deep Learning (DL) models, trained on interior datasets with semantic labels, which are open source and accessible through GitHub (Nvidia, 2021). The multiplicity of technological advancements on both hardware and software, such as the above, are offering possibilities of redefining the notion of spatial archives. The methodology presented in this paper was initiated by this possibility, and involves an experimental approach with different techniques and mediums.

The above techniques of decluttering 3D data and specifically about predicting the semantics and segmenting them, are similar to indexing archives of other forms. Namely, the archivists need to describe their holdings in order to allow users to access them, while creating search tools with analogue or digital mediums (Bearman, 1989). Along with the hardware technology to capture data, the ways to access them has also evolved through time and it's mainly relying on the concept of indexing in order to then quickly access specified material. A well known technique is the control card system guideline of 2009 (Nurdin, 2021, p. 31), where each of the specified categories was assigned to a physical card. This analogue system was then expressed digitally on computers and the folder structure, where each folder has a name and its own structure. Later smartphones incorporated this logic with buttons representing actions to perform tasks or show information.

As elaborated above, space as well as every-day human actions and behaviors have become a system of signals, part of vast digital archives which machines can understand and use to generate further information. Temporality is a main attribute of archives and it has been expressed through different ways in fiction. In his book Time Travel: A History (Gleick, 2016), James Gleick explores how we think about time and why its directionality has been a matter of discourse for many years now, using philosophy through literature and physics. Science fiction has been an inspiration of technological advancements and has been extensively related to time-travel, while Gleick identifies its origin in the novel The Time Machine by Wells (Wells, 2002). Another more recent example is the movie Interstellar, where the space is represented based on time while the person is moving in an undefined space (Nolan, 2014). This area of research is linked to humans' perception of reality in terms of time and the nostalgia of what was here before us.

Methodology

The definition of archive is vast enough to accommodate different applications, from social media platforms and personal archives to state-governed infrastructures, it can be on a personal or group level, static or dynamic (Nurdin 2021, p. 29). Here the focus is on the flexibility of the archival system as a dynamic entity which can represent the outcome of past events that happened in a space and affected its geometry. Space in this paper is studied as a signalized version of the physical, as a set of points with RGB attributes. Additionally, time is an essential part of the archive; multiple momentary spatial states are recorded, decluttered and stored, organized based on time and semantics. Lastly, this spatio-temporal information is communicated through a mobile device, while superimposed and attached in the same space with XR technologies.

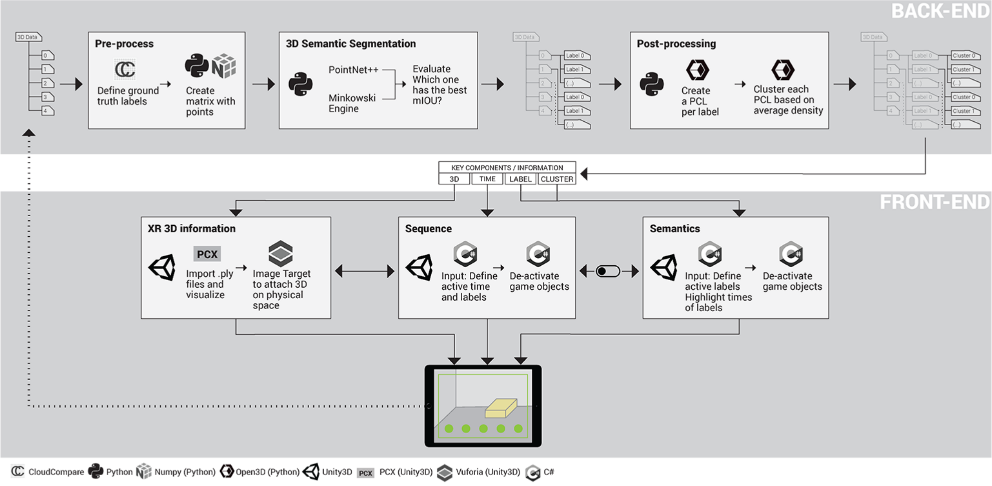

Fig. 06. Methodology diagram. The combination of methods is organized in the Back and Front-end. The dotted connection, to scan and upload new 3D models in the application, is not implemented in this paper, but it would be helpful for future work to close the loop.

Source: Image from author.

The selected case study is a bedroom, where the process started by collecting 3D scans of its architecture using appropriate technology (Figure 07). In this case, a smartphone (iPhone) interface with a LiDAR scanner (Apple, 2020) was used to capture depth information about the room's surfaces and objects. Regular intervals of scanning the bedroom created the first level of the archive; 3D information organized based on time, which includes the changes in spatial configuration of architecture and objects.

The outcome of 3D scanning is a technical image that falls within the spectrum of depictions and models, as Flusser defines the two district terms (Flusser 2011, 42). It is a depiction representing the actual space, while at the same time it can also be described as a model, in the current context, incorporating a possible configuration of the selected space on a specific time.

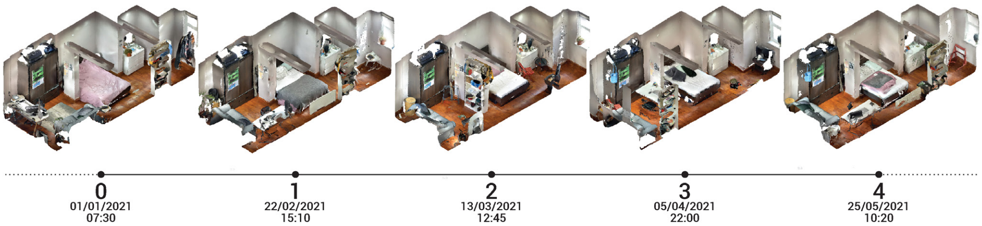

Fig. 07. Visualization of the case study's sequential input data. The resolution of the scans affected the quality and accuracy of the resulting 3D model. Higher resolution scans capture more detail and produce a more accurate representation of the room, while lower resolution scans may miss some small details or produce a less accurate model. The iPhone's LiDAR scanner has a resolution of approximately 1mm, which is sufficient for capturing most of the details in a typical bedroom. However,

the resolution of the scanner is limited by factors such as the distance to the object being scanned and the presence of any obstructions or reflections that may interfere with the sensor's ability to capture accurate depth data.

Source: Image from author.

Digitalisation of our environment and behavior, which means capturing and storing enormous amounts of data, is the way computers understand our reality. However, as argued in many publications, data is not that useful if we don't convert it into information (Pries and Dunnigan 2015, p. 153). Decluttering data to extract useful information can effectively be done using ML methodologies, which are able to recognize patterns and perform tasks much quicker than humans (Pries and Dunnigan 2015, p. 151). DL is a subset of ML that involves training artificial neural networks with multiple layers to recognize patterns in data. The key advantage of DL is its ability to automatically learn representations of data, rather than requiring explicit feature engineering by human experts. The semantics of space here are configured through semantic segmentation, making the type of object an additional index to the time parameter. More specifically, the Minkowski Engine (NVIDIA 2021) trained with the ScanNet dataset (Dai et al. 2017) was used to segment the PCL based on its individual objects (Figure 08).

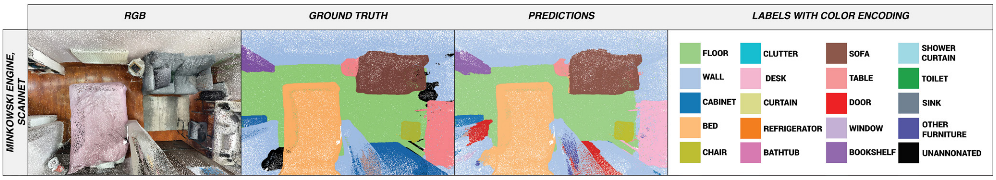

Fig. 08. Segmentation results from testing the Minkowski Engine trained with the ScanNet dataset. The first column showcases the 3D model, colored with RGB values, the second column is the manually annotated colors which correspond to a label and the third column is the predictions of the Minkowski Engine.

Source: Image from author.

Aiming to convert the above information into knowledge and make conclusions about the diversity, configuration and spatial change over time, a communication medium is made. Considering the possibility to enclose the whole process in a closed loop on the same device, from scanning and processing to storing and visualizing, the selected one here is an iPhone 12 Pro with an XR User Interface (UI). Unity3D (Unity Technologies, 2021) was chosen as the developing software with PCX (Takahashi, 2019) as a PCL renderer. Archive and medium in this case are both enmeshed into one experience of dynamic recording, incorporated into a device, the smartphone.

After 3D scanning, the PCLs are stored in the digital space, where scale is translated into information on a Euclidean coordinate system. Relating back this 3D information to physical space in the context of XR, requires an anchoring technique. Here an image target from Vuforia Engine (2021) was used to identify the orientation and position of the digital content on the physical environment. This image has a dual character and plays the role of the connector, minimizing the mental delay between object and digital artifact.

Any archival system requires indicators to filter and communicate the information stored. Visual cues and labels are parts of a system of signals, where real-time actions are represented on interfaces. These means of retrieval and interaction are expressed here as common UI tools in a 2D interface; sliders and buttons with text and color (Figure 09). At this stage the PCL archive consists of four kinds of information for each point in space: position, color, sequence and label. The first two are used for visualization of the segments. The next two are the main ways of organizing and communicating. The function of moving between different time levels in the 2D interface is represented through a rectangular slider, as seen in Figure 09. The design of the interface here is the process of sliding, both as a loop and linear, allowing to move from the present moment without any overlaid 3D information, to the past configurations augmented in the physical space and finally end up in the present again.

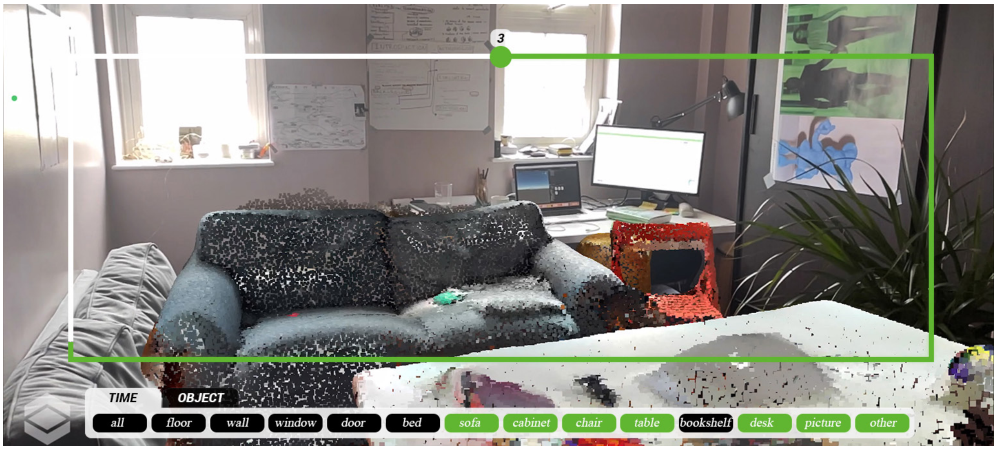

Fig. 09. The Time mode, where one can use the rectangular slider to de-activate different time levels, but also choose the shown objects with the specified labels through the buttons at the bottom of the screen.

Source: Image from author.

In parallel with the time slider and the organization based on time levels, the digital archive of 3D objects is also organized through the labels. The discrete objects comprising all the 3D scans, have their own local sub-archive: organized and cataloged information about their past states. In parallel with the logic of card separation (Nurdin 2021, p. 31), each label is represented through a button. Therefore one can select which of the labels or type of object will be visible in space. This function gives the possibility to track a specific object's past state or observe the overall change with all the labels activated. Additionally, the user is able to switch between the two different modes: TIME, to navigate through past states of the same space while having the ability to de/activate different labels, and OBJECT, to de/activate specific labels and track their origin in time (Figure 10).

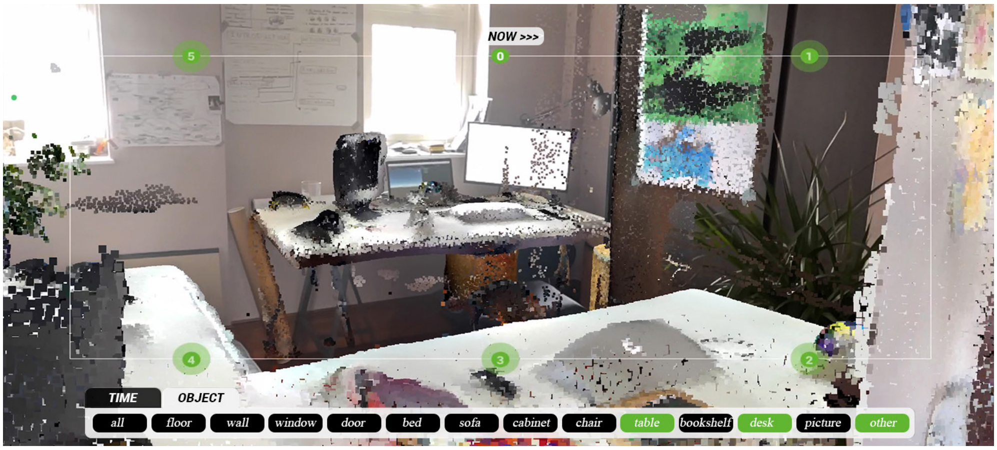

Fig. 10. The Object mode, where one can de-activate specific labels and view the equivalent objects on all time levels, with indications on the rectangle.

Source: Image from author.

Discussion

There is a growing availability and interest in developing spatio-temporal archives of PCLs as a means of preserving memories of the built environment and providing users with immersive experiences. This research draws upon broader theoretical and methodological frameworks, aiming to contextually place the development of such a system and relate it to contemporary media culture. The concept of "prosthesis" by Stiegler (1998), suggests that technology is an extension of the human, creating a technological unconscious and shaping our perceptions and understanding of the world. In this context, technology is used to enhance one's spatial memory and expand the temporal dimension of space, perhaps better understanding the space and its past.

The framing of the "extended present" (Ernst, 2017), is expressed here as a "window" in space, allowing for a glimpse of what was here before; the smartphone interface, which allows one to access and experience past events as if they were part of the present. The use of geo-located XR, which incorporated temporal and spatial attributes, aims to enmesh one's sense of the present and be able to exist in and inhabit multiple realities. It comprises a dynamic archive tied to the present and at the same time augmented with information from the past. All steps of the system's development are enclosed, as a loop, in a smartphone interface, highlighting the personal character of space and the increased accessibility and protection of personal data, as the whole system can be kept private. The smartphone interface has limited hardware capabilities as well, which may reduce the spatial experience, in contrast to other hardware such as Virtual Reality headsets which can be considered more immersive. However, the focus here is not experience-based. In contrast, the research encompasses different directions, from the more technique-oriented, to the archival and theoretical, and finally towards the user-oriented side of the system. While user testing, which has been conducted during the development of the prototype, is undoubtedly a vital part of the latter, it is beyond the scope of this paper, which aims to give a deeper contextual background on archival systems and the human relationship with them.

Fig. 11. Extended reality interface: An interactive interface to communicate with the 3D archive. *Source: Image from author.*

Conclusion

This paper explores how spatial memory can form an archive, through media traditionally used to represent space, and specifically 3D scanning. It builds upon a theoretical framing, equally important to the included methodology. Additionally, a prototype system is proposed to record, declutter, filter and communicate with spatio-temporal information. It is argued that human experience is enhanced through a smartphone (iPhone) interface by augmenting the present spatial configuration with the ones in the past. Part of the research's findings, considering the increasing availability of both hardware and software for volumetric recording, is the necessity of a system to manage 3D information due to its high complexity. A communication medium and specifically the smartphone, is crucial to allow for interaction with the information. In parallel to Stiegler's theory on the evolution of prosthesis, smartphones are the extension of a human's hands in contemporary media culture and an increasingly available medium. They are a complex apparatus which provide connections to embed meaning onto a surface and it is used for the whole loop of the system; from recording spatial information, to storing it and interacting with it. Namely, the iPhone interface is selected because it is used for other information systems such as social media applications, and it contributes to the sense of scale, having information attached to the physical reality. Scale, in this context, has a dynamic role, from 1:1 physical reality to the scaleless digital space and back to 1:1

XR. This progress of recording and processing data results in a loss of resolution, or even as framed here, loss in memory of space.

Scale is also defined here through the case study of a bedroom, but the process could be implemented in other contexts such as a museum, a construction site or even a natural environment; any kind of space where it's meaningful to preserve its visual dimension. An expansion of the system could be a network where spatio-temporal information is archived, from various personal smartphones. However, the main focus of the paper is the personal dimension of space and how we perceive and inhabit it through our tools.

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Plasticity of Scale:
Architectural Typology & Contextual Understanding

Introduction

The following paper is a critical reflection of a drawing exercise conducted by 25 2. nd semester, 1.st year students at the Royal Danish Academy - Architecture, Design, Conservation. Students were challenged to produce large scale drawings contextualised within Copenhagen; we describe these drawings as ‘operative drawings’. The drawing exercise and reflection is artistic research developed by the authors and should be understood as a means of informing critical practice within architectural education.

The focus of the paper will be to make a comparative analysis of the operative drawings set within a fictive Copenhagen context with a historic reading of Paestum. Abraham and Christiansen will provide theoretical context for the analysis. The ambition is to provide an analytical method framing the produced work and thus improving their future application in an academic context. The premise of the drawing exercise drew on a pertinent and immediate environmental concern; The UN predicts by 2050 68% of the world’s population will live in urban areas (UN DESA2018). Re-use, reprogramming and adaptation is therefore critical to the development of urban scale thinking.

The exercise required a single drawing by each student merging multiple programs. Two Copenhagen based multi-programmatic typologies would be merged into a mono-programmatic housing typology dating from the 1960´s. Focus on adaptation was intentional as was the housing typology dating from the 1960’s which is both universal and illustrative of a broader European context. Plasticity of Scale, refers to the qualities found within the drawing material produced: In these multiple scales operate simultaneously revealing imaginative and unforeseen typological arrangements. Divergent programs overlap and intersect creating new architectural potential. In this space historic traces and proposed intervention can be seen as a single overlapping entity.

The principle of reuse and reinterpretation of existing architecture as a means of revealing latent potential is both a pedagogical and ethical concern. It is a challenge to binary definition, new and old, instead prompting an affinity towards a reconciled understanding. Within this learning context, ‘existing’ and ‘new’ are not opposing forces but potential for nature and culture to coexist as a single contextual, architectural entity.

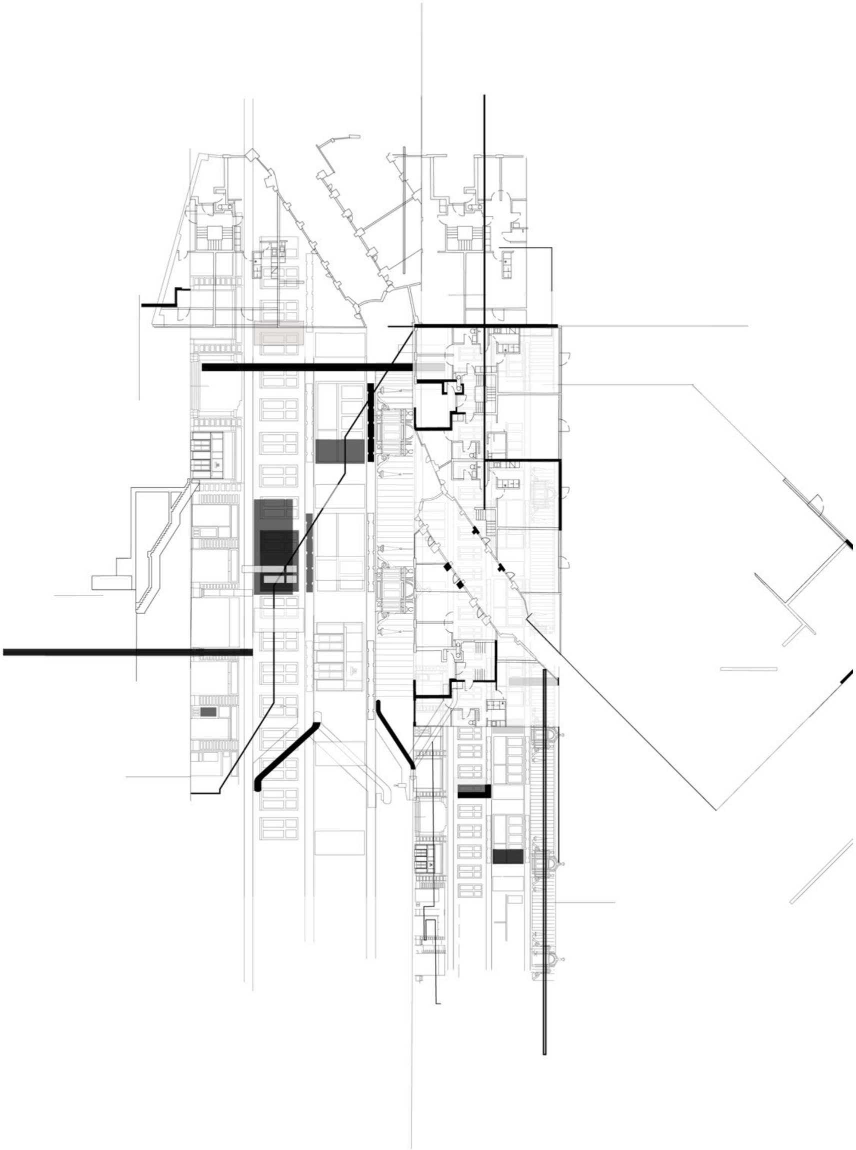

Fig. 01. Operative Drawing 01, fictive context Copenhagen
Source: Daniella Meinert (Student KOM, IBBL).

Paestum: A Historic Reading

Paestum, founded Poseidonia, circa 600 BC by the Troezenians and referred to by Aristotle is a graphic example of radical urban renewal and spatial reappropriation. As referred to by Virgil in his infamous quote; 'De Rosariis Paesti' Paestum can be characterised by its enduring qualities; a palimpsest of perpetual renewal. This process of reuse, alteration and adaptation of its building fabric is testament to the robustness of its architecture and a willingness to ignore style in favour of architectural continuity. These transformative qualities bear resemblance to the results of the operative drawing where we find the resemblance comparable.

As described by Richard E. Mitchell in 'Paestum a Roman Context', definition of a given style or period is ineffective due to 'Paestum's constant state of flux; archaic, classical, Lucanian, Roman, and even Christian styles' are present 'but these distinctions are not always convincing, particularly during the periods of transition from one to another' (Mitchell, 1985, P.44). This reading suggests fragments as the bearers of both physical and cultural continuity. The city can, through this lens, be seen as a landscape of continuous transformation.

The Roman Forum is an appropriation of the Greek Agora's southern quarter which preceded it. The axial north-south, east-west decumanus and cardo follow the remnants of pre-existing, non-axial Greek routeways. Adaptation of the urban grid-form accommodated pre-existing civic infrastructure. Similarly places of ritual and worship were fluid in their status, in the fourth century A.D the Temple of Ceres became a Christian church devoted to the Virgin Mary. In its Lucanian phase, the city was characterised not just by adaptation but adoption. The manifestation of this practice was evident as late as 18th century where the intact architectural expression of the temples became influential in Greek Revival architecture.

Complexity and richness are brought about through incremental change. Each re-appropriation of landscape and building fabric, iconography and ornament reveal latent spatial qualities. The operative drawing technique draws comparison; as with Paestum, space, scale, and time are gathered together in a single, legible entity. The overlaying of information as a drawing process acts as a catalyst; a collage technique to reveal complex spatial potentials inherent in the source material. The artistic and pedagogical relevance of this exercise is to shift focus away from the autonomy of rigid stylistic preference instead shifting focus toward urbanism's transformative potential and an ambiguity of stylistic preference. As with Paestum, the spaces captured in the operative drawings can be understood in a multiplicity of ways, in the context of this essay, void, edge and fragment allowed us comparative thematic content.

A New Nature

To establish a theoretical background as a means of understanding the new typologies produced and the ‘plastic’ understanding of scales applied we refer to Anders Abraham’s work; A New Nature (Abraham, 2015). In our interpretation of Abrahams doctor thesis, he challenges the typical methods of site analysis focusing on material and style, instead shifting focus towards a different understanding of architectural typology and the principle of the palimpsest as a means of creating new architecture. Abraham argues that proposed architecture and existing context cannot be separated but must be thought of as one and the same. In a New Nature the first chapter begins by quoting Carsten Juel-Christiansen:

> The wearing down of the historical city centre by urban renewal and the eradicating of the historical landscape in the city outskirts by urban growth indicate a tendency in the development of the new city, as a result of which town and country, past and future, merge to form a new entropic landscape. (Christensen, 1985, P.12)

Within the operative drawing exercise this quote is used as a premise; prompting students to create a drawing space where city centre, periphery, past and present become part of the same. It is therefore relevant to combine different building typologies as a means of creating new urban potentials.

From History to The Act of Drawing

Large format A1 digital drawings were the medium chosen for the exercise as this allowed digital processes i.e. copying, scaling, merging and deleting to occur quickly and effectively. The drawing itself is seen as a tool for exploration, a means of creating and questioning rather than that of representation. Effectively the drawing becomes a generative design tool rather than a representational device. Within the space of an infinite digital artboard plan, section and elevation become one and the same. A bell tower from a church can occupy the structure of a modular housing project, arches or other ‘found artifacts’ can replace load bearing walls. Social functions and the private realm are drawn close to one another, connections made between dissociated spatial arrangements. This method allows for imaginative and unforeseen typological arrangements to evolve through drawing via the subversion or merger of scales.

Divergent programs overlap and intersect creating new architectural typological potentials. We refer to the term ‘plasticity of scale’ as a way to understand this merger of building types and scales within a single drawing. What occurs is a kind of palimpsest city on speed. Processes that would take hundreds or thousands of years in reality can be created in a matter of minutes. The urban fabric becomes matter that can be cultivated like bacteria inside a petri bowl with the drawing acting as the catalyst. In this way the drawings become context and architecture simultaneously.

In the following section analysis of the operative drawings will be dissected bearing our historic precedent in mind. Attention is paid to the drawing as whole entities and to specific themes seen within the drawing matter. The drawing will be presented as a whole together with close ‘crops’ in order to study individual moments, as entities in their own right. This shift from ‘whole’ to ‘close-up’ correlates with our ambition to view scale within the drawing as something fluid. This method is chosen in order view the drawings produced not as pure composition but informative and generative design tools. In the drawing analysis Void (figure), Edge (condition) & Fragment will be themes used to analyse the drawing matter.

Each theme refers to a characteristic quality present within the drawing. We see these themes as a way of both understanding and creating urban form, density, grain, mass and volume within the picture plane. Subversion of scale and format, i.e simultaneous use of elevation, plan and section allows complex spatial possibility. This technique is not a means of generating new architectural form directly but a means of understanding potential in the pre-existing condition.

- *Void (figure);* Can be understood as the (complex) spatial quality of the (void) ‘figure’ in between the assumed volumes illustrated in plan form.

- *Edge (condition);* Can be understood as the perimeter line and its relation to the edge of the picture plane. Inherent is the form created in this interstitial space.

- *Fragment;* Can be understood as architectures in miniature, those elements within the drawing which can exist outside the context of the drawing in which they are placed.

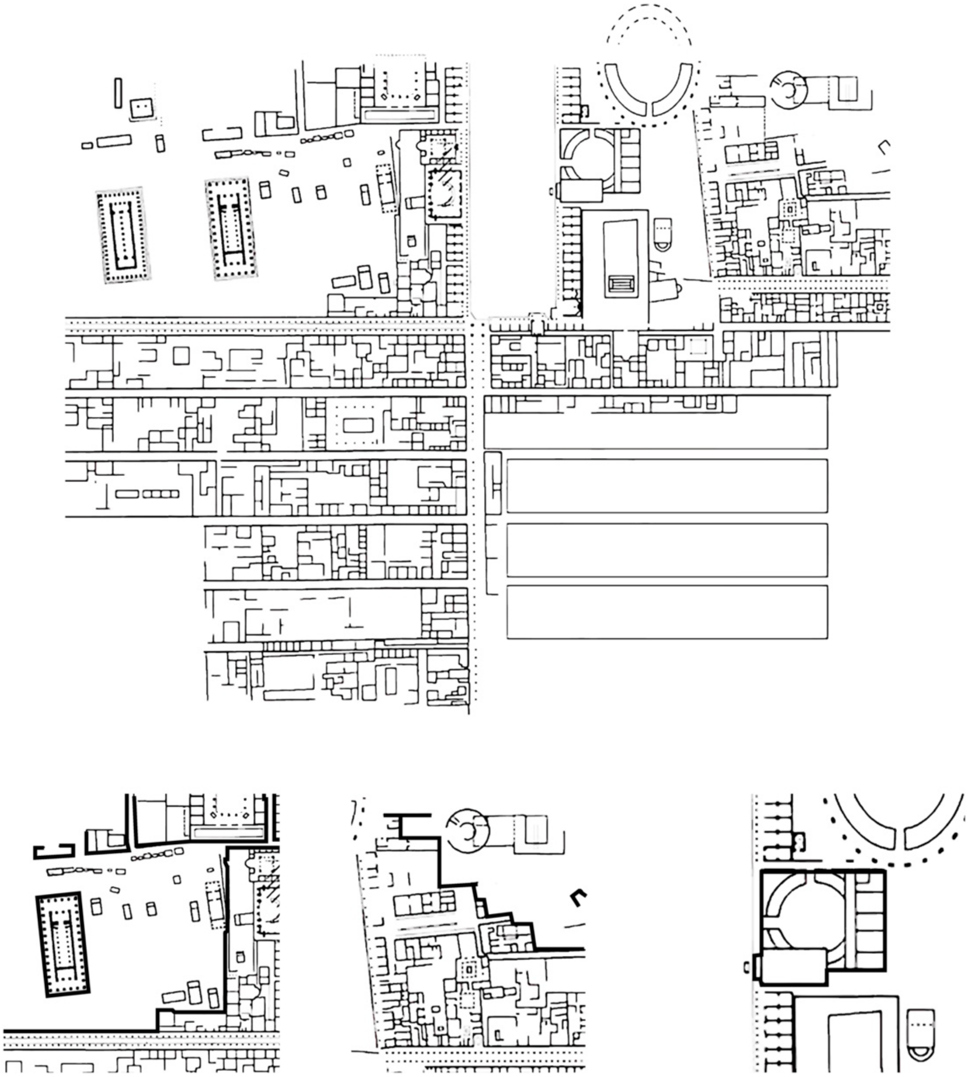

Fig. 02. Drawing Analysis of Paestum.
Top. Plan of Paestum, Bottom from left to right: Void, Edge, Fragment
Source: Ugo Erra, modified by authors.

- The plan of Paestum illustrates adaptation and adoption of architectural matter. Time has rendered both complexity and ambiguity within the urban form.
- The *void* figure, presents two Doric temples, off axis with the forum as well as architectural fragments.
- The *edge* is irregular and ambiguous, illustrative of an additive process, contrary to grid form planning.
- A *fragment* of a public space, partially revealed, incorporates at least two architectural languages. I.e The circular form and rectilinear spatial arrangement overlap creating complex poche space.

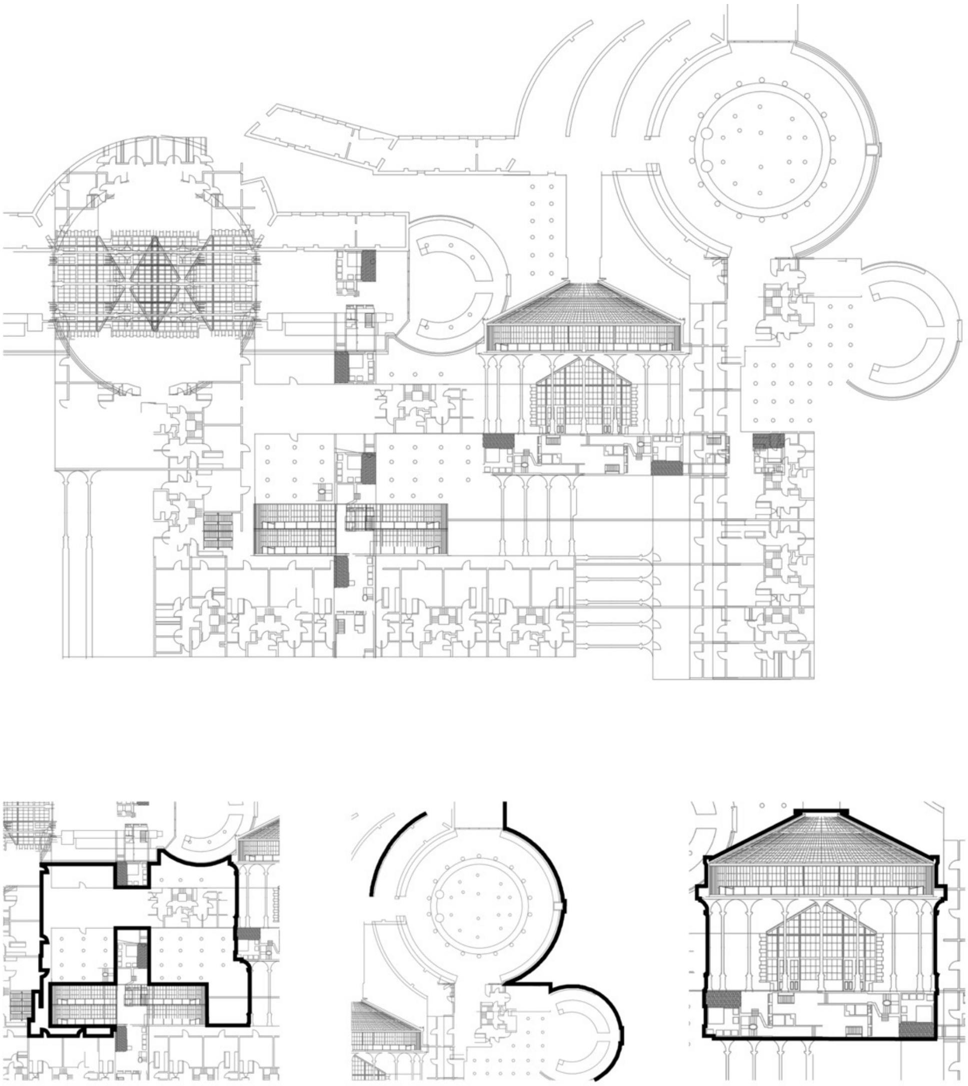

Fig. 03. Drawing Analysis of Operative Drawing 02, fictive context Copenhagen.
Top. Operative Drawing, Bottom from left to right: Void, Edge, Fragment
Source: Drawing by Jonas Stentoft Kirt (Student KOM, IBBL).

- *Operative Drawing*: Dynamic relationship between the axial building structures and circular, infrastructural forms. Relationship between size and scale is complex and multifarious.
- *Void*: Dynamic courtyard form shaped by surrounding façade, plan and elevation composition
- *Edge*: To rhs; circular motif defining enclosed edge. To lhs; fragments dissolving open edge.
- *Fragment*: Plan, section, and elevation motif merge into one architectural entity

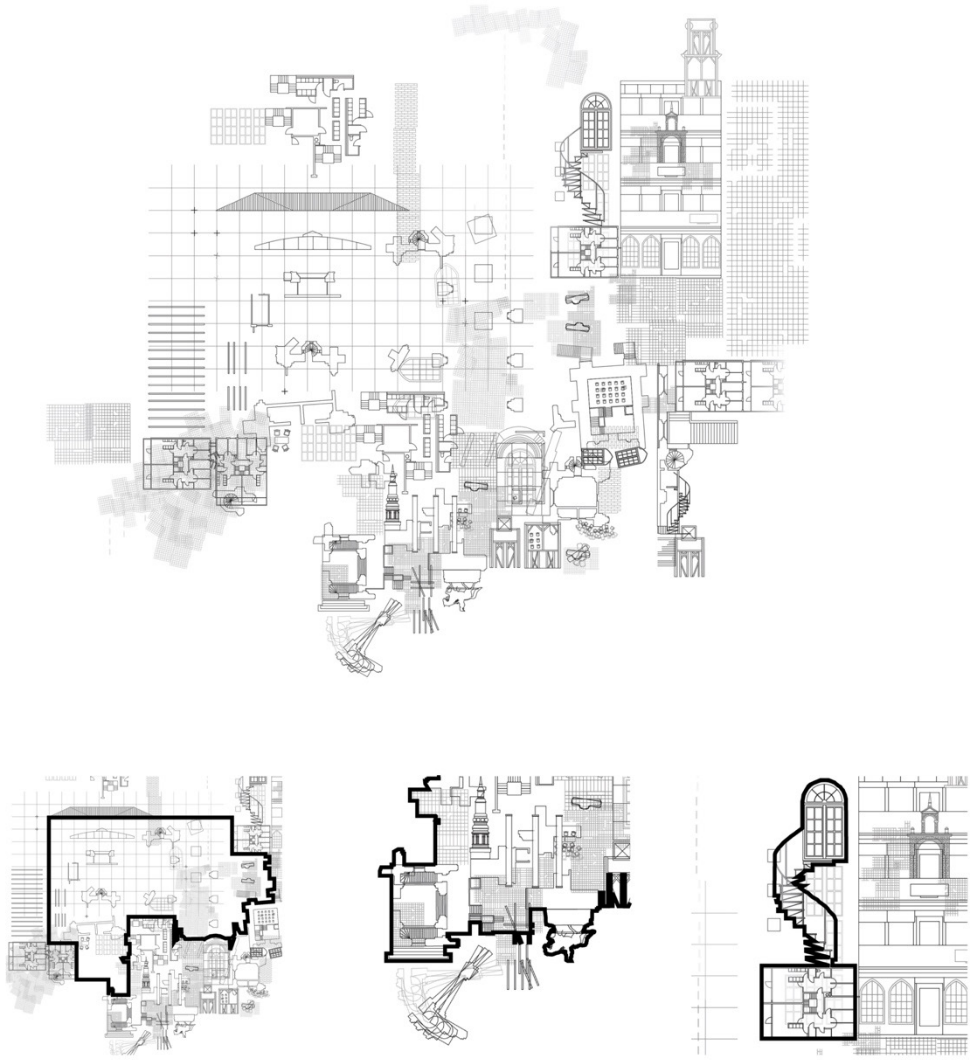

Fig. 04. Drawing Analysis of Operative Drawing 03, fictive context Copenhagen.
Top. Operative Drawing, Bottom from left to right: Void, Edge, Fragment
Source: Drawing by Ole Andreas Iversen (Student KOM, IBBL).

- *Operative Drawing*: Complex layering reveals interaction between different architectural periods and styles. The grid underlay is subordinate to baroque and modernist fragments.
- *Void*: Fragments arranged by grid structure define a complex plaza-like form
- *Edge*: The edge has a membrane quality; elements respond to conditions inside and outside
- *Fragment*: Alignment of sectional drawing to its corresponding plan flattens drawing hierarchy

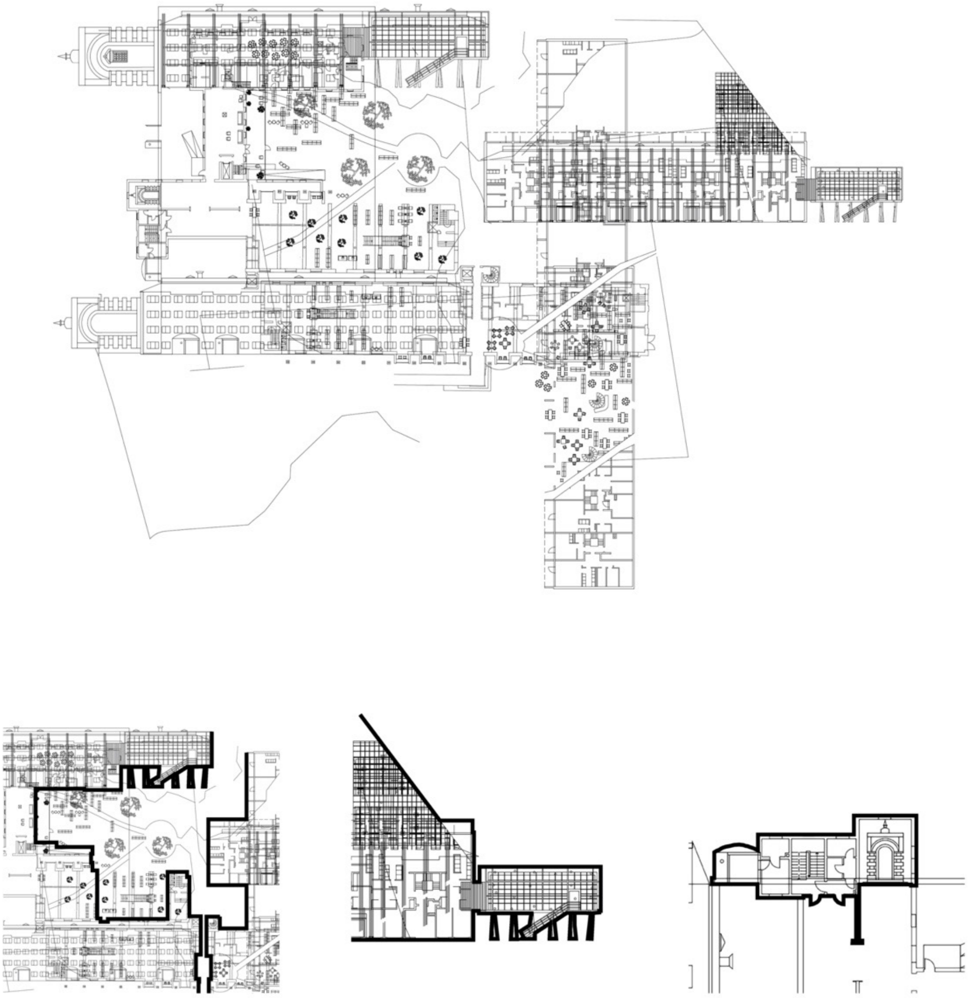

Fig. 05. Drawing Analysis of Operative Drawing 04, fictive context Copenhagen.
Top. Operative Drawing, Bottom. From left to right: Void, Edge, Fragment
Source: Drawing by Sebastian Hjortlund (Student KOM, IBBL).

- *Operative Drawing*: Describes complexity from furniture scale to the urban organisation of four building blocks capturing landscape within.
- *Void*: A semi enclosed landscape is contained by built structure, furniture elements mediate scale
- *Edge*: The edge has a strong geometry, directional quality, and outward reaching aspect
- *Fragment*: Merger of plan and elevation in tripartite composition has enfilade-like qualities

Conclusion:

The operative drawing technique exposed latent qualities within pre existing architectural contexts. These found qualities were subsequently applied within the imaginary space of the student's respective design proposals. Understanding of complex spatial arrangement prior to application within the designed 'context' of their own proposals afforded the students greater freedom and confidence. This process of reinterpretation and reuse was critical to their working method. A conscious shift from the purely imagined to a critical reflection and collage method. Plasticity of Scale, as an applied design exercise sought potential in contextual understanding. We hope the same imagination and analysis shown in the fictive drawings will be applied in real world contexts, where methods of radical reuse are necessitated by urgent environmental need.

We believe the drawings create, what we refer to as new context; without hierarchy or scale, time and space is gathered together, a layered composition of fragments to create a new whole. This technique, a reuse of existing architectural elements is designed as a means of heightening awareness and sensitivity to the potentials of the pre-existing condition. Imagination allows the incorporation of component parts, dissolving binary definition of new and old, instead prompting an affinity towards a reconciled whole. Within this learning 'context', 'existing' and 'new' are not opposing forces but seen as potential for understanding nature and culture as a single entity. We see this understanding of working with 'everything' as creation of context. A more developed understanding of this reading can be found in Bruno Latour's Facing Gaia;

> One thing is certain: the old role of "nature" has to be completely redefined. The Anthropocene directs our attention toward much more than the "reconciliation" of nature and society into a larger system that would be unified by one or the other. In order to bring about such a dialectical reconciliation, we would have to have accepted the dividing line between the social and the natural – the Dr Jekyll and Mr Hyde of modern history (Latour, 2017, P.120)

The operative drawings could include more than man made traces. If we want to create a deeper dialogue with nature, in accordance with Latour's thinking about nature and society as symbiotic, the next iteration of the operative drawing exercise, should incorporate other lifeforms in addition to the mapping of geological data and natural phenomena. This would point towards the exploration of a future nature.

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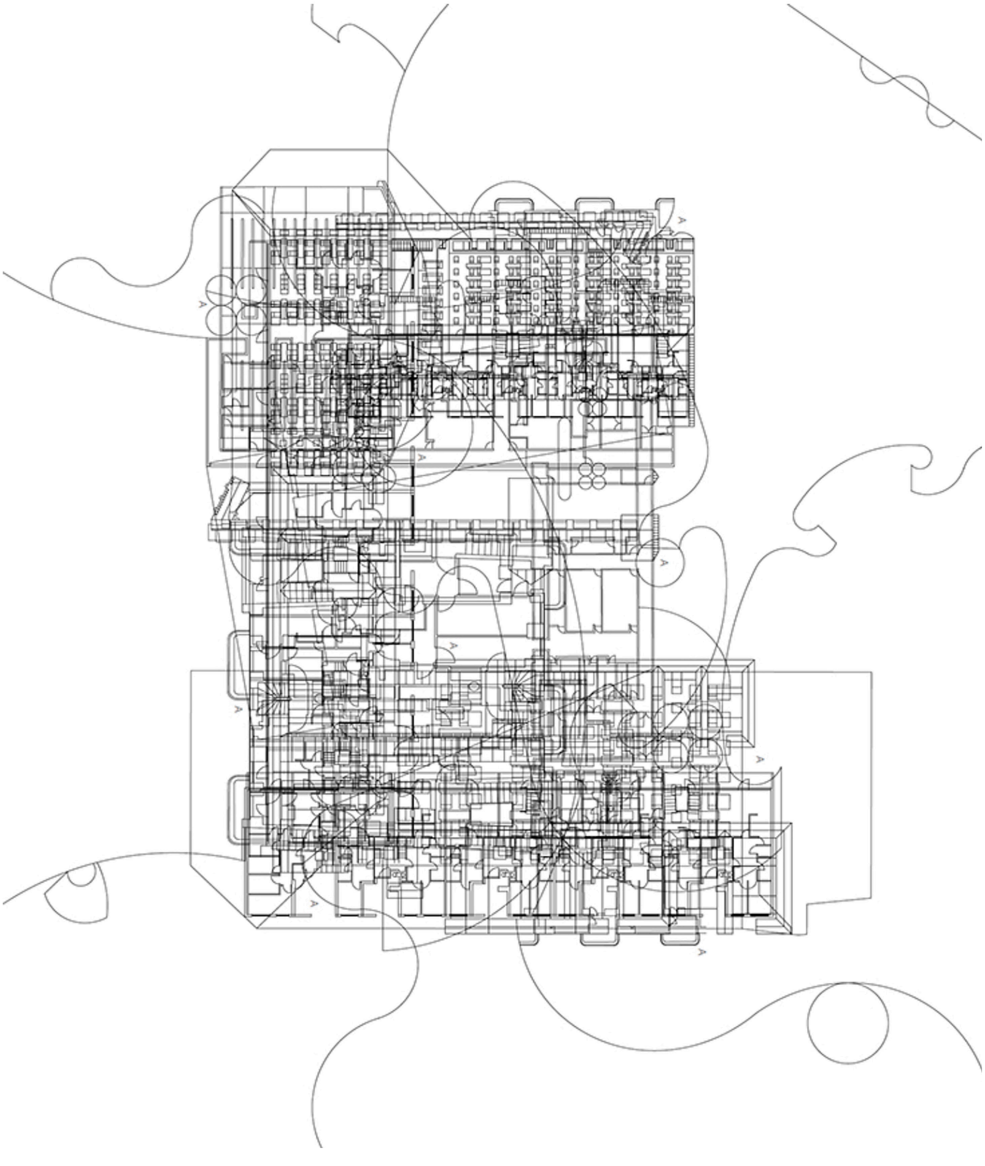

Fig. 06. Operative Drawing 05, fictive context Copenhagen

Source: Matilde Lise Houmann (Student KOM, IBBL).

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Exploring the use of Augmented and Virtual Reality in architectural and urban simulation laboratories: a study of Top 100 universities in QS Ranking

Introduction

Virtual Reality (VR) and Augmented Reality (AR) are increasingly used in various activities and are integrated into education and research in different fields, including Architectural Engineering and Construction (AEC) and urban design (Ummihusna e Zairul 2022; Whyte 2002). Portman et al. (Portman, Natapov, e Fisher-Gewirtzman 2015) presented an overview of the use of VR in architecture, landscape architecture, and environmental planning, highlighting the benefits of supporting design communication, visualization, and evaluation with VR by testing architectural design alternatives. However, as Portman argues, the application of VR in research and education shouldn't be focused on visualization only; moreover, an interdisciplinary approach in the field of urban simulation can be beneficial in education and research, as well as professional practice (Bosselmann 2005).

To outline an updated picture of the use of AR and VR in education and research at universities of architecture, urban design, landscape architecture, and civil engineering, this paper presents the research outcomes of an investigation aiming to review the use of VR and AR in urban simulation laboratories. To do this, the top 100 universities in the "Architecture and Built Environment" of the Quacquarelli Symonds (QS) university ranking system were analyzed to assess the types of technologies, or combinations of technologies, currently applied in courses, research, and collaborative projects. In this framework, our research questions are:

Q1. What is the current state of VR and AR technologies utilization in simulation laboratories at top-ranked universities specializing in architecture, urban design, landscape architecture, and civil engineering?

Q2. What are the geographical distribution and concentration patterns of VR and AR laboratories in the top-ranked universities for "Architecture & Built Environment"?

Literature review

The AR/VR visualization modalities favor the production of easy-to-understand scenarios to support the comprehension of design solutions and their progress from conceptualization to construction, including at a 1:1 scale. Gebczynska-Janowicz (Gebczynska-Janowicz 2020) surveyed architecture school students about their experiences in learning CAD skills and found that just 29% of students learned 3D modeling tools before university courses, and the majority of them (69%) found interest in these modalities thanks to university classes. Similarly, Soliman et al.

(Soliman et al. 2021) highlighted the need for designing effective teaching methods to maximize the potential benefits of VR in project design education; they propose to use a constructivist and variation learning approach, meaning that learners need to construct knowledge toward the exploration of alternatives and the direct experience of the effects of their choices, that is what VR/AR can help to experiment. Dvo et al. (Dvo et al. 2005), when describing the development of their VR center for architecture students, highlighted the potential of VR in improving students' skills in visualizing and solving three-dimensional problems, which is essential in preparing them for professional practice. Additionally, Fonseca et al. (Fonseca et al. 2021) reported that virtual serious games could increase students' motivation and interest in architectural and urban design education. The reviewed literature also indicates that using VR technology in education can improve students' design and problem-solving skills; for instance, Bashabsheh et al. (Bashabsheh, Alzoubi, e Ali 2019) found that VR technology can enhance students' understanding of building construction phases and improve their ability to visualize and communicate design ideas. Their work aims to integrate traditional education methods with VR, bringing a four-dimensional representation (geometry and transformations in time) of reality into a classroom and expanding the opportunities to experiment with the actual application of theoretical lessons.

AR is a valuable modality for ubiquitous learning that can be used for matching information with specific targets in the real world, generating strong associations of ideas (Chu et al. 2019), or engaging students to deepen their knowledge of places and design processes principles (Kerr e Lawson 2020). Different studies have explored the potential of AR for designing and planning on-site (Imottesjo et al. 2020; Search 2016; Thomas et al. 2011), proposing a spatial AR system that supports creating complex environments by allowing users to view virtual models overlaid on the real-world environment in an interactive process. The teaching process can also involve students manipulating 3D architectural elements to foster the connection of the design solution with the real world (Diao e Shih 2019). One advantage of AR is that it can be generally processed directly by mobile devices; at the same time, on the contrary, is that some issues that can affect a fluent experience with this solution are related to the technical capability of the device, e.g. gyroscope and the compatibility of the software of the GPS precision and AR engine with the device operative system.

Despite the potential benefits of VR and AR technology in education, some challenges and limitations should be considered. Difficulties in architectural education, especially in the first years, may lay on the need for a base knowledge in 3D modeling, texturing, and coding that may increase the cognitive load requested to students (Diao e Shih 2019; Sánchez Riera, Redondo, e Fonseca 2015). Davila Delgado et al. (Davila Delgado et al. 2020) highlight that while AR and VR can provide realistic scenarios for acquiring knowledge and skills in architectural and engineering constructions, reducing costs, and improving safety while learning practical procedures, these technologies are not yet extensively diffuse modalities in the AEC industry mainly due to technical issues and low investment in acquiring devices. Anyhow, Milovanovic et al. (Milovanovic et al. 2017) propose the use of these modalities to overcome pedagogical challenges in traditional education to keep continuity in the several representations students produce from 2D to 3D.

By the way, scholars agree that collaborative design approaches can be favored by systems such as Tangible User Interfaces (TUIs), AR, VR, and immersive environments; the advantage of using an immersive environment is integrating the three-dimensional representation with the iterative feedback of face-to-face dialogue (Milovanovic et al. 2017). For instance, integrated systems such as the CORAULIS environment show a mixed SAR system application involving a table-top with augmented plans/mock-ups and an immersive screen where several people can discuss the project alternatives. Tangible User Interfaces (TUI) are human-computer interactive systems able to link physical tokens and digital elements in an interactive way (Shaer 2009). An earlier experiment of augmented projection for architecture was conducted by Raskar, Welch, and Chen (Raskar, Welch, e Wei-Chao Chen 1999), who presented a table-top Augmented Reality system that merged physical models with projected imagery. Dias et al. (Dias et al. 2002) used tangible markers to manipulate basic geometries to develop a conceptual architectural design. Kim and Maher (Kim e Maher 2008) conducted a study on the impact of TUIs on spatial cognition during collaborative design; they found that using TUIs reduced cognitive load in performing spatial tasks, in particular, managing spatial relations, and improved users' ability to explore, manipulate, and communicate spatial concepts. Maquil et al. (Maquil et al. 2018) checked the effects on communication and engagement levels using a Geographic Tangible User Interface involving different types of professionals; the authors evaluated a relevant change in inducing more active participation and generating more discussions with a playful tool that is also usable for laypeople.

Method

The top 100 universities in the QS World University Rankings for “Architecture & Built Environment” in 2022 were analyzed to list research and/or education laboratories of these institutions that are active in the fields of architecture, civil engineering, urban design, urban planning, and mobility simulation. We collected data from institutional websites, social media platforms, and other sources that published information on their activities. We classified each laboratory’s expertise with the VR and AR visualizations adopted based on the official laboratory description, declared research, courses, and events presented online. Beyond the declared involvement in research, courses, and other students’ activities, we also verified if they conduce collaborative processes with private companies, citizens, and public administrations. All the information collected is recorded in a PostgreSQL database linked to a Django app designed for this research. This app was designed to store and aggregate data and present related statistics as maps and charts. The worldwide geographic distribution of the laboratories and the instances of AR and VR expertise expressed in their websites are calculated using this tool and represented on a Choropleth map. The involvement of laboratories in academic research, courses, and workshops, support for student individual activities and projects, as well as citizen participation processes, are all examined; these activities often overlap, and a Venn diagram of frequencies is calculated to highlight these overlaps. To identify the equipment of the university laboratories, we visited the main website of the laboratory; we also searched for their pages on social networks such as Facebook, LinkedIn, and Instagram; we also searched for other independent websites or blogs presenting their work. All laboratory equipment information has been recorded, including the specific brand and model, when available; if these details were not explicit, we identified the device type from the laboratory's pictures. We recorded whether a device was available or not and assessed the kind of device used in the laboratory. The list of devices and tools was then organized into technical categories and related subcategories.

- *Visualization/Interaction Devices*: Head-Mounted Displays, immersive projected environments, mobile/tablet, holographic display
- *Motion and Sensing Equipment*: motion capture systems, environmental sensors, neuro-physiological sensors
- *Audiovisual production equipment*: 360 cameras, 3D scanners, microphones, projectors, speakers, green screens / room
- *Vehicle / pedestrian simulation equipment:* treadmills, driving simulator cockpits, VR steering
- *Computer clusters/servers*
- *Human-Computer Interaction Equipment*: multi-users touch screens, Tangible User Interfaces, and Haptic Interfaces
- *Unmanned aerial vehicle equipment*: drones

We then calculated the occurrences of tools and devices found for each case; this measure does not consider the number of owned devices but just the presence of a type since it was not possible to verify how many copies of the same device are owned by a laboratory.

Results

We identified 34 laboratories dedicated to urban scenario simulation using VR, AR, and driving simulations from the top 100 universities classified in the QS ranking of the Architectural and Built environment. Most of them are concentrated in Great Britain (20. 6%), followed by the United States of America at 17.6%; Italy at 11.8%; China at 11.8%; Australia at 6.0%; Germany at 6.0%. The remaining percentage is equally distributed among the following countries: Sweden; New Zealand; Norway; Netherlands; Monaco; France; Finland; Spain; Switzerland. The geographic distribution of these laboratories and the percentages by country are represented in Fig. 01. The Ven diagram in Fig. 02 shows that 26.5% are focused on academic research; 17.6% are linked to specific structured courses and are involved in research, too; 14.7% supports individual students' activities besides research projects; 5.9% mix the academic research with support to specific courses or students' individual activities. There are no laboratories devoted to courses or collaborative projects only. 5.9% are involved in academic research and collaborative projects; 8.8% mix academic research with collaborative projects and individual student projects supporting; 2.9% involved in collaborative projects offer support for student activities as well. 8.8% focus on supporting students' activities only. The equipment and the activities described on the laboratories' websites involves both VR and AR visualization modalities (Fig. 03). 46.4% apply the VR modality only, while 46.4% can use both VR and AR; only 7.2% focus on AR only. Looking at the percentage of declared device types by all collected laboratories sample, it results in: 48.1%

visualization/interaction devices; 15.9% motion and sensing equipment; 14.8% audiovisual production equipment; 10.8% transportation/pedestrian simulation equipment; 5.2% computer clusters/servers; 3.2% human-computer interaction equipment; 2.0% unmanned aerial vehicle equipment.

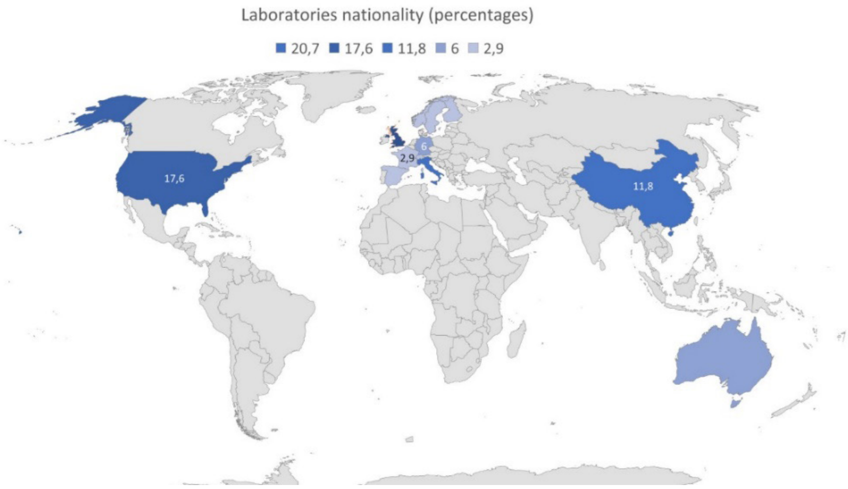

Fig. 01 Geographic distribution of the laboratories applying VR, AR, and driving simulation for urban scenario simulation among the top 100 Architectural and Built environment universities according to the QS ranking.

Source: chart and map drawn by the authors.

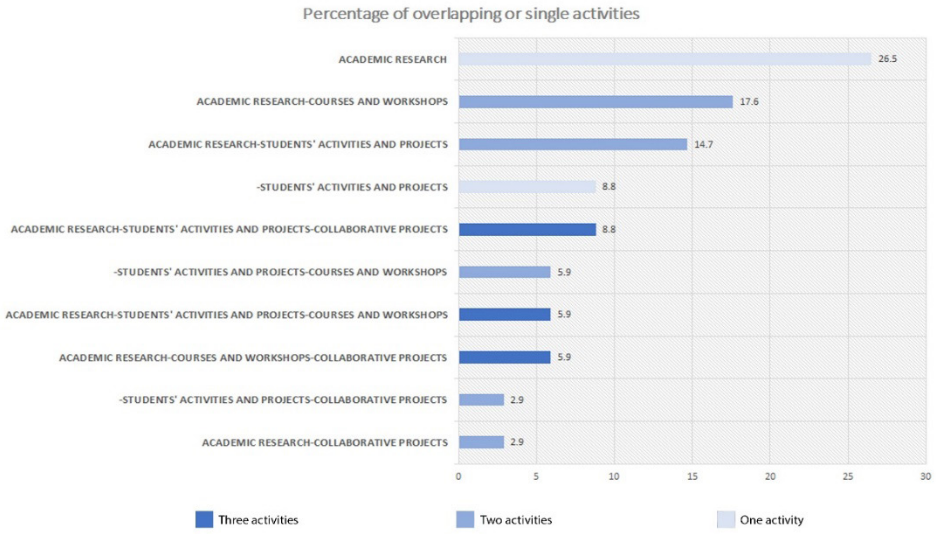

Fig. 02 Venn diagram of laboratories activity types. The diagram shows how many times the activities are declared exclusive or how they are combined.

Source: diagram drawn by the authors.

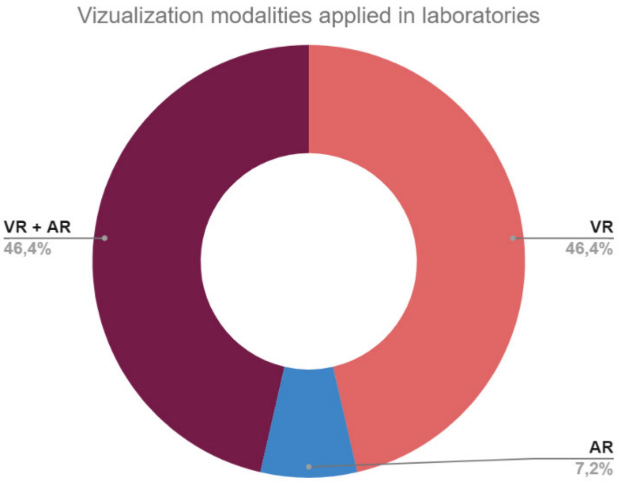

Fig. 03 Visualization modalities applied in laboratories. 46.4% focus on VR only, 46.4% work on both VR and AR; 7.2% are focused on AR only.

Source: chart drawn by the authors.

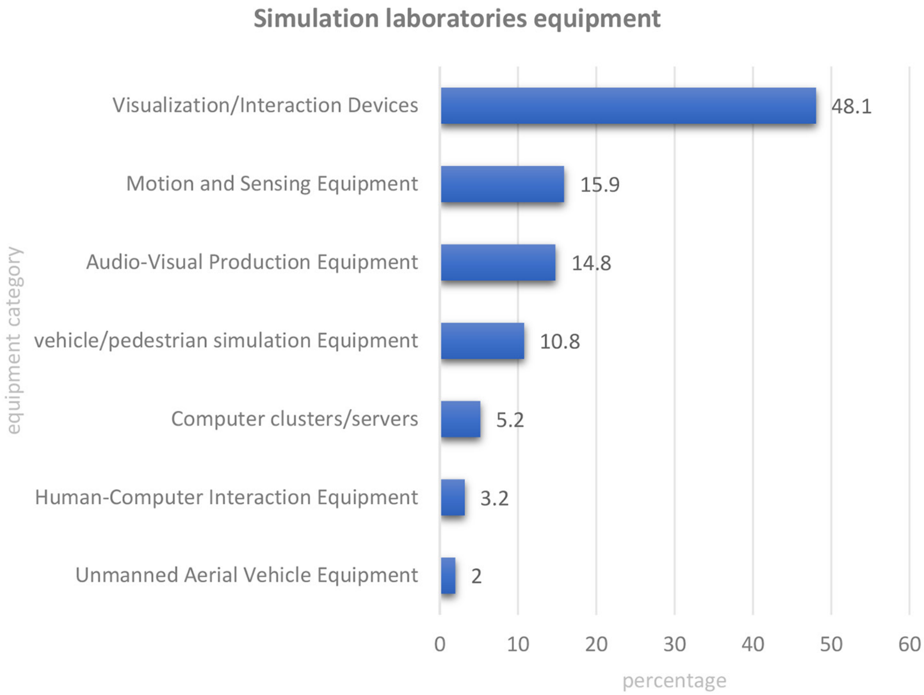

Fig. 04 Percentage of declared equipment (by category) in the laboratories sample.

Source: chart drawn by the authors.

The laboratories further described represent a sample of the aim, equipment, and activities hosted by the universities to develop a seamless process that links research, educational, and planning purposes in urban development.

At the Politecnico di Milano, two laboratories are involved in simulations with different aims: Labora (Fig. 05), provides mainly students with a cylindrical immersive environment and a treadmill to develop projects checking the effects at a real size scale; Labsimurb (Fig. 06) employs AR/VR visualization modalities with mobile/tablet, HMD, a Luminous Planning Table (LPT), environmental sensors, physiological sensors for evaluating the person-environment relationship in terms of well-being and comfort, applying these technologies for multisensory urban design and masterplan, social impact assessment, experiential walks, collaborative processes. At the Eidgenössische Technische Hochschule Zürich (ETH), the Chair of Cognitive Science (COG) (Fig. 07) of provides architecture, urban planning, and engineering students with an interactive environment to learn a human-centered and evidence-based approach to building design. The laboratory hosts a CAVE immersive environment, a driving simulator system, and sensors such as eye-tracking and skin conductance to track the observer experience with the simulation. Architectural students receive education on spatial cognition applied to the built environment and how different layouts affect the observer's reactions.

At MIT, the Media Lab developed in 2013 a Tangible User Interface named CityScope, a Luminous Planning Table for collaborative educational and professional design processes. The platform can track physical tokens placed on the table; the participants can freely reconfigure the token, representing quantities of specific urban functions; a computer program can dynamically calculate the impact of functional block compositions and provide feedback as projections onto the table and charts on a screen. At the University of New South Wales Sidney (UNSW), the City Analytics Lab (CAL) (Fig. 08) is involved in research and teaching for master classes. The CAL laboratory has wide multi-user touch screens, three VR/AR rooms, a Tangible Table sandbox, and an observation room. This facility aims to support and improve city planning and decision-making to develop sustainable and resilient cities.

At the University of California Berkeley, the XR lab is focused on architecture, urban planning, and climate change issues. The methods employed in the laboratory include parametric and generative design and scientific simulations. This laboratory provides didactical support in architectural courses using HMD and mobile applications.

Fig. 05 Labora, Politecnico di Milano. On the left the holographic table, on the right the cylindrical immersive environment.

Source: LABORA. (2023). Retrieved on March 2023, from https://www.polimi.it/ricerca/la-ricerca-al-politecnico/laboratori/grandi-infrastrutture/labora.

Fig. 06 “Laboratorio di Simulazione Urbana Fausto Curti (labsimurb)” at Politecnico di Milano. On the left, Augmented Reality for public participatory processes; on the right, integration of micro-camera and physical model.

Source: LABSIMURB – Laboratorio di Simulazione Urbana Fausto Curti / Dept. of Architecture and Urban Studies – Politecnico di Milano. (2023). Retrieved 20 March 2023, from https://www.labsimurb.polimi.it

Fig. 07 The Chair of Cognitive Science (COG) of the Eidgenössische Technische Hochschule Zürich (ETH).

Source: The Lab. (2023). Retrieved 16 March 2023, from https://cog.ethz.ch/the-lab.html.

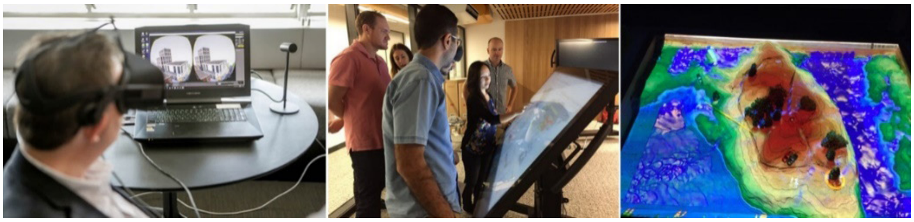

Fig. 08 The City Analytics Lab (CAL) developed by the University of New South Wales Sidney (UNSW).

Source: City Analytics Lab, Retrieved 16 March 2023, from https://www.unsw.edu.au/arts-design-architecture/our-schools/built-environment/our-research/clusters-groups/city-analytics-lab.

Discussion and Conclusions

The analysis of the top 100 universities in the QS World University Rankings for "Architecture & Built Environment" in 2022 revealed 34 laboratories in 28 different institutions dealing with urban scenarios simulation using VR and AR. Some universities host more than one laboratory; less than 30% of the top 100 institutions invested in developing facilities dedicated to VR/AR laboratories for teaching, simulation, and analysis in architecture, urban design, and planning. The geographic distribution of these laboratories showed that most are concentrated in Great Britain and the United States, followed by China, Italy, Australia, and Germany. A significant percentage of these laboratories (26.5%) are focused on research only; however, most laboratories also support individual students' activities and design courses. Regarding the visualization modalities applied by the laboratories, nearly half of them (46.4%) use VR modality only, and an equivalent percentage use VR and AR, while AR represents a residual portion (7.2%). This indicates that the usage of VR is almost double compared to AR solutions.

Regarding the specific devices and tools used by the laboratories, it emerged from the study that visualization/interaction devices were the most commonly used, followed by motion and sensing equipment, for simulation responsiveness or as a tool for analyzing users' reactions to the virtual environment, and audiovisual production equipment. The presence of transportation/pedestrian simulation equipment aims at integrating transportation elements in their simulations for urban planning and design. Even if visualization/interaction is more diffused, laboratories are not merely focused on this aspect, as the presence of other devices demonstrates a variety of activities that use immersive simulations in academic research, courses, students' projects, and collaborative processes. Integrating VR/AR technologies in architecture, urban design, and urban planning education enables a deeper understanding of the complexity involved in real-world project workflows.

By fostering complex spatial thinking and promoting a relational understanding of the city and building layouts, these technologies enhance students' comprehension and subjective experience in their learning process. The potential of these technologies in architecture, urban design, and urban planning is broad at various levels, and, particularly in education, they can foster complex spatial thinking by students by favoring a relational understanding of the city and the layout of buildings and the related subjective experience. Furthermore, employing different tools and devices that support simulations at different scales and involving dynamic feedback can promote a shared vision in design processes and improve problem-solving skills in planning, thus contributing to more effective and innovative design and planning outcomes. These implications of employing such tools make their application in pedagogical processes relevant. Future research on this topic would benefit from a deeper understanding of the actual condition and its evolutionary trend. It would be valuable to explore whether other institutions outside the top 100 invest in developing facilities focused on these modalities employing different assets. At the same time, more detailed insight into the specific activities of each laboratory would be beneficial, mainly if conducted using a collaborative logic of sharing within the laboratory network.

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Authors contribution

The authors' contribution, according to CRediT (Contributor Roles Taxonomy), is described as follows. Conceptualization, B. Piga, L.Pogliani; methodology, G. Stancato, B. Piga; formal analysis, G. Stancato; investigation, G. Stancato; data curation, G. Stancato; writing—original draft preparation, G. Stancato; writing—review and editing, B. Piga, L.Pogliani; visualization, G. Stancato; supervision, B. Piga, L.Pogliani. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

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The Scales and Forms of Narrative: Reflections on a Selection of Case Studies

Introduction

The following paper critically reflects upon a series of research projects which employ interpretations of narrative at different scales and in various forms. In all these projects, scale has taken on an important role because it has triggered or informed the development of theories, methodologies and artefacts (both physical and digital), as well as the application of tools and representational techniques (both analogue and digital). The main aims are to identify and make evident the multiple connections between scale, form and narrative, to propose a preliminary classification, and to suggest research areas that can inform further projects and investigations.

Various publications have explored relationships between narrative and architecture, including Psarra (2011), Coates (2012), and Bleeckere and Gerards (2017). Moreover, many historical and contemporary buildings can be considered narrative architectures, as their characteristics can deliver meanings and tell stories. Indeed, many architects, including Steven Holl (1947 -) and Daniel Libeskind (1946 -), have used narrative to inform their projects. The interest in narrative aspects of architecture and urban design is increasing, but it seems that the different scales and forms of narrative, and the relationships between them, are topics that have not been adequately explored so far.

By investigating and understanding the multiple relationships between narrative, scale and form, it will be possible to use narrative with an increased awareness of its usefulness in architecture and related disciplines, and thus improve the final results.

The paper analyses a selection of research projects through their main outputs, which are constituted by conference papers, articles and book chapters. Much of the value of this research stems from the variety of projects under consideration, which allows the formulation of more general reflections applicable to several other case studies.

The following sections will explain the relationships between scale, form and narrative, discuss the value of reflective writing and, following a description of the methodology, will critically analyse a selection of case studies.

Scales and forms of narrative in architecture and related disciplines

Written narrative can take different forms, including biography, fable, historical fiction and screenplay. All these forms are associated with the use of written texts. Scale can be interpreted in relation to narrative forms in different ways; for example, in terms of size or measure, size could be applied to the length of a novel or biography, which could be short or long. Scale can also be applied to specific content that is being described in a novel, including descriptions of buildings and places such as those, for instance, in The Lord of the Rings (Tolkien, 1968). Size can also be interpreted in relation to form, for example, the dimension of the physical book, which could be big or small.

In architecture and related disciplines, scale and form combine with narrative to generate an even wider number of interpretations. In the Oxford Dictionary of Architecture and Landscape Architecture (Curl, 2006), the first two definitions of scale refer to the "proportions of a building or its parts with reference to a module or unit of measurement" (Curl, 2006), and to the size of architectural representations (orthographic projections) in relation to the dimensions of the actual building. The fourth definition also considers an aspect related to the human experience and how a building's "[...] proportions might be such as to render it 'out of scale' and uncomfortable to the eye" (ibid). Hence, scale can be related to tangible or intangible elements. Moreover, it can be connected to aspects that are visible or invisible. For example, an architectural element such as a column is a tangible and visible element, but at the same time it has intangible qualities including colour and shadow, and may also have a narrative attached to it (for example, related to specific meanings); the latter may be invisible because it is not visually communicated, but it could be documented in a written text.

Within the architecture field, form can also be interpreted in various ways. In the Cambridge Dictionary Online (Cambridge Dictionary, 2022) there are two definitions that suggest how the word can be used in this field. The first describes form as the "shape and appearance of something", while the second refers to "a type or kind of something, or the particular way in which something exists". Hence, it could be the shape of a particular building or space, such as the shape of the Guggenheim Museum designed by Frank Gehry, but it could also represent different types of narrative, like a building, a space, a decoration, a drawing, a virtual environment or a written text, to mention just a few. The two definitions of form could also co-exist because a building can exist in the form of a museum (type of building) and have a specific form, for example, characterised by a particular geometry.

This paper identifies and critically reflects on how the word narrative has been interpreted and used in relation to scale and form in various research projects. Then, it proposes how these different combinations of narrative can be classified into a few preliminary categories.

The value of reflective writing in architectural research

The importance of reflective writing has been highlighted by different scholars, including Schon, in his seminal work, The Reflective Practitioner (Schon, 1994), and in other academic publications including those related to design education (Lousberg et al., 2020), as well as others outside the discipline of architecture such as from the field of education (Cannady and Gallo, 2016) and nursery (Jasper, 2005).

For architects and architecture students, reflective writing has always played an important role in their development. In two modules entitled Personal Development 1 and 2[1], part of the BA Architecture course at the University of Huddersfield, students are asked to keep a Reflective Learning Journal (analogue and/or digital), where they can include sketches, drawings, visual analysis, photographs, rendered images and inspirational images, all accompanied by their own reflections and annotations. Architects have always used sketchbooks and notebooks to record and develop their ideas, and writing has been a reflective tool for many of them. Aldo Rossi, for example, in his Scientific Autobiography, reflected upon his experiences and projects, and the book became a project in itself (Rossi and Venuti, 2010).

After nine years and several research projects, it is possible for the current author to look back, analyse the work undertaken and, by identifying and reflecting through writing on different elements, discover new connections. Reflecting on one's own writings also provides the advantage that the author is familiar with the details and has a general overview gained through direct experience in those research projects; this experience cannot be developed by just reading a number of publications.

Methodology: reflection, interpretation and classification

The methodology involves a mixed approach that combines aspects of reflective writing (Jasper, 2005), logical argumentation and case studies (Groat and Wang, 2013). Reflective writing and logical argumentation share some common characteristics. Both methods allow the researcher to analyse different sets of information and establish new links which can lead to new interpretations and understanding and produce new knowledge.

The central role is assumed by a critical analysis of the selected case studies through reflective practice. These reflections will focus on a series of research projects, and in particular on the content published in 11 peer-reviewed documents including conference papers and articles, and book chapters. These pieces of writing were published between 2014 and 2023 and relate to research projects developed between 2013 and 2023, hence over a span of approximately ten years. Some of them are the products of individual work, others of collaboration. As part of these and other research projects, further activities and outputs have also been organised and created, but the publications represent a more homogeneous set of information for the aim of the current reflective work. It should be noted, however, that the other activities and outputs convey different details which could provide further and different insights at a later stage. A look back at the list of all the author's publications from 2009 until today reveals that several are connected through the common thread of narrative, even if the interpretation of this word and some of the research areas have been quite different. In terms of the publications selected for this reflective study, narrative has been a relevant component of all, though not always the only or the main one. Moreover, scale and form have been relevant aspects in all these research projects, though sometimes their relevance has been implicit. However, through research activities, it is possible to analyse the same body of work under different lenses which allow the discovery of hidden links and meanings. For example, the exhibition and

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[1] The subtitle of Personal Development 1 is 'An Introduction to Communication Skills', and that of Personal Development 2 is 'Techniques of Representation'.

related publication entitled Monet and Architecture (Thomson and National Gallery, 2018) interpreted and presented for the first time the connections between Monet's works and architecture, even though architecture did not always have a declared central role in many of his paintings.

The first step in the reflective process was the identification of the publications with a connection to narrative. These were then listed chronologically in an Excel spreadsheet, where they were analysed as in a literature review. The literature matrix created in Excel included columns for various pieces of information, including title, year, type of publication, keywords, main aim/problem that the research addressed, methodology, tools and links to narrative, scale and form. The information included in each cell was extracted from the publications and, when necessary, annotated. This systematisation allowed the relevant information to be made explicit and the main aspects of those publications to be compared. The subsequent step involved grouping publications that covered similar research aims and areas of research. In this way, it was possible to create categories in order to identify research areas that can be generalised.

Case studies

The case studies documented through the 12 publications are also linked to other scholarly outputs and activities including exhibitions, digital and physical artefacts, workshops and presentations. The selected research projects and activities represent a diverse body of work which provides a variety of interpretations of the word narrative in relation to different scales and forms. Even within some of the projects, the interpretation of narrative is multifaceted because it is connected to different activities undertaken at various stages. This section proposes a preliminary classification based on the content of those publications and the aim of this paper. As previously mentioned, this preliminary classification is the result of the information organised and analysed in the literature matrix.

It is important to highlight that a few publications have aspects that pertain to more than one category, because of the multifaceted nature of the research projects and the possibility of interpreting narrative in different ways. The relationship between narrative, scale and form is made explicit in each section.

The following are the six main categories identified according to their main aims and content:

- Analysis of narrative architectures and urban environments in the physical world
- Design of architecture and places with narrative qualities in the real world
- Analysis of narratives connected to cultural heritage
- Collecting, storing and sharing narratives for participatory design activities
- Analysis of architecture, cities and their narrative characteristics in virtual environments
- Design of architecture and places with narrative qualities in the virtual world.

Analysis of narrative architectures and urban environments in the physical world

The first category is related to the analysis of architecture and places, which are interpreted as narrative items that communicate stories, meanings and/or evoke emotions. Two publications (Di Mascio and Maver, 2014; Di Mascio, 2018) document part of a research strand that aims to formulate a few definitions, including those of Narrative Architecture and Narrative Urban Environments, to outline theoretical approaches, and to develop methodologies and explore tools for identifying, investigating and documenting narrative characteristics of buildings and places. The goal in this category is to be able to identify and analyse, through direct experience, elements that have different scales and forms, from a single architectural detail (for example, a capital of a column) to an entire settlement such as a town or city. Hence, the approach can be defined as multi-scalar. Each paper presents a case study that tests the interpretations, the definitions and the methodology. The first piece of writing focuses on the Glasgow School of Art, designed by C.R. Mackintosh, a building with strong narrative qualities (Fig. 01). Unfortunately, this building has been severely damaged because of a large fire in 2018. In this case, the narrative analysis relates to a lost building, and hence a lost architectural narrative.

The second paper focuses on a very different case study in terms of form and scale, namely a street, its public spaces and the building facades that flank it. Grainger Street is located in Newcastle upon Tyne (UK); it is approximately 500 metres long and features several buildings, mainly historical ones. The reading of the street identifies spaces, buildings and their architectural elements, all covering a wide variety of scales and forms.

Within this series of analyses, an important concept connecting scale and narrative is the idea that multi-scalar elements contained within each other can be considered nested narratives, where narrative elements of decreasing size and form are placed inside one another. In terms of forms of expression, they are all real architectures and places with their related details.

Fig. 01. Nested narratives in the lost spaces of the Glasgow School of Art.
Source: author's personal archive.

Design of architectures and places with narrative qualities

Two recent publications (Di Mascio and Diggle, 2022; Di Mascio and Darnell, 2023) explore narrative in a context which is more design-oriented and which also has educational aspects. Both of these are connected to a project entitled (Re)Imagining Huddersfield's Narratives through Culture-Led Regeneration Projects. The first two design studio modules in the BA Architecture course at the University of Huddersfield explored a series of projects, including the Culture Pod, the Culture Pavilion, a Video Games Art Museum, a Bookshop Cafeteria with Gallery Space and a Visitor Centre, all connected to artistic and cultural themes. The main aim of these speculative design projects was to reimagine the narrative of Huddersfield, a town located in West Yorkshire (United Kingdom) that has an industrial past.

All the projects developed so far have been of different scales, from the small scale of the Culture Pod to the large scale of the Video Games Art Museum. Each project was characterised by specific requirements in terms of size. Generally, the Culture Pod and the Pavilion had one or two storeys while the Video Games Art Museum had a maximum of five. Moreover, each type of project (pod, pavilion, etc.) had a different form (Fig. 02). Each design intervention also had the aim to improve urban elements which were, in turn, of different scales, for example, a street, a square, a park, a neighbourhood and ultimately, the entire town.

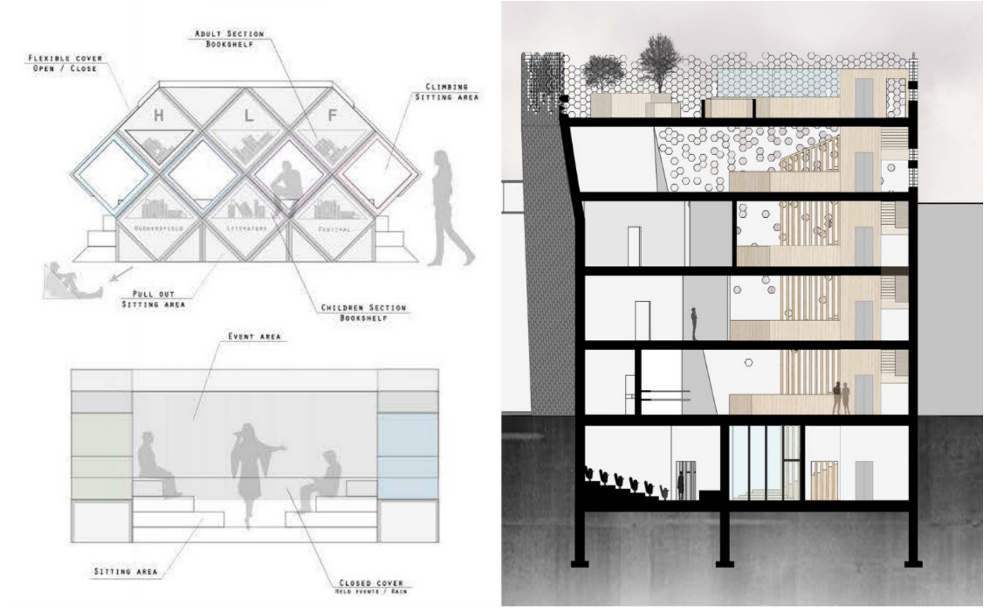

Fig. 02 Narrative architectures at different scales and forms: (left) Example of a Culture Pod by student Fidelia Florentia; (right) Example of a Video Games Art Museum by student Julia Rondinone. *Source: final portfolios submitted by students.*

Analysis of narratives connected to cultural heritage

This research area covers the analysis of narratives connected to cultural heritage with a specific focus on architecture and places. Four publications (one conference article and three conference papers) describe a series of workshops, the Contextualized Digital Heritage Workshops, while another conference paper presents a collaborative work undertaken on a reconstructed medieval townhouse, Barley Hall, located in the historical city of York (UK).

The Contextualized Digital Heritage Workshops (CDHW) are a series of workshops that have tried, probably for the first time, to connect people, digital technologies and objects, buildings and/or places pertaining to the cultural heritage of the location where the event was organised (Di Mascio et al, 2016). Obviously, as part of cultural heritage, there are items of very different scales, from small artefacts to entire settlements and places, both artificial and natural, all of which, thanks to their history, have strong narrative qualities. The conference article 'Connecting People, Heritage, Narratives and Digital Technologies: The Contextualized Digital Heritage Workshop' (Di Mascio, 2021), makes explicit the link between narrative and many other aspects of this workshop series, including those related to scale. For example, the buildings investigated during the four workshops organised so far are very different in terms of scale and form. In Oulu, Finland, participants directly explored and analysed a cathedral and a castle/observatory; in Suzhou, China, a historical street. Another workshop focused on a site with a multi-layered history of relics and buildings from different historical periods, including the Middle Ages and the industrial period, located in Lodz, Poland, while yet another considered historical artefacts, buildings and sites located in and around the city of Buyeo in South Korea (Di Mascio, 2021).

The project on Barley Hall in York applied aspects of the theoretical and methodological approach developed to analyse narrative architectures and urban environments, but also considered the narrative layer of the history of the canons who had lived there in the past (Di Mascio, 2021).

When analysing buildings connected to cultural heritage, it is also possible to discover small objects that pertain to cultural heritage (which may have different forms, even if of similar scale), but which are not related to architectural elements, such as the paintings within a religious building. These add another narrative layer to buildings and places.

Collecting, storing and sharing narratives for participatory design activities

A further category identified in research projects and related publications (Di Mascio and Dalton, 2017a; 2017b) is the design and development of digital and physical artefacts for participatory activities. The first of these was a virtual environment, to scale 1:1, which users were intended to explore as a navigable virtual environment in a game engine. This virtual environment, called the Architectural Portal of People's Narratives, was developed as a tool to improve dialogue and collaboration between designers and citizens during participatory design activities (Di Mascio and Dalton, 2017a). The idea behind this portal was to digitally reconstruct the historical Grainger Street (which is also the case study in the project about Narrative Urban Environments), and to use this virtual environment as a container for people's narratives (memories, stories, etc.) linked in various ways to this street.

The second artefact was a physical model of the same street, also designed for participatory activities. The model was exhibited in the central library of Newcastle upon Tyne and visitors were encouraged “to write, draw and share their memories and stories directly on the facades” (Di Mascio and Dalton, 2017b). For this reason, this section of the exhibition was entitled ‘Narrative Facades of Grainger Street’.

The model was not represented to a specific scale, but all the facades and details kept the original proportions and forms (Fig. 03). In terms of appearance, the physical model represented Grainger Street’s facades in a diagrammatic way, and the arrangements of the facades did not follow the same sequence as the real street.

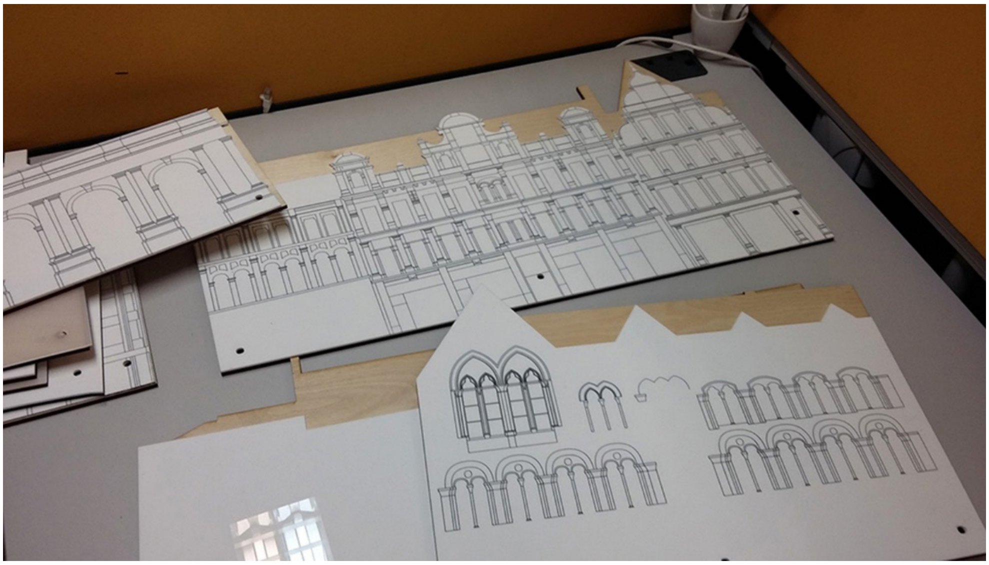

Fig. 03. Some of the narratives facades that collected, stored, and shared people’s stories and memories connected to Grainger Street.

Source: author’s personal archive.

Analysis of architecture, cities and their narrative characteristics in virtual environments

A few research projects and related publications investigate aspects related to architecture and narrative in the virtual environments of video games. A conference paper published in 2017 proposes a framework for reading and systematising the main elements influencing the 3D representations of cities in video games (Di Mascio, 2017). A set of these elements is constituted by narrative layers. One of them is the main setting, characterised by all elements that the player can directly experience while exploring the virtual environments.

A book chapter (Di Mascio, 2020) focuses on cities in the Assassin’s Creed series, and in particular, on the cities in the first Assassin’s Creed (Damascus, Acre, Jerusalem), in Assassin’s Creed Unity (Paris) and in Syndicate (London). This publication tests the previously mentioned theoretical framework with the aim of developing it further. In the book chapter, the definition of narrative layers is expanded and the word narrative is considered in two main ways: as sequences of facts that involve characters in multiple ways, and as “meanings, emotions and information communicated by objects, buildings and places" (Di Mascio, 2020: 133). Within these video games' virtual environments, narrative is connected to elements which, similarly to their real-world counterparts, are multi-scalar. However, their form also includes small objects, such as letters, books and scrolls placed around many locations, especially interior spaces; the scale and form of these objects are similar to those in objects pertaining to cultural heritage. Obviously, the scale and form of narrative in video game virtual environments are also influenced by the specific game's storyline (Fig. 04).

Fig. 04. The scale and form of narrative architectures in Assassin's Creed Syndicate are influenced by the Industrial Revolution.

Source: Author's personal archive.

Designing, sharing and experiencing virtual environments with narrative qualities

A conference paper published at the eCAADe conference in 2022 tells the story of the creative production of an international community of level designers who designed and shared imaginary virtual navigable environments for the video games of the Unreal Tournaments series (Di Mascio, 2022). A section of the paper also describes the narrative and experiential qualities of these virtual environments. The design of many of these game levels was inspired by specific themes and narratives, and they, in turn, communicate specific stories through objects, spaces and architecture (Fig. 05). For example, they can show spaces with statues, decorations and lights that can tell something about who inhabits or inhabited them, and what happens or happened there in the past.

An interesting aspect of the virtual environments designed by these level designers is that they have been shared and played/experienced by other designers and players all over the world, and all can be explored to scale 1:1. The conference paper in question also represents a written narrative, because its aim is to tell a specific untold story.

Fig. 05. Example of an imaginary virtual environment (DM-AscensionDay) that communicates its story through objects, spaces, and architecture.

Source: Author's personal archive.

Conclusions and future developments

This paper has critically reflected upon the content of a series of publications which employ various interpretations of narrative at different scales and in different forms. It has also proposed a preliminary classification and identified research areas that can inform further research projects and investigations.

The work is a reflective piece of writing that has allowed the identification of various connections between narrative, scale and form. The macro areas that have been defined can contain multiple sub-areas and inspire further research.

Future research includes expanding and testing the proposed categories with more examples from the literature, and developing diagrams which can support scholars' work within areas of research that intersect narrative, scale and form.

The multiple variables in each research publication and the different interpretations of narrative posed some challenges in selecting the various connections between narrative, scale and form. Obviously, because the word narrative is open to multiple interpretations, the classification proposed in this paper only represents one possibility. However, reflections elaborated in this piece of writing can be generalised and applicable to similar case studies.

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Tactical Urbanism | Social Exchange and Community Building

Introduction

> Making is thinking … the craft of making physical things provides insights into the techniques of experience that can shape our dealings with others. Both the difficulties and the possibilities of making things well apply to making human relationships.[1]

The Tactical Urbanism course frames the theory of creating small-scale design interventions in public space to create a long-term impact that shapes our cities' social and cultural life. Pedagogically, the design-build nature of the class provides opportunities for upper-level architecture students interested in exploring design-thinking and making skills to build a one-to-one fully deployable structure as artifacts to test as provocations in the city in a public event. Tactical Urbanism[2], Guerilla Urbanism, Streets Alive, and Parking Day have become annual events in many large cities. Such events bring real-life opportunities to design-build pedagogy in the classroom for meaningful social engagement and community building, thus expanding the role of education as a participatory practice-based design research and fabrication lab.

This strategy engages students directly with social and spatial justice issues within our cities and public spaces. It leverages design thinking skills to provide new urban imaginaries around place-making, shelter, and sustainability. The power of applying design skills to re(imagine) and re(think) social interactions through playful design-build artifacts as provocations redefine the role of architects as social agents of change for the *common good* that connect all citizens.[3] The process is rigorous, giving students real-life experience of project scope: from conception to design, to prototyping testing scalar mockups, to actual fabrication and deployment, whereby engagement with materials, tectonics, and tools intuitively gives them design feedback that is critical to the creative process as attested by Richard Sennett[4].

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[1] Sennett, R. 2008. *The Craftsman.* Yale University Press.

[2] / tac·ti·cal urbanism / A city and/or citizens-led approach to neighborhood building using short-term, low-cost, and scalable interventions intended to catalyze long-term change.

[3] Lefebvre, H. 1991. *The Production of Space.* Blackwell.

[4] Sennett, R. 2008. *The Craftsman.* Yale University Press.

This paper critically examines the Tactical Urbanism projects undertaken, specifically, *Walls as Living Surfaces* through the lens of Scale and Representation and its deployment to generate and promote critical discourse around issues of equity - Social Engagement and Community Building.

Design Build | Walls as Living Surfaces

Inspired by Rem Koolhaas's, questioning of the architectural elements as basic building blocks: wall, floor, ceiling and more at the Venice Bienalle exhibition[5], students explore the notion of Walls - to re(imagine) and re(think) the needs around shelter and placemaking by developing a prototype through scalar interrogations engaging program: as a plantar, as a pop-up bookshelf, as seating, and as a collaborative social exchange space. Each design-build class explores the issue through a public forum[6] to test its efficacy for further exploration.

Genesis | Walls as Living Surfaces

The genesis of *Walls as Living Surfaces* follows a trajectory of tactical urbanism design-build projects around street activation, place-making, and shelter, where projects respond to a given prompt as a problem. Scale and Representation are at the core of this process as form, space, design, programming, materiality, tectonics, access, and safety are interrogated through an iterative process. Students work in teams to brainstorm, conceptualize, and test scaler mockups for fabrication details. Project management skills are tested to keep teams on task and project coordination with the wood shop and digital fabrication labs: from material delivery, storage, logistics around the CNC machine, cleaning, waterproofing, painting, finishing, assembly, testing details, and on-site deployment and transportation. Through a multi-prong approach, the class collectively develops a discourse on how design thinking contributes to the material production of space as socially engaged constructed artifacts: modular structures as playful provocations for the community to engage and gather evidence-based data. *Walls as Living Surfaces* build upon the research and findings from TU 2019 - *Ubedeh* and TU 2020 - *Inhabitable Plantar* as listed below:

- *Ubedeh*

Students participated in *Hi Hat Competition7* to design a prototype for a shelter that challenged the notion of the Wall as a programable vertical surface: an urban garden to generate produce as an economic driver and social exchange to improve the quality of life of the homeless people.

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[5] Koolhaas, R. 2018, *Elements of Architecture.* Taschen

[6] Tactical Urbanism public engagement: 2019 – Ubedeh, *Hi Hat Homeless Shelter Competition.* 2020 - Walls as Living Surfaces, *AIA GA Research Grant.* Tiny Parks, *Liveable Buckhead. Fibonacci Nook,* KSU Math Club

[7] Mad Houser Hi Hat Competition 2019, KSU CARE Services and KSU Architecture Department. https://cobbchamber.org/ksu-students-re-imagine-shelters-for-the-homeless/

Applying their research, Ubedeh[8], questions how a shelter as an architectural construct rethinks its elements: *Walls as Living Surfaces* for growing food that can generate income and allow for social exchange. This project theorizes the utilization of 'lo-fab' building techniques that integrate reclaimed wood and leverage structural, kinetic, and tectonic joinery systems. The prototypical structure provides solace to those experiencing homelessness through intuitive construction techniques that exemplify modularity and deployability to "rehumanize" social issues surrounding homelessness as attested by Michael Murphy[9].

Fig. 01. Walls as Living Surfaces: growing, social exchange
Source: Tactical Urbanism Class 2019

- *Inhabitable Plantar*

Students in TU 2020 were tasked to interrogate Walls as a vertical garden using the following prompt: 'Walls are defined as edge conditions in our cities that act as boundaries/dividers/thresholds, physically separating public and private realms while acting as facades projecting a public face to the street. Within this most simplistic definition of a wall, how do we as architects/builders start the conversation to redefine the Walls as Living Surfaces - an assemblage engaging social, cultural, and economic framework suitable for today's day and age? '

Through precedent studies, walls as the vertical surface were explored as building skin and a structural system. The interplay between light and geometrical forms and shapes was interrogated. Concepts were developed to illustrate two iterations a) as a pavilion in the park for play and social exchange and b) as an inhabitable interactive planter wall engaging air and light to create a phenomenological experience as illustrated in the images.

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[8] Murphy, M. *Architecture that's built to Heal.* Ted Talk

[9] ibid

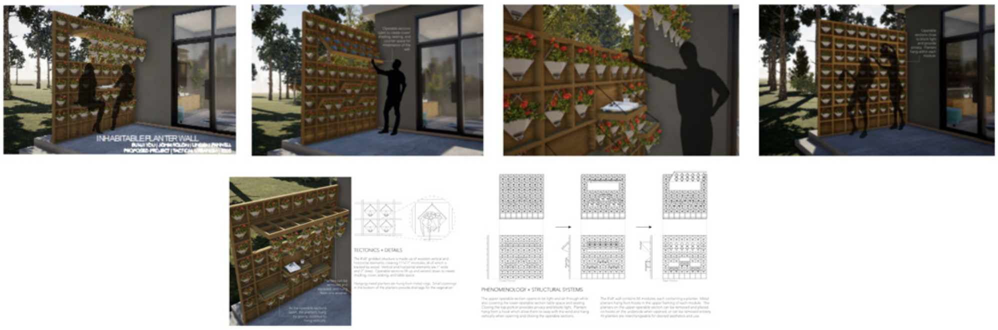

Fig. 02. Inhabitable Planter Wall
Source: KSU Tactical Urbanism 2020

Walls as Living Surfaces | Pop-Up Bookshelf

TU class 2022 was charged to respond to the KSU Math Club's desire for a pop-up bookshelf to engage students in the greens of the Math building at KSU. Student teams were challenged to conceptualize the Walls as Lving Surfaces engaging the following program: i) hold books, ii) provide seating, and iii) provide a collaborative social exchange space.

Design Scope - Defying Walls

Individual exploration combined with group work provided an enabling environment to push the concept forward. Students started the process by analyzing the site outside the Math building. In teams of two, the notion of a wall was interrogated as a 2d and 3d representative artifact to be further explored. Through sketches, physical and digital models' ideas were presented to respond to the design brief for a modular component-based wall system engaging the given program. As per Richard Sennett, humans are apt to create since they exist in material reality. The craft of making physical things using materials and tools in digital and analog modes establishes a feedback loop in an iterative method that informs design outcomes[10].

Fig. 03. Concepts of a Wall, Students Explorations
Source: KSU Tactical Urbanism 2022

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[10] Sennett, R. 2008. *The Craftsman.* Yale University Press.

Design Exploration Through Scale

Design Concepts were explored at incremental scales to test modularity, assemblage, ergonomics, and ease of construction: waffle structures, boxed structures, stacking methods, and mesh forms were some of the initial design proposals. The exercise of scaled physical model-making introduces a threshold that sends students on an immediate series of feedback loops when testing different design iterations. Using this methodology, students progressed from sketches to physical/digital models, mockups, to building prototypes.

The following narrative outlines the process and highlights the importance of *scale* and *representation* as an iterative tool to make critical decisions in the act of making[11].

Fig. 04. From Sketches, Physical Models, to Building

Source: KSU Tactical Urbanism 2022

The iterative design process continued as two teams were joined from the original four groups to refine another design iteration within budget considerations. They communicated their initial design ideas by creating 1’=1/16” or 1’=1/8” physical models. As the design developed, the feasibility of the proposals was tested through a change in scale. The next step was to produce 1” =1’0” models to test modularity, assemblage, fabrication, ergonomics, and ease of construction. The following two projects were the final proposals for the pop library.

1 *The Summit* focused on developing a waffle structure to provide seating, storage, and a wall for the enclosure. The site inspired the form; the shape is intended to weave through the foliage in the site and create an environment of comfort and calmness. The tectonics of this design uses vertical and horizontal wood slats to create a waffle structure. The porosity of the structural system allows for a phenomenological experience: light, air, and the function of storing books. Moreover, the organic nature of the waffle structure allowed students to think about ergonomics. The final form was then shaped in terms human body’s comfort.

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[11] Sennett, Richard

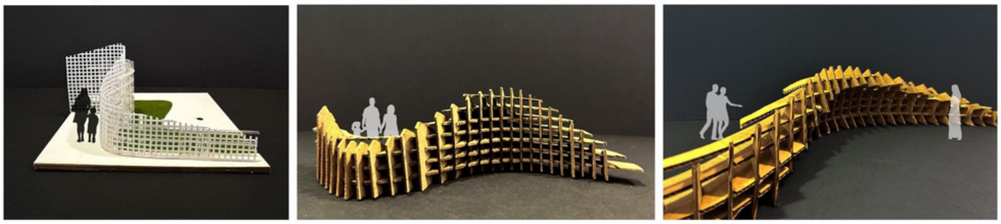


Fig. 05. The Summit. Waffle Structure Explorations
Source: KSU Tactical Urbanism 2022

2 *Fibonacci Nook's* concept of the Fibonacci sequence explicitly defines the shape and form of the design. It employs a stacking strategy for the structure and seating spaces which follows a topographical gesture at the lowest point creating a circular space for seating and collaborative exchange. As the form rises, the highest part transforms into a Wall with rectangular openings to create a sense of porosity, providing the function of a bookshelf.

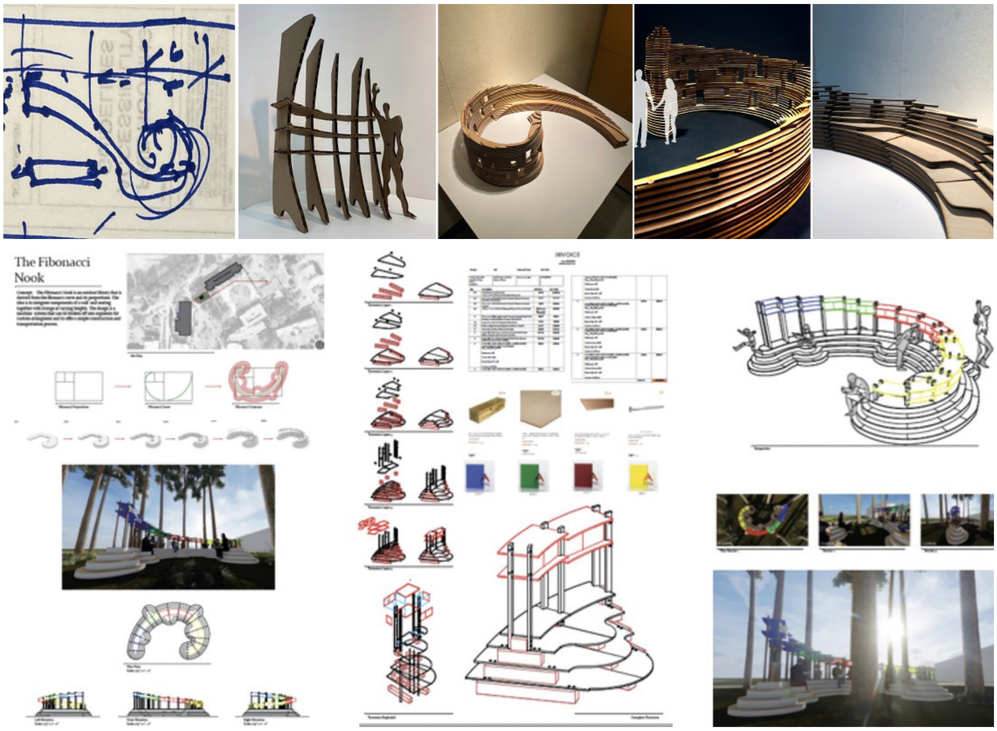
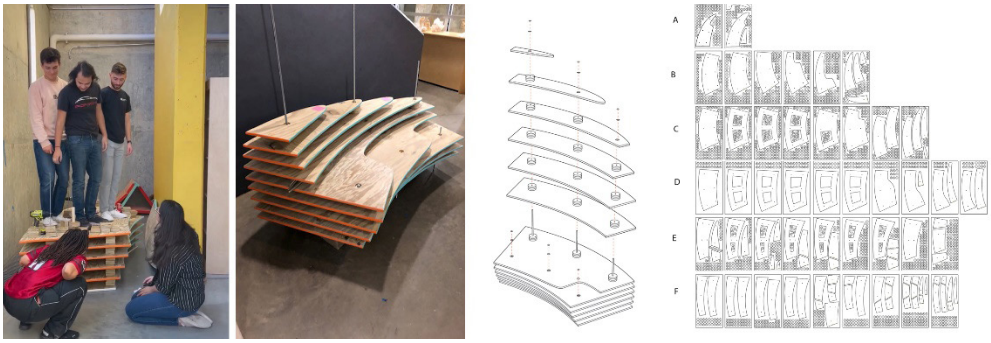


Fig. 06. Fibonacci Nook Explorations
Source: KSU Tactical Urbanism 2022

Testing Through Scalar Mock-Up

Testing through scalar mock-ups was the key in this and every other design-build project in the Tactical Urbanism course. A threshold between digital to scaled physical model-making provides an analogical opportunity to test tectonic details on a one-to-one scale which generally can be presumed to work in the digital modeling platform. When digital design ideas are carried forward into the analog world, details refine and expose problems with specific materials joining together to create an assemblage tectonically. Selecting a section of the design to explore in 1 to 1 scale brought many issues to the surface, as the resolution of details becomes clearer once as the assemblage is put together piece by piece in the material world.



Mock-up testing

Assembly Drawing

Fabrication Drawings

Fig. 07. Fibonacci Nook | Shop Drawings | Assembly Details | Mock-up and Testing

Source: KSU Tactical Urbanism 2022

Fabrication and Assembly

Engaging students in hands-on exploration in design, using multiple scales, calibrates the designers-in-training in terms of thinking and practicality of accessible stock materials and how they translate over into the real world in making and prototyping. Fabrication of the mockup model and assembly unfolded to the students that the material selection, at this scale, gave the module tremendous weight.

Considering this design must be transported, the team decided to solve this issue by subtracting unneeded material from the lower submodules that did not affect the structural integrity of the overall module. Another discovery that translated over into the real world unsuccessfully was the size of the threaded rods used for guiding the submodules down onto each other in a stacking manner. The ¼” rods buckled under loads of the modules during assembly and once they were set, the lateral loads of a user leaning back on the backrest did not provide enough structural integrity to seat someone safely. This design feedback loop communicated to the students to increase the diameter of the threaded rods to ½”, ensuring the loads are safely directed at this scale.

Fig. 08. Fibonacci Nook | Fabrication and Assembly Process
Source: KSU Tactical Urbanism 2022

Installation and Testing

The prototype, once completed, was deployed in the architecture building due to weather constraints for a soft opening to test its efficacy through public engagement: the math club, students, faculty, and other guests interacted with the installation. The task set out for *Walls as Living Surfaces* proved to be a multi-faceted experience as a playful provocation inviting the audience to engage with the structure: bookshelf, seating, and collaborative social exchange space.

Fig. 09. Test Installation and Opening Night
Source: KSU Tactical Urbanism 2022

Fibonacci Nook won many accolades. Students took great pride in accepting the AIA Georgia 2023 Merit Award. Learnings from the project were disseminated through conference presentations[12].

Fig. 10. Wall as Living Surfaces
Source: KSU Tactical Urbanism 2022

Conclusion | Social Engagement and Community Building

The project Walls as Living Surfaces illustrates how pedagogy can engage with notions of Walls to re(imagine) and re(think) elements of architecture - first, as a shelter in Ubedeh, and second, as an Inhabitable Planter, learnings from which was then applied to the Fibonacci Nook providing the function of a bookshelf, seating, and collaborative social exchange space.

As an elective course, Tactical Urbanism design-build strategies allow upper-level students to engage with spatial and social justice issues by leveraging design thinking skills as a generative tool to create small-scale design interventions as artifacts that are playful encounters as provocations for meaningful social engagement and community building, thus expanding the role of education as a participatory practice-based design research and fabrication lab. The theory put into practice with actionable design-build projects has an immense value that can further be developed as independent research projects beyond the scope of the class that generates a life of its own, as is evident with Art on the Beltline *Enfold Pavilion*[13].

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[12] 2023 BTES | Building Technoogy Educators Society. (2023). *Beyond the Artifact: Constructability, Complexity & Constraints.* Arcosanti & Cosanti

[13] https://art.beltline.org/art/enfold-pavilion/

These projects allow students to develop research as competitions and conference papers as they leap into the profession or pursue graduate work as "**making is thinking ...** an enduring, basic human impulse, the desire to do a job well for its own sake."[14]

Fig. 11. Tactical Urbanism Porjects

Source: KSU Tactical Urbanism Elective Class

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How Tall is that Mushroom? Design and Story Telling with Artificial Intelligence, Virtual, and Augmented Reality

Introduction

The Mixed Reality Design Studio (Xr Studio) is an experimental educational initiative that incorporates virtual reality (VR), augmented reality (AR), and artificial intelligence (AI) tools into the design process of a 3rd-year, interdisciplinary studio consisting of architecture and interior design students. The Xr Studio approaches design problems from a technologically and physically blended process of design, with the understanding that the computer and the programs used can become an extension of ourselves, and we can leverage these tools to influence how we think about and create a design. The studio also challenges young designers to question the role of emerging technologies in the the design process, professional ethics, scale, proportion, and architectural representation while fostering a more immersive, collaborative, and interactive design experience.

The inaugural ten-week digital studio was born out of the COVID-19 pandemic, and challenged students to interact, design, and present entirely in virtual reality. This studio was designed to be inherently flexible, resilient, and evolving, which enables the course content to adapt to shifting needs and new collaborations. The convergence of a digital design studio met with the global pandemic underscored the importance of utilizing digital technologies to augment and adapt the way we work. The studio utilized VR software and physical equipment to simulate users' physical presence in multiple virtual environments, enabling them to interact with, construct, and critique their designs in an immersive digital environment. Although the utilization of VR was meant to develop into a hybrid mode of studio where we could all gather and work, it was not a completely distributed event; software limitations, access to hardware, and access to reliable Internet connections prevented the entire class from gathering collectively into one virtual space; instead, only a fraction of the students could gather in one space simultaneously, with the rest observing from their screens across the state. After exploring the pros and cons of the first year, it was apparent that students were better served in a studio that met in person, rather than one that met in virtual reality, as the technology currently exists.

In the following year, recognizing that much of the VR experience exists inside the interior environment, a more holistic project could be achieved by incorporating the interior design discipline into the studio, thus creating the Mixed Reality Studio (Xr Studio). The Xr Studio brought new challenges such as collaboration and teamwork combined with the introduction of the emerging technology of VR and AR. Understanding that there is currently little precedent for teaching students how to design in and for virtual and augmented reality, we found ourselves with an unprecedented opportunity to re-think the traditional design studio.

In the third year of the Xr Studio, we began to explore AI as another way to augment and blend together digital processes with human experiences and interpretations of the built environment. The use of AI in the studio allows students to question not only the immersive experience of our bodies navigating the solid void and geometrical relationship of architecture but also to consider architectural environments at the perceptual and cultural levels.

Architectural Scale and Biometrics

Architectural representation has always relied on scale and proportion, with a strong connection to the human body's biometrics. Traditionally, architectural understanding relied heavily on physical models, mock-ups, sketches, and drawings, but the shift from a physical to a more digitally immersive world has had significant implications for our understanding of scale and its representation in architecture.

> The visual perception of architecture, as with any other visual perception, is a two-dimensional image mapped on the surface of our retina. [...] Creations of architecture are three-dimensional solid artifacts generated by the molding of space. Nevertheless, the final perception is a sequence of two-dimensional images that generate the identity of a certain architectural space. In the act of seeing we not only create an objective image of the external world but also bring our subjective background, coming as cultural and psychological impressions. (Bertol, 1997)

Our understanding of scale is ingrained in our bodily experiences and our interactions with physical objects in space. We use tools like scales and measuring tapes to quantify and represent scale, and we understand the relationship between scale and proportion as it relates back to our bodies and minds, the interpreters of form, space, and light. However, in a digital world, our understanding of scale may be more fluid and abstract, as we are no longer bound by the physical limitations of our bodies. With the increasing use of digital tools in academia and the profession, students may come to view the digital world as infinitely scalable or scaleless, which can create challenges for those who do not have a command of scale as it relates to the body or the built environment.

VR and AR technologies are increasingly being adopted in architectural and interior design practices, both in academic and professional settings. According to the 2020 AIA Firm Survey Report in 2019, 'only 9% of firms were using virtual reality for design/project services.' (Baker, n.d.)

These tools offer designers the ability to immerse themselves in digital environments and combine digital and analog processes for a more comprehensive design experience. As VR and AR technology continues to advance, they offer a new way to question the creation of space as well as offer clients or those outside of the AEC profession, a more approachable way to digest and/or interact with design concepts, and schemes, which has the ability to enhance the overall design process.

Xr Studio; Year II - A Journey to the Dinner Party

In the second year of the Xr Studio, students were divided into teams of 2 interior design and 2 architecture students. Each group was given a character from *Alice in Wonderland* as their client. Each character selected appeared in the novel and films. The character's backgrounds (or lack thereof) were the most important aspect when deciding who would be chosen – characters who had established homes or grounds were excluded from selection (Alice, Red Queen). Similarly, characters that only appeared in one or two of the media, or did not play a substantial role interacting with Alice, or whose fates were known, were also excluded (White Queen, The Mock Turtle, Jabberwocky). The list of clients was then allocated to the White Rabbit, the Mad Hatter, the Cheshire Cat, the Dodo Bird, and the Caterpillar. Each of the characters selected had enough backstory and idiosyncrasies to become a client with specific needs, wants, fears, ambitions, et cetera, for students to craft a strong narrative around.

Fig. 01. The Caterpillar's Dinner Party Building.
Source: 2022 Xr Studio

The teams then researched their individual "clients" by reading excerpts from the novel, watching the movies, and surrounding themselves in lore, while simultaneously investigating the character's background, and researching time periods from the original novel and the three film adaptations. This research enabled the teams to create an in-depth narrative from which to design. Analog mood boards and storyboards pulled key scenes for reference. Out of the large network of intricately linked scenes, historical events, and cultural trends, unique worlds began to emerge, formed around each character.

> Hence, designing the time in which the building exists requires understanding "time" as a history to be made, in which we as designers and as world-makers, must be active participants. (Castro, 2022)

The teams then expanded outside of the movies and novel to design a current-day dwelling, a space for a dinner party (separate from the dwelling), and portals that would transport characters from their dwelling to the book in 1865 and movies in 1951, 2010, and 2016. Equal to the narrative and time aspects of the project, the ability to manipulate scale and orientation with ease in virtual reality keyed into the design of the projects. As Alice grows and shrinks throughout the story, she eventually meets the Caterpillar at a robust 3 inches tall. The Caterpillar is well known for his sitting upon a mushroom, and the realization of the onlooker also being of similar height recalibrates the observer's perception of space. As you can see in (Fig. 1), the approach to Caterpillar's Dinner Party may not seem to deceive you at first, until you register the building as being roughly the height of the adjacent cattails.

The back and forth between the real "constraints" of the characters and the program with the fictitious environments in which they were placed created a duality of existence. The Dodo - purveyor of the nonsensical Caucus Race in which there are no rules, no directions, and everyone wins - seems like a slight character. However, through developing the narrative of the Dodo's history (both real and imagined) the dwelling and dinner party for the bird illustrate the idyllic conditions it once inhabited and its ultimate demise as a species living on a remote island. (Fig.2)

Fig. 02. The Dodo Bird's Dwelling and Dinner Party.

Source: 2022 Xr Studio

Xr Studio; Year II - Presentations

Basic guidelines and requirements consisted that each group must include a set of VR images or a walk-through, interactive AR drawings or QR code links (Fig.3), and physically printed boards. Beyond those few requirements, each group determined what they needed to tell the narrative they had crafted throughout the 10-week quarter. Including the required materials, each group displayed a variety of sketches, models, material samples, graphic design collateral, as well as costume design, and a movie trailer. This concluded with an exhibition that conveyed the conceptual and narrative goals of each group in a curated vignette.

Fig. 03. The Mad Hatter's Dwelling.
Source: 2022 Xr Studio

Xr Studio; Year III – Create Your Own Adventure

The inaugural year of the Xr Studio helped to uncover many lessons in the development of the class. Developing a detailed narrative for the "client" proved to be an important step in the process of design. First, it developed a deep understanding for whom they were designing. Secondly, it pushed students outside of their comfort zones and allowed them to open up to their team to play and explore, leading to more interesting projects. Lastly, it created a detailed storyline and "rulebook" for the teams to design from.

Collaboration between architecture and interior design proved to be beneficial to the students, the projects, and the programs. Students were forced to create spaces that were designed from the outside in as well as the inside out. Often students were required to redesign certain aspects of the building based on the decisions and actions of the counter-discipline. This led to a deeper appreciation for the allied disciplines that they will work within their future career.

Building upon knowledge assessed from the previous years, the next iteration of the Xr Studio brought new opportunities and challenges to aid in the development of the class. With the advancements in AI and the introduction of the OpenAI's language model, ChatGPT, we embraced the new technology as a digital team member and a way for the students to engage the schematic project narrative and imagery sooner with less resistance. In Steven Pressfield's book, *The War of Art*, he discusses resistance as the metaphysical enemy of our conscious minds, constantly tempting humans to give up and do what is easy instead of pursuing the creative goals that make us nervous. "Most of us have two lives. The life we live, and the unlived life within us. Between the two stands Resistance." (Pressfield, 2012). We recognize that many students suffer from the fear of starting a new project, and began to explore if the use of AI would augment the creative process by acting as a collaborative partner for researching basic information and generating preliminary concept art and narratives.

Students were tasked with creating a short story using a combination of prompts given to each group. (Fig. 4) They then took portions of the generated story and began to enter them into image-based AI tools, such as Midjourney and Dall-E, to create preliminary landscapes and environments that would become the future site for the buildings they would develop during the remainder of the quarter.

Fig. 04. AI-Assisted Environment and Character Creation.
Source: 2023 Xr Studio

This exercise in AI led to the exploration of professional ethics and discussions about creation, ownership, and the role of AI in the design process, ultimately challenging students to navigate the complexities of integrating artificial intelligence into their creative workflows. The incorporation of AI in the design process sparked critical discussions among students regarding the ethical implications of using AI-generated content. Questions of ownership, originality, and the impact of AI on the creative process emerged as central topics of debate. Students were expected to push the limits in order to see where AI stops and human creativity must interject.

> Simple activities adopt a mystical and cybernetic quality once the means of their operation are conducted via a silicon chip. Embedded in such apparently basic operational changes exists an essential paradigm shift, one that forces us to question our relationship with others, the structures that constitute our community, and indeed the nature of our existence in the world. (Pearce, 1995).

Students grappled with the notion of authorship in a world where AI tools can create stunning visuals in a matter of seconds. They questioned whether the use of AI-generated content diminished the value of their own creative contributions, and if relying on AI could ultimately stifle their growth as designers. Additionally, the students considered the broader implications of AI on the profession, as well as the potential for AI to disrupt traditional design practices. They discussed the importance of understanding the underlying algorithms and biases within AI systems and the responsibility of designers to ensure that AI is used ethically and effectively in the creation of built environments.

As AI continues to evolve and become more integrated into the design process, it is essential for educators to expose students to these emerging technologies and to foster critical discussions about their ethical and practical implications. By doing so, we can better prepare future designers for a world in which AI plays an increasingly prominent role in the creation of our built environments.

Conclusion

In an era where digital technologies are transforming the way we perceive and interact with the built environment, and in accordance with the conference theme “Envisioning Architectural Scales in the Analogue and Virtual Representation of Architecture”, we have challenged students to rethink traditional notions of scale, representation, and storytelling. By integrating VR, AR, and AI tools into the design studio and using narratives as a catalyst for creative thinking, educators can empower students to develop innovative solutions that transcend the boundaries of conventional architectural design.

By employing narratives as a central component of the design problem, students are encouraged to harness the power of storytelling and familiar contexts to inspire creative digital thinking processes. Extracting ideas from their written narratives, students are pushed to think beyond traditional design methodologies and create new strategies tailored to the unique requirements of both the analog and digital worlds.

The fantastical and surreal aspects of the narratives provide students with a platform to test the limits of what is achievable in virtual or augmented reality environments. By venturing into the realm of the extraordinary, students can challenge conventional notions of space, scale, and proportion, investigating new ways of manipulating and representing these fundamental design elements in both analog and virtual contexts.

As students immerse themselves in these digital environments, they gain a deeper understanding of how to create compelling and engaging experiences that push the boundaries of traditional architectural design. Experimenting with impossible geometries, non-Euclidean spaces, and other-worldly aesthetics that defy the constraints of the physical world fosters a sense of wonder and curiosity that fuels their creative endeavors.

Incorporating VR, AR, and AI technologies into the design studio paves the way for a new paradigm in architectural education that embraces both analog and virtual worlds. By harnessing these cutting-edge tools, educators can empower students to develop a diverse set of skills and a more expansive understanding of design possibilities.

These new approaches prepare students to be adaptable and versatile designers, capable of tackling the unique challenges that will arise as technology continues to evolve and shape the design landscape. By nurturing a mindset that embraces experimentation, risk-taking, and continuous learning, we can cultivate the next generation of architects who will push the boundaries of what is possible in the ever-evolving world of analog and virtual architectural representation.

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Peering Into Matter - Observing the Scale of Micro-Structures as a Tectonic Model

> The microscope and microphotography discloses a new world. They reveal, in this age of haste and superficiality, the marvel of the smallest unit of construction: our substitute for the longer period of time that primitive man could devote to observation (László Moholy-Nagy,)

Introduction

As educators, we want architecture students to not only gain a clear understanding of scale in design but also acknowledge that design operates at multiple scales. In this paper I will explore a pedagogy that initiates the design process in foundational architecture design studios by using the microscopic scale as a point of departure to develop a language of construction – or a tectonic language. I have been teaching architecture since 2004, and have been running studios that use micrographs as a point of entry to study architecture. As we enter a familar/unfamilar microscopic-scape, we can engage both the precision of observation and the spark of curiosity as a way to reveal and harness the magic in the everyday.

Background – Observation as an active act

The microscope allows us to use optics as a "mechanical eye" (Kemp, 2006) and peer beyond what is visible to the naked eye. As Lynn Gamwell observed:

> As Images of microorganisms made with an achromatic microscope became for the mid- to late-19th-century public what celestial images recorded by the Hubble Space Telescope are today: They offered an extraordinary sense of being transported to another scale — an exotic place tinged with danger, they were exquisitely beautiful, and they were reproduced everywhere. (Gamwell, 2003:49–50)

The microscope extends our perception beyond our own human scale, and in so doing, we may re-frame how we view both tectonics and the composition of our physical world. Looking beyond the threshold of human perception, we find that even surfaces that we consider flat and thin are made of complex structures. When we introduce this to students, we open an interior trapdoor so we can embark on "a trip into the thickness of things," that allows us to 'invade' their characteristics and expose them to new light (Ponge, 1945:14). This peering and observing allows us to harness curiosity and deepen our investigation, and scale is an essential aspect of this process. As architects, the immediate scale we consider in architectural education is the human scale, or scales that could be experienced through human perception. But with the advance of tools of observation, we have acquired mechanical eyes much beyond our natural capacity to see.

In the film Powers of 10, Charles and Ray Eames take the viewer through a multi-scalar journey (Eames, 1977); as we magnify or retreat, we witness how principles of structure may be shared across scales. The Eames' gaze suggests a seemingly fluid transition between scales, a smooth equalizing journey. But the complexity of scalar transition is greater and escapes human control. In each scale, different environmental factors inform tectonic evolution in distinct ways. As Donna Haraway poses, using observational technology is understood as a highly specific and active act that constructs a world from its particular viewpoint:

> The 'eyes' made available in modern technological sciences shatter any idea of passive vision; these prosthetic devices show us that all eyes, including our own organic ones, are active perceptual systems, building on translations and specific ways of seeing, that is, ways of life. There is no unmediated photograph or passive camera obscura in scientific accounts of bodies and machines; there are only highly specific visual possibilities, each with a wonderfully detailed, active, partial way of organizing worlds. (Haraway 1988: 583)

Similarly van Dijck sees the interior gaze into the body as an active shift in perception and conceptualization, claiming that "every look into a human interior is also a transformation – 'seeing is intervening' – because it affects our conceptualization and representation of the body" (van Dijck, 2005: 8). When we adopt Haraway's active view as a way to begin to imagine an act of world making from our particular framing of values, we can use the microscale to shift our perception and conceptualization of the physical world. The microscale opens a lens to a world built by non-human forces, similar to Haraway's insights. We use this non-human lens as an instigator of our world building, bringing awareness to a larger context .

In this pedagogical approach, students begin their architectural studies by closely observing structures that make up the fabric of our world from a different perspective. Acknowledging that we cannot displace tectonics from the micro scale without adaptation, students examine microstructures through an act of translation and re-interpretation. By introducing a less-familiar mode of building, these scales broaden our ideas of the built world beyond a human-centric frame of reference. I do not suggest an automatic adaptation from one scale to the other, but rather an engagement in the process-based translation of observed spatial and structural principles into universal ones that allow a development of a tectonic system that may be deployed in an array of scales that respond to different programmatic agendas.

Method - Micrograph providing a tectonic model

Act one – The micrograph

Almost a hundred years ago, László Moholy Nagy wrote that studying the micrograph allows us to step away from haste and superficiality and observe the marvel of the smallest unit of construction (Moholy-Nagy and Bauhaus, 2005). Today his comments still resonate loudly. We begin with a micrograph as an object of inquiry and spatial exploration. In some studios, the micrograph is a found object developed by others, and linked to a field of study, while in others the students actively create microscopic imagery of a three dimensional object, actively shifting their perceptions and preconceptions of the material world.

Students observe a world that is both foreign and familiar, one in which the structures are not human made, but observed and reframed. These structures are operating under different constraints and pressures at the microscale. At these introductory design studio levels we do not claim to fully grasp the ecosystem of parameters and factors affecting material makeup, but rather we use the microscale as a key to unlock an alternative act of world making. Students formally break down the image and the tectonic component, viewing the micrograph as a two dimensional composition as well as a three dimensional construct.

Act Two – Universal tectonic translation

> Pure vision shows us this original unity [of spirit and nature] as an enduring force in all things, as the universally shared force common to all things. This deepest universal element was termed by Aristotle substance – that which is the thing-in-itself, existing of itself, independent of those accidents of size, form, or qualities which constitute only the outwardness by which substance is manifested… If substance is the enduring force then a direct representation of the universal (or direct plastic expression of substance) is not merely justified but required. (Mondrian, 1917:48)

Mondrian adopts an Aristotelian approach where ideas contain qualities that are beyond scale and can abstractly manifest plastically. In our design process we use language to define these unscaled universal ideas. We investigate a micrograph and the conditions it holds, extract principles from it, taking it outside of its scale specificity, and deploy it in a different scale with an intelligence that responds to requirements imposed by that secondary scale. Each project has a set of requirements dictated by how the architecture's intended use, or its program. These requirements give us the conditions to respond to once the universal principle is enacted in a specifically scaled architecture project.

Students observe, analyze and draw, deriving systems of measure. They translate their observations into a universal abstraction. Extracting structural, spatial and tectonic principles embedded in the micro scale from which to develop a language of building. They identify core ideas identified in language "word joint" and understood in construction as a physical joint – abstract building blocks.

Act Three – Intervention

Based on site, scalar, and programmatic constraints, the design principles transform from the universal to the specific. In this instance each developed project manifests the qualities that are required for human centric design – be it the scale of a housing project re-addressing the urban/landscape scale, the scale of a pavilion, or a house.

Through the study of the micrograph, students identify universal principles that present opportunities for further developments in the context of an architectural project. We do not blindly adopt form, but open our minds to strategies that could be translated from one scale to the other, studying the programmatic implications of this act of translation.

Results - Case Studies

A semester's work is not merely the final project delivered at the conclusion of a semester, but it is the process itself. I explored this approach in my paper "out of time" (Erel, 2012) where I explain that in the design process we make a series of artifacts that are connected, but once they are built, they become autonomous. This duality presents a design process where artifacts can be reintroduced with a different reading in a nonlinear fashion, presenting the student process as a temporal merge of 'being' (moments in the process) and 'becoming' (the process itself). Therefore, I will reference different artifacts or moments–drawings, models, and renders–of each student's process to be able to explore the process of each of the three acts.

From a broad range of projects taught over a ten year span, I have selected a number of projects from different studios ranging from a foundational first-semester, first-year studio designing a pavilion or kindergarten building, to a second-semester. first-year studio studying a pavilion, to a housing project in a fourth-semester, second-year project, where students are asked to respond to a larger set of constraints. Each one of the examples allows us to see either a different aspect of the process, or how scale and program may impact the outcome of an investigation.

The foundational kindergarten- Case Study

I will start with a case study that examines work in a first semester architectural design studio. To begin, I have selected a kindergarten program, as it relates to scale quite directly. The programmatic constraints of a kindergarten are scalar in nature since they involve adults as well as children, leading to a variety of sizes and scales to consider. As a pedagogical approach, the kindergarten uses playfulness as an educational tool (Montessori, Zinger), hence students are encouraged to embody a playful attitude in the design of the architectural environment. We draw on Dewey's observation that "What nutrition and reproduction are to physiological life, education is to social life" (Dewey, 1916) and use it as a design guide. This studio took place in the students first semester studying architecture, where they developed both their skills and an introduction to the world of construction tectonics and material.

In both kindergarten development projects, the students first unpacked a micrograph image through a series of drawings studying the structure of the image (See figure 1A and 2A). The students defined the universal condition in the image in two words, a verb and a noun and developed study models that reflected on those conditions in a tectonic way (for example in Kindergarten Project 1 they coined the terms Cluster Assembly and Intersecting Network - figure 1A and in Kindergarten Project 2, they defined the condition as Contracting Cell - figure 2A). From the universal principles students develop grids and models that would be the beginning of their tectonic language (see figures 1B, 2B).

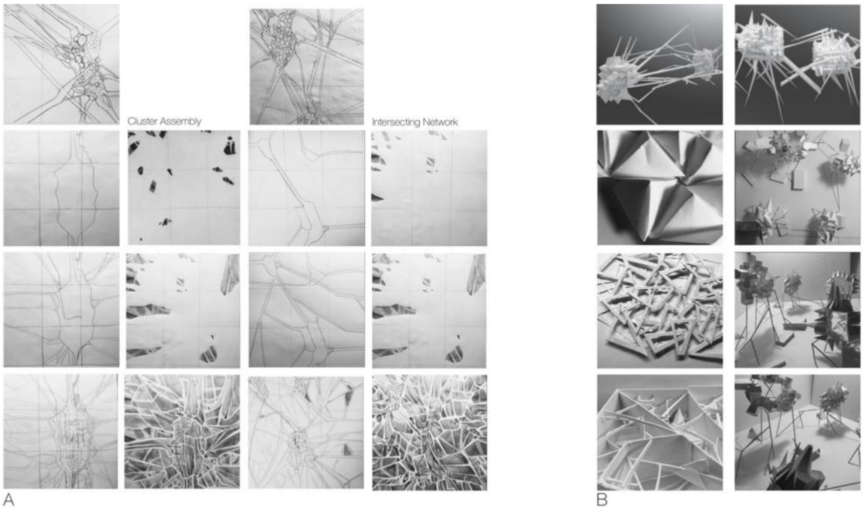


Figure 1 - Kindergarten Project ex.1 in Architectural Design Studio 1 - Extracting a Universal design language
A) studies of rain coat fibers, based on Micrograph - Pencil on paper by student B)Study *Models.*
Student work by Abigail Light, RPI Fall 2020.

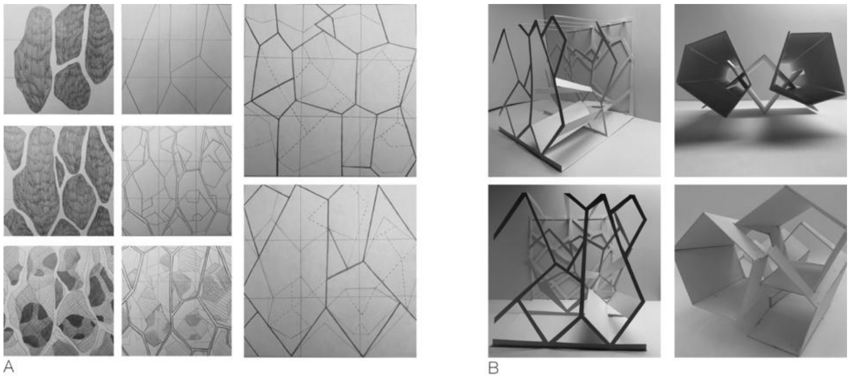


Figure 2 - Kindergarten Project ex.2 in Architectural Design Studio 1 - Extracting a Universal design language
A) studies of rain coat fibers, based on Micrograph - Pencil on paper by student B)Study.
Student work by Hellen Worden, RPI Fall 2020.

Once the students engage with the kindergarten program requirements, they enact the tectonic principles they developed from the micrograph analysis and address program requirements.

In Project 1, the structural fibers in a raincoat (Figure 1) are translated into linear structural members as well as programmed circulation elements such as slides and walkways (Figure 3), whereas the massing elements developed in stage one become whimsical classrooms envisioned as adventure play pods with unique light and program qualities (Figure 3).

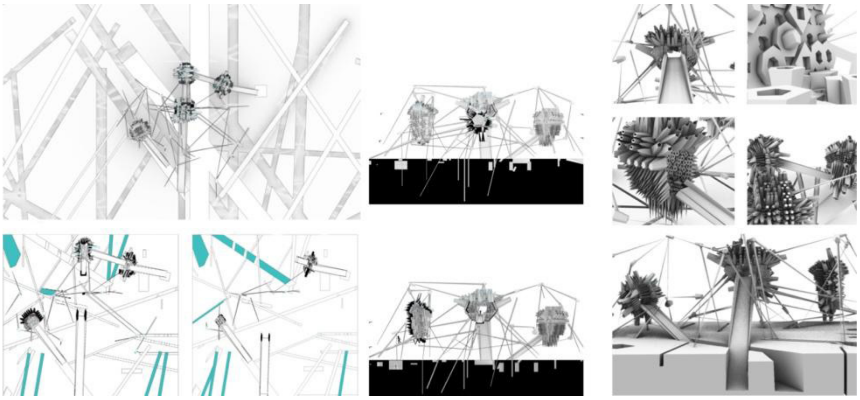


Figure 3 - Kindergarten Project ex.1 in Architectural Design Studio 1 - plans sections and model
Student work by Abigail Light, RPI Fall 2020.

In the second kindergarten example, we see how the student built on the distinct language developed based on individual caribou hair cell structures (Figure 2) in multiple scales; for example, the student created large spatial divisions as well as smaller scale elements of play and occupation (Figure 4). The process of universal translation allows the discovery of tectonic possibilities that could manifest in a variety of ways depending on the requirements that are placed on the architecture.

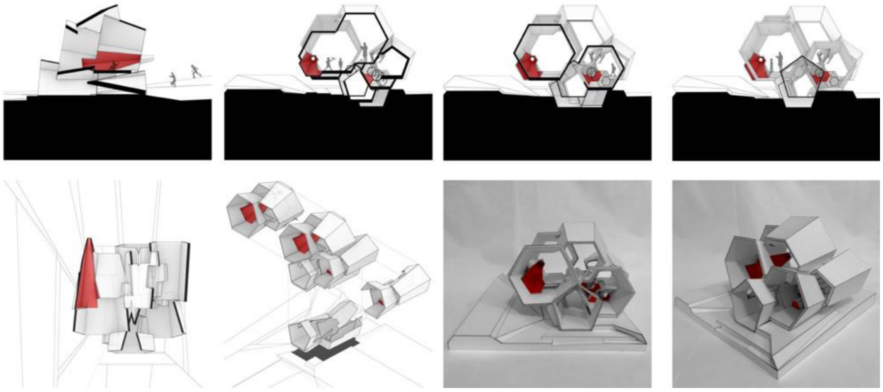


Figure 4 - Kindergarten Project ex.2 in Architectural Design Studio 1 - plans sections and model.
Student work by Hellen Worden, RPI Fall 2020.

The Urban Pavilion – Case Study

The urban pavilion is also an example of a first semester studio project. In this semester, students photographed their own micrograph with a hand-held, close-up microscopic camera (see Figure 5). This technique allowed the students to uniquely understand the object they were investigating, taking into account the multiple aspects that affect our spatial understanding of the element as a whole. This way, students understood what we can see with our naked eye in contrast to the depth we could see with an enhanced 'mechanical eye' (i.e. the microscopic camera).

Developing their project, students explored key aspects in the microstructure of sea creatures. Based on architectural consideration of occupation, light, view and sequence, students chose how to deploy different characteristics adapted from the microscopic scale. From porosity to structure, the characteristics evolved to capture architectural requirements and desires.

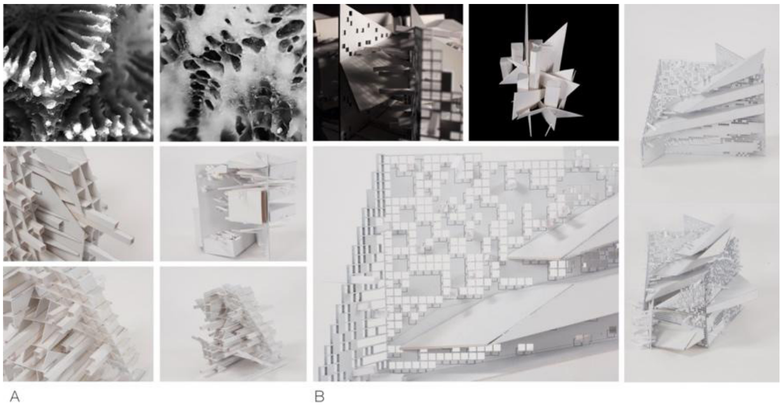


Figure 5 – Pavilion Project in Architectural Design Studio 2 - A)Microphotograph of a coral and initial development of tectonic language B)Initial tectonic Models.

Student work by Olivia Krewer, RPI Fall 2015.

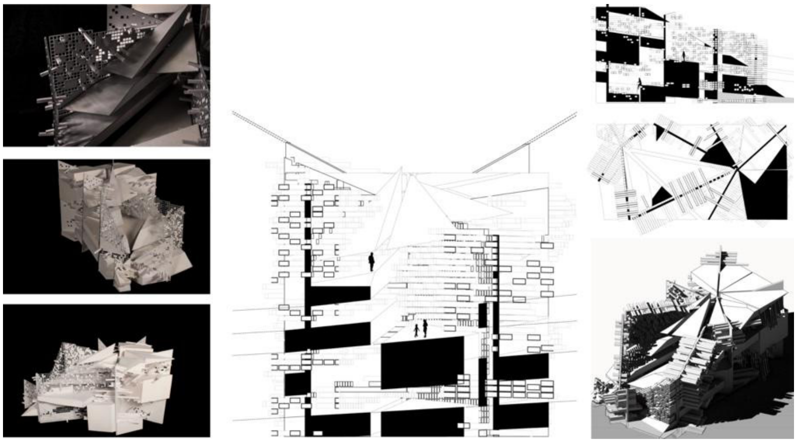


Figure 6 – Pavilion Project in Architectural Design Studio 2 - Plan Section and and model of Pavilion.

Student work by Olivia Krewer, RPI Fall 2015.

The Observation Machine – Case Study

The *Observation Machine* is a Pavilion on the water edge. Students looked at the act of observation as pivotal to the development of the architectural requirements of the pavilion. The *Observation Machine* asked students to observe conditions through the architecture that may not be visible otherwise: light, sound, water flow, water levels, etc. Similarly to the urban pavilion and kindergarten project, students took a close look at the microscale and mined it for structural, tectonic and organizational insight (See analysis of the structure of a coffee bean in figure 7).

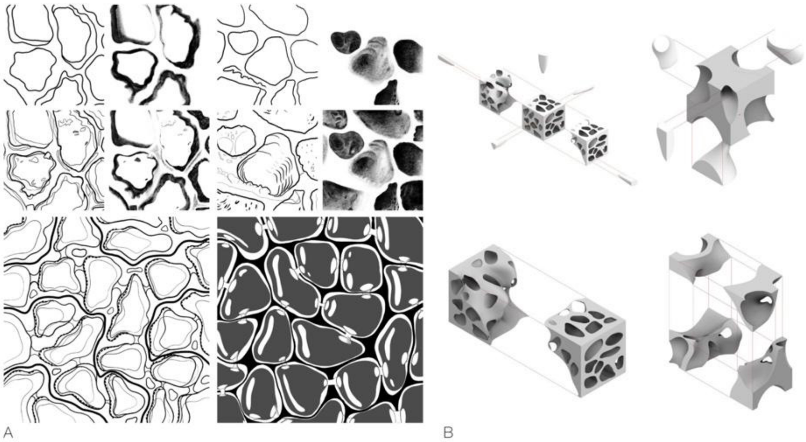


Figure 7 – Observation Pavilion Project in Architectural Design Studio 2 - A) Analysis of Coffee Bean structure B)Development of tectonic models.

Student work by Javier Torres, RPI Spring 2022.

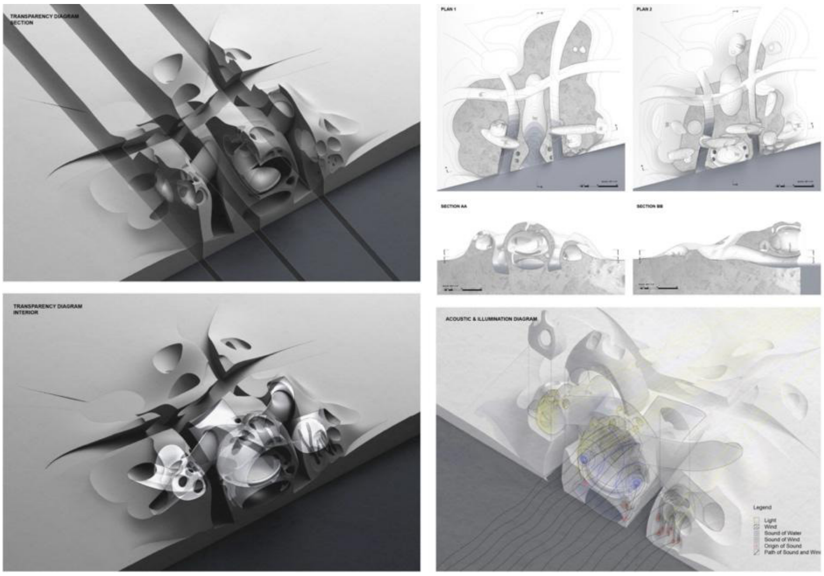


Figure 8 - Observation Pavilion Project in Architectural Design Studio 2 - Plans, sections and diagrams of pavilion.

Student work by Javier Torres, RPI Spring 2022.

Urban Housing – Case Study

Lastly I would like to look at an example that architecturally relates to the urban and dwelling unit scales–an urban, high-density housing program. In these scales the implications of the micrograph are played out relative to a more complex program and addresses a larger urban fabric. In both examples below (Figures 9-12), students located artifacts on the proposed project site and photographed them to reveal micro--patterns and structures. Through analysis and investigation they revealed a structure that could be transposed onto a scaled architectural project. In Figures 9-10, we see the analysis of a rock–a seemingly solid stone–leading to a housing/film center that provides a porous urban community, a sponge-like housing project that allows the housing program to flow into the city and vice versa.

Figures 9 - Housing Project 1 in Architectural Design Studio 4 - A) Microscopic Studies – based on student micrograph of rock found on project site B) Plans C) diagrams.
Student work by Jessica Gentile and Sarah Morsches, Spring 2016.

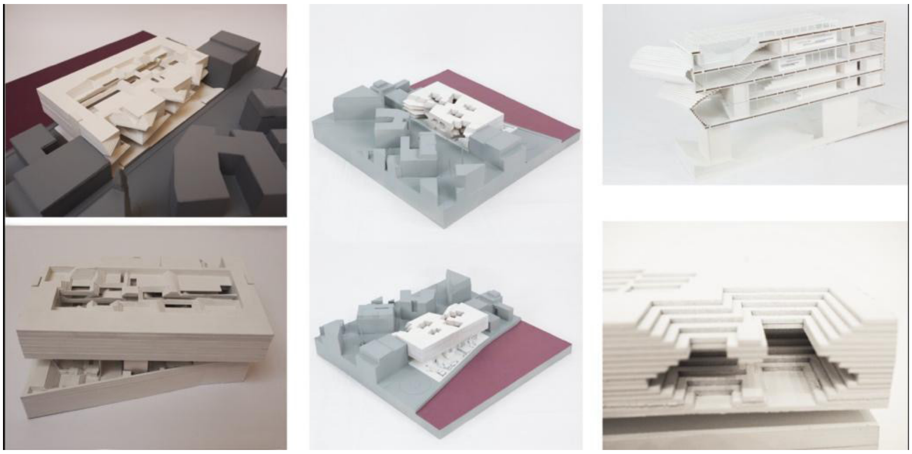
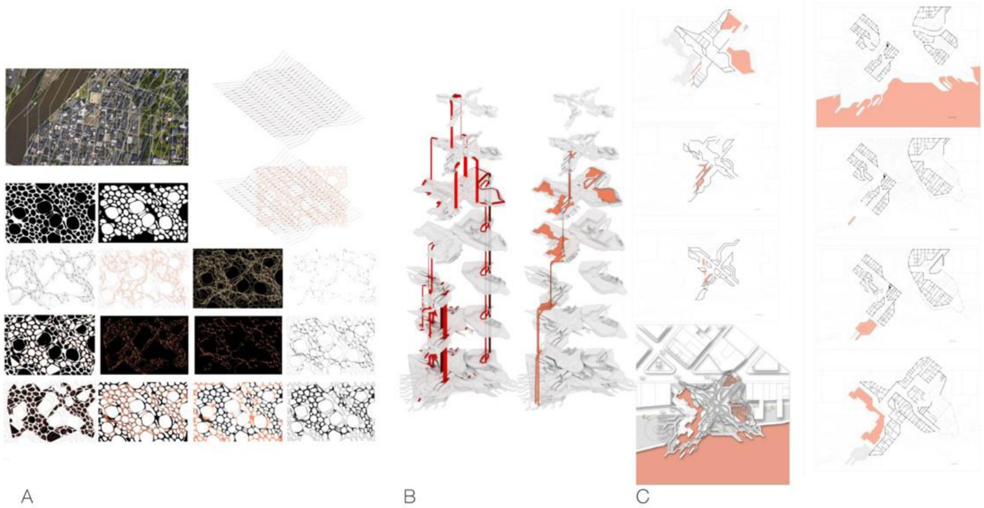


Figure 10 - Housing Project 1 in Architectural Design Studio 4 – Models.
Student work by Jessica Gentile and Sarah Morsches, RPI Spring 2016.



Figures 11- Housing Project 2 in Architectural Design Studio 4 - A) Microscopic Studies of leaf found on site and urban grid B) Housing Circulation Plans C) Housing Plans.
Student work by Xu Lui and Mengzhe Zhang, RPI Spring 2016.

Figures 12 - Housing Project 2 in Architectural Design Studio 4 - Models.
Student work by Xu Lui and Mengzhe Zhang, RPI Spring 2016.

In Figures 11-12 we see how the students merged the porous and structure of a found leaf with the underlying grid of the city. In the analysis phase, the students merged an urban grid with the leaf grid to find an organizing principle for their housing. They incorporated the flow of circulation of people and water as key ingredients in their project. In all presented cases, the students did not blindly copy a microstructure and formally force the geometry to work in an architectural scale. Rather, they underwent a process of translation where they uncovered critical universal principles and asked larger questions of them–questions that could be answered in a specific scale of inquiry.

Conclusion

Micro-structures hold teaching potential. The microscale is constructed by a distinct, non-human design process. It opens the young architect's imagination to a different reading of what construction in the human scale may become. As we transform the observational scale, a new context emerges, which, if seen abstractly, can become a productive design tool that operates on different levels, from actual biomimicry–learning from biological structures–to a foundational tectonic lesson–observing formal and organizational principles to inform a language of construction. In either strategy we use the micro scale's abstract principles and formal strategies that translate to the question we are posing in that design stage/scale.

In different scales of design, the impact of the micro structures on the process may be different. When looking at early initiation to architecture (i.e. first and second semesters), this point of departure serves as a way to challenge assumptions about architecture. Students begin to see architecture as a language, and find new ways to conceive of formal strategies, material composition and production. At this stage, we use the micro-structures as a way to link concept and form, as well as create a design strategy in multiple scales of inhibition, taking special care to look at ergonomic criteria that may affect the design at the human scale.

Once we get into slightly more advanced years (shown as a fourth semester housing project in this paper), students have a better grasp on architectural tools and concepts. A housing project, which in itself is multi scalar, operates on urban, housing aggregation, unit and detail scales. In this stage of their education, students can use the micro-structures as a way of questioning new structural ideas and urban approaches, as well as a way to elevate standardized design with another set of logics. At the urban scale, we can see examples of extending the micro-scale logic into questions of edge, flow of view and site, as well as create different types of urban voids and continuities. The microscale can be read and re-read to provide different insights at each scale, all the while also providing a new way of seeing the physical world. Entering from a micro-scale unleashes potential readings that allow for a fresh tectonic interpretation that is both anchored and abstracted and could be highly productive in fostering creative yet tectonic imagination.

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Scalable Impact

Introduction

> Q: Why didn't you make it larger so that it would loom over the observer?
> A: I was not making a monument.
> Q: Then why didn't you make it smaller so that the observer could see over the top?
> A: I was not making an object.
> Tony Smith's replies to Robert Morris's questions about his six-foot steel cube [a work titled Die].

The engagement with scale has a long tradition in architecture education beginning with the full scale mockups of details in apprentice guilds to the inclusion of plaster casts of architecture details and building elements in support of a Beaux-Arts education. There is also the collection of scale drawings for the reference of students to study great works of art and scratching out a plan in the dirt as the start to a rudimentary construction project. We engage in conversations of scale at the beginning design studio to create a shared language for discussion of the work. How we teach this technical knowledge also has the capacity to go beyond just the scale of representation. It can begin to speak to the exactness of appropriate scale and to the capacity of the scale of impact. From the object to the monument to that which is neither, how we engage in the discussion of scale as a design tool is a critical part of the profession as we create new spaces.

The introduction of scale is a fundamental component of the beginning design studio. Students utilize their architectural scale to develop drawings and models of their site(s) and design(s). Students engage in discussions about what is the appropriate drawing or model scale to develop their design, asking questions about what can be seen at different scales and the level of detail required for each scale. Beginning design students are also introduced to concepts of scale related to users and context. Students are asked to relate the human scale to the context and describe how their design relates to a person or group of people. Students also examine the context and how their design relates to the existing scale. Through different methods of design representation, students zoom in and out of their design and test their iterations at different scales and evaluate the appropriateness of their design for users and the context. All this development equips them for future design studios in how to utilize scale to represent and evaluate design. But there is more to scale than size and notation of measure, there is magnitude and amplification.

The beginning design studio discussed here is framed by a pedagogy based on the following questions: Can the fundamentals of teaching scale to beginning design students include amplification to demonstrate the impact of design on the built environment? Can small projects or interventions be evaluated on their ability to be transferable to a larger context as a means of teaching scale through scalability? Can a sequence of assignments exploring scalability and amplification, magnitude of scale(s), give agency to students to realize the potential of architectural performative spaces for positive change?

Studio Framework

In the beginning design studio at Montana State University, students engaged in questions of scale related to their design's capacity to amplify an intervention's impact and its ability to be scalable and transferable to a larger or different context through a series of projects over the course of one semester. The studio framework utilized sites students could easily return to for investigation, such as the architecture building and the waterways of the town of Bozeman, Montana. Students were assigned a zone in the building and a specific transect in town to observe and document specific phenomena generated by nature and human desire. They identified the interconnected relationships happening on the site and causality / feedback loops that manifest the existing conditions. Based on this analysis, students then designed for people to engage in an existing phenomenon and the amplification of that condition.

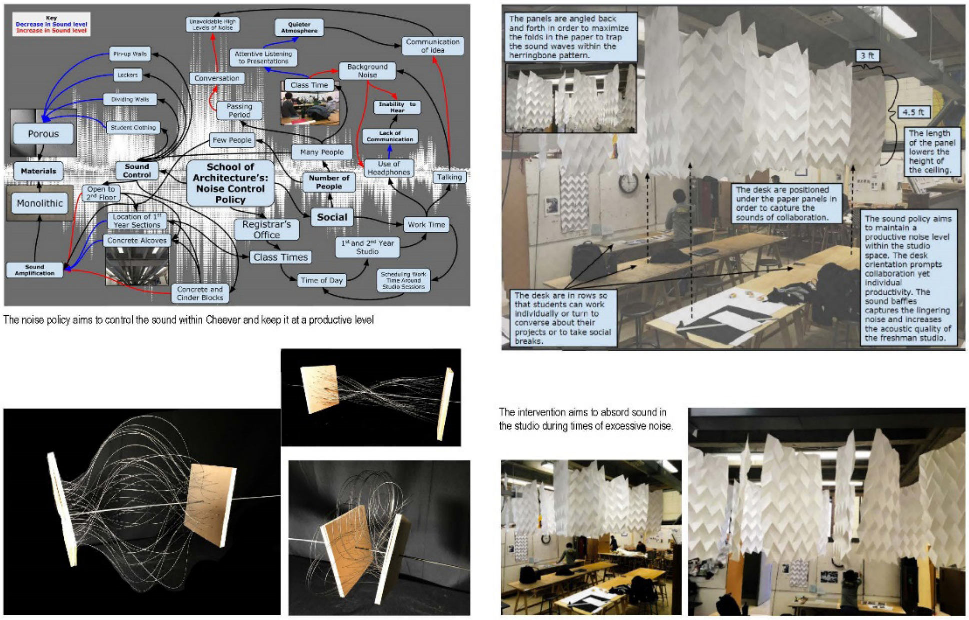
As iteration in design and methodology are critical to the development of internalizing learning, the studio was organized into a short introductory project followed by a longer project, both utilizing the same methodology. The longer project was able to build on the introduction and add complexity and depth to the student engagement with scale. The projects worked with a multiplicity of scales over the course of the semester with each iteration adding more dimension to the use of scale in design.

Introductory Project

To introduce the design process and relationship of people to the environment, the students were placed into teams to examine the space of the architecture building. The students began by looking at the organization of the spaces and how the different school policies and pedagogies of the faculty, virtual ordering systems, shaped the space. They also observed how natural phenomena, like the sun or wind, have an influence on the space and human behavior. They examined how these impacted an individual, a small group, a class and all that inhabit the building. They examined and documented the scales of impact these phenomena, policies and pedagogies that informed the resultant space through photographs and diagrams.

Once students could demonstrate how the existing systems influenced space, they moved to full scale testing of strategies that could work with these existing ordering systems. The goal of the project was to amplify one or more of the existing systems to enhance its goals or influence. Students developed and tested strategies that looked to increase collaboration, reduce overall noise while not limiting individual's sound, work with recycling policies to increase student learning, and to improve the air quality of the building among many others. The strategies were installed within the studio environment and engaged both students in the course and others in the building as a way of evaluating the scale of the installation in relationship to a person and the scale of impact each installation had on the existing environment.

Students worked quickly with multiple iterations of their intervention over the course of a week, resulting in a final installation for discussion and group evaluation. The final documentation of their intervention incorporated photographs of the installation that were annotated with the scalar impact of their design that connected back to their earlier diagrams.



The noise policy aims to control the sound within Cheever and keep it at a productive level

The panels are angled back and forth in order to maximize the folds in the paper to trap the sound waves within the herringbone pattern.

The length of the panel lowers the height of the ceiling.

The desk are positioned under the paper panels in order to capture the sounds of collaboration.

The sound policy aims to maintain a productive noise level within the studio space. The desk orientation prompts collaboration yet individual productivity. The sound baffles captures the lingering noise and increases the acoustic quality of the freshman studio.

The desk are in rows so that students can work individually or turn to converse about their projects or to take social breaks.

The intervention aims to absord sound in the studio during times of excessive noise.

Fig. 01. Studio Intervention Documentation showing how the system diagram and parametric tool where used to generate an intervention in the existing studio to engage and manipulate the existing ordering systems of the space.

Source: Chole Andrews, Christopher Kearns and Rachel Macklin

Through this four week exercise the students went through the process that would be utilized in the longer project for the remainder of the semester. The group work built a small group dialogue that could be utilized in the individual project that followed for peer-to-peer learning. The short project also built confidence in first year architecture students that they have the capacity to observe a site, document how that environment is constructed and utilized, and that they could determine design interventions that would enhance an existing ordering system based on their research and not the direction of someone else. Students commented on how they had very little knowledge that this is what architecture is, but that they could see how the logic could aid in future designs. All of this equipped the students to repeat this process in a new site and with new parameters that utilized scale in its multiplicity.

The Iteration Project

The next project moved to the waterways coursing through the town and students were assigned a transect for the remainder of the semester. This allowed the students to go through the same process as the introductory project but with more time and iterations of the design, creating a deeper understanding of the methodology. Students again developed a site analysis mapping of the causal relationships and ordering systems of the site. They looked at both physical and virtual logics that informed the site conditions. Through their analysis they identified a specific phenomenon that had a significant influence on the form of the site and were asked to create a new relationship with this phenomenon for exactly one person.

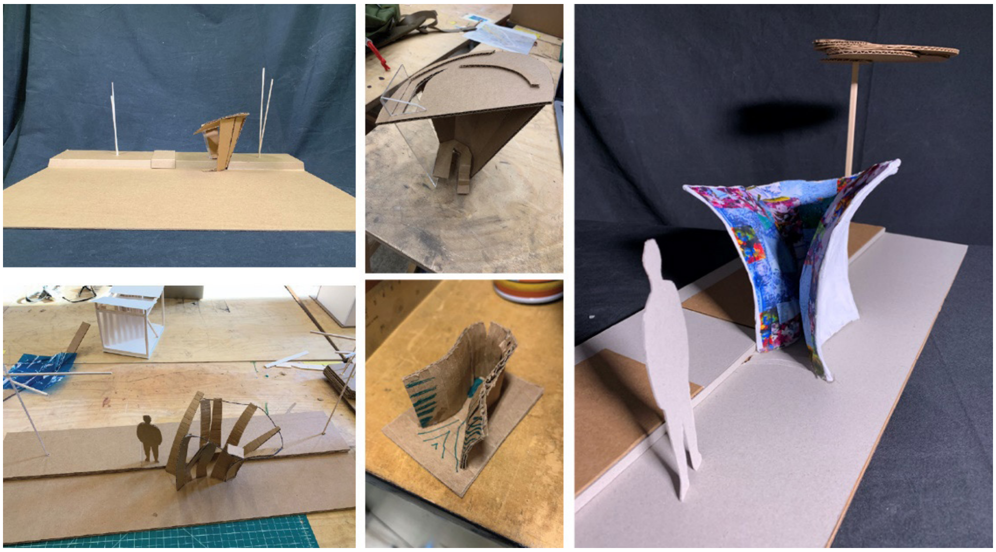


Fig. 02. Model iterations of the Space for Exactly One Person to engage in the existing natural phenomenon.

Source: Jack Sells

The design of the space for exactly one person began with an in-situ peer assignment where students used their bodies to describe the architectural space for one person to engage in an existing natural phenomenon. They acted as both a person and not a person to evaluate the scales of the site, the phenomena and that of one person. This created a low stakes design exercise that allowed for multiple iterations in a shorter period of time as compared to the design iterations of models and drawings, linking into the scale of time invested. Students documented their spaces through photographs that were then used to inform the next iteration of their design through physical modeling. The models were developed at 1:10 scale, a foreshadowing of the larger relationship to scale for the studio. The designs were then further developed through section drawings at the same scale as the model (1:10) and a detail at full scale (1:1). The drawings included photographs of a user exactly inhabiting the space. The evaluation of their design focused specifically on the volume of space for exactly one person, requiring students to calibrate the space to position the inhabitant to relate to the phenomenon.

After the discussion of their designed space for one, students returned to the site and reexamined the causal relationships on the site with a new objective, how to amplify the phenomenon. Students now engaged in concepts of scalability and transferability working in diagrams, a drawing that has both scale (its actual size) and is scaleless (can be applied at numerous scales). The diagrams identified the relationships of the site and what parameters could be manipulated. Once students understood the interconnected systems that informed their site, they were tasked to alter the site utilizing a leverage point or points. Students tested the capacities of the different systems and how changes to intensities or inputs would impact the overall. To do this, they created physical parametric tools utilizing materials that embodied the characteristics of their systems. These constructs allowed the students to manipulate one or more of the site parameters to reveal its influence on the rest of the site. In this process they were determining which inputs had more influence and which required significant effort for little change. The parametric device became a tool (1:1) for them to evaluate the site and their future interventions (scalable).

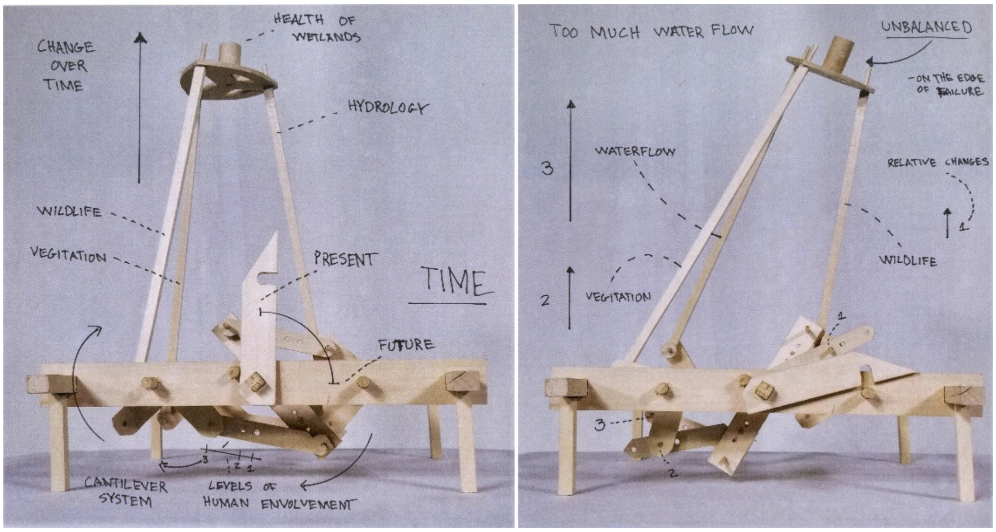


Fig. 03. Parametric Tool for evaluation of Design Intervention demonstrating the interconnected relationships of the systems and how a change to one aspect will impact the overall system.

Source: Logan Madsen

The next prompt was to increase the phenomenon and a human being's capacity to engage that phenomenon by a factor of ten. Critical to this process is that students can identify how the parameters are being amplified and not changed, similar to the way that a beach cruiser relates to a high-performance bicycle. Both have two wheels and are human powered by pedaling, but the high-performance bicycle can go ten times faster because of its mechanical design and positioning of the human body. The interventions continue to engage the students in an evaluation of the specific scale of a person while adding the capacity for design to change the existing context. This continues to deepen a student's understanding of the human scale and now expands the conversation to include how design can leverage existing conditions to have a larger impact, empowering students to see how small moves can generate a larger change.

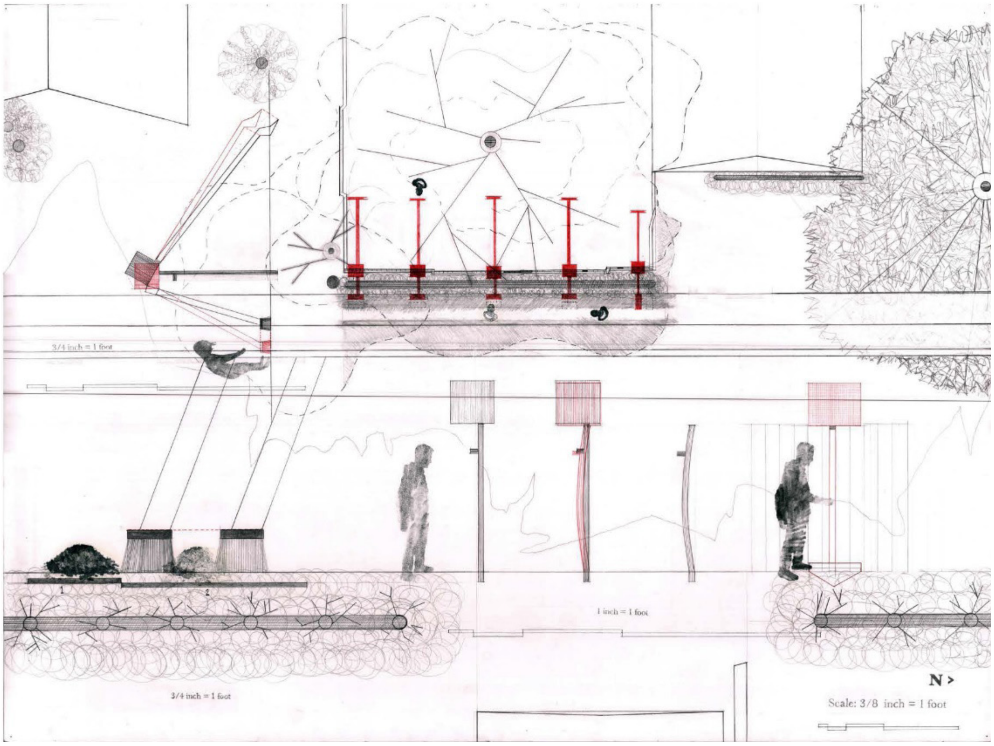
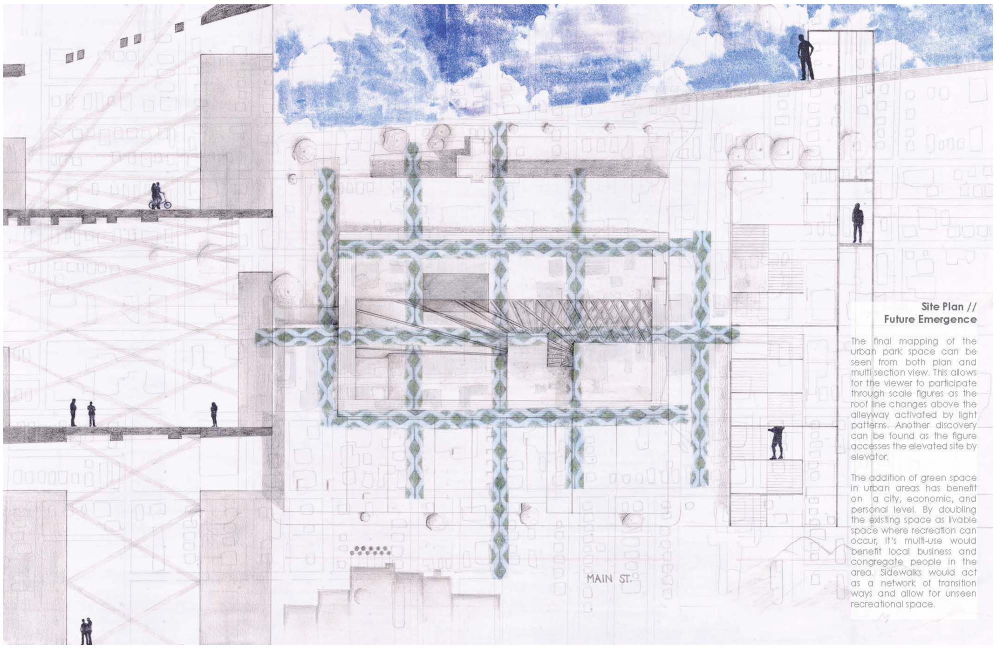


Fig. 04. Design Intervention drawing demonstrating how the intervention engages with the existing systems and creates a new space for an individual to engage the phenomenon.
Source: Shannon Eppard

The last project engaged students in the transferability and scalability of their logic. Students went back into the field and identified a new site that had similar relationships to that of their previously assigned transect. Utilizing diagrams, students presented their new site through annotated photographs that demonstrated the causal relationships of the existing context and described how their prior analysis was transferable to this new place. The students used their parametric tools to evaluate the new site and program, engaging them in the conversation of both the transferability of the tool, but also the scalability of evaluation criteria. The new space was for ten people to engage in a new phenomenon that was amplified by a factor of ten. In this project, students also had to determine the scale of their drawing to develop design, again returning to questions about what can be seen at different scales of representation. Asking the students to determine the scale of each new drawing gave them confidence in utilizing the fundamental tools of design communication. In the end, students presented this iteration of projects as a singular body with the ability to utilize the same analysis, diagram and parametric tool, as a way of describing multiple designs with different scales and magnitudes of amplification.



Site Plan // Future Emergence

The final mapping of the urban park space can be seen from both plan and multi section view. This allows for the viewer to participate through scale figures as the roof line changes above the alleyway activated by light patterns. Another discovery can be found as the figure accesses the elevated site by elevator.

The addition of green space in urban areas has benefit on a city, economic, and personal level. By doubling the existing space as livable space where recreation can occur, it's multi-use would benefit local business and congregate people in the area. Sidewalks would act as a network of transition ways and allow for unseen recreational space.

Fig. 05. Transferable and Scalable Design Intervention drawing demonstrating how the previously developed design strategy can be implemented on a new site using the established evaluation criteria. *Source: Anne Dominico*

Conclusion

Through an iterative series of projects engaging in discussions of scale, students identified the interconnected systems and the micro-conditions of a specific site as agents for place-making. They engaged in different scales of design communication, human scale, and the scalable impact of design. Each assignment utilized the multiple ways in which scale is a part of design, with each iteration adding a layer of complexity to the discourse. The sequence of assignments equipped students with the necessary drawing and modeling skills for future studios and an ability to evaluate the scale of spaces while also enabling students to see how their design impacts the world around them and how logics can be scalable and transferable. The methodology gives agency to students for future design studios and empowers them to examine the world in a way that they can enact change. The pedagogy provided the capacity for students to engage in the nuanced conversation of scale generated by Morris's questions to Smith about the steel cube and to further interrogate the complexities of scale and scalable impact.

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Lightn' Porcelain: Envisioning scales of light and material in the realm of 3D-printing

Introduction

The way light reveals form, construction and material has occupied architects, designers, artists, and craftsmen for centuries. Light provides visual information of form and material and thus bring a certain perception to how objects, spaces and buildings are observed and experienced. (Arnheim, 1969; Lam, 1977; Böhme, 2013; Cuttle, 2015). 3D-printing has brought new ways to create form and thereby also new potential to the emergence of material by means of light. In this paper, we explore and discuss how illuminated 3D-printed porcelain can create new expressions and atmosphere to be envisioned by shifts in work operations, scale and representation. The project is a collaboration between an architect specializing in lighting and a ceramic designer specializing in 3D printing with the aim of studying how light and 3D-printed material can inform one another across the fields of design and architecture.

The form generating logics and practicalities of 3D-printing have brought new ways to give form and are adopted by many design professions by the way a 3D-printer transforms digital information into a physical object and build up added layers of printable material (Hoskins, 2013). A potential of 3D-printing within the fields of design and architecture is how easy it is to obtain a visual effect, when combining light with geometries and materials of 3D-prints. Being based on a parametric design, 3D-printing offer complex forms and variations, which immediately catches the eye by the way light traverses the material and openings in the print and how gradients of light and shadow occur. By first sight this is a potential, but we also experience a challenge because of the complexity of parametric design in relation to the material qualities and form printed. Therefore, we suggest studies of light in relation to 3D-printed material to learn more about how 3D-printed material expression is created and 'tuned' by means of light with the purpose to create material atmosphere and experience.

The experimental pavilion „Bloom" by Emerging Objects[1] exemplifies the potentials of 3D-printing in relation to light; the pavilion is made by 3D-printed blocks out of cement into a lightweight self-bearing structure, which creates a play of light and shadow on the inside, made by how the form and the structure of the pavilion allow daylight from outside to pass to the inside (Rael and San Fratello, 2018). Another example is the project "Harnessing plastic deformation in porous 3D

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[1] Images, work process and partnership of „Bloom" are described in the book „Printing Architecture. Innovative Recipes for 3D Printing" and at http://emergingobjects.com/project/bloom-2/

printed ceramic light screens" by Clarke-Hicks et al (2022), where functionally graded 3D-printed ceramic screens are produced for decorative lighting applications. In the project Clarke-Hicks et al explore methods involved in altering plastic deformation during the wet-processing of porous clay structures and the corresponding light-scattering behaviour of their ceramic counterparts.

The above-mentioned projects are representative examples of how 3D-printing enable to obtain certain visual appearances when combined with light. But while these projects work in a scale of full size, we are in this project rather occupied by the potential of how light and a small size 3D-printed object enable us to envision illuminated material in more architectural scales. Thus, this paper concerns the theme of scale and representation, and how an architectural model can be produced, explored, and represented as an object of scalability by means of 3D-printing.

A study of light and 3D-printed material to enhance one another

With an interest in how light and 3D-printed material create atmosphere by enhancing each other's presence, the 3D-printed object is regarded a light-like object. By a light-like object we refer to the German philosopher Gernot Böhme and one of his notions of light related to the creation of atmosphere. Emphasizing that the perception of light does not require the simultaneous experience of a light source, Böhme makes a distinction to what he refers to as a 'light-like object' (Böhme and Engels-Schwarzpaul, 2017). To Böhme a 'light-like object' can be a luminous ceiling or the coloured glass window in a Gothic church, appearing as a luminous wall. In other words, light when experienced as a luminous object.

Fig. 01. The parts of the 'light-like object'

Source: Tvede-Hansen and Bülow

The 'light-like object' consists in our case of 3D-printed, fired, and glazed porcelain illuminated by an organic light emitting diode (OLED). This combination makes a design system in which the OLED works as constant luminosity and the 3D-prints as variations of geometric patterns to be tested, allowing the discovery of ways to create atmosphere for the use of architectural representation, see figure 01.

Of importance to us is Böhme's understanding of lighting as atmosphere to be experienced by the appearance of light in space and on things, and that it is a phenomenon to be understood and tuned by variations of colours, distribution, intensity, concentration, and diffusion of light. According to Böhme, light creates appearances such as brilliance, flickering, radiance, iridescence, fluorescence depending on the surface of a material (Böhme and Engels-Schwarzpaul, 2017). Just like the Danish Architect Steen Eiler Rasmussen recognizes the way daylight makes valuable objects behind the windows of old merchants' houses in Amsterdam appear sumptuous by enhancing the material qualities (Rasmussen, 1957, 1992), Böhme understands how light and material can blur or enhance each other's mutual presence by saying:

> We can indeed see things in the light, without actually noticing the light about them. However, in the case of brilliance and shimmer, light become explicit about things.[2]

Observing material expressions by means of light - and vice versa - the expressions of light by means of the material, we explore how atmosphere emerges when bringing light and 3D-printed porcelain into a light-like object. The atmosphere of the light-like object is further explored by envisioning architecture in various scales. Joining the even light from OLED and the geometry of the glazed, slightly translucent 3D-printed porcelain, we ask: What kind of atmosphere will a light-like object in this project be able to produce? How can the light from OLED and porcelain enhance each other's presence? How can a light-like object become scalable and able to represent architecture? And, what kind of architeture is envisioned using illuminated 3D-printed porcelain to represent architecture?

The iteration process

The study reflected an iterative process that was composed of five operations creating an output, see figure 02. Operation A was developing a digital representation based on a digital parametric setup, which made up the path for 3D-printing in porcelain (operation B). Operation C was firing the 3D printed porcelain, which was then combined with the OLED light source to produce a light-like object (operation D). Finally, the light-like object was explored as an architectural representation through photography envisioning illuminated architecture (operation E). Operations A, B and C was developed in a feed-back-loop that built up an understanding of the relationship between the digital representation and the fired ceramic object, while the operations E and D reflected individual in-depth studies. Furthermore, the study of the light-like object enabled a feed-back-loop to rethink the previous operations.

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[2] Böhme, G., & Engels-Schwarzpaul, A.-C. (2017). *Atmospheric architectures: The aesthetics of felt spaces*. London: Bloomsbury Academic, Bloomsbury Publishing. p. 155.

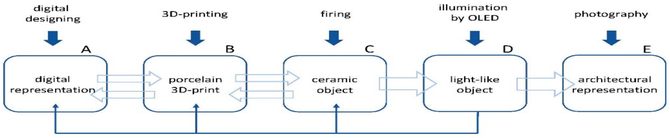

Fig. 02. Iteration Process

Source: Bülow and Tvede-Hansen

Digital preparation, physical printing and firing

The 3D modelling software Rhino and its graphical programming interface Grasshopper was used to create the parametric setup for the digital design of the porcelain to be 3D-printed (operation A). The parametric setup allowed dynamically for a range of patterns within the capabilities of the 3D printer, see figure 03. This setup enabled us to explore a pattern before it was printed e.g., in relation to dynamics between open and closed areas, curved and straight lines as shown in figure 03. The initial digital design was of great importance to the 3D-printing of the porcelain, since the amount of lines as well as the shape of the lines had to be adjusted in relation to the size of the coil produced by the 3D printer. In our setup the digital printhead simply produced a coil of porcelain along the line's shape and position referring to the digital designed line that made up the pattern (operation B), see figure 04.

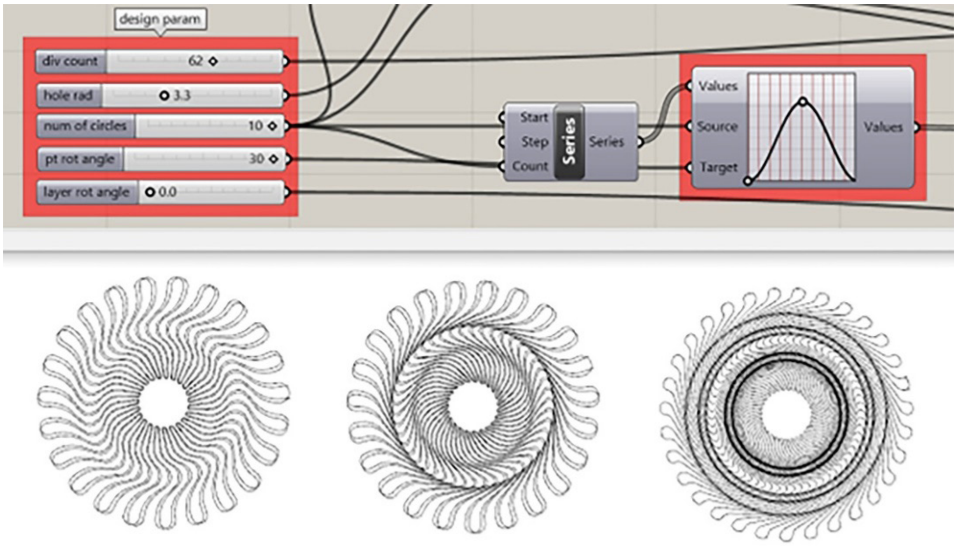

Fig. 03. The parametric setup for digital design

Source: Lim, Tvede-Hansen

Porcelain is known for its fine particles and translucency when fired. The degree of translucency is related to the thickness of the wall. The thinner the wall is, the more translucency. To experiment with the 3D-printed porcelain in relation to the digital design we challenged the material in relation to gravity by printing on lasercutted forms in foam, to be placed below the 3D-print, see figure 04. The foam acted as add-ons to the digitally controlled print. The add-on changed the usual flat foundation into higher and lower areas in relation to the 3D-print, which enabled us to explore and challenge the extruded porcelain as tiny and refined layered coils that naturally hang in relation to gravity. The results partly dissolved the pattern into to the behaviour of free hanging coils of porcelain and revealed new unforeseen expressions and openings in the pattern, see figure 04. Furthermore, this new expression was explored in relation to the firing process, which through a chemical process transforms the porcelain and develops the translucency in relation to the glaze (operation C).

Fig. 04. 3D-printing in porcelain, lasercutted foam and 3D print on foam

Source: Tvede-Hansen

The light-like object

The circular 3D-printed porcelain was added to a circular OLED of 12 cm in diameter in order to establish a light-like object in the understanding of Böhme. Light from the OLED positioned below the 3D print would traverse through material and openings in the printed geometry and reflect from the surfaces of the porcelain. Preparing the light-like object to represent architecture, two sub-operations took place; 1) investigating the appearance of the light-like object by means of the light from OLED and the 3D-print, 2) make the light-like object into a spatial structure.

Comparing series of backlit 3D-printed porcelain of different geometrical patterns, glazed with glaze of variating thickness, and printed with or without add-ons of lasercut foam, different appearances and atmospheres was distinguished according to how the light from the OLED would traverse the 3D-prints, see figure 05.

Appearance of the light-like object

In some 3D-prints, the light from the OLED would create large variation of direct and filtered light, resulting in contrasting appearance of brightness and shadow. In 3D-prints not allowing direct light from the OLED to pass, the translucent qualities of the porcelain would appear together with light reflected from the covering surfaces creating a clear pattern made by the parametric form and the layer of porcelain, receiving more or less light.

A range of visual merge between the OLED, the light and the 3D-printed porcelain emerged. In one end of the range the 3D-prints would appear as two different objects, in the other end they would appear as one light-like object. The emergence of the one light-like object was established partly by the openings through and across the coils of porcelain, made by the printing technique developed, and by light reflecting the whiteness of the porcelain as well as traversing the thick layer of glaze, only covering parts of the print. Together, the light, the porcelain and the thick glaze created a wide number of gradients between bright and dark areas as well as a subtle gradients between cool and warm shades of colour.

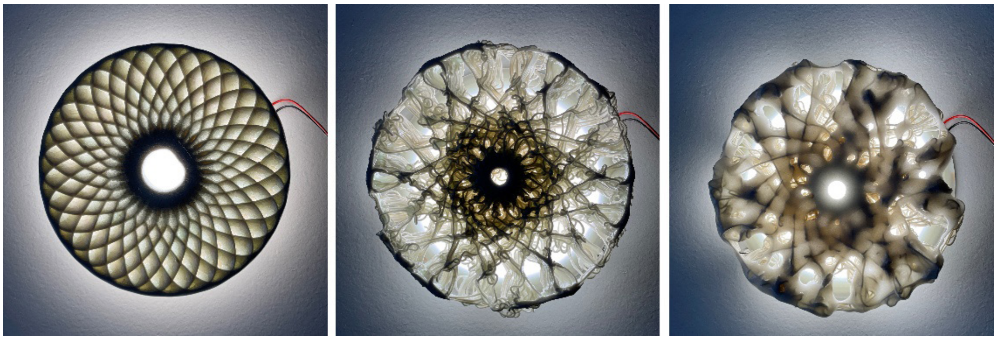

Fig. 05. Light-like object studies

Source: Tvede-Hansen and Bülow'

Development of the joined light-like object was depended on the iteration process and a growing understanding of the correspondence between the digital representation of the print to be printed, the geometrical pattern of the 3D-printed porcelain, the firing and glazing of the ceramic object and how the ceramic object would appear together with the light from the OLED. It became just as much a matter of the physical 3D-printed porcelain forming the parametric setup as of the parametric setup forming the 3D-printed porcelain.

The light-like object as a spatial structure

The sub-operation, to join the porcelain and the OLED light source in a spatial structure, was established to bring spatial qualities to the light-like object in order to further investigate it as an architectural representation. Making it spatial required additional elements. Bendable sticks out of brass was used to fix the 3D-printed porcelain and the OLED in position through holes in a ring attached to the OLED. This simple solution allowed for more spatial structures of a light-like object to be

created and studied. The spatial structures allowed observation from many angles, bringing understanding to the distinctness of each individual item of a structure and how it was joined, see figure 06.

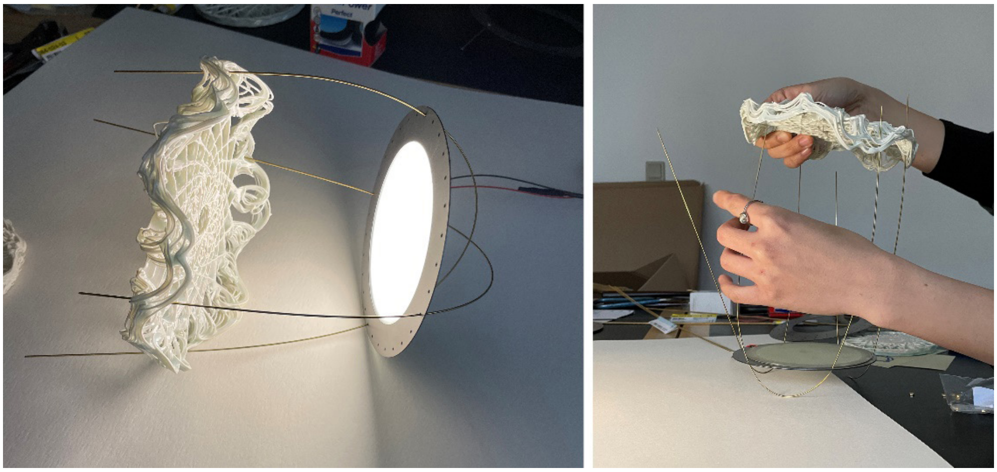

Fig. 06. Light-like object made into a spatial structure
Source: Tvede-Hansen, Bülow, Lim

The architectural representation

The light-like objects were created partly by the iteration proces and partly by means of the internal compositional balance between light, material, pattern, and additional parts. In order to represent architecture, they could thus be of any scale. Using the classic method of adding a scale figure to the illuminated 3D-print, the scalable potential became evident; the illuminated 3D-print would appear in various sizes according to the size of the scale figure added. While the size of a scale figure became an agent to envision the scale of an illuminated 3D-print, the number of scale figures and how they suggested occupancy allowed the illuminated 3D-print to envision a certain architectural element. If a few figures in 1:50 would relate to a horizontally positioned 3D-print, it would envision a light-like urban element, if many figures in 1:200 would pass a vertical positioned 3D-print, it would envision a light-like façade, see figure 07 and 08.

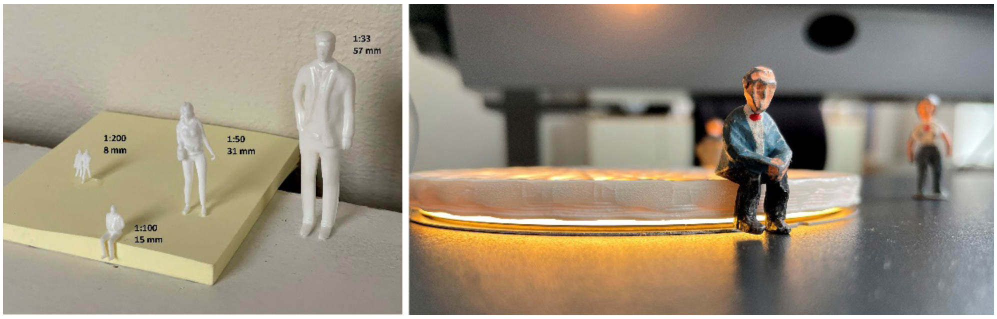

Fig. 07. Size of scale figures
Source: Bülow

Exploration by photography

The illuminated 3D-prints was further explored through photography, which added more opportunites to envision the light-like object in scales of architecture. The way to frame the image and position a potential observer with regards to distance and eye level brought various ways to represent the illuminated materiality. Framing

Fig. 08. Scale figures and the light-like object
Source: Bülow, Tvede-Hansen

e.g., only a part of the light-like object and position the camera at a low eye level near the illuminated 3D-print, the atmosphere of the light-like object would magnify into that coming from a large structure, see figure 08. A group of small size scale figures, placed like if they pass a building, receives light on one side and emphasizes the way light emanates from e.g., a facade.

By photographic framing and close-up view attention to gradients of shades, colours, shine as well as the layer of coils is directed. Warm white, pale orange and turquoise colours, created from the firing, emerge and the lustre of the glaze and the lustreless of the non-glazed parts become central to the representation. Together with the gradients of light and shadow, the irregular geometric pattern of thin extruded layers of porcelain, an inviting light-like façade appears, which seems to drop the material as if it was textile, at the same time as holding on to itself, see figure 08.

The scale figures played an important role exploring the light-like object through photography. Not only to envision an imagined size of the light-like object, but also to invistigate atmosphere as it could appear by different kinds of use and in various scales. This observation is supported by American architect and researcher, Alex T. Anderson, who states that people understand the world through the body’s ability to act in things (Anderson, 2002). Anderson believes an important role to scale figures is to demonstrate not only scale, but also to envision a possible future. Being lit from the side by the illuminated 3D-print, the scale figures enhance the envisioning of a lively and inviting facade created by the atmosphere of the light-like object. It looks like the figures pass the facade while on their way somewhere else not within the frame of the image.

Shifting media and scale

To the architectural theorist Philippe Boudon, a matter to the architect regarding scale is the concept of *shifting.* What is not yet built is investigated in other media before construction (Boudon, 1999). In addition, Boudon states “Architectural design is not a gradual step-by-step transfer from one scale to another, developing towards a ratio of 1:1” (Yabena, 2005). Architectural anthropologist Albena Yavena (2005) also builds on this concept in her article “Scaling Up and Down: Extraction Trials in Architectural Design” in which she unfolds ethnographic research on architects designing a large and complex building. During the project work the architects produce loads of physical models of various scales while designing, observing, and discussing. After multiple up and down transitions between small- and large-scale models, the building emerges, becomes visible, material real, which reflects the architects’ cognitive implications and how they involve themselves in a comprehensive dialogue with materials (Yavena, 2005).

Improvements of ways to produce, explore and represent architectural models since these writings of Boudon and Yavena include 3D-printing. By requiring a digital file to make the physical print, 3D-printing connects the digital realm with a physical output. Hereby a profound *shift* between digital representation of no scale and the size of the physical print takes place. Within the field of architecture, the 3D-print itself can take more directions regarding scale, e.g., the 3D-print can be in a scale of full size, when printing modular elements for architecture or even buildings.

The 3D-print as a physical model

Nevertheless, the 3D-print can also be scaled with the purpose to become a physical architectural model. To provide an example of an architectural model, we can use our light-like object to demonstrate a design process of more *shifts.* First, the object was printed in porcelain in a size that reflected the digital geometry. Second, the object was fired, where it went through a chemical transformation before it was created and explored as a light-like object. The exploration of the light-like object made a *shift* while we investigated the appearances based on light in relation to the form and materiality of the 3D-printed porcelain. Furthermore, the exploration of the light-like object enabled a feed-back-loop to rethink the previous operations of digital designing, 3D-printing and firing to understand the becoming of the light-like object's appearances and to refine it. Finally, the *shift* towards scalability took place, when the light-like object was further created and explored as an illuminated material representation of various architectural scales.

The many *shifts* of this iteration process might seem laborious, but they brought a growing and thorough knowledge of how relations between a 3D-printed material and a light source create appearance and atmosphere. If the methodology used in this iteration process was to be part of the development of an architectural project, the study of illuminated 3D-printed material could work as the initial, inspirational, and open-minded exploration or as a study running on the side with the aim of discovering new appearances and atmospheres created by specific combinations of light, form, and 3D-printed material.

A potential of studying illuminated 3D-printed porcelain for envisioning architecture is the fact, that clay has great potential when 3D-printing in scales of architecture (Rael and San Fratello, 2018). Some of the appearances created could be obtained by printing modular elements, another option could be to create new material appearance by means of light inspired by the photographic explorations of architectural representation.

Conclusion

In this study we explored 3D-printing within the field of ceramic design to discover how 3D-printed porcelain and light can inspire and influence the envisioning of architecture. The study allowed for an explorative approach, offering alternative ways to use the actual size of 3D-printed porcelain. Creating the light-like object to become an architectural representation of architecture was based on continuously shifts between the digital representation, 3D-printing in porcelain and firing that was investigated in relation to the OLED light source. The iterative process towards the architectural representation consisted of feed-back-loops and ongoing adjustments, which refined the result.

The 3D-printed porcelain was created as an object defined by its own mutual measurements, form, and materiality. When adding light for studying the various appearances the 3D-print became a light-like object according to Böhme's notion of atmosphere in relation to the experience of light. The light from OLED and the 3D-printed porcelain enhanced each other's presence by a more irregular pattern and uneven cover of glaze, made possible by the grain size of the porcelain and the lasercutted foam used during the printing, allowing light to transfer the 3D-print in a varied way. This technique resulted in a warm and inviting atmosphere and a multi-facetted and sophisticated appearance, expressing the physical result of the 3D-print process.

Scalability was established by adding scale figures of different sizes to the illuminated 3D-print. The size of the scale figures and the way they seemed to relate to the light-like object created the possibilities to envision the illuminated 3D-print in sizes of architecture. Exploring and representing the illuminated 3D-print by photography expanded the possibilities of envisioning architecture by the atmosphere created. The atmosphere was created by the even light distribution of OLED and the material qualities of the 3D-printed and fired porcelain. The atmosphere discovered could be re-established by large scale 3D-printing in other material or taken further in another explorative proces.

As discussed by Boudon and Yabena, we consider the concept of shifting and the investigation of the architectural representation in other media and scales while designing, observing, and discussing of great importance to discover new ways of envisioning and representing architecture. Especially in relation to the emergent and fast development of digital and lighting technologies we see a great potential turning to the traditional fields within crafting, such as ceramics, to discover new atmospheres for architecture, because of the diversities in media and materiality.

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Digital and Real Scale

Introduction

This paper explores whether the traditional digital model as such lacks the relevance of measurement in itself, while the virtual reality (VR) model actually does contain the *architecturological* scales of *reference*, *measurement* and *relevance* that Philippe Boudon links to the semiotic system of Charles Sanders Pierce as *firstness*, *secondness* and *thirdness*. The paper is an exploration of the nature of scale of the digital models used in representation of architecture. Through the establishment of a framework of terms and methodologies derived from Philippe Boudon, Charles Sanders Pierce, and Albena Yaneva, the paper argues, through case studies, for a use of virtual reality models that brings architectural representation closer to the experience of real-world spaces than other uses of digital architectural models.

Forms of representation of architecture have always been inseparable from the design of architecture. Traditionally an array of tools has been used in the process of representing architecture through scale models, drawings, and in the last half century, also other media including digital models. This paper explores how an existing potential use of scale models in virtual reality might bring the representation of architecture in the design phase closer to its purpose as a framework or articulation of the interaction intended to be taking place within the finished building. Representations of architecture are in their fundamental mode of operation not in themselves the final product, but only showing an aspect of the potential full-scale architectural idea. In relation to scale, the representation of architecture has to be aware of this link between the full scale and its representations that makes use of many different scale ratios showing different aspects of an architectural idea, according to their size and level of detail. To some degree, this aspect has changed with the digital models where zooming in and out has become trivial as a possibly both useful and confusing way of working. The paper will in conclusion show how a virtual reality system has been designed to accommodate some of these issues using the potentials of the implicit human scale possible in the virtual reality architectural representation.

Literature Review

This brief review of literature will be dealing with relevant aspects of scale models and perception in digital scale models in virtual reality. Though almost chronological, it is understandably not a full review of all literature in the field, but rather a selection deemed interesting for the reader of this paper. Charles Sanders Peirce, Philippe Boudon, and Albena Yaneva will be addressed seperately in their own right, and are thus not included in this brief review.

The article ‘Defining Virtual Reality: Dimensions Determining Telepresence’ (Steuer, 1992) is included here because it defines virtual reality in a matrix of vividness and interactivity and so expands the understanding of VR to something that potentially enables and engages more than just a visual relationship.

In ‘Distance Perception and the Visual Horizon in Head-Mounted Displays’ (Messing and Durgin, 2005) the topic of mesurement and percieved distance distortion in vrirtual reality is tested and examined. Another interesting field in relation to the virtual environments and the sensation of being present is found in ‘From presence to consciousness through virtual reality’ (Sanchez-Vives and Slater, 2005) where the claim is that the concept of presence engendered by virtual reality is sufficiently similar to consciousness that it can sustain research within this domian. ‘How we experience immersive virtual environments: The concept of presence and its measurement’ (Slater *et al.*, 2009) introduces a notion of presence as the extent and capability of participants in a virtual environment to respond to virtual situations and events as if these were real. This is due to the idea of the brain as a correlational engine producing reality. In a paper dealing with two- vs. three-dimensional (in virtual reality) presentation of mental rotation tasks the conclusion is, that this type of test is easier in 3D in virtual reality than in 2D (Neubauer, Bergner and Schatz, 2010). This is interesting and correlates to assumptions that virtual reality can be easier accesible in order to understand architecture than 2D architectural plan and section drawings (Hermund, Bundgaard and Klint, 2018). The mental rotation task has been performed with similar results (Kozhevnikov and Dhond, 2012) showing that the task in 2D and flat 3D on a screen are very different from results using a virtual reality headset. Immersion - the objective level of sensory fidelity provided by a VR system - is another important aspect when talking about perceived presence in the digital models. This can be furthered by the use of avatars (Leyrer *et al.*, 2011) or even used to change or transcend the sense of self (Slater and Sanchez-Vives, 2014). A study indicates that user engagement and flow states in immersive virtual reality are higher when using your hands to navigate instead of keyboard and mouse, though performance in the test game was lower (Brondi *et al.*, 2015). Other smaller pilot-studies have been dealing with assessing the difference of perceived size, scale, and spaciousness in virtual reality presentations of High-Density Apartments (Griffiths, Lamb and Pelosi, 2017) and how architectural design impacts on the users (Moleta, 2018) and can be neurologically measured (Hermund, Myrup Jensen and Klint, 2019). Attempts have been made to quantify the architectural experince in a case study using virtual reality analyzing visual traits in relation to various algorithms developed upon processing fluency theory (Maghool, Schnabel and Moleta, 2020). This type of framework could presumeably, in combination with AI machine learning, be a powerful tool to qualify the experience of digital scale models in virtual reality. Another take on the connection between human emotions and architecture focuses on the aspect of geometry (Shemesh *et al.*, 2021). Here emotional reactions to space, both positive and negative could be measured by changes of curvature, protrusion, scale, change of proportion in height or width of virtual spaces. On the topic of cognitive load - whether an architectural representation in virtual reality requires more mental energy to experience than reality or flat 2D digtal models – there are different opinions and indications. A recent study (Breves and Stein, 2022), with a extensive summary of the various positions and arguments, shows that there is neither more nor less cognitive load in the virtual reality representations, unless the user experiences motion sickness, which is unfortunately not an uncommon phenomenon. This being said, then the spatial presence is perceived higher in virtual reality in relation to flat 2D media representation, which plays an important role for the virtual reality system created by the author's research cluster and displayed in the final part of this paper.

Scale and Representation of Architecture

While the benefit of digital models operating less statically in relation to scale can be a topic of discussion, and probably to a certain extent depends on individual preferences, it is important to distinguish between digital models on a flat screen and digital models as seen in an interactive virtual environment. The argument of this paper is that the virtual reality model can be closer to the architectural perception of space than other digital models, simply because of its implicit relation to scale.

For a better discussion of the term "scale" it seems useful to examine it from a couple of different angles associated with architecture and the world in which architecture exists.

Scaling up and Down

An example of a discourse that discusses the immediate effect of scale, or scaling, on the perception and conception of architecture, is the ethnographic study performed Albena Yaneva. By following architects working with scale models in the design process, Yaneva studies how the scaling up and down between different architectural physical scale models help the architects to understand the space they are designing (Yaneva, 2005). She notes how the different sizes and levels of details in the models each work in their own respect contributing to the overall design process by informing on several layers of scale, shifting back and forth. Especially the endoscopic working method, using a small monocular, inserted into a cardboard scale model, allowing the architect to experience the space from his own analogously simulated eye height, seems interesting when comparing to contemporary possibilities of digital virtual simulations.

Use of the semiology of Charles Sanders Pierce

With the combination of his work on *architecturological scales* (Boudon, 1992) with the semiological system of C.S. Peirce, Philippe Boudon expands and adds to the discussion of scale, or scales, as an important frame of reference in understanding architecture and its conception. Peirce based much of his semiotic theory on triads in order to structure the perception of the world as a series of interrelated signs. A theory that can be interpreted as a complex system (Feibleman, 1960), which in this context is used mainly in its principal division between Firstness, Secondness, and Thirdness.

In the Peircean triad *Firstness* is simple and elemental, potential; *Firstness* is not yet involved in a conceptual relation and marks the experience that the world is more and different from what we know, and that we must continuously relate creatively to this otherness in order to orient ourselves. *Secondness*, by extension, marks our conscious relation to that which has not already been named; *Secondness* can be a realization of the *Firstness'* quality in a relational experience, that we by a *Thirdness* reflexive approach to the relation can name as a scale. Then, if *Firstness* is feeling and *Secondness* is marked experience, *Thirdness* is naming of the relation between *Firstness* and *Secondness*. *Thirdness* is relating quality and (when it comes to architecture) giving measure, or scale, to that relation. Habits, the laws and science are found here. *Thirdness* realizes a given phenomenon from the *Firstness* of possibilities associated with a *Secondness* of events. Or put another way: *Firstness* is equivalent to the predicate, *Secondness* to the subject and *Thirdness* to the relation and to the naming of the relation between *Firsness and Secondness* (Peirce, 1994).

Architecturology

Philippe Boudon continues to work with definitions of scale and its different meanings in relation to geometric space, that does not require concrete measurements, and architectural space which on the contrary does have specific measures, or at least need those in order to be build. In “Back to Scale” (Boudon, 2009), Boudon establishes a definition of scale as the “relevance of the measurement: no longer a graduated ruler, but the relevance of the latter.” This is an important definition that stresses the construction of a relevant relation between the measured as the measurer. This can be understood as connecting the physical Secondness with the quality of Firstness, through inherent mental processes of Thirdness. Scale understood as relevance of the measurement consequently substitutes the mundane heterogenous meaning with empirically identified relevancies of the measurement. In conclusion Boudon arrives at the three *architecturological* concepts of *reference, dimension* and *relevance* (Firstness, Secondness, Thirdness) permitting to understand the complexity of the term scale.

Different interpretations of the term scale in relation to digital representations

With the intention of activating new reflections on the nature of the digital models as representations of architecture, the hope is towards an opening up to a discussion instead of the closure of (too) permanent conclusions. Through examples of scale in a sereies of experiments in virtual reality performed by the author’s research cluster, the issue of scale in the real world and digital world is discussed using the abovementioned theory and ideas from Peirce, Boudon, and Yaneva. Focusing on the scales of the digital model, the paper will discuss the potentials and inherent caveats of digital and virtual scales, using examples and feedback from using a digital virtual reality dialogue tool prototype in evaluation of universal design and architectural quality.

Digital Scale

As an example of the fundamental importance of both *reference, dimension,* and *relevance* and the possible s*caling in and out* in the digital representation of architecture, let us begin by looking at a digital model and a photo of the garden of the Royal Danish Library in Copenhagen.

When looking at a digital 3d model representation of the Royal Danish Library complex (Figure 1 left) we can most probably discern at least the buildings and elements of infrastructure from the green parts and the water. If we know the area, we can probably recognize this typical part of the city, even though we do not usually see it from a bird's eye perspective. While the perception of cities from the sky is an interesting topic on its own accord, it is, for the sake of this example, rather the level of detail and its relation to *relevance* one should pay attention to here. In the bird's eye view it seems appropriate for our senses to accept that this is a part of a city. But if we change the scale, and zoom in, while maintaining the same 3d model (Figure 1 right), we probably begin to experience that something seems wrong in comparison to our expectations of a perception of the everyday world experienced at more or less our own eye height.

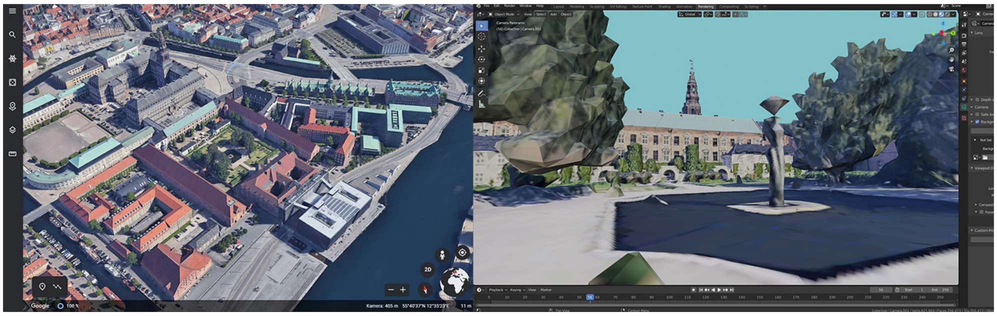

Figure 1 - Google Earth 3d digital model of the Royal Danish Library in Copenhagen (left) and Google Earth model of Royal Danish Library garden extracted and shown in the 3d modeler Blender (right). *Source: Google and the author.*

This becomes evidently clear if compared to a photographic image of the garden at more or less the same place, and even more, if the texture images are removed (Figure 2). It is easy to tell the many differences between the photographic representation and the digital model representation, but the point here is, that even though the digital model inherently contains the possibility of very fast scale changes, this does not necessarily link up to any criteria of relevance e.g. for the level of detail. In other words, while a digital model reproduces scalability in relation to quality (colours, geometry) and quantity (buildings, tress, water), it does not contain the scale as a relevance of the measurement. At least not before this relevance has been established by a specific cognitive use of it. Fortunately, this Peircean *thirdness* can be established rather easily, but one has to know how to decide what is appropriate in each given situation. What level of detail will be sufficient for a specific 3d digital architectural model to exactly convey its purpose, has to, or will unconsciously become, decided by a human being, a *measurer*. In an architectural design process this human being could very well, and preferably, be an architect.

Moving into the model

As opposed to the lack of scale-relevance in a digital model, something happens when we *move into the model*. As mentioned above with Yaneva's study of the endoscopic investigations of cardboard models, the immersion into a simulated full-scale room seen from human eye height proves helpful, if not crucial, in the architectural design. With virtual reality a digital model allows this full-scale immersion to varying degrees. With bilateral vision humans are physically present in physical reality (Sussman and Hollander, 2015). VR head mounted displays are working by generating exactly bilateral vision creating a sense of depth in the digital model, so perhaps we are actually not scale-less to the same degree in a VR digital representation model, as in a 3d model on a screen.

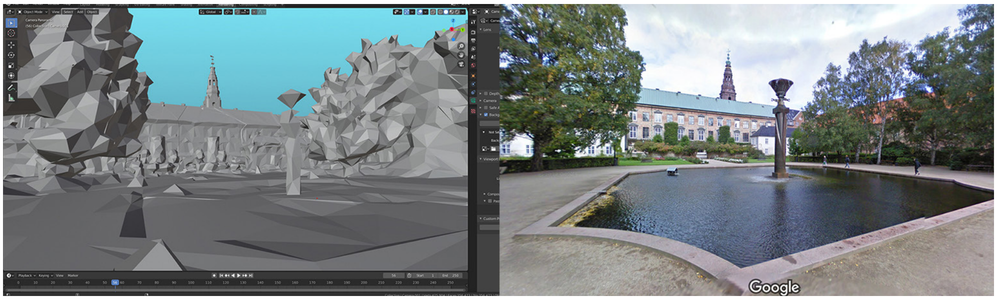

Figure 2 – Blender 3d model without textures (left) and a Google Earth 360 photographic image of the garden of the Royal Danish Library (right)

Source: Google and the author.

Studies of proxemics, i.e. "the interrelated observations and theories of human use of space as a specialized elaboration of culture" (Hall, 1990), has been performed also in VR showing correspondences with real life behaviour (Hecht *et al.*, 2019). Also, in addition to the scale and dimension studies mentioned in the literature review, studies have been made in relation to measurement of distances in VR. Curiously, most of this research show, that there is an evident underestimation of distances in VR (Jamiy and Marsh, 2019), which is an issue of investigation. Nevertheless, a VR model could perhaps in its very fundamental mode of operation provide the missing architecturological thirdness of scale to the digital model, owing to its inherent immersive effect for the user. In this way the user's own body could possibly provide the relevance of scale.

Virtual reality case studies

An initial experiment was set up by the research cluster of the author to test the correspondences between real life and VR. The experiment used a medium size auditorium as the real-life scenario and a building information model of the same auditorium as the virtual scenario. An architectural space was then presented to two groups of test subjects in real life and in VR. Afterwards the experiences were compared through both eye tracking analysis and a quantitative/qualitative interview matrix. The study suggests that VR can indeed simulate a physical scenario to a degree where human behaviour shows correspondences, and that a virtual scenario contains the possibility to incorporate interactive elements which cannot be provided to the same extent, using traditional drawings or even non-immersive 2D and 3D models (Hermund, Bundgaard and Klint, 2017).

A continuation of the study with focus on the estimation of sizes (length, width, height) within the virtual environment compared to real world and to plan & section drawings showed a very high correlation between the VR model and the real-world space in contrast to comparisons with the plan & section drawings. Remarkably did this study also show that the test subjects estimating the measures in the VR environment came closer to the actual measurements than subjects experiencing the real-world space. However the estimations were all quite close to the actual measurements (Hermund et al., 2018).

Virtual Scenario Prototype

The studies mentioned above led to the programming of a prototype tool using VR to simulate architectural projects in the design phase, (Hermund, 2021). A real architectural project in the early design phase became the testbed for the functionality of simulations in VR (Figure 3 left). The VR model was presented for users to walk around in, and their behaviour was tracked in order to get feedback. What is special about such an experience is the sensation of being immersed into a full-scale model while maintaining the knowledge that it is only a model. To sustain the user's experience of walking around in a not yet finished building, decisions were made to preserve a cardboard like quality of the experience, by removing materials and using non-photorealistic stand-ins of people simply to stress the sketchy phase of the design. Feedback of where the users looked in the models (Figure 3 right), where they moved, and if they collided with furniture or edges on the way, was collected in a report.

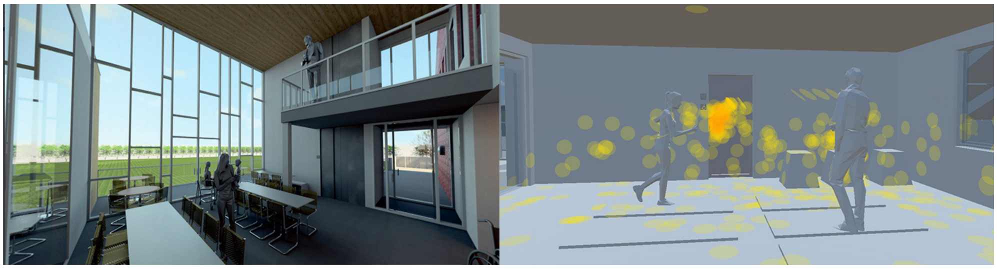

Figure 3 - A 3d rendering from the project (name omitted for peer review) (left) and heatmap showing where users looked when traversing the VR model (right).

Source: The author.

Because the eye height is exactly the users own, and the user can see virtual hands in the model, the sense of scale is referenced through the sensation of one's own body size in comparison with the sizes of spaces, openings and furniture in the model. The relevance of scale in this VR case is thus fundamentally related to the users own experience of moving through space.

Level of detail

Even though an early architectural sketch project does not yet hold much information about materials or colours, the digital VR model does permit to include these levels of detail, when the architect decides. But even though including this kind of information can enhance the feeling of presence, it is presumably not necessary for feeling immersed in the VR model. It seems that there are some visual levels of detail that are more or less autonomous in relation to the relevance of scale. However, they might reinforce the firstness as the quality of sensing the materials, or the secondness in relating more directly to dimensioning traits of the physical world (Figure 4 left & middle).

Figure 4 - Quality of e.g. materials in different flooring relates more to firstness and secondness than to thirdness of scale (left and middle) and wheelchair-user commenting on distances (right).

Source: The author.

Universal design seen from a virtual wheelchair

The suggestion is that it could be the intricate relation between one's own body scale and the VR model that, through relevance, connects reference and measurement. But the VR representation also allows a different jump in scale, so a user can experience an architectural space from the point of view of someone else i.e. a child or a person using a wheelchair. Enabling a feature in the prototype system allows feedback from the movement through the building seen from the eyes of disabled people. A report based on the observations in the VR representation is then brought back to the architect that can align the project according to the suggestions and enter a qualified dialogue with the users. The user in the specific space (Figure 4 right) pointed to the scale of the landing which should be at least 1.5 m to be spacious enough, even though the permitted minimum requirement is only 1.3 m. In this case and similar occasions (Hermund and Bundgaard, 2019) an experienced scale in the VR sketch model was sufficient to point to areas of the architectural design, that needed further attention from the architect. In such a case all scales from reference and measurement to relevance are used in the VR model, e.g.: The sensation of spaciousness (or in this case the lack of it), the actual physical measurements of a wheelchair, and the relevance of the body, and the fact that the law requires a distance which is insufficient for the bodily space in a wheelchair.

Discussion

As stated earlier, this paper has the intention of spurring new reflections on the nature of the digital as representations of architecture. An invitation to a discussion.

The different scales of digital models that provides different use - the local scale of a building information model (BIM) with less extension than a geographic information system (GIS) model covering large areas with relatively fewer local details, and the VR model that could be a possible back to nature (of the human scale) in a digital regime. The ideal of a digital model is not a map containing all information about a given architecture, but a repository for information that can be pulled when relevant at the right time for the right person. The VR model could as such be seen as a supplementary representation of full-scale architecture with a lot of potential, but not a substitution for all other methods of architectural representation. The explorative nature of this paper, as mentioned, calls for a discussion rather than a conclusion, and it is the hope that the suggestions in relation to the use of scale applied to the different uses of digital models, can inspire such a debate among designers and architects working with the representation of their work through digital media and models.

The claim for discussion is now that the virtual reality model relates more naturally to an experience of an actual real-world experience, than other types of digital models, because of its intricate relation to relevance through the scale of the human body. This would be interesting to discuss. Could the relevance of measure of architecturological scale be found implicitly in the VR representation? Even though the VR model is indeed a virtual reality, could it really be bringing us all the way back to Protagoras with a crispy digital “HOMO MENSURA”?

Conclusion

Despite the above discursive attempt to evade a too conclusive closure of a potential discussion, it seems fair to conclude that moving into the virtual reality model has the potential to re-introduce measurement on the scale of the human body in a hybrid relevance of digital rigidness and sensous bodily non-scalability.

Using the term borrowed from Philippe Boudon it seems that the virtual reality model potentially sustains the architecturological scales of reference, measurement and relevance, if applied with the fundamental understanding of the right level of detail and interaction in the model.

Through the virtual reality case study introducing the virtual wheelchair, it can be said that all scales from reference and measurement to relevance are in use. Consequently, the sensation of spaciousness relates to firstness. The actual physical measurements of a wheelchair, and the relevance of the body, relates to sencondness. The fact that legislation is questioned, based on the virtual reality model, relates indirectly to thirdness. This points to an actual possibility of capturing more relevance of measurement in dealing with the virtual reality representation than a mere reductionist cartesian dimensionality or a purely visual representaion of the world. In other words: this type of virtual reality model implicits human scale.

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Scalar Agency: Ambiguity, Potentials, and Challenges in Design Thinking

Introduction

Our institution aims to educate good designers through a ten-semester studio sequence that proceeds from the fundamentals of architectural design, through the technical aspects of building and comprehensive design, to investigations of the urban conditions. This framework requires students to negotiate scales at both the macro and micro levels. Learning to be a good designer begins with developing the foundations of architectural design and understanding the relationship between space and the body, in which the understanding of scale is crucial. As students move through the program, they zoom-in on details and out to the city, to understand more extensive relationships and infrastructures. Our research evaluates these ideas as they move through our curriculum. We look at the beginning design studio exercises and the end of our program with fifth-year projects and thesis explorations. Scale is a factor through which designers comprehend their designs. However, it does not come naturally as it is an acquired sense and knowledge. Thus, as one learns to become an architect, scale is a part of the fundamentals in design to be cultivated. In this line of thought, this paper explores the relationship between developing an understanding of scale and cultivating design skills and design thinking in architectural pedagogy. Conceptually, they also relate to the issues of representation and thinking. How does the development of the sense of scale inform the growth of skills in architectural design? What would be a proper methodology to integrate both aspects?

Method of the paper

The paper will assess and analyze studio outputs from our program across different years. It will study drawings and models from these studios, documentation of design processes, and final designs of the design projects. In particular, it will focus on the relationship between scalar changes and developments of design by analyzing drawings, models, and documentation of design processes. It will also analyze the relationship between the spatial and formal qualities of the final designs with the development of the understanding of scale through different media and techniques. Along with these analyses, the paper intends to assess the development of the understanding of scales as students build their aptitudes in various manual and digital media and techniques. The paper will review the literature on design thinking to establish connections between existing knowledge in design thinking and the findings from the analyses. Through these findings, this study would reflect on our pedagogical methods and approaches to continue refining our design teaching. It also intends to contribute to knowledge in architectural design pedagogy.

Literature: Scalar changes and design thinking

In Visual Thinking, Arnheim discussed the development of human cognitive ability, in which seeing or visual perception is not a passive process, simply reading, collecting, and storing information from the environment as stimuli, but an active process, forming concepts (Arnheim, 1997 (1967)). It is based on the mind's ability to read the environment, on which mind receives and perceives stimuli from the world around us through visual means. In this sense, it is about seeing. Seeing relies on the readability of the information from the environment, which points to the clarity of form. In this process, reading the environment goes through the process of the selections and organization of stimuli. Further, the mind operates to the process of simplification and generalization. In this process, our mind search for the most basic and recognizable form from stimuli. The mind also seek to identify a complete basic form of visual stimuli. It also seeks to differentiate a stimuli from the context. Further, the mind would seek for relationship between forms. This relationship points to the notion of visual patterns. In this line of thought, the cognitions of visual stimuli or the readability of the environment lies not only on the geometric descriptions of the stimuli, but also on comparison between objects. Hence, scalar comparisons come into play. Ching mentions visual scale, which was about visual relationships between an object or building to another (Ching, 2014). However, these visual comparisons are more than visual perceptions. He argues that we have expectations of the comparisons between objects or scalar preconceptions. In this vein, he emphasizes the notion of human scale, in which we tend to use human bodies as the base of our sense of scale. Indeed, Rasmussen argues that humans tend to quantify our perceptions of the environment through mathematical ratios (Rasmussen, 1964). This notion of ratios connects the concepts of scale to that of proportions.

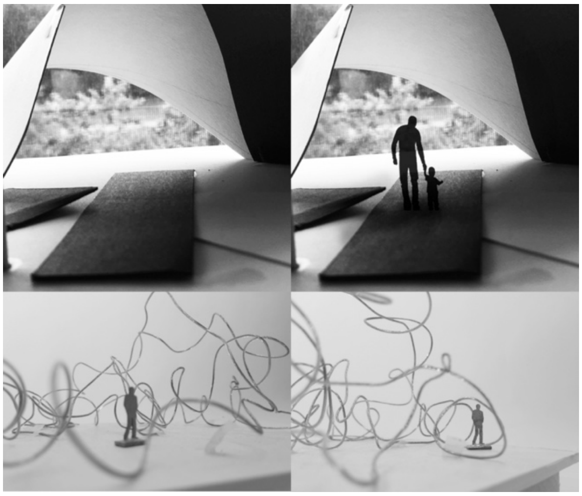

Fig. 01. First year studio explorations, student: Ferdinand Walden.
Source: Image by Author.

Sennett has discussed humans predilections to changes that happened through metamorphosis (Sennett, 2008). This metamorphosis could occur through three different trajectories. The first is through evolution that yielded variants of a basic type. The second emerged out of unexpected juxtapositions. The third changes happened through a domain-shift. In this line of thought, we intend to harness the potential of the effects of metamorphosis, especially the notion of the domain-shift. We relate the domain shift with the notion of the scalar changes, that it, that our perceptions change when an object is compared with another one. In another word, we are interested in the spectrum of changes from scale less to scaled. It also the changes of the same object, from perceived as a small to a large.

Fig. 02. First year studio explorations, student: Brandon Parker.
Source: Image by Author.

Smith and Warke point out that scale is essentially relative and fleeting. We can only comprehend the scale of an object only in the relationship with other things (Smith, Warke, 2014). In this sense, our sense of scale depends on position, including the positions between objects and between the observer and objects of observation. Thus, they differentiate physical and perceptual scales. The former is the understanding of scales based on actual differences in measures of objects on comparisons, while the latter refers to our visual perceptions of the environment. As Picon has pointed out, digital tools can zoom-in and zoom-out on screens (Picon, 2010). Through this faculty, they allow designers to miniaturize large-scale projects. In this line of thought, designers can manage the complexity of large-scale projects by moving through scalar transformations. However, this miniaturization is double-edged. On the one hand, it allows for formal explorations beyond Cartesian geometry. However, this formal potential has made structures and materiality less relevant. . In this line of thought, Latour points out that changes in scale is not similar to optical changes of lenses, as in zooming (Latour, 2014). Hence shifting from a small to a large scale is different from zooming-in or zooming-out. The metaphor of zoom implies hierarchy of data, in which data in the smaller scale is nested within the larger scale; while in fact, is not always the case. Using Google Earth as an example, zoom-in led to extractions of different set of data. Although Picon's argument is rooted in the digital tools, these observations on the artificial capabilities are also relevant to other prosthetic to human eyes, both digital and mechanical, including cameras.

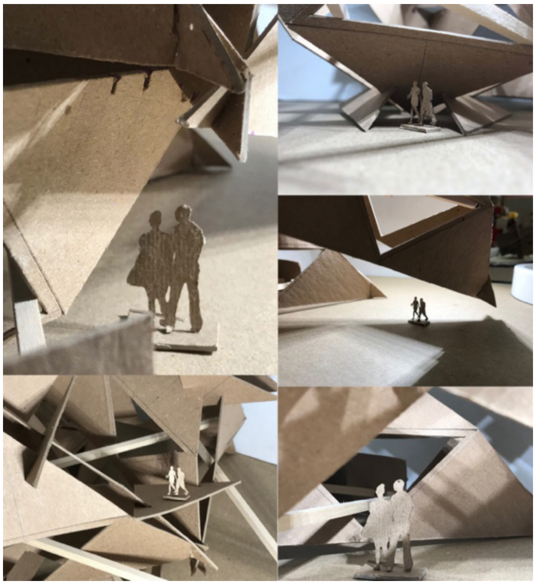

Fig. 03. First year studio explorations, student: Noah Stogner.
Source: Image by Author.

Case study - First-year zooming-in, Fifth-year zooming-out

The first set of exercises in the First-year studio or the beginning design studios intends to introduce students to skills in space-making intuitively. The exercises introduce students to basic hand-drawing skills, including contour lines, gesture, and tonal drawings. Each technique forms a set of exercises that ask students to draw from observations of the built and natural environment. However, these exercises do more than just develop skills in drawing. Instead, the drawings serve as the basis of a sequence of inquiry into space-making and spatiality. After each exercise in a specific drawing technique, the exercise asked students to develop a three-dimensional construct based on the drawing they produced. In the beginning, students tended to recreate the object they drew as they built their models. However, the brief guided students to develop models that create space based on lines or planes from their drawings. Hence, it directs students to construct spatial enclosures rather than objects. The models emphasize fluid lines and irregular shapes. After students finished their models, the brief asked them to take photographs, zooming into cavities inside the model. These procedures initiate the student to learn to see space using a camera as a prosthetic tool. The exercise asked students to cut figures and insert them into their models' cavities. The brief directed students to create cutout figures in different sizes.

In this way, the project directed students to compare and contrast the different proportional relationships between the space and the cutout figures. It intended to introduce students to the notion of scales, developing their sensibilities to the aspects of scale. In the subsequent exercises, the brief introduced students to some basic commands in Adobe Photoshop, in which they inserted human figures into their photos. These montages offered a way to imagine inhabiting space and conceptually transform a scaleless cavity into a habitable space. This sequence of exercises introduced and developed basic skills in hand drawing, model making, and digital. Pedagogically, they cultivate students in learning to see and observe, to document through drawing, to make space, and go back to see and analyze space in small objects. The notion of scale is developed through comparisons with human bodies.

Fig. 04. First year studio explorations, student: Noah Stogner.
Source: Image by Author.

The next project in the First-year is based on the cube exercise. The brief for the project provided a gridded cube as the constraint for students. Students divide the cube into smaller spaces using basic geometric elements of lines and planes. These spaces juxtaposed and intersected with each other. They started with small study models to explore initial ideas. It intends to introduce formal and spatial order. As they refined their understanding of a three-dimensional organization that exemplified developing skills in formal and spatial order, they developed larger models based on these study models. In developing the project, the brief asked students to sketch out the sectional cuts of models, both in the horizontal and vertical directions. Eventually, as students produced large models, the project asked students to develop sectional drawings of the model. Spatially, the project intends to continue cultivating the ability in space making, turning cavities inside the cubic organization into habitable space.

It intends to introduce and develop fundamental skills in measured drawings and orthographic projections. In a way, it introduced basic plans and sections. In this manner, the project introduces the notion of scale based on conventions in architectural representations. The project also tasked students to construct axonometric drawings. Crucial in this set is the notion of precision that guides the construction of drawings. By calibrating the scales of drawings and photographs, students reimagined these cavities into architectural space through changes in scales and measurements. This methodology explores the capabilities of graphic representations to introduce the understanding of space and form, which then feed into the subsequent design iterations.

Fig. 05. First year studio explorations, student: Tim Gatto.
Source: Image by Author.

The semester's final project aims to integrate the learning and lessons from these two modules. The brief tasked students to design a small structure, which includes an entrance, a passageway, and a personal space. The latter is within the confine of twelve by twelve by twelve feet maximum. The project asked students to use their cubic project as the starting point for their design iterations. In this line of thought, their orthographic and axonometric drawings were crucial. Students explored possibilities of transforming their drawings; in a way, they explored changes and transformations of proportions of their drawings. In a way, the brief directed students to the possibility of transforming scales in order to change a scaleless construct into a scaled, habitable entity. It combines the scalar transformation from their first exercise and the measurable procedure in the second project. The precisions in the second project guide the scalar transformations. In this line of thought, the scalar transformations inform the formal and spatial features and organizations.

The second semester of the design foundation studios focuses on making, fabricating, and constructing. In the first project of the semester, students explored precedents of wood architectural details. These details were collected from the work of prominent architects in modern architecture, such as Alvar Aalto. Students gathered the orthographic drawings and analyzed these details to identify their formal features and organizational principles. Based on these findings of the design rules, the project asked students to develop their design of three-dimensional constructs. They should develop their artifacts based on the design principles of their precedent. Next, students moved to the wood shop. In this stage, the project tasked students to fabricate and construct wood artifacts based on their precedent. The project did not intend to recreate the original detail. Instead, it asked students to use lessons from the precedent, and the formal organizational principles from the details, to develop their arrangement. The project provided a set of constraints for the wood artifact, including using linear elements and wood tiles with specific dimensions. Besides introducing students to the notion of working with limitations and potentials of materials and techniques, that is, wood and wood joinery. Design-wise, this project intends to bring formal organizational principles across scales. In a way, this project moved from scaled information of the precedent into a scaleless wooden artifact.

The final project of the semester and the first year asked students to design a pavilion for students to study. The project called for a design to accommodate a large space for group study, four to six small spaces for individual study, entrances, and circulation space. Further, the project specified that the design should integrate the wood artifact into the design. The iterations should transform the artifact's design as a thematic part of the design. These could range from the assembly of structure and enclosure of the building based on the formal organization of the artifact to the organization of space following similar organizational principles.

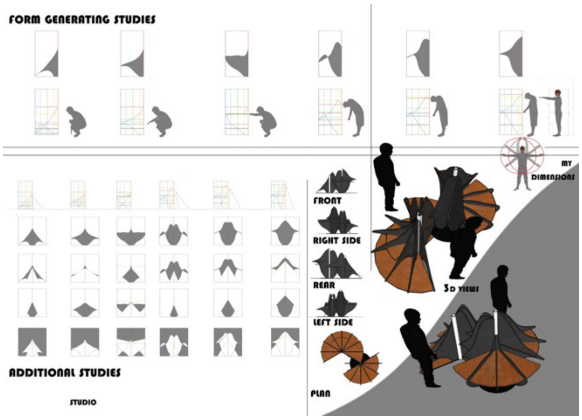

Fig. 06. Focus Studio anthropometric study and analysis of the body, student: Robert Bochenek.
Source: Image by Author.

In a fifth-year project devoted to materiality and making, building on the long heritage of design build at our institution, the project centered on the design and construction of a moveable kiosk for the school's chapter for AIAS. The kiosk was envisioned to support the Freedom by Design program and act as the home for their bake sale fund raising events. The exploration began with two smaller studies investigating recycled materials searching for ways to repurpose the discarded and understand the relationship between the body and space by analyzing anthropomorphic data and how the human body gets integrated into the design process as it relates to issues of aesthetics, function, structure, economics, and construction technology. The first studio exercises started with an open-ended experiment into materials and materiality. The agenda for the experiment was to develop a tectonic object focusing on an architectural construct, such as surface, skin, enclosure, tactility, structure, and fabrication.

The criteria for material selection was quite open and extremely flexible though the tectonic object had to be developed out of an object or series of objects that have been discarded or basically forgotten. The student explored the flexibility of their media engaging its possibilities through a series of mutations and transformations. Scaler transformations required the creation of a larger framework for replication. The tectonic object was investigated through the use of physical study models and documented through drawing and representation. Students documented the performative and experiential qualities of the artifact and illustrated the aesthetic and technical aspects of the design. In every instance the relationship back to making and experience was highlighted.

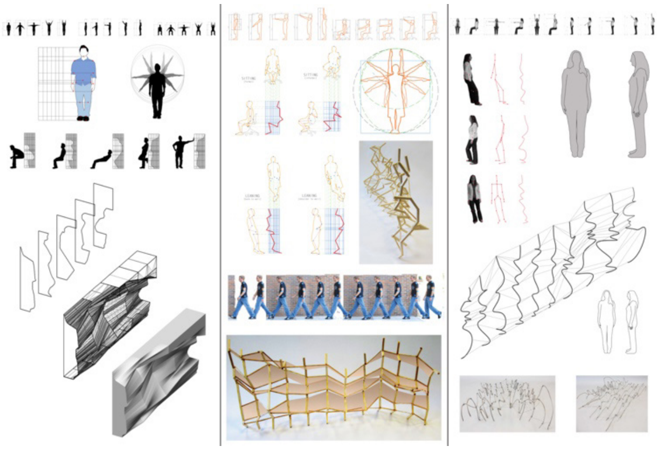

Fig. 07. Focus Studio anthropometric study and analysis of the body, students: Kevin Chong, Jonathan Davis, Sarah Roland.

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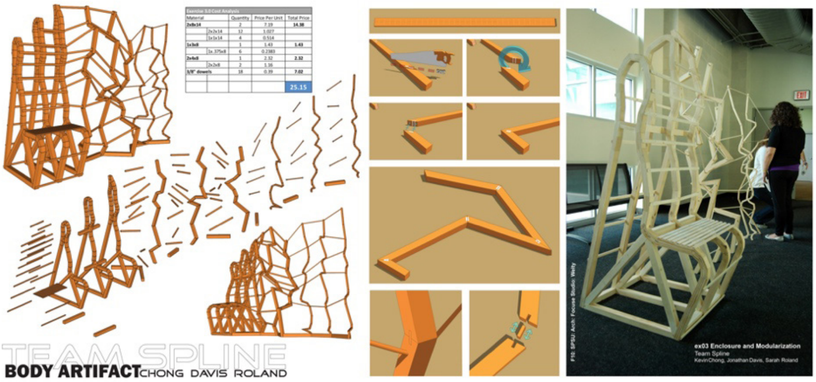

Exercise 3.0 Cost Analysis

Material		Quantity	Price Per Unit	Total Price
2x8x14		2	7.19	**14.38**
	2x2x14	12	1.027	
	1x1x14	4	0.514	
1x3x8		1	1.43	**1.43**
	1x.375x8	6	0.2383	
2x4x8		1	2.32	**2.32**
	2x2x8	2	1.16	
3/8" dowels		18	0.39	**7.02**
				25.15

Fig. 08. Focus Studio anthropometric study and analysis of the body, students: Kevin Chong, Jonathan Davis, Sarah Roland.

Source: Image by Author.

The body provided the starting point for the second project with an exercise centered on anthropometric study and analysis of the body. The human body is viewed as the design agent, bringing critical issues of scalar relationships, ergonomics, cognitive and sensory perception. The investigation begins with documentation of the body. Catalog and map the body to develop a studio module inspired by le Corbusier's le modulor. Students developed a series of graphical diagrams that described spatial relationships of space, activities, and spatial requirements. They started with static poses documenting limits and extends. Then created a graphic avatar representing themselves, scaled to their body proportions. From here a series of drawings were produced similar to the anthropometric charts found in Graphic Standards. The goal was to create a catalog of the dimensions of their body and its parts. Combining these diagrams and spatial studies was used to develop an ordering system or module for the studio. We are attempting to develop some rules for spatial organization. The body postures and movement were documented through static poses. Include in this investigation social situations that might be encountered in our kiosk, such as interacting with a patron, sitting with friends, reading alone, moving through the space, lounging, or discussing. These studies recall exercises from the first year to understand the relationship between body and space by analyzing anthropometric data and the human body related to issues of aesthetics, function, structure, economics, and construction technology integrated into the design process. Through these first two exercises the notion of scale was engaged through the physical with analog artifacts providing a direct connection from mind to hand. Scaler transformation that were not possible to material or size constraints were explored and represented by digital means.

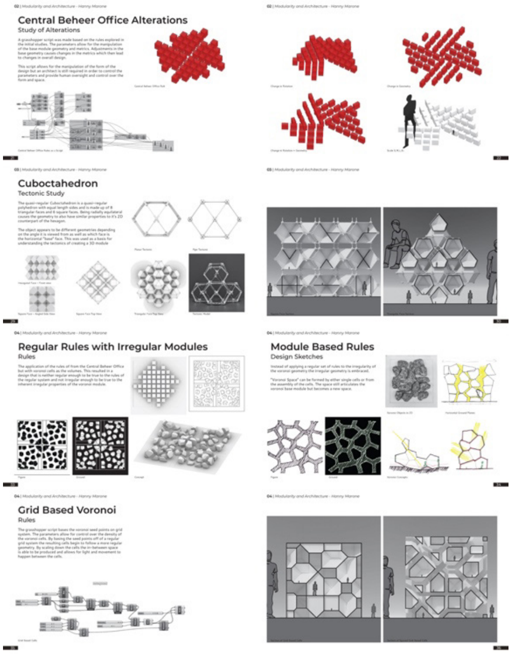

Fig. 09. Thesis Studio, Modularity and Architecture, student: Hanny Marone.

Source: Image by Author.

This documentation led to an ordering system and rules for the formal, spatial organization that guides a design/build project of a wooden kiosk. It also informed the method of construction of the kiosk. These projects develop the foundations of architectural design. More importantly, the methodology also informed projects in subsequent years through the final level. In a studio in the fifth year, the project directed students to trace human figures. However, these lines are only part of the complete outlines of the body. Instead, this step generates a series of line drawings that traces a series of the posture of the human body in a specific position. These lines, arrayed in vertical directions, formed the construction lines for an artifact. The project led students to transform this design into a structure that would fit a human body. However, the project continued as drawing. It continued into a built structure on a one-to-one scale.

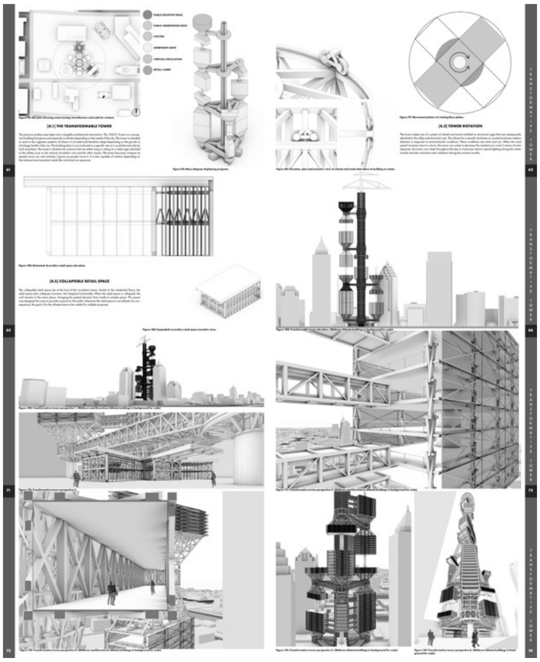

Fig. 10. Thesis Studio, Transformable Architecture Through Kinetic Mechanisms, student: David Feregrino.

Source: Image by Author.

Further, some projects from our thesis studio explored scalar transformations through digital means. A thesis revisited the notion of mat building to generate designs for tall structures in urban settings. It experimented with elements and configurational rules in the digital space without scale definitions. The findings led to basic modules for designing a tall, multi-story building. The thesis then translated scaleless modules into those appropriate for a tall building. One of our thesis students focuses his research on mat building. The students studied the literature on mat building as well as an analyzed precedent of mat buildings. This research allowed the student to extract the design principles of mat building. In this vein, it hinges on elements and a set of rules that govern and organize the design of the mat building. The student brought these findings to focus on exploring elements and configurations. In this line of thought, the student explored various geometric shapes for the elements. In turn, the geometric shapes informed the formulations of possible rules for the configurations to form the mat organization. The research began with physical objects. However, the students then brought the findings to conduct explorations in the digital realm. It allowed the students to expand the range of formal explorations. In this vein, the studies offered the possibility to explore various geometric shapes, from regular to irregular geometry. It also provided opportunities to explore possibilities of varieties of shapes from the basic shape; in line with this, it also allowed for varieties of dimensions from a similar geometry set. Historically, mat building worked in a horizontal direction. This thesis intends to apply the principles of mat building in the vertical direction.

The design inquiries started from a series of plays and explorations that focused on defining basic elements and possible rules for configurations of these elements. The iterations tested different geometry of these elements, followed by possibilities to alter the proportion of these geometries. The next set of iterations explored these elements and configurations as three-dimensional elements and configurations. These explorations happened in the digital space without definitions of scale. The findings from these experimentations served as the basis to define a set of basic modules for designing a tall, multi-story building. As the design process progressed, the student refined the translation of the scaleless modules into modules appropriate for a tall building. This scalar transformation necessitates the student to apply and integrate knowledge learned throughout undergraduate education. Along this vein, another thesis project pursued the question of expanding kinetic architecture into generative design. Based on findings from literature and examples, the thesis studied a series of elements and connections in digital space that were fabricated through a three-dimensional printer. These artifacts allowed the student to experiment with different alternatives. These included horizontal and vertical directions and small, medium, and large. The thesis tested the possibilities of generating tall buildings based on these principles of kinetic architecture.

Discussions

Throughout our design sequence, students encounter a series of projects exploring various scalar transformations. This methodology also informs projects in subsequent years through the final level. The exercises aim to enhance creativity and possibility by exploring the unimagined. They empower the student to move beyond what they know and embrace the possibility of what they might find. Exploring scale through analog and digital means gives the student the basic tools for expanding their experiences and widening their design perspectives. The exercises follow a similar approach, whether analog or digital, in all studio years. They begin with seeing and then making. This artifact becomes the area of study where students investigate possibilities through scale transformations of small, medium, and large. The exercises challenge students to explore the potential of these findings, transforming the knowledge into the possible.

These scalar transformations necessitated the student to apply and integrate knowledge learned throughout undergraduate education. These studios explored the ambiguous nature of scale, moving from scaleless two-dimensional graphics and three-dimensional constructs into architectural space and structures, putting various design representation techniques and genres at the center of the process, including varieties of analog and digital media and techniques. In this vein, scale could act as analytical, measuring, and generative means in design processes. As an analytical tool, scale provides a framework for analyzing formal and spatial properties. As a measuring device, scale provides a base to achieve precision. The exercises stress the importance of scale in relationship to the body and our perception. Through a process of zooming in and out, the transformation is achieved in understanding possibilities. As a generative means, it lends to possibilities of spatial and formal transformations. Deciphering the structure, organization, or rules leads to a framework for design development.

By analog means, scale becomes a direct connection through the use of physical artifacts. It is a tactile event informed by the material, the process of making, and analyzing. In the virtual space of the computer, scale becomes much more ephemeral, almost scaleless in the limitless potential to zoom in and out. This freedom allows the design to be explored at many levels though it provides its danger with infinite scalar, often scaleless representations. This shift in scale requires students to suspend judgment on what they know until the investigation is complete and the series of representations or drawings is complete. Similar to design, teaching is a process of inquiry. The understanding of scale remains rooted in our design process through direct engagement with the tools, techniques, and procedures. These conditions provide constraints and opportunities to inform the development of generative principles. Scalar changes mine different sets of information embedded in the documentation of a project that feed into the design process.

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Measurable and Immeasurable Scales: Speculative Transformations of Architectural Photography

Introduction

Architecture is always designed in response to a wide range of scales – the macro scale of site context, the micro scale of building assembly, and all the spatial, structural, and social concerns that fall in between. Architectural design at all scales must respond to measurable and immeasurable inputs and constraints. For example, the flow of solar energy toward a building is a measurable input to which design must respond in different ways at different scales – from scale of site to scale of a construction detail. The way people move toward a building, enter it, and experience it is an immeasurable input that must also be responded to in different ways at different scales. A measurable constraint such as a dimensional limit placed on a building or component of a building, and an immeasurable constraint such as the desire of a client must also be addressed in different ways at different scales. These are just a few examples of the many ways architectural design must accommodate measurable and immeasurable concerns at different scales.

Given these complexities of measurable and immeasurable scale, how should the topic of scale be introduced to beginning architecture students, particularly when digital drawing and imaging environments make it extremely challenging to grasp scale in relation to the physical world? This essay will present the framework of a visual studies exercise given to first-year architecture students that attempted to address this question.

Pedagogical Context – Time and Scale

At the beginning of the course, to initiate a discussion about the nature of drawing[1] in architecture, students were asked to consider drawing in relation to two very broad concepts – time and scale. With respect to time, drawing was discussed as an artifact representing an idea, and as an act performed in time. In his book *Architectures of Time,* Sanford Kwinter argues for an approach to architecture that engages time to bring novel things into being. Rather than thinking of architectural design as similar to making ice cubes, which are formed into already determined shapes, he suggests that architectural design could be more like the genesis of snowflakes. The

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[1] In the course, students were asked to produce a series of visual works combining images, lines, and surfaces in two- and three-dimensional digital design environments. In this essay these works will be referred to as 'drawings' mainly because they are being used as drawings have been used historically in academic and professional settings – as instruments in a design process. What 'drawings' are in architecture today is certainly up for debate, but this debate is beyond the scope of this essay.

genesis of snowflakes engages time as it draws matter into a difference-producing process that does not have a determined outcome (Kwinter 2001, p. 26). Kwinter notes, however, that structures of civilization, Western civilization in particular, seek stability and generally attempt to tame the difference-producing 'wildness' of time. But rather than accepting the predictability of stability, he suggests one might be better off embracing the onslaught of difference time produces. "For the very same principle that 'corrupts,' transforms, and diminishes Forms, evolving them toward disuse, decrepitude, and disappearance, also *gives,* produces, and creates."[2] As a response to Kwinter's proposition, this course asked students to consider how they could draw something novel and possibly somewhat 'wild' out of a conventional, acceptable, or stabilized view of an already existing building. It was suggested that their drawings, dynamically produced in time, might be seen as 'transformations' or even 'corruptions' of canonical works of architecture.

With these notions of time in hand, the issue of scale was addressed. Scale is a particularly difficult concept to teach beginning architecture students because most, if not all of what we call 'drawing' in architecture school is done in digital environments where a canvas, drawing board, or model space is infinitely zoomable and therefore has no fixed or intuitively understandable scale. Scale, however, is so ingrained in how architects conceive and represent buildings, that its deep significance may be at least partly hidden from us as practitioners. Edward Robbins has observed in his anthropological study of architectural drawing that it is necessary to step outside a culture to understand it more fully. Because Robbins is interested in uncovering how the various ways drawings work remain hidden to architects, he takes a different view of drawing than most architects would by foregrounding its role as a social practice rather than a representational object (Robbins 1994, p. 5-6). Albena Yaneva takes a similar anthropological outsider's view in a study of how scale is used in a design project by the Office for Metropolitan Architecture. Yaneva embedded herself in OMA's office during design of the Whitney Museum extension, an unrealized project adjacent to Marcel Breuer's iconic building on Manhattan's Upper East Side. Yaneva describes her work as an 'ethnographic' study, which required her to 'live' in the architect's office (Yaneva 2005, p. 868). From her position as an outsider embedded in an architectural office, Yaneva makes a number of important observations regarding how a series of physical models are used to visualize and discuss design of the building at different scales. Although her study concerned the use of physical models, her observations and conclusions are seen to be applicable here in relation to this student drawing exercise. Three of Yaneva's observations will be used to frame the discussion of scale: 1) that a concept of 'fuzziness' is productive as it relates to cognition of design, 2) that circularity between scales sets up iterative development, 3) that architectural models capture heterogeneous design parameters.

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[2] Kwinter, 2001, p. 7.

1) FUZZINESS

While size of a building or object is quantitative, scale is qualitative and relative. In scale, something is larger or smaller than something else, but how much larger or smaller is not specified (Morris 2009, p. 9). As a result, the scale at which a building should be represented is not definitive, though Yaneva notes there is a typical way architects use scale, which is to start designing at smaller scales and progress to larger ones. (Yaneva 2005, p. 870). Smaller scales limit the amount of information that can be contained and conveyed by a model. Architects often refer to small scale models as 'abstract,' implying that they foreground an idea (or something immeasurable) rather than representing something like the configuration and assembly of building materials (or something measurable). Starting at a small scale works well in the realm of physical models and drawings because at a small scale dimensions of the architect's body and perception constrain dimensions of their tools and materials, and thus constrain dimensions of their work. In the physical world, there is a limit to how small or closely spaced an individual part of a model or an individual line in a drawing can be. But this is not the case in the digital world where elements of a model or drawing can be constructed and inspected at indefinitely larger or smaller sizes. When dimensions of the physical world are removed, it becomes difficult to determine how small is too small, and how much information is too much information. As a result, for beginning students at the beginning of a design process, it is difficult to conceive how a model or drawing can be abstract or contain something as immeasurable as an idea. Yaneva, however, introduces another term, 'fuzziness' (Yaneva 2005, 870), which seems useful in translating abstraction that happens inherently in the physical world to the digital world. Rather than burdening representation with a need to have a positive quality (i.e., it is abstract and thus contains an idea), fuzziness implies that certain aspects of design simply do not need to be attended to presently. They can be temporarily forgotten or pushed off to the side; attention can be diverted to other aspects of the design at other scales.

2) CIRCULARITY

As a design process progresses, moving between scales is not linear; it does not simply progress from small scale to large. Yaneva observes the OMA architects moving from a smaller scale model to a larger scale model and back again, evaluating the position of an escalator in relation to how they are able to visualize it in different ways at different scales. She finds there is circularity between the two models as the architects physically move back and forth between them, and this puts an iterative design process into motion (Yaneva 2005, 883), which eventually allows the architects to determine the most desirable position for the escalator. Decisions made while working on one model require decisions made while working on the other model to be reconsidered. In the physical world, the fact that the models are two different and distinct objects forces a separation of scales. If a digital model or drawing represents all scales at once, is it still possible to create a similar circularity that encourages constant reconsideration of a design problem?

3) INCORPORATING HETEROGENEOUS DESIGN PARAMETERS

In an architectural model, such as OMA's site model for the Whitney Museum extension, heterogenous design parameters come together in a new gathering.

> For example, a small concept model with barely visible figures takes into account the adjacent buildings, the tiny slot allocated for the site, the eclectic features of New York city fabric, the dense network of local districts, the zoning fragmentation, the variety of building heights, the marks of history, the city politics, and the neighbor's relationships.[3]

Some of these parameters such as dimensions of the surrounding buildings and the site are measurable, and others such as 'marks of history' and city politics are immeasurable. These heterogeneous parameters operate at different scales, from the scale of the of the city down to the scale of the building. Yaneva describes models such as these "not projections or anticipations of the building; rather they are new compositions shaped according to multiple constraints."[4] In other words, a model works as a generator and container of knowledge rather than a facsimile of the building. She states that nothing is more convincing for showing the 'composite' character of a building than a physical model because of how it accommodates heterogeneous parameters. As with Yaneva's other observations concerning fuzziness and circularity, the potential to composite heterogeneous design parameters will be discussed in relation to the drawing exercise presented here.

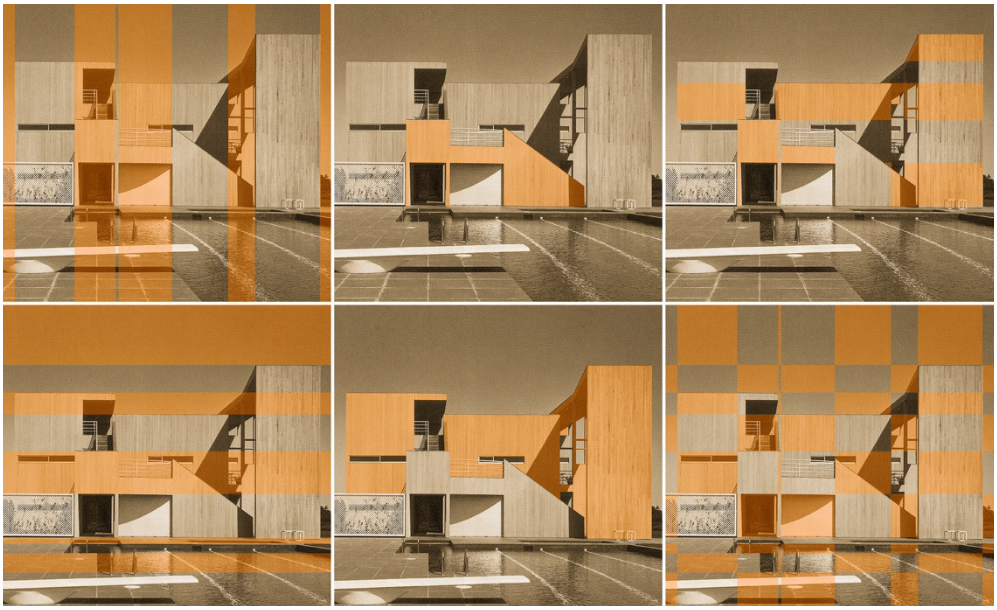

Fig. 01. Analytical images of Gwathmey Sigel Architects, de Menil Residence, East Hampton, NY (1983). Photograph by Yukio Futagawa. X-Y grids in left column, figural grids in center column, combined X-Y and figural grids in right column.

Source: image by author

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[3] Yaneva, 2005, p. 872.

[4] Yaneva, 2005, p. 873

Architectural Photography

Within this pedagogical frame dealing with time and scale, students began an analysis of architectural grids found in a photograph by Yoshio Futagawa of a late 20th century American house. Futagawa was the founder and one of the principal photographers of *Global Architect (GA)*. For more than 50 years, *GA* has been a highly regarded and widely distributed publisher of contemporary international architecture. As such, *GA* could be considered a major purveyor of legitimacy or acceptable standards and practitioners in contemporary architecture. With this in mind, students were asked to select one of Futagawa's photographs that looked frontally at one exterior side or interior wall of a house, a single-point perspective view that is as much like a two-dimensional elevation drawing as a photograph can be. Architectural grids were overlaid on these photographs in two ways: 1) as horizontal and vertical (X-Y) grids which align with horizontal and vertical datums in the architecture, and 2) as figural grids highlighting prominent two-dimensional shapes in the façade [Figure 1].

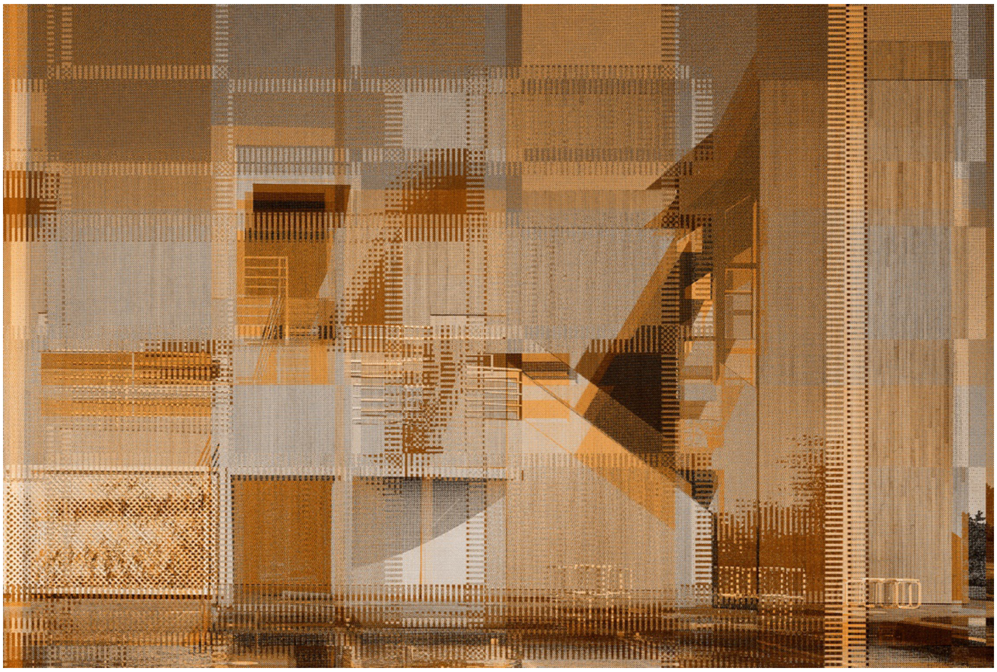

Fig. 02. Transformed image of Gwathmey Sigel Architects, de Menil Residence, East Hampton, NY (1983), based on photograph by Yukio Futagawa. Two-dimensional transformations of an analytical image (see Figure 1) introduce new grids in a different scale and register.

Source: image by author

These grids were drawn as transparent overlays so the photograph remains visible through them. The grids themselves do not apply measurable scale to the image, but the photograph does. So, whether viewed on a computer screen as the student zooms in and out of windows while working, or printed for presentation, the photograph represents recognizable architectural features such as doors, windows, and stairs. The resulting analytical images have a measurable scale that can be perceived by the student, allowing an intuitive estimation of the size of the building, and thus the scale of the image.

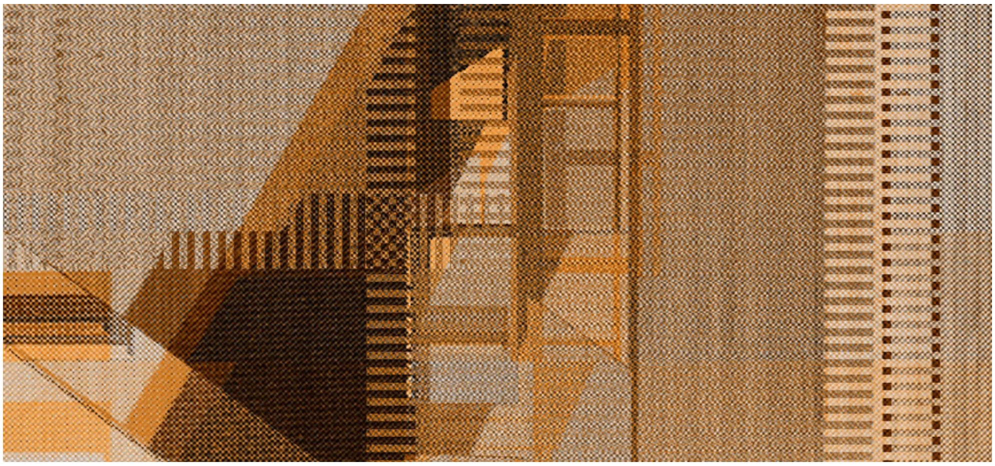

Fig. 03. Transformed image of Gwathmey Sigel Architects, de Menil Residence, East Hampton, NY (1983), based on photograph by Yukio Futagawa, detail. This detail shows an area of the image where architectural features are unrecognizable and an immeasurable scale is introduced.
Source: image by author

The Drawing Process

With this intuitively recognizable scale built into the analytical images, students were asked to transform them by engaging in a process that 'corrupted' (to use Kwinter's terminology) the original architectural photograph. Transformations introduced new grids, which were based on the architectural grids described above, but at different scales and in different registers [Figure 2]. As described by Rosalind Krauss, grids are visual structures that resist narrative or sequential readings. For Krauss, a grid is "flattened, geometricized, ordered…" "In the flatness that results from its coordinates, the grid is the means of crowding out the dimensions of the real…"[5] As new grids are introduced to the image at different scales, dimensions of the house as seen in the photograph are 'crowded out' to make way for another scale and register of visual information. This new scale is much smaller, and it is a registration of the software used to transform the image rather than of the architectural image. Particular areas of the image are transformed to an extent that the architecture is no longer recognizable [Figure 03], or there is a 'fuzziness' introduced that encouraged the students to divert their attention away from the original house. In these fuzzy areas, scale becomes immeasurable because there is no longer a visual reference to recognizable architectural features such as doors, windows, handrails, etc. Students were asked to work on this type of transformed image until the initial architectural photograph was still recognizable in some areas of the image, and unrecognizable in other areas. Or

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[5] Krauss 1979, p. 50.

until it sustained a relationship between measurable scale and immeasurable scale, and it composited heterogeneous parameters including the architecture of the original house and the logic of the software.

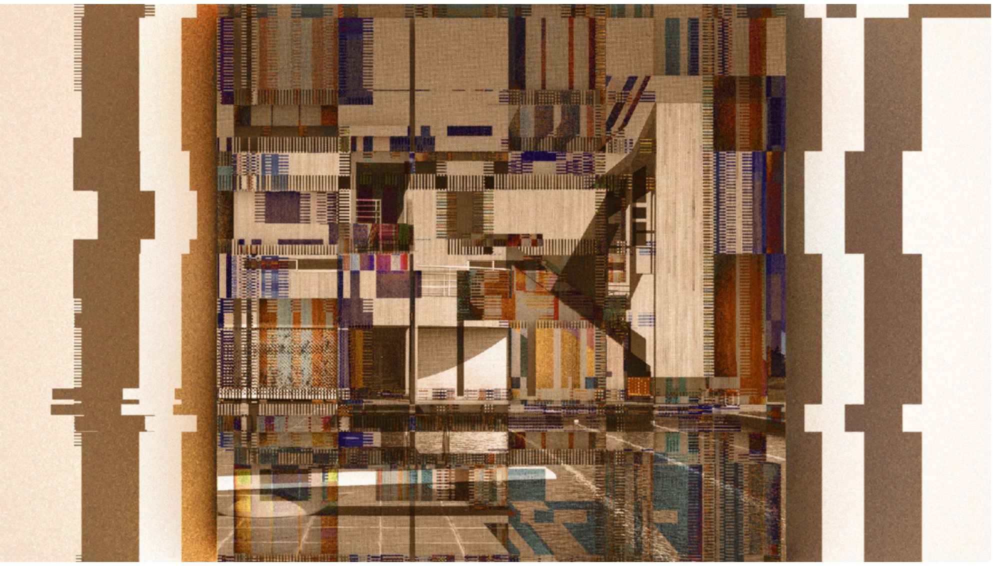

Fig. 04. Transformed image of Gwathmey Sigel Architects, de Menil Residence, East Eampton, NY (1983), based on photograph by Yukio Futagawa. This image is an orthographic view of a three-dimensionally extruded model, texture mapped with the transformed image. Z-axis scale is invisible but revealed indirectly through shadows projected by multiple lights.

Source: image by author

Krauss notes that grids tend to flatten imagery, and this is true for the transformed image. Architectural grids overlaid on the original photograph and abstract grids transforming it tend to reduce its perspectival depth. This flattening was countered by considering another type of immeasurable scale in the image, the Z-axis, or dimension perpendicular to the image plane. The Z-axis was introduced by extruding elements of the new scale and register in the transformed image. Another image was then produced from an orthographic view of a three-dimensionally extruded model, and texture mapped with the transformed image. In this image, the Z-axis scale is invisible, but revealed indirectly through shadows projected by multiple parallel beam lights shining on the three-dimensional model [Figure 4]. This sets up a type of circularity within a single drawing, which consisted of flattening through the initial introduction of grids to the architectural photograph, re-introducing depth through three-dimensional extrusions, flattening again by texture mapping the three-dimensional model with a two-dimensional image, and finally re-introducing depth through shadow projection. In a similar way to how Yaneva observes the two physical models working in OMA's office, this drawing exercise sets up a circularity that produced iterative design development. The image resulting from this iterative development contains two types of fuzziness: 1) visual coherence of the architecture from the original photograph, sometimes it is legible, sometimes it is not, and 2) two-dimensional vs. three-dimensional readings, grids tend to flatten, but perspective and shadow add visual depth. The fuzziness produced through different types of grid-based transformations allowed students to imagine different scales into the final image. It became possible to consider that the image might represent something larger or smaller than the house in the original photograph, and it allowed the students to imagine the scale of implied depth in an orthographic image, all without completely loosing perception of measurable scale from the original photograph. As the drawings were explicitly process-oriented, students were able to see how iterative development unfolding in time evolved the form of original canonical house toward 'disuse, decrepitude, and disappearance,' as it produced something novel. In this way, the exercise took Kwinter's recommendation to embrace the 'wildness' of time.

Student Assessments

One to two years after completing the course, students were given a questionnaire regarding key outcomes of the course and were asked to describe how they understood them from the perspective of having completed a significant portion of the school's architectural curriculum in the meantime. To some extent, students were able to grasp key aims of this drawing exercise. Summary statistics and some of the most relevant responses are presented here:

1. Question: Generally speaking, how easy or difficult do you find it to perceive and understand scale of a building you are designing when you are working on it in the computer in two and/or three dimensions?

   Summarized answers (out of 11 respondents):
   Can understand scale well – 5
   Cannot understand scale well – 5
   Answer unclear – 1

   There are times when I model in 3D and draw in 2D where I don't realize how big or small the space actually is. – Dawson Chak

   I find it very difficult to perceive and understand scale when working on a computer. Both the human body and the building's surrounding context are great to refer to when understanding scale. – Haley Korwan

2. Question: How do you think your ability to perceive and understand scale while working on the computer has changed since you took this course as a first-year student?

   Summarized answers (out of 11 respondents):
   Ability to perceive and understand scale has changed for the better – 8
   Ability to perceive and understand scale has not changed for the better – 2
   Answer unclear – 1

I realized that you can work on the tiniest detail like a baseboard then zoom out to the entire building and it almost seems insignificant. Since I was a first-year student I noticed that the more effort you take in the small things, the more the larger views look complete. – Logan O'Neill

As a first-year student, I understood the logistics of scale, but I did not fully understand how it can influence a project. – Sami Detwiler

3. Question: In this class, how did you perceive scale in the transformed Photoshop drawing [Figure 2]? What features or qualities of the drawing allowed you to understand how large the building in the drawing is? Were there areas in the drawing where you found scale easier or more difficult to understand?

   Summarized answers (out of 11 respondents):
   Can describe how scale is perceived in the transformed image – 4
   Cannot describe how scale is perceived in the transformed image – 6
   Answer unclear – 1

   The railings, stairs, columns, and beams that move across the house allow the scale of the structure to be understood. – Haley Korwan

   I think I saw scale through the details such as the doors and stairs and went off of that comparing those standard dimensions to other parts of the building to imagine how big everything else was. – Alec Kim

4. Question: In this class how did you perceive scale in the composited image/model drawings [Figure 4]? What features or qualities of the drawing allowed you to understand how large the building in the drawing is? Were there areas in the drawing where you were able to perceive three dimensionality?

   Summarized answers (out of 11 respondents):
   Can describe how scale is perceived in image/model drawings – 8
   Cannot describe how scale is perceived in image/model drawings – 1
   Answer unclear – 2

   I think scale can be seen are in the big chunks or areas where aspects of the images are clear or not as glitched. These areas give some sense of scale, ignoring the original scale and creating a new scale where you can read scale of the broken-up pieces and how that might introduce a new scale to the project. – Christopher Elias

   I would say starting out and working in photoshop at least for me it registered at a smaller or even residential scale, but as we moved through the semester and began developing the final images like in question 4 [Figure 4] to my eyes the scale seemed to change to a more urban level. – Cooper Myers

5. Question: If some aspects of architecture can be considered measurable (the dimensions of a building for example), and some aspects can be considered immeasurable (the way people move toward a building, enter it, and experience it), how might you describe measurable and immeasurable scales in the composited image/model drawing(s) you did in this class?

   Summarized answers (out of 11 respondents):
   Can describe measurable and immeasurable scales – 8
   Cannot describe measurable and immeasurable scales – 1
   Answer unclear – 2

   I think scale is measurable in the identifiable regions (doors, windows, columns) and immeasurable where the transformations so obscure the drawing that nothing distinct can be drawn out (is it a wall? a shadow? a floor? etc.). – Casey Rosen

   For composite images, the immeasurable space can also be thought of as the depth and dimension that the filter [created in Photoshop] imposes on the original image and form of the building. – Haley Korwan

Fig. 05. Right: transformed image of Gwathmey Sigel Architects, de Menil Residence, East Eampton, NY, USA (1983), based on photograph by Yukio Futagawa. Left: transformed image of Robert Stern: Residence in Llewellyn Park, NJ, USA (1981)

Source: student work by Zonglin Li (R) and Clara Cruz (L)

Conclusion

As this course was for beginning students, focus was on design thinking fundamentals and work remained abstract, with the understanding that more advanced courses would explore issues of scale in less abstract, more technical ways. In this context, students acquired skills to produce a particular type of architectural drawing, and hopefully insight to understand resulting drawings not just as an artifact, but as architectural knowledge allowing them to imagine a design for a novel building. While this building retained a memory of a canonical work of architecture, the pedagogical frame dealing with time, scale, and grids, helped guide the students through a process that did not accept the canonical work as a given, and found a contemporary image for architecture by allowing the conventional to be overwritten and at times forgotten.

It should be acknowledged that the ease with which evolving digital technologies allow new architectural imagery to be produced and multiply has the potential to call imagery's legitimacy or seriousness into question. Robin Evans made note of the fallibility of images even before computers began to be widely used in architectural design education:

> In a situation where everything is mobile, where only one thing at a time can be held down and kept still, images are the easiest items to immobilize. We should nevertheless recognize that possession of these easy captives is not a sign of victory, but a sign of fallibility. The art of composing images retains its preeminence largely because architecture has to be taught. The question is, how much more is ever brought within the scope of the architect's vision of a project than what can be drawn?[6]

For Evans, the preeminence of the image, or the drawing, in architecture is a result of it being both a result of architectural knowledge and producer of architectural knowledge – drawing has to be taught to students in order for it to teach them. So, what can be brought into a student's vision of a project beyond what can be drawn into an 'immobilized' image? The hypothesis in developing this drawing exercise was that using an architectural photograph as an underlay for an iterative drawing process that transformed or 'corrupted' the initial photograph would give the students a sense of scale as they developed a novel architectural image. Based on students' responses to the questionnaire given after the course, this appears to have worked reasonably well. In addition to using the photograph as a reference for size, many students are able to articulate a difference between measurable scale residing in recognizable architectural features of the photograph, and immeasurable scale residing in more abstract regions of the drawings. Teaching the course and reflecting on it afterward has revealed a more comprehensive reading of how these drawings work in relation to scale, which has potential to further expand the students' scope of vision. This has been articulated in terms of three observations made by Yaneva: 1) fuzziness is an important quality for architectural representation because it diverts attention away from things that do not need immediate attention, 2) circularity, either forced by multiple physical representations of a project, or built into different stages of a digital drawing process is what sets up an iterative design process, 3) architectural representations incorporate heterogenous design parameters, which is what allows a drawing or model to deal with measurable and immeasurable scales simultaneously. These are the findings from the research presented here that will be carried forward into development of subsequent visual studies courses.

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[6] Evans, 1995, p. 360.

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Retaining the Absent: Cultivating Imagination through 1:1 Drawing

Introduction

The visual conversation between the seen and unseen in drawing should be introduced and cultivated early in the education of an architect. If skill improves through the hand-and-eye connection, can the linking between hand and imagination develop in parallel? Is analog drawing an opportunity to better engage the imagination in early architectural education? Considering imagination as the "retention of the absent" or the ability to retain things not readily seen, the imagination's relationship to design is undeniable, and its relationship to drawing is essential. (Ferraris and Campillo, 1999) As designers, we are consistently charged with creating anew, developing new ideas, and delineating new spaces; but all of these must connect back to something existing or some known conditions in a meaningful and considered way. The imagined drawing is markedly different from an abstracted process; it reuses the known to generate something new. This paper presents a first-year drawing assignment introducing such a gap into a common prompt. In this project, students work at 1:1, or full scale, to examine and re-imagine a simple tool. They complete the project through observation, survey, collage, and re-drawing, while the process of re-thinking includes intentional gaps for students to create anew.

Imagination in Drawing

Beyond architecture, cultivating imagination is critical to the interdisciplinary work needed around immense, seemingly unsolvable problems. But "[a]ccepting a central role for the imagination does not mean that we abandon standards for assessing the validity and reliability of the knowledge so generated.."(Brown *et al.* 2010) Imagination is valuable for seeing beyond what is known and considered to be possible. Learning imagination is a contradiction; rather, it is an act of cultivating cognitive processes already in place. This position suggests that imaginative acts rely, in part, on known conditions.

> There are fundamental 'gaps' that must be resolved for individuals to think or act in relation to the world. Resolving these gaps through image making constitutes the self and the world in the same process. It is inherent to the structure of human cognition and action. (Pelaprat and Cole, 2011)

Gaps exist throughout the design process "gap between idea and drawing is where unanticipated events occur, eliciting new possibilities in the exchange between drafter and drawing; a site of exception where ordinary rules are suspended." (Emmons, 2019) The physical act of drawing, and the use of drawing to fill these gaps is an essential skill. The filling of these gaps implies an interdependency on seemingly disparate parts with one another.

Drawing is an opportunity to enact and build one's practice of imagination alongside other, more common, techniques. Full-scale drawing provides a direct physical and figurative connection between the known and the imagined. The practice of 1:1, or full-scale drawing, is well documented in architecture. Full-scale drawings were relied upon from Antiquity to the Baroque in the form of floor tracings; by testing the validity of arches or other details, for instance, in the location of their future construction. (Courtenay, 1997, Calvo-López *et al.,* 2016) Often, the tracery drawings were incomplete and reinforced the notion of a gap, modeling enough known information to imagine the in-between. In this case, imagination implies a process which builds on facts to create anew. In relationship to art, architecture, and building, John Ruskin wrote extensively on the imagination. These theories were deeply connected to the use and representation of nature to create anew. Rather than gaps, Ruskin referenced threads. (Ruskin *et al.,* 2013) The 'threads' of nature, the facts observed by the artist, are woven into a pattern by the imagination." (Sprinker, 1979) Both theories suggest the re-use of existing elements, referential and in some ways deferential to the known. Understanding these elements at full scale and observing and documenting them with great detail and clarity contributes to the imagination.

This paper suggests 1:1 analog drawing as an opportunity in beginning design education to encourage imaginative solutions while maintaining the importance of foundational skill-building. In any drawing assignment, there are likely a range of objectives, such as building technical ability alongside the grasping of key concepts. An example is the technique of drafting construction lines, and varied line weights reinforce the concept of orthographic projection and depth in two dimensions. This pairing could successfully help a student test the idea, but without a deeper connection to one's perception or imagination, this approach can quickly become rout practice. Absent a gap to fill, the exercise is to copy the example rather than to project possibilities.

Methods

This paper presents an approach to incorporating the imagination in a structured manner for foundation drawing. Surveying the existing, testing imagined conditions, and then defining those decisions to reveal the imagined as a new artifact of the student's creation. This assignment is part of a first-year architectural representation course in an undergraduate program. The course enrolls approximately 40-50 students per year. Each student must take this course concurrent with their design studios. While the skillsets taught in the representation course support the studios, they are not directly linked to any design project. This structure differs across institutions but is an important consideration when incorporating an imaginative gap into an existing set of assignments.

Analog drafting is far less common in architectural education today and rarely used in professional practice. Once perfected over many years, hand drafting is now considered a novelty or curious component of curricula. Yet the importance of a connection between hand and mind is not as readily contested. Physical making in the form of models is more commonly used to reinforce this value. However, physical models most often represent scaled forms of something else and are less commonly seen at full scale in a beginning design setting. While the work presented here utilizes hand drafting as a technique, the implementation of it at full scale is paramount.

Survey and Observation

As a first step, students survey a small gadget or tool such as a can opener or garlic press. This common prompt has many benefits as a starting point. It generates the need to resolve problems of geometry, scale, and projection. Across the class, ten tools are available to allow for shared knowledge and variation in the outcomes. As a first drafting assignment, students surveyed conditions, becoming familiar with their tool. This portion of the assignment relies on careful study, observation, and documentation. Tools are drawn at full scale and require more nuanced drawing techniques, such as applying a French curve to a unique form of the tool's handle. The rigor of this portion of the assignment comes from the student's ability to survey (Fig. 01) the gadget and translate those dimensions directly to the page.

The drafted form includes a top view and two side views as baseline documentation. Orthographic projection is a common representation technique and cornerstone of architectural documentation. The spatial and dimensional relationships between views are essential to this drawing type.

> Just as marks drawn on a page point or refer to something that transcends that physical substrate— those marks might make out, or indicate, the face of a person, or the relative location of places on a map, for example— so too is the mental image referential. (Gosetti-Ferencei, 2018)

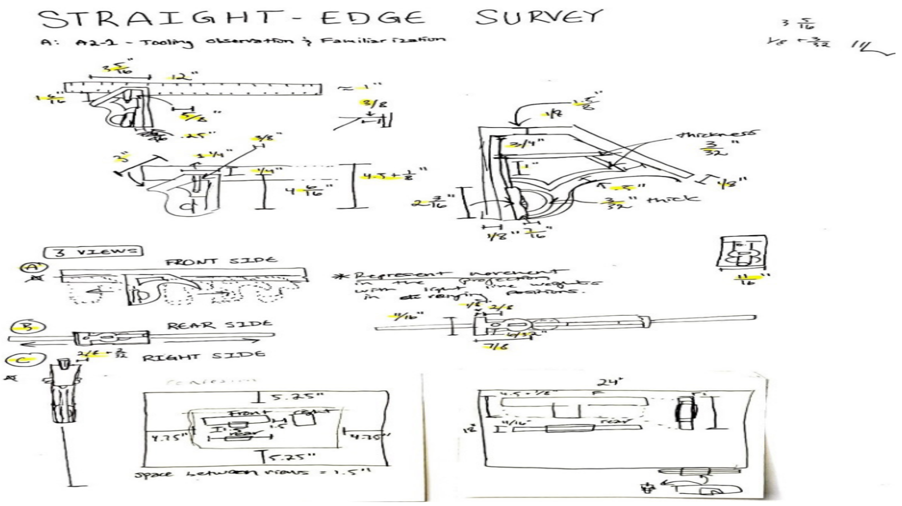

Fig. 01. Example of Student Survey Drawing.

Source: Student Work from Author, by Junior Rodriguez.

With a 1:1, or full-scale, representation, the view can be easily seen by rotating the object in one's hand and testing the drawing against reality. For students, this leap (projection or flattening) introduces an element of imagination by simply creating an analog or reference to the object.

Collage as Dissociation

As a second step, students rearrange distinct portions of the analog survey drawing from the views and details. They remake, or collage, these disparate parts into a "new tool" of which they imagine a new scale, form, and function (Fig. 02). This step evokes the exquisite corpse, or cadavre exquis, method and is shared with students as a reference. (Schneider, 1948) Digital copies of the original drawing are printed, cropped, and physically rearranged to test a range of options. An important detail in this step is the requirement of a literal gap between these pieces. Separating the cropped portions of the original drawing help distance them from their previous use and also allow space for interpolation between rectilinear and curved forms. The gap also proved to be the most difficult variable for students; reinforcing its critical relationship to the imaginative process. In some cases, a ½" distance for creating anew proved difficult but nonetheless important to engage. This second step of three in the drawing project also defines authorship in the students' work. It provides a basis for critique that is not reliant on direct comparisons. The differences yielded here also provide the opportunity for dialogue on technical skills through what the student imagines or has yet to define in the new tool.

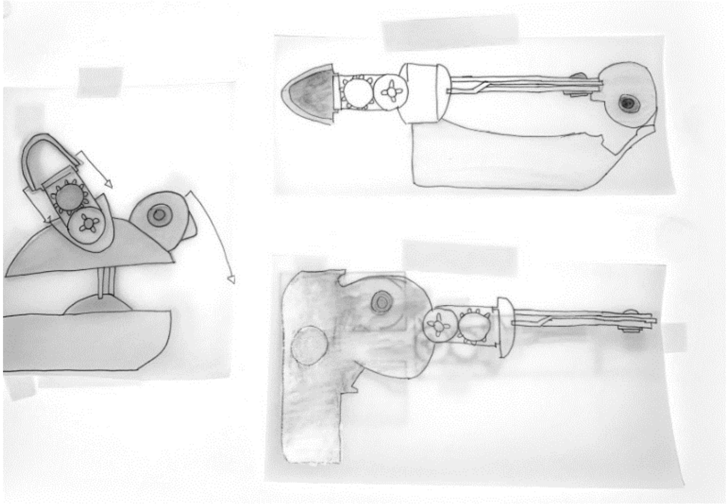

Fig. 02. Example of Collage Drawing Iterations.

Source: Student Work from Author, by Berlinda Alfred.

In these intermediate drawings, any indication of depth is not readily apparent. This lack of depth requires students to return to the original tool. It requires an assessment of its materiality, connections, and depth. Because the drawings at this step are at a similar scale to the original tool so one can infer a relationship between the original and the imagined. For instance, if a plastic handle originally wrapped a metal bar, the imagined solution would reflect that relationship but not copy it exactly. Those relationships are related and translated but often not reflected as duplicates from the original. The process of collage was a form of remaking that dissociated students from the original but left enough residue to imagine the possibilities of the new form.

Making it Real, Again

This sets up the last and final gap of the assignment process. Devoid of definition, rendering the drawing reveals unseen layers, function, movement, solid and void. This phase allows for malleability in what they imagined but also room to define what was not fully considered in the first iteration. Ownership over these distinctions reverses accountability in the project and creates flexibility in solving the problem.

Concurrently, other interpretations of their tool unfold simultaneously around the class, exposing the possibilities of resolution developed by their peers—preferencing conversation over comparison. The rendering process also forces students to define any vague understanding of the unresolved spaces in the previous iteration (Fig. 03). In this last step, lines become spaces and layers, making that which was imagined—seen.

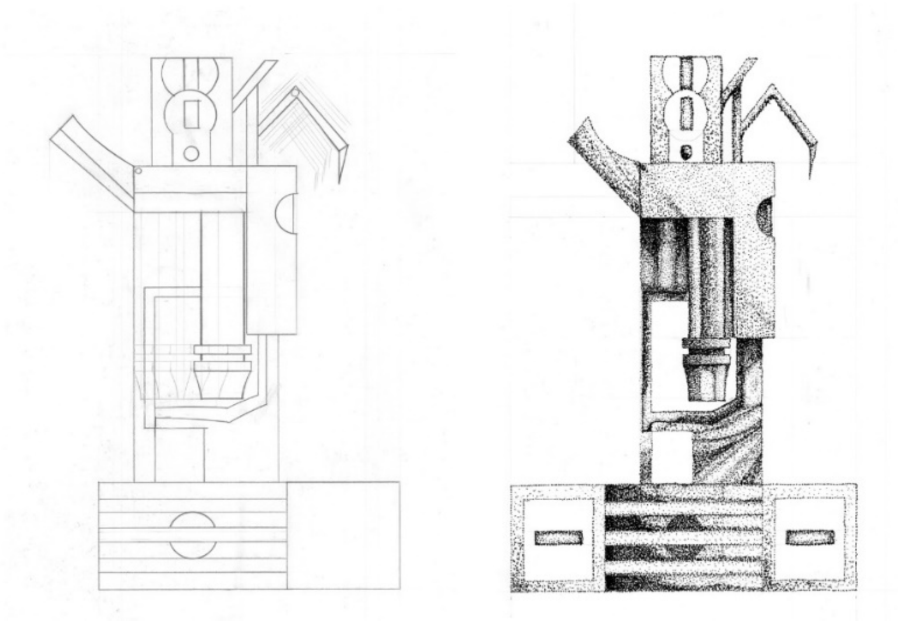

Fig. 03. Example of Line and Rendered Drawings.

Source: Student Work from Author, by Junior Rodriguez.

The value of revealing this to the beginning design student is two-fold. First, they can clearly see their own ideas, but they are also exposed to the possibilities their peers have also achieved. Next, rendering techniques are suggested, pencil hatching and stippling with a pen. Students are encouraged to select the rendering technique by revisiting the original tool's material qualities. A reflective material, smooth surface, or texture is re-considered in this final step. In the newly imagined tool, the application of material is suggestive of a new function and form. While many students defined this use or branded their object earlier on, the rendering of its form can provide clarity in this regard. The value of naming their inventions was an indispensable component of the process to aid in their final work and decision-making. The rendering of the object made the once dissociated and then re-imagined, now real once again.

Conclusions

This project serves as a case study for incorporating imaginative processes into future "supporting" coursework for beginning design education. This method could be tested in other forms, such as physical modeling, but is presented here through analog drafting. The presented example yielded a wide range of outcomes among the students relative to the novelty of their newly imagined tool. The conclusions here outline short-term outcomes, whereas future work could assess the longer-term impact on design problem-solving and collaboration skills.

The assignment is structured to repeat skills in different forms. For instance, the basics of hand drafting are incorporated twice with an imaginative "gap" between them (Fig. 04). This would be ideal in all cases and was not feasible for the rendering portion of the project. For some students, a second iteration would have helped clarify areas that remained spatially unclear after completing the project.

The use of a figurative "gap" or space to create something new was most apparent in its literal application. The most potential came when confronted with an empty space to connect to parts. This step helped scaffold the creation of something new for a class that doesn't allow the same latitude of creative testing that a design studio would. It combined interpolation and imagination, making it attainable for all students. The more difficult leap was recognizing space and depth in the reconfigured tool, and defining what was in front or beyond tested their reading of two-dimensional space and orthographic projection. This step flips their role as author and viewer over the span of the project.

The tool is a common problem for early drawing projects. The project outlined here uses this prompt in a new way through subtle changes in the process. Reflecting on these adjustments suggests that building on observation-based drawing assignments could yield similar results. Seeing, remaking, and, most importantly, providing gaps for invention and imagination are essential components of the process.

Fig. 04. Process Diagram of Parallel Skills, Concepts, and Imagination
Source: By Author.

Regardless of the subject matter or students' prior skills, this methodology aims to intentionally and specifically engage the imagination parallel to technical or skill-based learning objectives. The imagination cuts through many of the more common 21st-century skills necessary for students to engage in their education, such as critical thinking and collaboration. Cultivating imagination could support empathic design solutions by more nimble designers and is a powerful tool that students can use as readily as others we teach to solve problems far beyond architectural drawing classes.

Acknowledgments

I want to take this opportunity to thank the students for their commitment and openness to the creative process and the adjunct faculty who have supported the first-year representation curriculum and continue to engage with the ongoing project of imagination in this assignment and many others.

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Envisioning Architectural Scales

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Following the mission of the European Architectural Envisioning Association, the conference was intended as a platform for communication and exchange of experience, experimentation, research and collaboration in the field of envisioning architecture, and for this 16th edition with a special focus on architectural scales.

This publication presents the papers accepted after two double-blind peer review processes. Contributions from16 countries worldwide ensured a diverse and many-faceted collection of academic writings on the conference theme.

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