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### Sustainable Housing – The User Focus

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# ARCHITECTURAL TECHNOLOGY: THE DEFINING FEATURES

Conference Proceedings of the 4th  
International Congress of Architectural  
Technology

Sheffield 2013

Edited by Tahar Kouider

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## Table of Contents

### **Session 1: Architectural Technology: Theory, Practice & Research / Building Systems and Techniques**

|  |    |
|--|----|
| Architectural Technology: A Brave New <i>Design</i> ? .....  | 1  |
| The Architectural Technologist And The Constructing Architect .....  | 12 |
| Branding The Technology .....  | 26 |
| Architectural Technology As A Design Discipline: Ascribing Design Theory To The Practice Of Technical Design In Architecture ..... | 35 |

### **Session 2a: Sustainable and Environmental Design**

|  |    |
|--|----|
| Sustainable Design Strategies In Hospitals ..... | 46 |
|--|----|

### **Session 2b: Building Information Modelling in Teaching and Education**

|  |    |
|--|----|
| Energy Efficient Renovation of Social HousinG .....  | 57 |
| Reviewing the Extent to which 3D Printing May Offer an Accessible, Ubiquitous and Affordable Technical Design Tool for Architectural Technology Undergraduates and Practice? ..... | 70 |

### **Session 3a: Teaching and Education**

|  |     |
|--|-----|
| A Comparative Analysis of Architecture and Architectural Technology Undergraduate Degree Programmes in the UK..... | 84  |
| From elearning to ilearning .....  | 105 |

### **Session 3b: Building Information Modelling in Theory, Practice and Research**

|  |     |
|--|-----|
| Quantitative Materials, Dynamic Quantities .....                       | 114 |
| Architectural Technology And The BIM Acronym: .....                    | 122 |
| Preparing Architectural Technology Students for BIM 2016 Mandate ..... | 142 |

### **Session 4: CPD Bulletin**

|  |     |
|--|-----|
| CPD An Extension Of The Degree In Architectural Technology ..... | 159 |
|--|-----|

## **Appendix 1: Presentations**

|  |     |
|--|-----|
| Architectural Technology: Proofing, Perception & Promotion.....  | 173 |
| Sustainable Housing - The User Focus.....  | 185 |
| RE-SURFACE: Re-Surface: An Investigation into the use of Deployable<br>Gridshell as reusable, reconfigurable and intuitive formwork for the design<br>and construction of Form-active concrete shells..... | 224 |
| Adapting Education to Utilise BIM.....   | 260 |
| Exploring new pedagogic strategies of teaching BIM and associated<br>technologies.....   | 266 |
| Free-Thinking Students for a Sustainable Future.....   | 276 |

## **Appendix 2: Posters**

|  |     |
|--|-----|
| Renewable Materials.....   | 287 |
| ArchiCAD – useful BIM tool for full design and building cycle used in<br>commercial buildings..... | 288 |
| The Impact of CAAD on the Conceptual design Process of Final year<br>students.....                 | 290 |

## Forward

Architectural Technology (AT) is the professional discipline that latest stepped out of the traditional construction handicrafts to become an activity undertaken in the design office. Architecture, Engineering, and surveying became independent professions earlier but were, like AT, originally embedded in the construction handicrafts. These professional areas required relatively demanding skills that only experienced craftsmen or master builders were able to deal with. These disciplines no longer base their methods and traditions on handicrafts but tend to use research and innovation as a basis for their activities. This shift is about to happen with architectural technology which in its initial phase was mainly reliant on experience based feedback from a construction industry now working with new materials, new techniques, and new designs.

The International Congress of Architectural Technology (ICAT) has been established to support the development of such research and innovation based practise within AT. This forward together with the proceedings of the latest ICAT conference can be seen a further step forward in this direction. ICAT has not published the proceedings of previous conferences but intends to do so from now on. The fourth conference held in Sheffield in the spring 2013 had more research based presentations and papers than previously. This has provided the confidence to publish these proceedings knowing well that further improvements in academic / research quality and associated procedures are always sought by the board.

Individual academics representing Universities in the UK, the Nederland, Ireland, Spain, and Denmark had the initiative to establish the Congress and are all looking forward to further research to be undertaken, presented, and published for the benefit of the industry and of society.

Four subthemes supported the main theme of the conference: “*Architectural Technology: The Defining Features*” and the different presentations were organised within these subthemes. Consequently, these proceedings are structured in the same way and the reader may find the different topics approached rather differently on more in depth compared to the entertaining conference presentations.

I am sure that building design and construction professionals will find interesting and new ideas in the topics covered and may feel encouraged to undertake some research and present it at our next conference. If so, we will welcome you and your contribution subject to the normal peer review process. I wish you a pleasant reading and hope to see you at our next conference.

Dr Niels Barrett

Chairman of the ICAT Board

## ARCHITECTURAL TECHNOLOGY: A BRAVE NEW *DESIGN*?

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**Abstract.** Newly emerged degree disciplines, like Architectural Technology (AT), often face a unique set of challenges: pedagogically, conceptually and professionally. Novelty can entail an absence of a clear niche for a subject, whilst at the same time offer potentially exciting spaces for conceptual innovation. With the current lively debate surrounding the future shape of formal training for students of architecture, education for Architectural Technologists (ATs) is likely to be less than optimum if it simply replicates the existing pedagogy used in architectural education. Indeed, the rising technological and design challenges faced by ATs in practice highlight the need for a re-imaging of pedagogy at degree level, principally concerning how the design process is taught and understood. An appreciation of the evolution of AT as a degree discipline is crucial to further growth, as is greater definition of technologists' education. This paper will briefly outline historical growth of the degree discipline and review distinctions and definitions of AT that have already been stated in the UK and elsewhere. It will explore where greater uniqueness of identity can be shaped, and will suggest that that a development of pedagogy in design subjects is where increased distinction of AT programmes is most required. The paper will also offer a possible new pedagogy for teaching design.

### 1. Introduction

In recent years AT has matured as a discipline, positioning itself as one of the most respected professions in the construction industry. The Quality Assurance Agency (QAA) identifies ATs as bridging “the gap between concept (pure architecture) and construction (construction management) and

in doing so integrate the team”. This alludes to a profession with a “cross-discipline approach”, resonating with the findings of Latham and Egan in the 1990’s (QAA, 2007 p.2). By offering this link between the two professions, AT is in a unique position, providing technical solutions to allow the pure architecture to work.

Over the last two decades, the profession has positioned itself as a leader “academically, technically and professionally” in the integration of technology into architecture (QAA, 2007 p.2). The establishment of the Chartered Institute of Architectural Technologists (CIAT) has been fundamental in this progression (QAA, 2007). CIAT is well recognised and respected as a forward thinking institute, which has been at the forefront of the promotion of the discipline to government bodies, statutory organisations, professional bodies and indeed to wider society.

Recognition of the need for an institute for technicians dates back to 1962, when the Royal Institute of British Architects (RIBA) published a survey entitled “The Architect and his Office”. Findings from this survey emphasised the need for such an organisation. (Endacott 2005, p.10)

In February 1965 a meeting was held at which “the Society of Architectural and Associated Technicians” was founded (Endacott, 2005 p.11). This institute was renamed the British Institute of Architectural Technicians (BIAT) in 1986, and in 2005, after the grant of Royal Charter, became CIAT.

In terms of educational provision, the development of accredited AT degree programmes in the United Kingdom (UK) is quite recent when compared to accredited courses within other built environment disciplines. The first BIAT accredited degree courses were established in 1994, with undergraduate programmes at “Luton University, South Bank University and the University of Ulster” accredited in that year (Endacott, 2005 p.63). Presently there are over thirty programmes which are fully accredited, accredited in principle or approved by CIAT (CIAT, 2011). These include programmes throughout the UK and also in the Republic of Ireland and Hong Kong. Postgraduate provision is now also provided with three masters degree programmes currently recognised by CIAT (CIAT, 2013a).

## **2. The International Perspective**

AT in the UK is both a discipline and a recognised profession, but in other European countries like France, Germany, and Italy, the equivalent of a Chartered Architectural Technologist currently does not exist. While obtaining a job in a related field may not be a problem for applicants with work experience and a strong portfolio, it seems clear that AT is not considered as a profession per se, but rather as solely one of the many disciplines that make up the broad curriculum of an architect or engineer.



An architect is expected to be trained and therefore be competent in all matters relating to materials, construction and technology as well as history, theory and design practice. The code of conduct approved by the regulatory authority for the architectural profession in Italy for example clearly states that the architectural profession is an expression of both culture and technology (CNAPPC, 2009). This link between culture and technology is evident in the educational requirements for Architects which comprise various disciplines ranging from architectural history, theory and design, to urban planning, environmental science, architectural technology and other disciplines related to the construction industry (IUAV, 2009 and 2012; Politecnico di Milano, 2012a and 2012b, Università Sapienza di Roma, 2012a and 2012b). The degree programme aims at effectively integrating technical knowledge with design culture.

In Denmark it is possible to undertake a professional Bachelor's degree in Architectural Technology and Construction Management. This full time programme can lead to a job within architectural or construction companies (UCN, 2013). On completion, graduates can apply to become Bygningstekniker, which is a building expert recognised by the Konstruktorforeningen (KF), the Danish Association of Building Experts, Managers and Surveyors. CIAT and KF have a special agreement which "facilitates and simplifies the process of mutual recognition of qualifications and experience with regard to the discipline of AT between the UK and Denmark." (CIAT, 2013b)

In the United States' higher education system, the Bachelor of Science in Architectural Technology is a non-professional (NYIT, 2013) or pre-professional programme that focuses on Computer Aided Design (CAD), as well as graphic and oral communication skills, history, design, environmental systems, building systems and construction (Alfred State College, n.d.). While the programme does not make graduates eligible for the National Council of Architectural Registration Boards certification, it normally places them in the architectural profession as intern architects or advanced technicians e.g. model builders, drafters/detailers and specifications writers. Should graduates wish to continue their education, they can undertake a Bachelor of Architecture or a Master of Architecture.

In Canada, AT is an accredited profession with distinctive competencies and comprehensive training which encompasses all aspects of the architectural building industry (Holland College, n.d.), including CAD drafting, materials, environment, construction health and safety, building services, structures, contracts, law and professional practice, and specification writing (Algonquin College, 2013; Centennial College, n.d.; Humber College, 2013). There are various AT programmes offered by colleges across the country. Becoming certified gives an Architectural Technologist a professional credential recognised across Canada and around the world (CCTT, n.d.). Most provinces in Canada have an association

representing technologists and technicians, such as the Association of Architectural Technologists of Ontario, which also has a collaborative agreement with CIAT in order to facilitate and simplify the process of mutual recognition of qualifications.

As outlined above, recognition of the AT discipline varies considerably around the world. Countries such as Denmark and Canada embrace the profession and view it as playing an important role within the construction sector. Conversely, in Italy, France and Germany AT is not seen as a distinct discipline. Instead, architectural education has a strong technical emphasis where technology tends to be more interconnected with the design process as a whole. Consequently, the requirement for ATs is not as prevalent.

### **3. Creating Distinctiveness**

In response to the question of, “the difference between a Chartered Architectural Technologist and an architect”, CIAT (2011) state, “The difference is within the specialisms that they will bring to a project” Outlining that “Chartered Architectural Technologists' training and emphasis is the science and technology of architecture and Architects' training and emphasis is the design and philosophy of architecture”. This definition supports the notion that AT degree courses currently offered in the UK, offer a scientific and technological emphasis to their curriculum, delivery, assessment and course philosophy: that this is what sets them apart from architecture provision.

However, across the UK there seems to be a disparity between how design modules for students enrolled on AT programmes are delivered. Some institutions tend to focus on developing studio based aesthetical design, closely linked to aspects of architectural education, whilst others focus more on the application of sound scientific, functional and technological design principles. Similar views were expressed by Jones et al (2006 p.28), who produced a study that looked at the teaching of design within undergraduate AT programmes. They stated, “There was a range of interpretations as to what is meant by building design in the context of architectural technology education. In some cases, design was seen as purely technical problem solving, in others as an inventive and creative activity which integrated a range of factors relating to the making of buildings. It could be argued that the range of views which emerged from the study represented either a healthy diversity or alternatively lack of common purpose across this key component of a technologist's undergraduate experience.” Informal discussions with academics within the profession suggest that there has not been a great deal of change regarding the teaching of design since this study was published. This could be partly attributed to the interpretation of the QAA subject benchmark statement for AT.

Although the current subject benchmark statement (2007) clearly identifies design procedures as being one of the “four main aspects” of AT, there still appear to be differing opinions as to how it should be delivered.

In reality, all of the parameters of design; aesthetics, technology and function need be equally embraced and incorporated within module delivery if students are to be provided with a sound knowledge of the subject. Therefore, there is an argument that a re-thinking and re-imaging of design pedagogy within UK based undergraduate AT education is required to forge unique, discipline focused design provision, which is commonplace within all undergraduate programmes.

The role of design teaching within UK based AT degree courses becomes more urgent when considered in light of the AT professional role and, also, considered in relation to criticisms of architectural education. Over the last twenty years, in the UK, there has been a marked acceleration in the development and availability of technological systems and components available to designers working in the built environment (Emmitt, 2010, 2012). As a consequence, the complexity of design-decisions and technical knowledge required to effectively enact these decisions has increased: particularly, but not exclusively, in new-build projects of significant scale which aim for contemporary architecture (Harty and Laing, 2008). In such projects it is increasingly untenable to apply a division of labour around design where an AT will undertake less, or less important, design tasks than architects (Barrett, 2011). Indeed, arguably, the production of working details on such projects requires a higher skill-set because of the need to enact complex design decisions whilst at the same time being mindful of the multiple technical parameters involved in the materials and technology involved.

Recent criticism of architectural education has outlined the feeling that it has not responded to meet the needs of the new built environment (Jann, 2010) and, most relevant to this paper; that it has poor delivery of any conceptual understanding of design as a process required for ATs and architects alike (Barrett, 2011; Coleman, 2010). Therefore, with the rising technological and design challenges facing ATs in practice, the need for a re-think of the delivery of design modules, unique to the AT profession, is required which is separate to and not influenced by what architectural education is providing.

#### **4. Focus on Pedagogy**

The dominance of architectural education and its particular customs and practices within the UK make it difficult to imagine an alternative that is equal and also unique. In these circumstances, a viable way forward is for AT degree provision to focus upon distinct pedagogy, particularly that which

applies to teaching and learning of architectural design in the UK and elsewhere. By following a scaffold of principles for the teaching of design based modules, AT can forge its own identity as a design discipline, perhaps helping to forge a commonality of approach among institutions. Core markers of distinction might include:

- Teaching of design methodologies that lend themselves to generate architectural responses using technical information and factual data (CIAT, 2013c; Rittel, 2010)
- Quantitative approaches encouraged through analysis stages in design modules rather than artistic responses based on personal interpretation and abstract (Blyth and Worthington, 2010)
- A scaffold input from design tutors, which guides students effectively through the design process. Tutors act as facilitators rather than experts in the apprenticeship (McLachlan and Hagger, 2010)
- Collaboration in design rather than competition with a concomitant emphasis on cooperative learning and teamwork (Cuff 1991, Latham 1994)
- Design tutors to model team approach to design with their interaction with students. This implies a departure from the adversarial relationships found in traditional architecture crits (Crowther, 2010)
- A reconfiguration of main assessment methods used in design modules (Sara, 2001)
- Further evaluation and research into architectural technology degree programmes

There are common threads running through the markers above. A key one of these is a focus upon the quality of relationships around learning (tutor: students, peer to peer). Another is a systematic and explicit emphasis on process; this is almost akin to procedure adopted by disciplines which fall within mathematics and science areas. The markers also suggest that the end student output is less important than the process or learning journey. The first three of these markers are discussed below.

#### 4.1. CASE STUDY

One cohort of year two AT students at the University of Central Lancashire were given two short and very focused design briefs that ran simultaneously over a single semester. Students were asked to develop designs for both briefs at the same time. Each brief was assessed separately and carried equal weighting. By completing both projects, students were introduced to the range of skills inherent in a single brief covering the design process from inception to completion. Intentionally, students were steered away from

considering building form, encouraging students to focus upon process rather than product. Design decisions about aesthetics, stylistic preferences or precedent influences were purposefully minimised. This maximised student time spent on design decisions born out of data they had gathered or had been made available. For example: climatic information, environmental analysis, physical constraints and context.

#### *4.1.1. Brief 01: Containment*

This brief focused on internal arrangement and organisation of a particular building typology. In groups, students were expected to develop a site strategy for a given site to design a maximum building footprint with a set minimum car park/delivery provision. This building footprint then provided the design parameters for exploring internal planning. Space schedules were developed in groups before being developed independently by individual students into plans and sections. A set of environmental principles was also part of the containment brief – all key spaces had to be naturally lit and passively ventilated. Difficult urban sites had been purposefully chosen to highlight to students the complexity and impact of design decisions. Assessment criteria were specific, factual and based upon students' ability to explicitly communicate design solutions. For example: no marks were given for reinventing building typology or use of metaphor. Students were assessed through non-verbal presentations with all solutions being communicated through diagrams and architectural drawings – plans and sections – and how their designs met the environmental requirement. Students peer marked the work anonymously against the given assessment criteria of the design brief. Comments captured from peer assessment were used to inform the assessment grade awarded by tutors.

#### *4.1.2. Brief 02: Skins*

This brief utilised the group-work completed on brief 01, by using the same maximum building footprint generated by the site constraints and parking/delivery requirements. However, it did not consider any internal arrangements, but instead demanded students to develop four facades that responded to the external environment. For example: solar path, acoustic issues, right of light, privacy, site exposure and lifecycle. Students were asked to design concept facades and a working detail to scale 1:5. In contrast to the Containment project, Skins required the students to make self-evaluative verbal presentations. For focus, students were asked to highlight their most and least successful parts of their façade details. Post presentation, the cohort was asked to collaboratively suggest detail design improvements to each presenter's least successful detail. Assessment criteria were based upon clarity of drawn communication and the quality of self-evaluation and understanding and demonstrating understanding. Wherever possible both

design briefs minimised subjectivity in the design decision process. Subjectivity was replaced with pragmatic responses. Traditional 'crits' did not take place.

#### 4.2. FEEDBACK

Reflective discussions were held with the class as a whole at the end of both projects. From a pedagogic perspective, they offered many interesting and insightful views on how the assessment had been designed and managed. The students discussed their role in the assessment process and disclosed that understanding how assessment was designed and their required participation at the start of the projects had improved their sense of responsibility towards their own learning and also towards cooperative learning (students supporting each other's learning).

Students disclosed they spent less time worrying about the 'crit' which enabled them to focus more fully on their technical details. They also felt that they had found managing their time between two equally weighted projects of differing scales (1:5 details and 1:200 general arrangement plans/concept sections) simultaneously improved their productivity, as when they were having difficulty with designing at one scale, they switched to the other design brief. They stated that, although combined, the two briefs developed a full range of design skills from inception to completion, finding two smaller briefs less daunting. Student comments were wholly positive when discussing how explicit the tutors had been in teaching a pragmatic approach to design and analysis. Importantly, they stated that they had found this aspect of the projects to be most enlightening. They discussed how this had impacted upon their understanding of the differences between Architectural Technologists and Architects, which in turn allowed them to feel more assured of their role in professional practice. They felt more confident that they could explain the value they bring to any project.

The output for both projects, for the majority of students, exceeded the tutor's expectations to a point where the course leader felt the need to invite the year two cohort to submit work for the end of year degree show, usually reserved for final year students only. It should be stressed that the above feedback from students was qualitative and not part of a systematic research study.

### 5. Conclusion

Although in other parts of the world AT still has a long way to go to establish itself as a recognised profession, the situation within the UK is somewhat different. Since its founding in 1965, AT as a discipline has seen

continual growth. Within the UK built environment sector, the skill set of combining aspects of design, science, technology, procurement and information technology has meant that the profession is recognised as providing and delivering a key service to effectively meet the needs of society.

It is important that each institution, offering undergraduate AT provision, retains its freedom of identity when it comes to the teaching of design. However, there is the need for some commonality across institutions to ensure that students are provided with a solid understanding of the principles of design before expressing their creativity to make projects their own. Whilst this paper, and the study outlined within it, is not wholly conclusive, it offers some useful pointers, which, with further development and additional research, could begin to shape a scaffold of principles that forge a commonality for the teaching of design. The case study in this paper has shown that following the scaffold of principles outlined, when preparing design modules, can have a positive impact on student attitudes and potentially help AT forge its own identity as a design discipline.

In summary, the teaching of design for AT students is crucial in preparing them for their future professional roles and pedagogy can be a viable route for AT to become distinctive and unique. Once the underpinning principles or markers are decided; these provide pervasive direction at all levels of provision.

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# **THE ARCHITECTURAL TECHNOLOGIST AND THE CONSTRUCTING ARCHITECT**

*A comparison between the British professional and the Danish equivalent*

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## **Abstract.**

Along with the increased international exchange of service activities and the efforts to break down barriers for trade across borders it has become still more relevant to look at each other's professions and educations to find a common route for the future. This paper discusses and compares the present situation for the architectural technology discipline in the UK and Denmark and points at important challenges less recognised in both places. It defines and uses 'the best for society criterion' to measure what is appropriate and finds the present structures within the field of building design less appropriate. Furthermore, it points at fields of design-activities not sufficiently covered by education and therefore lowly prioritized in general. It uses a literature review, a case study, and interviews based on a questionnaire to collect its data and finally, it points at a higher level of awareness as a means to improve the situation and recommends that organization and education in the two countries adjust to such basis for further development.

## **Keywords**

History, Different approaches, Increased risk, Fragmentation in design, Two kinds of buildings, Space quality in urban fabrics, Learning environments, Mindsets

## **1. Historic Development of two Almost Similar Professional Disciplines**

In Britain, the university educated architectural technology professional stands on the shoulders of the well-known architectural technician who, again, represents an improvement of the background and position of the architectural assistant. Thus, the profession is seen as very closely related to the architectural profession and as something developed within that profession. This is stressed by the fact that it was architects who took the

initiative to the education in the first place. A high percentage of the educational staff is still educated architects.

Then, why did this professional appear during the last century when he/she was not there in the first place? What needs caused the step by step development of the profession and its education?

In short, the answer to the questions is that the old handicrafts of the construction industry and their traditional techniques are gone leaving us with a serious need for someone else mastering the new technologies and materials in use in today's construction (Eriksen and Thykir 1969 p. 95).

Before this happened, a lot of important technical and detail design decisions were left to the construction craftsmen because of their over centuries developed and rather advanced solutions to the technical problems of how to put a building together (Barrett 2011 pp. 40-48, Graham, Linford and Lobban 2007).

A hundred and fifty years ago many architects had certain training in the construction handicrafts achieved prior to or during their architectural training. Figures for how it was in Denmark in the period from 1754 to 1950 can be seen below (Barrett 2011 pp. 76-83, Weilbach, Boldsen and Engeltoft 1947-1952). The situation in the UK at different stages in history is accounted for by Crinson and Lubbock (1994).

TABLE 1. How Danish architects were educated 1754-1950.

[illegible]

An even more important part of the explanation is that the professional now required to take care of the coherent technical design constitutes a serious challenge to the educational system and to the industry to adjust to. This consideration is especially relevant if we want to make buildings of the same relatively high quality as the old handicrafts mastered. Traditionally, a craftsman's education was longer than that of today's architects and architectural technologists and they definitely belonged to a class in society able to select apprentices among the brighter young boys outside the gentry (Barrett 2011 p. 80, Winther-Jensen 2001).

What is funny about all this is that society and its industry does not tend to see it this way. There is an arrogant pretention among architects that they master both their own traditional discipline dealing with the arrangement and aesthetical design of buildings and at the same time the whole coherent technical design of the buildings. In fact, the responsibility for the coherent technical design of the building moved from the building sites and the workshops of the craftsmen into the drawing office of the architect. Where else was it to go when they were the ones who had the initiative to change the look and the materials of the buildings? Therefore, the architects needed someone to do this new part of the work, which, with the loss of well skilled craftsmen, had to be accounted for by the help of drawings and instructions addressing the new less skilled working force of the construction site (Barrett 2011 p. 68, Kielland 1920, Graham, Linford and Lobban 2007).

The history of the architectural technologist in different countries is quite as different as the countries themselves. In many countries the discipline is not yet recognized as a separate profession in its own right. In such countries mainly architects get a certain informal training in their drawing offices and after a longer period of years some of them become rather good technologists. This is very costly for society because it means that educated professionals are asked to do a job outside their training and profession. They are simply not educated for the job. Someone who, purely based on experience, masters the discipline then needs to check everything they do. As a result, they cannot earn their own salary for a start. They make a lot of mistakes and unfortunately not all of them are discovered by the senior staff. Therefore, a lot of fails and mistakes are continuously made by drawing offices – and this happens despite the fact that the necessary knowledge is available in the industry, even if it is at a less advanced level.

This situation can't continue. It becomes still more obvious that architectural technology is a professional discipline that needs recognition and needs to be supported with education and research at the highest possible level (Barrett 2011 pp. 290-296).

## **2. History of the British Architectural Technologist**

Around 1900 it was a common habit in Britain to employ architectural assistants in the drawing offices. Along with a development in the industry, taking still more industrial products and new materials into use, the craftsmen became unable to utilize their tradition based skills to solve the technical problems the way they used to do. The new kind of work to be accounted for went into the drawing office and the assistants there were asked to do it. Apparently, the new work was more or less outside the interest of the employers, the architects, but of course it needed to be done.

After a while, it was realized that the background of the assistants was not good enough to meet the challenge. An education as architectural technician was invented and introduced.

Since the early 1990es, UK universities have begun to run courses in architectural technology at bachelor and honours level and recently, some universities have even invented master's courses in the discipline (CIAT 2011).

This last development has caused an uncertainty within the business of architecture: Should these people be employed by drawing offices run by architects or should they begin to make their own businesses? – Should they be considered equal to the architects and quite as necessary in the drawing office so that the logical solution would be that both parties are considered architects just with different areas of specialization (Barrett 20011 p. 128)? Should RIBA and CIAT join each other and become one organization? What would serve society best?

## **3. History of the Danish Architectural Technologist**

Shortly after the old guilds lost their privileges by law in 1857 people feeling responsible for the education of building professionals went together and decided to establish technical schools for apprentices within the handicrafts and also a further education for some of the better skilled craftsmen. This further education took 2½ years and gave the title Master Builder. The master builder would make the drawings for most buildings for more ordinary purposes and they would also manage the execution of the construction work as master builders traditionally did (Barrett 20011 pp. 124-129).

Both the professional title master builder and this split-in-two business continued until around World War II. However, from around 1900 architects became socially engaged along with the development of the industrial society and began to design dwellings and multi-storey tenement buildings in a larger scale, because they were asked to do so by newly established building societies. Successively, fewer square meters were designed by

master builders and more and more projects got a large scale which attracted architects. In those days, many architects were trained as master builders before they achieved their architectural education as it can be seen in the above shown statistics (Barrett 2011 p. 79).

In the 1950ies, some of the master builder courses because of this development were renamed to the Danish “bygningskonstruktør” – directly translated it says “building constructor” but a more precise term in English would be “Constructing architect” which is the term in use at present. The title architect is not protected in Denmark and therefore architects use the additional letters MAA (Member of the Association of Architects) to demonstrate their membership of a recognized professional body. Since then, many constructing architects became employed in architects’ offices where they did the coherent technical design of the buildings and later the inspection work at the building site on behalf of their office.

From 1960 to 1970, the development changed the construction industry from being based mainly on old handicraft to being dominated by mainly new components and materials within quite new design contexts. This meant that the skills of the constructing architects with their handicraft background and the additional 2½ years of theoretical education were not good enough for the needs of the industry. As a result, the theoretical education was prolonged with a year and a special organizational frame for the educational institution was created in order to secure a high level of quality (Barrett 2011 p.124). – In those days, all medium long further education belonged to institutions outside the universities. The universities did not possess bachelor level educations. All university education lasted more than 5 years full time and must be considered being at a master’s level.

#### **4. The Resulting National Understanding of the Role of the Technologist**

Of course the two different historical backgrounds in the UK and in Denmark influence the way society and other professionals look at the architectural technologist today. As someone deriving from the position of assisting architects or as someone who is “only” a kind of advanced construction craftsman able to utilise his skills in the production of working drawings (Barrett 2011 pp. 127, 128). In both places, even the technologists themselves are in doubt about how their future roles should be. The organisation of architects in Denmark tends to see the technologists as competitors because the architects pretend to master the very same disciplines as they do, despite the fact that they are not at all educated to master the core area of the AT education (Hougaard 2007). In Britain the subjects taught within the course of architecture appear very similar to those of the technologists and so does also the distribution of the subjects over the respective years of study (Barrett 2011 pp. 193-198). One could think that

the only difference is that the architect's course takes one more year than that of the technologist. However, a further investigation reveals the fact that the approach to the subjects is significantly different for the two educations and this creates rather different bodies of knowledge and quite as different professional mindsets (Barrett 2011 pp. 230-238).

Does society profit sufficiently from the two different kinds of insights and capabilities? – Probably not! The construction industry possesses neither in Denmark nor in Britain the full understanding of the two different roles the educational backgrounds are pointing at. The professionals themselves are not sure about them and this means certain confusion. Should the technologist aim to master all the stages of the RIBA stage model because that is what society needs? Should the architect? – Wouldn't it be too much with two officially different professions who master exactly the same area of needed service to society? – Many would think it an unnecessary waste of time and resources.

Another and much more important objection is caused by the fact that the two different mindsets created in the educational environments points at two different roles within the stage model; the one role being art and design orientated and the other being orientated towards the coherent technical design of the building (Rubin 1921, Barrett 2011 pp. 115-120).

This consideration might lead to another question: "Why do we not face a mindset that embraces both attitudes in one coherent design activity?" A part of the answer might be that the discipline of architecture historically did not deal with the coherent technical design. This was normally undertaken by the different construction handicrafts in unification. Thus, the focus of the architect was purely on art and design issues. What the architect assistants were asked to do was the more boring relatively simple routine like but necessary technical information. But as mentioned, the handicrafts disappeared and a lot of technical information is now needed. We can conclude that the duration of an education to deal with both fields today would be extremely long and might result in less concentrated focus on both parts of the work because the more specialised mindsets would be replaced with one over all mindset (Barrett 2011 p. 272, Lawson 2006 p. 156). However, this is theory because what we can notice in the industry is that even people who possess both capabilities will be asked to do only the one field they have proved best at doing and the other part will be done by somebody else (Barrett 2011 p. 272).

Thus, the separation in two professional areas of specialisation appears quite natural. It is what suits the human mind best and what results in the best buildings for the service of society (Russell 1961 p. 284). Society needs a professional who is an expert in meeting its more subtle but no less important emotional requirements and also an expert who can secure the good technical performance of the building. We have to a certain extent the educations needed for the development of the required qualities but we need

a better general understanding of this to cause a more open accept of the two different roles. Not until this is accomplished will societies get the best possible buildings as a result. – Right now many buildings are lacking some technical qualities due to lack of insight or focus during the design process.

### **5. The Risk of the Lack of Recognition of the two Different Professions**

What are the needs of society? The history of society and its development into modern world's democracies shows us that the service to society of housing and buildings for its members has always depended very much on which part of society the individual belonged to. A member of the working class was put in one kind of premises and those belonging to the gentry or nobility in quite different structures. When looking around one still pretty much sees the picture of a class society in the build environment. Back in time the gentry got their buildings designed by architects whereas what was made for the working class was designed by craftsmen. In fact, the majority of square meters were planned and executed by craftsmen only. When architects got seriously involved it was only due to the fact that a vast number of dwellings were offered to them to design, otherwise it was below their level to touch such inferior purposes. The result became a disaster. Our old cities are surrounded by a boring functionally segregated large ring of unattractive structures - too large in scaling to suit even the simplest request for variation and visual entertainment. The individual is deprived all ability to express individuality and the dwellings can't be distinguished from one another. This is unpleasant and putting people far below the top of the pyramid of human needs if we consider the theory of Maslow (Maslow 1987).

How is it today? – Things have changed but not very much and architects continue to plan and design the type of structures we talk about. Are they designing for a class society?

In fact the answer is yes! And this can be illustrated with a small case story:

*At our second AT-conference in Amsterdam 2010 a couple of famous Dutch architects presented their latest buildings and the next day the whole party of architects attending the conference went out to see one of the presented structures. It was huge and obviously designed to be seen from a considerable distance. From this distance it looked interesting and appeared as a huge sculpture more than a place to house many families. As we approached we noticed that the detailing was delicate and innovative and all praised the design and would obviously have liked to be the architect of it themselves. However, it was unpleasant to be near the building due to a cold wind blowing down on our heads – a wind which will most likely be there most of the time. It was also boring to watch the structure after a little while*



*because now we had seen all of it and the street did not offer anything else to experience.*

*Now I asked my good colleagues if they would like to live in this building. They looked back at it and probably noticed that from outside it would be impossible to identify the limits of any of the flats in it. – The answer to the question was, without any hesitation from any of them, a – “NO!”- But I got no answer to my next question which was: “Why not?”*

*A little later we visited a street where a land surveyor obviously had outlined a lot of small pieces of land to be bought and build on by private investors who desired a building for themselves and their families. There must have been a local plan or other means of regulation because all the buildings now erected had 3 levels. Apart from that they were all of a design quality that proved that they were designed by architects and there were no two equal. To the one side of the street the dwellings went directly out to the harbour and many, we noticed later, had a kind of garage for a boat at a lower level to this side.*

*Now again I asked my colleagues if they would like to live in this place if they were to stay in Amsterdam with their families. – This time the answer was without any hesitation: “Yes, of course!” They would probably have preferred to design their own building there, but they would all be willing to buy, now that all properties were with an existing building.*

This was the story and we could ask: “How come that architects continue to design structures they would not live in themselves?”

The answer we will not get is this: “The reason is that they together with the investors without being aware of it still think we live in and should design for a class society and that they themselves belong to the minority that deserves better than the majority.” This answer is mine and mine only, but I hope my readers will think about it and try to find a better answer if they can! I have been trying to do so but haven’t been successful. What I have found instead is information about what people in general prefer and would like to get when it comes to the environment they would like to surround them when positioned in an urban fabric. The answer from my colleagues referred to above gives a clear indication and a small study undertaken by the help of students in 2012 says the same:

TABLE 2. Urban space preferences

**Street Walkers' opinion about urban space**

Results from a survey undertaken by students using questionnaire supported interviews of people walking different places in the streets of Copenhagen. – 126 interviews were made and below you can see the results. The interviews took place in the spring of 2012.

The main question to answer was: "What would you prefer in the streets you would like to walk and stay in?" The following detailed characteristics were proposed and responded to:

**Result:**

From 126 respondents

| number | Statement                                 | Number of supporters | Support percentage |
|--------|---|----------------------|--------------------|
| 1      | Relatively small buildings                | 75                   | 59.52%             |
| 2      | Buildings containing shops and their like | 102                  | 80.95%             |
| 3      | Buildings with a varied look              | 103                  | 81.75%             |
| 4      | Old buildings                             | 69                   | 54.76%             |
| 5      | Places to eat and drink                   | 120                  | 95.24%             |
| 6      | Places to sit                             | 113                  | 89.68%             |
| 7      | Car traffic                               | 23                   | 18.25%             |
| 8      | A mix of building functions               | 102                  | 80.95%             |
| 9      | A relatively wide street                  | 63                   | 50.00%             |

May be this requires an analysis to make its saying quite clear:

1. **Relatively small buildings 59.52%.** This does not mean that 40% preferred big buildings because most of the remaining percentage expressed uncertainty about the question.
2. **Buildings containing shops and their like 80.95%.** This is leaving no doubt.
3. **Buildings with a varied look 81.75%.** No doubt about the preference.
4. **Old buildings 54.76%.** Little more than half of the remaining respondents preferred new buildings. The rest 20% were

uncertain. This means that twice as many preferred old buildings than those preferring new buildings. This will be further commented below.

**5. Places to eat and drink 95.24%.** This was a bit more significant than anticipated.

**6. Places to sit 89.68%.** This result is less surprising.

**7. Car traffic 18.25%.** A not surprising result. – Those who were positive stated that watching the car traffic could be a bit entertaining even if it is less so than watching people walking or bicycling.

**8. A mix of building functions 80.95%.** Functional diversity is obviously a preference to most people.

**9. A relatively wide street 50%.** This statement and its alternative “a relatively narrow street” created an uncertainty because what exactly does it mean? It was simply too vague formulated to give a useful answer.

If we ask ourselves why so many people prefer old buildings in their neighbourhood, of course we have to consider a number of possible explanations. Personally, I am not sure they are aware themselves. They might say it is a question about taste but when we see it in its context with the other answers it springs into the eyes that the desired characteristics of an urban environment can almost only be found in old centres where the buildings tends to be old. People totally lack the experience that new structures can give them the combination of characteristics they prefer (Barrett 2005 pp. 45-50). – Who will show society that new structures can behave quite as well as old ones by creating the desired urban fabric characteristics? Will it be planners? Or architects? Or – perhaps it will be the architectural technologists?

## 6. The Role of the Professions

As it is right now all indicators tell us that there are no profession that possesses the combination of skills, awareness, will, and power to give society what it desires from its urban environments. The architects are very much in charge of the development because society sees them as its professionals within the task of designing the environments of the future. They win the competitions and they have created the culture that judge the quality of their proposals and therefore they win.

It is not surprising that it is this way because architects are trained to and good at impressing people with spectacular structures and because of lack of

awareness people too late realise that such things do not automatically create the desired kinds of environments. In fact, when it comes to pleasant environments it is not at all useful that all buildings are spectacular. They do not need to be beautiful to behave well to society. It is exactly as with members of society. The best behaving are not necessarily the best looking or those with the most remarkable appearance. As to general experience, a tendency towards the opposite can even be traced.

The mindset of the architect is from ancient times adjusted to the main task: to design the spectacular outstanding building to demonstrate the extraordinary importance of somebody or something to the rest of society whether it was the local earls palace, the cathedral for a bishop or buildings representing the monarchy or the state. This has been going pretty well hand in hand with the eagerness to demonstrate own genius (Feldthaus 2007 p. 57, Brochmann 1969 p. 24).

Outstanding buildings need something to stand out from and if we only create outstanding buildings we just make visual noise and that is unfortunately what is happening so many places today (Barrett 2005). We tend to be missing the good ordinary environment that shows that we are not all participants in a fight with each other but that we are agreeing in participating in the same democratic society. Our words state that we do so but our building habits tend to say the opposite.

In the old town centres all the common buildings were designed by the master craftsmen or master builders. As shown above the architectural technologist is now the one who is educated to fill the gap after the old construction handicrafts. That is what they are trained to do with mainly the same kind of buildings as those the architects are designing. When it comes to buildings that fills the above described gap there are no one who makes them. The new technologies do not implicate that the resulting structures should be quite different from the old ones when it comes to scaling, diversity and good behaviours. The new technologies, industrialisation and new economic orders have just made it easier to make huge mistakes.

Even if the planning profession is a relatively new one it has long ago developed a rather two dimensional mindset. It is very much about lay outs and maps showing how different functional needs should be physically separated in huge isolated areas with as much distance between buildings as possible because people over time will tend to build as much as they can using large scale structures. Smart infrastructures with more or less separation of the different kinds of traffic to optimise security contribute to complete the resulting unpleasant fabric. There is absolutely no outdoor urban space of quality in these areas. It is luck that planners and architects can take their cars and pass through them within a relatively short time. Unfortunately, not all people can do the same. Most people have to stay there.

The mindset of the architectural technologist is trained to think in three dimensions like the one of the architect but it doesn't implicate the same ambition of making the outstanding. It is much more at ease with the good performance even if anonymous. This seems close to the ideal for those who should begin to make the good urban environments of the future but it requires a new awareness in society, among politicians and among professionals. The mindset of the architect is also needed but only for the structures that deserve to stand out because they are meant to give service to or represent society as a whole (Barrett 2005). These structures also need the technologists as they previously needed the handicrafts. It is the ordinary fabric that is missing its designated professional right now. **Should the technologists have the extra training required to undertake this most important kind of work?**

## 7. Conclusion

Architectural technologists in the UK and in Denmark are in fact filling the same gap left in the building industry after the old construction handicrafts went out of use. This is not seen so clearly because of different newer developments of the professions and educations.

Society doesn't get the service from the professions of the building industry it needs and deserves.

This is due to lack of recognition of the right roles for architects and architectural technologists when we talk about the type of buildings that should stand out from the ordinary.

The type of buildings, that should establish the basic or ordinary good quality fabric, technically possesses the same kinds of lacks and mistakes as the first mentioned and due to the same reasons. They are also totally misbehaving and failing in working together on the creation of public spaces of quality and hosting a pleasant mix of functions as desired by all kinds of people in society.

The mindset of architects is opposing the role to do the more ordinary or humble. The mindset of the technologist is much more likely to accept such an aim but the AT-training of today does not create the insight and ability needed to do this job even if it would not require a lot of effort to establish such a situation.

First and foremost, a lack of awareness of needs and possibilities constitute a barrier for society and industry to create a much pleasanter situation than the present!

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## BRANDING THE TECHNOLOGY

### *Delivering the Cream*

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**Abstract.** Just as the title Mr (Ms/Mrs) rather than Dr (Doctor) is a badge of honour for surgeons, documenting the sequence of how the profession emerged from a craft in the 19<sup>th</sup> century, so too is the branding of technologists on the cusp of shedding the image of the misconstrued subordinate role to architects. This will allow technologists to claim their rightful place shoulder-to-shoulder with other design professionals within construction.

By branding the role of the technologist, through technology, a similar path can be taken to establish the title and build a robust and well founded plinth upon which to promote their undoubted skills. Such an action will see their meritocracy improve and consolidate their rise from technician, while also opening new specialisms. Moreover, it will profile their services and present their wares on a surer footing.

Being able to figure and document constructions makes design better informed. Analysing and simulating models, makes models useful. Building information into models is the rightful domain of the technologist. Building Information Modelling (BIM) is the platform to make the technologist not only indispensable but critical. Modelling removes prototyping from the site, consigning costly mistakes to the past while installing certainty and predictability to the much maligned sector.



## 1. Introduction



**Figure 1 'Angelus Novus', Paul Klee 1920**

*'A Klee painting named 'Angelus Novus' shows an angel looking as though he is about to move away from something he is fixedly contemplating. His eyes are staring, his mouth is open and his wings are spread. **This is how one pictures the Angel of History.** His face is turned towards the past. Where we perceive a chain of events, he sees one single catastrophe, which keeps piling wreckage on top of wreckage and hurls it in front of his feet. The angel would like to stay, to awaken the dead and make whole what has been smashed. But a storm is blowing from Paradise; it has got caught in his wings with such violence that the Angel can no longer close them. The storm irresistibly propels him into the future, to which his back is turned, while the pile of debris before him grows skyward. **This storm is what we call progress.**'*

*Walter Benjamin, Thesis on the Philosophy of History (1940) (Frampton 1998)*

The master builder's endemic style of the middle ages has grudgingly given way to the dedicated design team's procurement methods of the modern era (Barrett 2010). This is now increasingly giving way to the broader stakeholder's role in the supply chain process (Harty 2012). This new scenario is one that encompasses more than the traditional handover procurement method renowned to the most of us, for one that stretches from initial financial modelling (pre-project) through to life cycle operations and maintenance - bringing users and third parties into the mix. These additional stakeholders were previously peripheral operators or merely concerned citizens (Harty, Laing 2010a). This enlargement and liberation of the process comes at a price, but it is one that is happening and as Thom Mayne said at the AIA National Convention in Las Vegas in 2006:

*'It's about survival. If you want to survive, you are going to change; if you don't you're going to perish. It's as simple as that... you will not practice architecture, if you are not up to speed with this... (Mayne 2006).'*

Essentially, this was intended for architects but it applies across the construction spectrum. The 'it' he refers to is building information modelling (BIM), and the digitalisation of the procurement process. 'BIM is not a particular product, but rather a description of the process and intent of the deliverables used to describe, construct and even maintain a facility' (Aubin 2013). While it appears to be the implementation of a technology (Eastman 2012), it is in fact the psychology of how we can work together, collaborate with each other and trust each other's work. It is about how we share data, use data and present data, in forms that are meaningful to the intended recipients. Of interest here is how this filtration process can be accomplished and who can deliver what it entails (Harty, Laing 2010b). There comes a paradigm shift where levels of detail, augmented reality and geographic information systems (GIS) embellish the model making it robust and transparent but requiring solid management (Smith, Tardif 2009).

Finding a discipline competent and knowledgeable to understand modelling is not immediately easy; architects would like to regain their status at the top of the design team hierarchy (Gehry 2008), engineers having seen BIM's potential and would like to hijack the enterprise (Throssell 2010), contractors gain better control on time and resources with its implementation (AGC 2008) and lastly owners and clients are beginning to see that certainty accrues from having a model in place (Deutsch 2010). But while each have their well-intentioned reasons, none have grasped the gauntlet and taken ownership across the board (Harty, Laing 2011b).

There is huge potential here for a discipline to brand this facet of technology (Harty, Laing 2010b). The timing of this is also well adjusted since (with regard to BIM), we are past the innovator stage which saw the emergence of digitalisation, and the early adopters category which heralded the great

strides in reforming the construction industry. We are now entering the early majority phase which will see a generally beneficial period for users, to be followed by the late majority leaving finally, the laggards who are in principal driven only by an overriding fear of debt (Rogers 2003).

With the title of technologist, it is befitting that the scope or range of that discipline broadens to encompass this digital phenomenon. Furthermore, the rigours of a technologist's work regularly take them into close proximity with the other professions (KEA 2013). From a position of being a generalist, which is cherished in Denmark the time is right to exploit this situation and drive bull-headed for the finish line. All it requires is a mind-set and this well underway to be cemented through many initiatives both from within and without the profession (Harty, Laing 2011a).

The construction industry is accepted as being fragmented (Smyth, Pryke 2008) specialists for whom it is advantageous to operate alone, bidding for individual projects and occupying a niche which can be guarded and cherished, making the whole process quite conservative and reluctant to change (Smyth, Pryke 2006). But being lightweight also makes it easier to adapt and adjust to the peculiarities of each project if the conditions are right (Sigurðsson 2009). There are also many main contractors for whom it is easier to outsource aspects of contractual work, rather than carry the risk that might be associated with employing someone, and paying overheads, just to be able to offer that particular service or deliverable. This firmly bases the construction industry in pre-industrial times (Kristensen 2011).

The pre-industrial times charted the dominance of the master builder, supported by craftsmen and apprentices, which operated in a relatively closed framework of building methods and practices. Masons were masons, carpenters, carpenters and so on, each knowing what was required through a learned process of apprenticeships with expectations that were essentially ring-fenced. This clearly served the society of its time, as witnessed by the calibre of buildings produced then.

With the advent of steel and reinforced concrete came innovative developments that fell outside the confines of the previous regime (Lemoine 2006). This led to designers having to ground their designs, requiring larger teams of experts making qualified decisions. It heralded the role of the engineer in building procurement. These included structural requirements, service installations and the emergence of performance related tasks. In 1865, MIT (Massachusetts Institute of Technology) emphasised teaching students to use machine tools rather than finished products (Mack 2005). Regarding education, there was a problem whether to teach engineers the classics, science or merely provide training, resulting in them finally turning to the applied sciences. Enter now the architectural technologist, where these actions became even more complex, but who are traversing a similar path (AAU 2011). The comparison with surgeons relates back to the battlefield where they were the barber surgeons cutting limbs off with little scientific or

technical knowledge bereft of the application of systematic research (Barrett 2010).

## **2. The Architectural Technologist**

### **2.1. DEFINITION**

Defining an Architectural Technologist is difficult from country to country, and ranges from a generalist to a person that screws (a Danish term) a building together. The synergy that drives the architectural technologist could also be said to derive from the artistic, which encompasses design, is somewhat intangible albeit creative; together with the procedural, being ordered, deliverable and managed; coupled with the practical, that is functional, tangible and technological (Emmitt 2012). The cornerstones of the design manufacturing process start with a conceptual cycle where ideas are hatched. This evolves into a functional phase where there is an assessment of fit-for-purpose, to an aesthetical stage where the form emerges. From here, there is a transition from design to manufacture called fabrication. Finally, there is an underlying process to underpin the methodologies used in all the above operations (Kowalski 2012).

Because of the diversity of terms, roles and engagements across Europe and indeed the world, there are many definitions and impressions of the technologist. The title ranges from architectural technologist, to constructing architect (DK), to tecnico (E), to constructeur (F). Each country has a national body representing and protecting their title, such as CIAT (UK) or KF (DK). There is also an umbrella European body, the Association of European Building Surveyors and Construction Experts (AEEBC), which has launched a European Building Expert (EurBE) scheme accrediting suitable qualified professionals across Europe as candidates who meet the experience and competence requirements jointly agreed. Similarly, there are long standing bodies such as Royal Institute of Chartered Surveyors (RICS) who have reinvented themselves, not only as quantity surveyors (as traditionally known) to property professionals with expertise in land, property and construction (RICS 2012).

Despite all of these noble endeavours, technologists still have not received their rightful place alongside other construction professionals, or the prestige that goes hand in hand with this. Beyond the generalism that they clearly wield, there are currently little or no advancement possibilities available to them. Construction is acknowledged as being poor and at early teething stages within academic circles (Knight, Ruddock 2008).

### 3. Meritocracy

#### 3.1. THE DEMISE OF PATRONAGE

In the 1870's patronage was effectively abolished from the British civil service in favour of competitive entry. This was due largely to compulsory education being made available to the masses. Thus, 'merit became the arbiter, attainment the standard for entry and advancement in a splendid profession' (Young 2008). In turn; '...it would be natural to expect that so important a profession would attract into its ranks the ablest and the most ambitious of the youth of the country...' (Northcote, Trevelyan 1853). As a result of this Young goes on to tell us that; 'today we frankly recognise that democracy can be no more than aspiration, and have rules not so much by the people but the cleverest people; not an aristocracy of birth, not a plutocracy of wealth, but a true meritocracy of talent'.

This emergence of the word talent should not go unnoticed. Furthermore, the idea for merit to be earned should also be noted. Both of these things make knowledge and technology valued entities. In parallel fields (IT for example), much work has been done in Technology Acceptance Modelling (TAM) and Innovation Diffusion Theory (IDT). Essentially they are addressing people's perception and adoption of technologies through their Perceived Usefulness (PU) and their Perceived Ease-Of-Use (PEOU) (Davis 1989). The root of the problem stems from a reluctance to embrace new technologies or to be open and accepting of foreign entities.

This behavioural trait is therefore a barrier to adopting new technologies for a variety of reasons including attitude, intention and reliance. To overcome them they have to be seen as positive, and beneficial to the user. Finally, a marketing ploy known as product placement is a method of peer acceptance that new technologies have adopted to encourage acceptance. This is known as diffusion and it is the rate by which a new idea or a new product is accepted by the market (Bass 1986).

Technologists need to adopt these methods and be seen for their worth within the construction sector. Being able to figure out and document constructions makes design better informed. Being able to analyse a construction brings certainty to the market. Being able to justify, through simulation, choices taken, puts the technologist onto the critical path.

## 4. Conclusion

### 4.1. THE BENEFITS

The Architectural Technologist's cause is not to present the profession as a technological solution in itself, but to promote the benefits of that technology. This means endorsing the return of investment, authorising case studies and proven methodologies and diffusing the message from one stakeholder to the next, which feeds the end-users' tangible benefits for their adoption.

Ultimately, this means being able to quantify the needs, demands and requirements to enable works, rather than posing as the mere technologist equipped with the proper technologies to deliver the same. This difference is important, because if you cannot measure it, you cannot deal with it.

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# **ARCHITECTURAL TECHNOLOGY AS A DESIGN DISCIPLINE: ASCRIBING DESIGN THEORY TO THE PRACTICE OF TECHNICAL DESIGN IN ARCHITECTURE**

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**Abstract.** The role of design generally and in particular technical design in the discipline of architectural technology has yet to be fully articulated, however the endeavour provides an interesting topic for exploration as the word design alone conjures up many different constructs. Firstly this paper seeks to approach the concept of technical design in architecture through comparison with other allied design disciplines namely engineering, industrial design, product design and indeed, architecture. Secondly, technical design as a model remains to be expressed in terms of design theory notwithstanding that a full understanding of design in all its manifestations is still fragmentary. Yet Schön's idea of design as reflective practice and by contrast Simon's concept of design as rational problem solving do provide a foundation for a tentative glimpse into how the concept of technical design in architecture could be defined. The purpose of this paper is to propose a conceivable model in order to initiate dialogue and research rather than offering a definitive answer.

## **1. Introduction**

To many who operate in the professional disciplines closely allied to mainstream architecture, the word design conjures up countless differing constructs. There are numerous interpretations of the word, ranging from a very restricted view that it forms the creative element in architecture to the much wider and all encompassing view that design is the planning for the construction of any object or a system. Significantly however, the role of design in the specific discipline of architectural technology has yet to be fully articulated.

As a professional discipline, architectural technology is defined by the various professional bodies that represent practitioners working in the field; as an academic discipline however, it is still fairly undeveloped and particularly pertinent is its relationship to the concept of design. It is beyond

the scope of this paper to attempt any wide exploration of the discipline but taking a more focussed view on the technical creation process in architecture, can allow an interesting examination of the process and how it relates to the notion of design.

To begin with and to provide a benchmark for further discussion, Mat Hunter, Chief Design Officer at the Design Council, offers a very elegant and simple definition suggesting 'Design is all around you, everything man-made has been designed, whether consciously or not'(Hunter 2012). This allows us to start from the premise that the technical creation process in architecture is indeed design of some form. Where Sir George Cox former Chairman of the Design Council writing in the Cox Review (2005) states that 'Design is what links creativity and innovation. It shapes ideas to become practical and attractive propositions for users or customers. Design may be described as creativity deployed to a specific end.' he opens the door to explore the application of design as a process found in similar yet discrete disciplines such as engineering, industrial design, and indeed architecture.

It does not take much reading around the subject of design theory for the various disciplines mentioned above, to quickly come to the conclusion that none claim to own a definitive design theory; yet all are embroiled in debate and considerable research to further thinking in this area. Two fundamental schools of thought, Schön's idea of design as reflective practice (Visser 2010b) and Simon's concept of design as rational problem solving (Visser 2010a), do stand out however as powerful and at times conflicting theories of design.

As well as the benchmark provided by the Design Council, it is anticipated that a brief exploration of the role of design in the allied disciplines will also provide some points of reference with which to compare and contrast the design activities in architectural technology. In addition, it is expected that a deeper examination of design as reflective practice or rational problem solving will provide a tentative proposal of how technical design in architecture could be defined. The purpose of this paper is to propose a model simply in order to initiate dialogue and research rather than attempting to offer a definitive answer.

## **2. Design in allied disciplines**

Returning to the Design Council for a balanced and dispassionate view of design because it has no allegiances to any particular design field, it soon becomes clear that the concept of design is synonymous with the concept of good design. Mat Hunter states, 'The question therefore isn't so much 'what is design and why does it matter?' but 'how can I use good design to make the world around me better?'(Hunter 2012). This expectation is by its nature subjective and therefore increases the difficulty in obtaining an objective

deduction. The problem this poses is 'what is the converse of good design?' which leads onto 'if it isn't good design, it must be bad design because it cannot just be design.' The notion of 'just how good?' then has to be confronted to compare the 'adequately good' solutions with the 'exceptionally good' solutions. A less emotive term may be 'effective design' as it brings into consideration the idea that the efficacy and thereby the quality of the solution can somehow be measured. An example that illustrates the importance in achieving this clarity of definition is that of weapons design; they can be described as effective design or otherwise but, depending on your personal viewpoint, are rarely described as good design.

The fact that the concept of good design continues to dominate the thinking of many great designers is inescapable however. Dieter Rams (Rams 1973) a distinguished industrial designer came up with his 'ten commandments' namely;

1. Good design is innovative
2. Good design makes a product useful
3. Good design is aesthetic
4. Good design makes a product understandable
5. Good design is unobtrusive
6. Good design is honest
7. Good design is long-lasting
8. Good design is thorough down to last detail
9. Good design is environmentally-friendly
10. Good design is as little as possible

Rams's list does have something of a religious feel to it and also provides support to a definition of industrial design provided by the Industrial Designers Society of America (IDSA) who state that 'Industrial Design (ID) is the professional service of creating and developing concepts and specifications that optimize the function, value and appearance of products and systems for the mutual benefit of both user and manufacturer' (<http://www.idsa.org/what-is-industrial-design>).

Interestingly, in their 348 word definition IDSA never once use the word 'good'.

If the professional discipline of architectural technology is to take anything from this brief look at industrial design, it is the reflection on what good design might look like although substituting 'effective' for 'good' may be preferable. The actual practice of industrial design however does not seem to have an apparent parallel in architecture.

Moving on to the discipline of engineering and to be more precise, the specific area referred to as engineering design. The National Aeronautics and Space Administration of America (NASA) state that for them, 'The Engineering Design Process is a series of steps that engineers use to guide them as they solve problems. Engineers must ask a question, imagine a solution, plan a design, create that model, experiment and test that model, then take time to improve the original – all steps that are crucial to mission success at NASA.'

([http://www.nasa.gov/audience/foreducators/plantgrowth/reference/Eng\\_Design\\_5-12.html](http://www.nasa.gov/audience/foreducators/plantgrowth/reference/Eng_Design_5-12.html))

Australia's National Committee on Engineering Design in a article prepared by Cliff Green claim that 'Engineering is Design'.

(<http://www.ncedaust.org/index.php?select=63>).

This bold statement is however preceded with a persuasive declaration suggesting that, 'Engineering is the application of science to problem solving. Design is the creative expression of knowledge...' Green goes on to assert that design must be creative; if the creative expression is emotional it is art but for it to be design the expression must be of knowledge. He also acknowledges significantly that art and design are often encountered as a combination of the two as are the concepts of science (analysis and research) and design.

These are important concepts for the discipline of architectural technology where a similar relationship exists with the science of building and design (The Chartered Institute of Architectural Technologists (CIAT) maintain that, Chartered Architectural Technologists are specialists in the science and technology of architecture, building design and construction - <http://www.ciat.org.uk/>). Cliff's closing words in the article are particularly relevant here where he states 'Research & analysis is science. Both Engineering and Science are important; but knowledge alone is of no consequence to the future of life if it does not manifest itself into material significance through design'. The word engineering could easily be substituted with architectural technology.

To conclude this section it is necessary to spend some time looking at design as it is manifested in the very closely allied discipline of architecture. Although the alignment is close in that both the discipline of architecture and that of architectural technology exist in close proximity and are often confused by the layperson, those closely involved know the differences to be quite clear despite some significant overlaps.

The Royal Architectural Institute of Canada (RAIC) state that, 'Architecture is a passion, a vocation, a calling – as well as a science and a business. It has been described as a social art and also an artful science. Architecture must be of the highest quality of design'

([http://www.raic.org/architecture\\_architects/what\\_is\\_architecture/index\\_e.htm](http://www.raic.org/architecture_architects/what_is_architecture/index_e.htm)). This description brings together most of what has been described earlier

in this paper and although commendable in its aims, on the evidence seen so far it could also be described as an ambitious aspiration. Clearly it is not and possibly this lack of a definitive clarity may well be one of its strengths.

To encapsulate the range of design methods and theories that can be found in mainstream architecture is a major undertaking and well beyond the scope of this paper. However just as the quotation above from the RAIC can be used to illustrate a certain angle, there are others that can help in a search for design perspectives that can contribute to a deeper understanding of the process of technical design. One such viewpoint comes from a straightforward and concise account of design methods in architectural design management by Henri Achten. This short paper quickly recognises that much of the daily practice of architecture varies considerably yet all are to some degree classified as design. In addition, although he also points to the two underlying theories of design as reflective practice or rational problem solving, Achten acknowledges that, 'It is fair to claim that our current understanding of design is still incomplete' (Achten 2007). He also recognises that the complexity of the design situation in architecture presents a classic example of Rittel and Webber's 'wicked problems' where the 'interdependencies' of the various design parameters means that solving one means revealing or even creating further problems down the line, illustrating the 'ambitious aspiration' referred to earlier (Rittel and Webber 1973).

An interesting development in architectural design thinking is that concerning the concept of evidence based design in architecture. Brandt et.al., contend that architecture has become over reliant on intuitive design and 'must be able to rely on evidence to anticipate the effects of our work' (Brandt et.al. 2010). In supporting the concept they point to research as the primary supply of the required 'evidence', and in so doing echo the stance of Australia's National Committee on Engineering Design in Cliff Green's article. Their statement suggests the following criteria for effective evidence based design:

- A clearly defined and proactive research question, related to client goals and informed by prior research and experience (Hypothesis)
- Use of both disciplinary and interdisciplinary knowledge as a foundation (Epistemology)
- Use of accepted standards for measuring performance outcomes (Metrics)
- Striving for the most reliable and valid performance predictors, preferably from more than one study and using more than one methodology (Strength of evidence)

- Peer review to certify the quality of methodology and reasonableness of outcomes (External validation)
- Clear and understandable communication of research approaches, including assumptions, limitations, constraints, and methodology, so others can make good critical judgements about applicability to their context (Transparency) (Brandt et.al. 2010).

This list of research criteria has great significance in that it matches fairly closely the publicly stated position of the Chartered Institute of Architectural Technologists (CIAT) who state that the following description applies to professional architectural technologists in the United Kingdom

"The Chartered Architectural Technologist, MCIAT, will be able to analyse, synthesise and evaluate design factors in order to produce design solutions, which will satisfy performance, production and procurement criteria. This will be achieved through the design, selection and specification of material, components and assembly and the management, coordination, communication, presentation and monitoring of solutions which perform to the agreed brief and standards in terms of time, cost and quality". (<http://www.ciat.org.uk/>)

### 3. Design Theory

Technical design in architecture as a model remains to be expressed in terms of design theory although Achten and many others point to Schön's idea of design as reflective practice as having an important part to play in architectural design, and by contrast Simon's concept of design as rational problem solving is found to support engineering design.

However the world of engineering design and particularly engineering design education is now looking toward reflective practice to provide a theory based framework for dealing with the complexity of many design problems. According to Adams et al. 'the reflective practitioner model is well suited for capturing professional activity in which practitioners must grapple with unique, value-laden, and uncertain situations and, from these situations, constructively shape problems that can be solved' (Adams et.al. 2003).

As a reminder, the aim of this particular paper is to provide a foundation for a discourse into how the concept of technical design in architecture could be defined. As such it is compelled to consider more closely the two foremost design theories on offer, rational problem solving vs. reflective practice. Writing in 2010, Willemien Visser produced two articles in the same journal (Collection #2, on "Art + Design & Psychology" from the Paris College of Art.), each a review of one of these two theoretical frameworks. From this work it becomes clear that Simon's Symbolic Information Processing

(renamed rational problem solving by Dorst in 1995) is the earlier work and is based very much around the concept of design as science. Simon's work is very wide ranging however and of his 700 published papers, only 10 are concerned directly with design. Indeed even his most influential work, *The Sciences of the Artificial* (Simon 1969/1996) only has two chapters dedicated specifically to design. With its roots in cognitive psychology, it seems as though Simon's design realisation is more likely to be found in the further work that it has inspired. According to Visser, 'There are also many authors who globally adopt Simon's framework, but propose more or less profound complements or modifications' (Visser 2010a). One of these may well be Schön, the alternative theoriser, even though Visser suggests 'Schön is the first author after Simon to introduce a new approach to cognitive design theory' (Visser 2010b).

Schön's work by contrast was based very much in the domain of architecture and also 'concerned with the way in which "professionals think in action" as "reflective practitioners", and with "educating" this reflective practitioner' (Visser 2010b). Schön also introduces another important concept when he suggests that "competent practitioners usually know more than they say. They exhibit a kind of knowing in practice, most of which is tacit..." (Schön 1983) In so doing he appears to recognise the innate, intuitive skill of designers.

The essence of Schön's ideas is however summed up by Visser with the suggestion that 'In their reflective conversations with design situations, designers frame and reframe problems. In such conversations, the practitioner's efforts to solve the reframed problem, yields new discoveries which call for new reflection-in-action. The process spirals through stages of appreciation, action and re-appreciation' (Visser 2010b).

Another important piece of work in this context is the comparison between the two design concepts presented by Dorst & Dijkhuis in their paper *Comparing paradigms for describing design activity* (1996). Although the sentiment appears to lean toward reflective practice, the paper in summarising the two methods does delineate a similar course of action for rational problem solving. In comparing the 'designer', the 'design problem', the design process', 'design knowledge' and what they provide as an 'example/model', a simple yet seductive comparison emerges. Table 1 from Dorst & Dijkhuis (1995) provides an intriguing depiction for consideration although the term 'information processor' is unfortunately uncomplimentary despite the qualification and after Green (accessed 2013), the term 'knowledge processor' maybe more appropriate.

Table 1

|                             | <i>Rational<br/>Problem<br/>Solving</i>                                     | <i>Reflection<br/>in Action</i>  |
|-----------------------------|---|--|
| <i>Designer</i>             | <i>Information<br/>process<br/>or<br/>(in an<br/>objective<br/>reality)</i> | <i>Person<br/>constructing<br/>his/her<br/>reality</i>   |
| <i>Design<br/>problem</i>   | <i>Ill<br/>defined,<br/>unstructured</i>                                    | <i>Essentially<br/>unique</i>  |
| <i>Design<br/>process</i>   | <i>A<br/>rational<br/>search<br/>process</i>                                | <i>A reflective<br/>conversation</i>   |
| <i>Design<br/>knowledge</i> | <i>Knowledge of<br/>design<br/>procedures and<br/>'scientific' laws</i>     | <i>Artistry of<br/>design:<br/>when to<br/>apply<br/>which<br/>procedure/<br/>piece of<br/>knowledge</i> |
| <i>Model</i>                | <i>Optimisation<br/>theory,<br/>the<br/>natural<br/>sciences</i>            | <i>Art/the<br/>social<br/>sciences</i>   |

*Adapted from Dorst & Dijkhuis 1995*



To be exact however, a true comparison between the positions of Simon and Schön is not possible because there is no output from either that can be compared directly. So as in Dorst et.al we end up comparing Schön's ideas with the many interpretations of Simon's work; clearly not ideal. However Dorst & Dijkhuis do concede that 'Describing design as a rational problem solving process is particularly apt in situations where the problem is fairly clear-cut, and the designer has strategies that he/she can follow while solving them'. They go on to conclude that 'Describing design as a process of reflection-in-action works particularly well in the conceptual stage of the design process, where the designer has no standard strategies to follow and is proposing and trying out problem/solution structures' (Dorst & Dijkhuis 1995).

Continuing to consider the information in table 1, particularly that listed under *rational problem solving*, an impression emerges suggesting the contention of Brandt et.al., that architecture requires evidence to predict the effects of design, is not too dissimilar to what might be expected in a 'rational search process' (Brandt et.al. 2010). In fact the entire list provided the term 'knowledge processor' replaces 'information processor' fits quite neatly into the CIAT description noted above. In order to '*analyse, synthesise and evaluate design factors*' a significant working knowledge of the subject is required, '*performance, production and procurement criteria*' as any involved in the process will verify is a standard ill defined or unstructured problem, also the '*the design, selection and specification of material, components and assembly and the management, coordination, communication, presentation and monitoring*' can be portrayed as a rational search process subject to scientific laws and definitely seeking the optimum solution.

Conversely it could also be argued that technical design in architecture, so closely related to performance, has less need for most of what table 1 offers under Reflection in Action, although as Adams et. al. (2003) have found a 'reflective conversation' can add significantly to the value of a 'rational search process'.

#### **4. Conclusion**

The purpose of this paper was to propose a conceivable design model for technical design in architecture in order to initiate dialogue and research rather than offering a definitive answer. The brief look at allied disciplines produced some interesting information although only engineering design

could be said to offer anything like a comparable experience, something that most involved in the process would not be unduly surprised to hear. Engineering as the application of science to problem solving with design being the creative expression of knowledge is a particularly transferable paradigm although requiring some further interpretation for architecture.

Probably the most helpful contribution and perhaps unintended, comes from Dorst & Dijkhuis (1995) where in attempting to objectively compare the two methods, they produce a compelling argument in favour of *reflective practice* but also introduce the subjective notion of 'artistry of design'. In doing so they leave a simplified yet highly effective methodology for approaching technical design where objective and optimal performance is the crucial attribute of the required solutions.

This paper has deliberately avoided intimating which parts of the architectural design process can or should be described as technical design. Clearly this is a particularly pertinent and fascinating subject and, although beyond the scope of this paper, there is a need to establish whether the antonym to technical design is definitely aesthetic design; and then before choosing particular design theories, whether it is reasonable to assume that the process of architectural design is essentially made up of various phases that move between the technical and the aesthetic, perhaps requiring distinctly different design approaches for each. Or more simply is it possible to suggest that the physical, performance aspects related to the natural sciences should follow the *rational problem solving* route whereas the aesthetic, conceptual aspects related to the social sciences should follow the *reflective practice* route. This unsophisticated solution does have value providing the merits of each system are not excluded from the other; or is the design process in reality already a blend of the two.

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# SUSTAINABLE DESIGN STRATEGIES IN HOSPITALS

*Daylight and ventilation, complexity and relations*

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**Abstract.** This paper presents a small part of a master thesis study, which investigates the sustainability effects and overall strategies concerning ventilation and daylight hybrids. The present paper is exploring the complexity and relations of daylight and ventilation hybrids in hospitals. Hospitals are facing the challenge to optimize and focus on creating "good results". Hospitals need to be streamlined supporting a development with fewer re-admission and reduce the admission time. Knowledge about the ambient effect on healing is getting more attention. Designing an environment that plays a therapeutic role for patients as it's done very well in *Alvar Aalto's* Paimio Sanatorium in the late '20s. The hospitals have to reduce the footprint and moving toward carbon neutrality, the health sector can demonstrate a path to respond to climate change, advocating a coherent healthy and sustainable future. The master thesis explored various strategies to lower energy consumption in order to improve the healing environment in hospitals, with a focus on daylight and ventilation strategies. Ventilation and daylight are linked together, from the overall hospital structure and flows to the smallest window in the envelope and have influence on both the indoor environment and the potentials of lowering the energy.

## 1. Introduction

The aging population (65+) will increase with 50 percent by 2030-2040, representing an increase from 800,000 to 1,200,000 people in Denmark. It's estimated that health cost will increase from 6.5 to approx. 8 percent and 10-13 percent if the period is extended to 2050 (Teknologirådet 2002). It is not only in Denmark the amount of elderly people is increasing but also in Europe and USA. The future hospital will have to meet the challenge of a growing population above 65 years old. This is not the only challenge also the effect of climate changes in the future will have an influence on healthcare. World Health Organization (WHO) has reported:

*“A warmer and more variable climate threatens to lead to higher levels of some air pollutants, increase transmission of diseases through unclean water and through contaminated food, to compromise agricultural production in some of the least developed countries, and increase the hazards of extreme weather” (WHO, 2009).*

Hospitals are facing the challenge to optimize and focus on creating "good results". Hospitals need to be streamlined supporting a development with fewer readmissions and reduce the admission time. New knowledge about the ambient effect on healing is getting more and more attention. Evidence-Based Design (EBD) documentation has created a new paradigm in hospital design. It is no longer sufficient merely to take account of function, hygiene, construction costs and logistical issues. Other factors such as environment, light, sounds, surroundings, safety, view, nature and colours have an influence on the patient's healing and employee's wellbeing. This means that many hospitals are to be updated from previous clinical functionalism to create stimulating environments. EDB is not the only design principle; it is also necessary to look at other areas such as adaptation to the requirements of the quality reforms and the sustainability and energy conservation in design and architecture of the hospital.

This paper will address the health sector's climate and comfort potentials, identifying the potentials and challenges of new build hospitals and future developments.

## 2.1. RESEARCH QUESTION

My hypothesis is that we have to rethink daylight and ventilation hybrids in hospitals. We have to move away from standard solutions and norms, designing from user's point of view together with sustainable architectural and structural influence. We have to be more precise in analysis of user behaviour and at the same time be quite flexible in a fast developing business and constant developing technology for healing purpose. We cannot rely on technical and practical solutions alone in the process of healing people; we have to go far beyond these solutions to reach a high level of comfort and low energy solutions.

A wide range of challenges will be limiting the design of new hospitals, unless new design principles and methods organizing the hospitals are rethought. When we today have to reduce the energy consumption and at the same time create a healing environment in hospital design, we have to find new solutions of high potential; shortening the healing process, creating an attractive work environment, lowering the energy consumption, not only as

energy reduction parameters but also reduction of the whole building lifetime cost.

What is, in the design of hospitals, the relations and complexity of achieving low energy consumption and improving comfort, using natural ventilation hybrids together with optimized daylight strategies? And how is daylight and natural ventilation linked?

## 2.2. METHODOLOGY

The approach in this thesis is based on sustainable architectural theories. Sustainable architecture, that is determined by three images of architectural sustainability; the natural image, the cultural image and the technical image where the three images are caricatures in a practice that hence to include more than one image at the time: the natural image with environmental concerns, the cultural image with concerns to place and people and the third technologies and global environmental impacts (Williamson et al. 2003).

As part of the empirical study, I have chosen to conduct interviews with a number of persons having practical knowledge and experience in hospital design. All informants have experience in newly built hospitals, in Norway, Holland and Denmark. The interview is done with key persons having been deeply involved in designing and executing of the hospitals: Akershus hospital, St. Olav's hospital and Martini Hospital.

The aim of the interviews and the visits to the hospitals is to investigate the potentials and challenges minimizing energy consumption while achieving greater comfort seen in a relationship between building and context, improving patient room and hospitals in general.

To gain knowledge and experience from already built hospitals and specific sustainable design strategies towards reaching low energy and high comfort by daylight and ventilation hybrids. This is together with achieving different perspectives to future objectives when designing sustainable hospitals.

## 2. The Sustainable Hospital

Hospitals are energy and resource-intensive buildings, as they operate today they contribute substantially to climate change. The benefit from

reducing its magnitude and consequences will ultimately, not only improve the hospitals sustainability, but also prevent an inadvertently contribution to cultivation physical illnesses whilst polluting. By reducing the hospitals footprint and moving toward carbon neutrality, the health sector can demonstrate a path to respond to climate change, advocating a coherent healthy and sustainable future.

The output of social cohesiveness in the local community surrounding the hospitals must work to cultivate a better physical health as well as increasing its ecological wellbeing. In order to implement a sustainable design it has to contain the ability to adapt to a local sense of place - a *genius loci* that will define the hospitals civic identity.

Deeper qualities and sensibilities of place are rarely expressed in recent hospital architecture. The sad fact is that most recent hospitals often do not contribute anything of this sort to their community, they dilute the concepts of civicness, environmental sustainability and stewardship, therefore undermining the before mentioned qualities – resulting in placelessness (Verderber 2010).

Studies conducted, recognize a link between the physical environment of a hospital, its architecture, interior design and indoor environment, and its impact on human healing. This develops recognition towards using healing architecture as a strategy to optimize economic values (Lawson 2002).

This awareness has in recent years been evolving from justifying itself from a purely humanistic theory with a qualitative reasoning into being perceived to be a supplement to combine with science and quantitative scientific theories and arguments.

Hospital buildings are the second largest energy consumer in the U.S. (Monk 2005) and the Ministry of Health in England estimate that 25% of the public CO<sub>2</sub> emissions comes from healthcare. This demonstrates an environmental potential is present and the investments needs to be integrated in the planning phases of hospital designs to ensure effectiveness in future building projects.

The effectiveness of alternative energy sources increases with great haste their approachability becomes larger. The necessity to plan with certain

### 3. Healing Architecture

Aesthetics and the physical environment affect the human body, mind and wellbeing directly and indirectly. The layout should be done with attention to existing knowledge and experience on how light, art, colours, and green areas affects patients' health and wellbeing. The healing environment has an influence on how patients experience quality and the employees' satisfaction, and should be incorporated as an integral part of future hospital design

EBD, Evidence-based design is a method qualifying and developing design and architecture based on scientific documented knowledge. The core of the method is hypothesize that better design will lead to better outcomes. The method is developed and based on scientific research methods, including evidence-based practice and findings from disciplines such as neurology, evolutionary biology, immunology and environmental psychologist. There are identified "outcome" areas affected by the hospital's architectural design such as; staff efficiency, stress and fatigue, patient safety, patient/relatives' stress and wellbeing, and overall clinical outcomes (Frandsen et al 2009).

Historically, hospital design has been based on the latest experiential knowledge of the engaged team of technical advisors rather than research, resulting in a perception that hospital buildings is an environmental burden rather than a substantial source with a possible positive output. This way of thinking is connected to the inability to link facility resources with the healthcare providing safe quality patient care, family support and a benefit from positive and safe work environment.

The first initiatives in this field was Roger Ulrich (1984) who did a pioneer study on the effect of patient being able to see nature and trees rather than a neighbour building, from the window in the patient room. The study proved that these patients subsequently required less pain medication and shorter admission time.

It is important to be critical when comparing EBD research in one project to another; building codes, climate etc. are often not comparative, the design of each individual and unique project has to be considered.

Evidence-based design demonstrates measurable potentials in building performance, economics, resource use and resource investments, as well as user satisfaction and productivity. There is limited professional research in the field, which significantly brings scientific evidence and evidence from



several other disciplines and traditions together. It is therefore essential that users, whether it is the decision maker or the practicing architect, is critical to interpreting the present data usability in the context-specific design situation. (Frandsen et al 2009).

#### **4. Integration of Design and Healing**

In Renzo Piano 10 commitments for the future hospital (Piano 2009) the preliminary three points, which he stresses, are equally important as written below :

- The human approach, the environment of patient should be on a human scale, ensuring safety, comfort and privacy.
- Integration with the city, the hospital should not be considered as a remote entity; rather it should represent an extension of the city. In other words, it should be an “open hospital” encourages integration in a socio-cultural context.
- In which one finds oneself immersed, and receptivity to cultural activities and entertainment organized by citizens associations and voluntary organizations.

Renzo Piano's commandments might challenge the structure of future hospitals, which focus very much on rational dispositions of hospital function as main drivers. Renzo Piano contends that the three first points are equally important in the design of a hospital, which is very different from the more well-known approach by effectiveness and functionality (Piano 2009). The more organizational efficiency is number four on his list. This is turning away from more functional effective monolith totally depended on mechanical ventilation and artificial lightning.

Without doubt, healthcare represents a complexity, it is intimate personal information that must be shared with strangers, frightening and painful procedures must be performed, and buildings are difficult to navigate. The healthcare environment is a work environment, a healing environment, a business environment and a cultural environment. The healthcare industry has an essential role to play in developing buildings that demonstrate economic, social and environmental benefits of green building in the context of high performance healing environments.

The complexity of a hospital environment and design relations are substantial; the diagrams here illustrate the relations between design frames, parameter and effect on health or comfort on theme-based level. Air and daylight related parameters are connected with continuous lines.

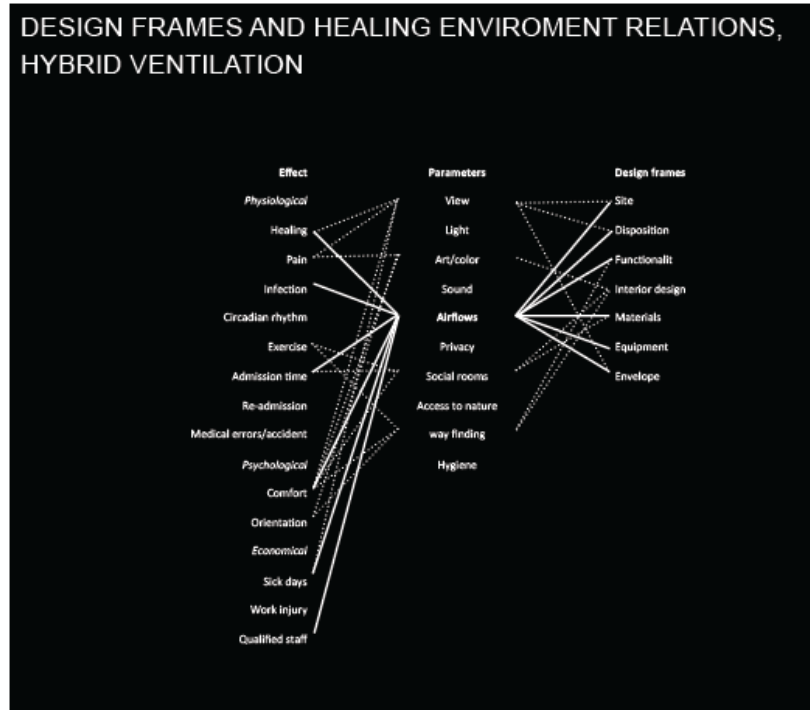


Figure 1. Design parameters for ventilation strategies.

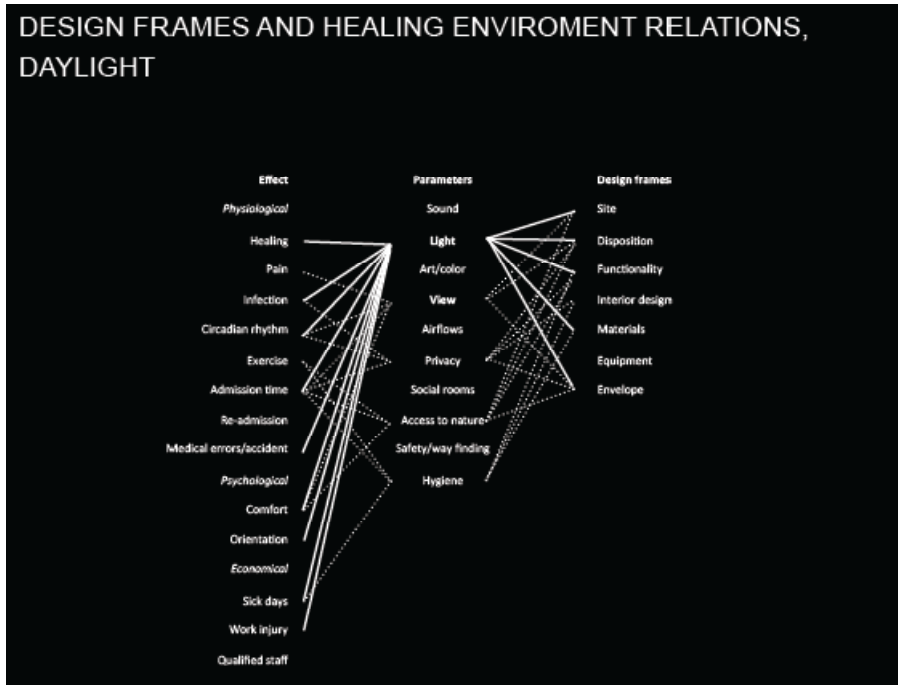


Figure 2. Design parameters for daylight strategies.

As shown in the diagram for ventilation and daylight, many design parameters are in common for both strategies. The Design frames are discussed and explored more detailed in the publication of the master thesis and to extensive to cover in a paper submission as this. The design parameters in common are; site, depositions, functionality, materials and envelope. These parameters together with the psychological and physiological effects which variants in daylight and ventilation are analysed in the master thesis publication.

## 5. Daylight and Ventilation Impacts

Illustrated aesthetic and affective responses in hospitals with outdoor visual environments, proves a tendency that surgical patients preferred natural scenery from urban views that lacked natural elements. Natural views spurred positive feelings, reduced fear and stressful thoughts. While findings suggested that the natural scene had therapeutic influences, it should be recognized that the urban view in the studies was a largely monotonous brick wall and it cannot be extended to all urban views. Results imply that hospital

design and depositions should take into account the quality of patient views. (Ulrich 1984)

In 2002 it was documented that retinal ganglion cells are sensitive to light, containing a photo pigment (melanopsin). This fact describes the brain's biological clock which is synchronized by daylight variation and spectral compositions. This is connected to the pineal gland that produces the hormone melatonin. Melatonin, also called sleep hormone, plays a major role in regulating circadian rhythms, and secretion stimulated by darkness and inhibited by light. Cancer Society states that melatonin strengthens the immune system, helps to protect body cells against particular cancer; it reduces the harming effects of radiotherapy and chemotherapy and inhibits the production of estrogen, which some tumors depend on.

A patient-study proves that patients exposed to interruptions of sleep in four days had a significant lower amount of antibodies than a group with good sleeping patterns. There is a connection between direct daylight and normalized cardiac rhythm (Heslet 2007).

Another interesting study concerning airflows was, 27 papers were judged as conclusive or suggestive cumulatively described a total of 23 studies, eight carried out in Sweden, seven in USA, three in Finland, two each in Denmark and Canada, and one in Norway. The papers generally indicated that low ventilation rate is associated with an increased risk of allergies, SBS symptoms and respiratory infections although not all studies found significant associations. A ventilation rate of 25 l/s per person is more than typically required in many ventilation standards and guidelines. Increasing the ventilation rate to more than 25 l/s per person would result in increased costs and energy, but the health-related economic benefits may greatly outweigh the energy costs (Fisk and Rosenfeld 1997).

Studies, conducted mainly in Nordic countries, suggest that a low ventilation rate was associated with increased risk of allergies. This finding is relevant since many standards are promoting energy efficiency in buildings have the potential to reduce ventilation rates in homes and other buildings. There is a lack of good studies that have measured natural ventilation rates in offices and their relationship with health.

When looking at the challenges by the effect of air quality and ventilation systems in hospital the major focus is to create comfort and infection control. Ventilation with outdoor air plays an important role influencing

human exposures to indoor pollutants. So in this case the positive effect on the view actually also is beneficial to the outdoor air quality or could at least be applied by green atriums or nearby outer spaces.

This review and assessment indicates that increasing ventilation rates above currently adopted standards and guidelines should result in reduced prevalence of negative health outcomes. It should be avoided to plan with low ventilation rates unless alternative effective measures, such as source control or air cleaning, are employed to limit indoor pollutant levels. This are just a few examples, out of several EBD research in the master thesis to indicate that there are evidence, to gain by exploring daylight and ventilation hybrids in Hospitals, on the triple bottom line. The common link between hybrid ventilation and daylight concerning the design frames are; Site, disposition, functionality, materials & envelope. These parameters will be explored more deeply in the publication of my master thesis *“Adaptability as sustainable design strategies In Hospitals”*.

## 6. Conclusion

The hospitals play an important role in civic awareness, of how to create an environment with a certain individual responsibility to own health and well-being. Healthcare providers must use this “upgrading of hospitals” as an opportunity to act in a leadership, even visionary and take a role as environmental stewards in the aspect of health promotion. Strive for wellness by creating opportunities for staff and others, to use public transportation, to cycle or walk, a focus on outdoor wellness through physical activity, even a system benefitting the use of sustainable transportation and focus on supply with low CO<sub>2</sub> emissions.

The design of hospitals has to be a broad view of climate. The context in which the building is located, involves both the atmospheric and cultural climate. It is important to not create a building which is out of place and out of scale, which does not capture the light or take into account the spirit of the location.

A commitment to environmental protection and understanding of human behaviours that affect ecology will be needed to design ventilation as well as good daylight. The “window”, providing a dual function, not only admitting light to indoor environment also allowing visual contact with the outside world. Daylight is also the amount of lux on the floor and totally linked together with temperature and solar shading. The quality of the view and

daylight will depend on the envelope and its adaptability to meet the demands from the functions behind it.

There is surely a lot of interconnected relation between daylight and ventilation hybrids as shown in the diagram on page 8. The effects are often different but the design parameters are clearly connected. There is today a certain amount of EBD research available, but in order to get clear and more specific design parameters or impacts on patients and staff we need more EBD research on the actual place, culture and conditions.

We know so much about ventilation, daylight, and noise etc. while the wholeness of the sensory perception that we receive from the environment and affect our body and health in a situation being sick and not in balance with the surroundings. The quality of the indoor environment is inextricably linked to outdoor environment in the immediate community context and also on a global scale.

*“I like to associate the word sustainability with elevation. The more I remove whatever is excessive, the more I economise in materials. The more I reduce the material, the closer I get to nature, and enter into a relationship with light and the wind. The quality of a building depends to a large extent on good lighting and the pleasant effects of the ventilation” (Piano 2009).*

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# ENERGY EFFICIENT RENOVATION OF SOCIAL HOUSING

## *How to Develop a Common Strategy*

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**Abstract.** This paper presents a case study which investigates a strategic and methodological approach to future proofed renovations of social housing in an environmental, economically and socially sustainable way.

In years to come the social housing sector must undergo major renovation. The housing sector is out of step with modern requirements when it comes to plan arrangements, energy frame calculation, flexible building services and social challenges. It is no longer enough to focus on developing efficient products concerning energy renovation. To be able to achieve an environmental, economically and socially sustainable objective, which seeks towards energy efficient renovation as an overall, systemic and interdisciplinary collaboration, the construction industry needs to focus on developing, testing, evaluating and implementing tools and methods to optimize and improve processes in a value-creating way.

The project meets the challenges above by contributing with two findings:

First we present methods on how to carry out value generating interdisciplinary collaboration between the housing sector parties, such as residents, housing administration, politicians, advisors, producers and contractors.

Secondly we present follow up methods for developing an overall future energy efficient renovation housing sector strategy.

All in all, our project contributes to the building sector by testing new methods and suggesting methods for meeting challenges concerning energy efficient renovation. It also contributes to the strengthening of knowledge sharing within the housing sector, and the creation of a framework for long term investments and jobs.

**Keywords:** Methods, tools, testing, evaluating, implementing, energy renovation, interdisciplinary collaboration, social housing

## 1. Introduction

Energy renovation of existing buildings is a complexity of many different processes. What has value for the client and what is the optimal technical solution and in what order do we do it? It is important to build on top of existing energy renovation approaches in order to develop a robust common strategy for the future of the existing building stock of Horsens. The experiences of already implemented energy renovations can give us important information in the development of a new approach and identify the challenges that are energy renovation.

Energy renovation is not just about energy savings, but also economy, climate and comfort, the aesthetics of buildings (architecture) and durability of the building. There may be uncertainty about factors as the process of renovation, on the availability of an appropriate financing, subsidies are granted, whether you can get qualified counseling, etc. and furthermore, depending on e.g. building design, construction, and user behavior from building to building. Energy renovation is therefore more than "just" reduced energy consumption, and solutions must be found by to take a holistic approach to finding optimal solutions in concrete projects. In years to come the social housing sector (SH) are foreseen to undergo major renovations. The SH is out of step with modern requirements when it comes to space demands, energy frame calculation, flexible building services and social challenges. The potential for renovation within the social housing sector is increasing rapidly due to the lack of enticement in making energy investments (National conference the 9<sup>th</sup> of May 2012 on the construction industry's contribution to a national strategy for energy renovation, Henrik L. Bang, Director of the Danish Association of Construction Clients):

*"We are facing a unique opportunity: Large parts of Danish buildings within the next 20 years faces a major renovation, and it will be a socio-economic and environmentally misstep not to use the opportunity to simultaneously embed it in the planning energy efficiency thoroughly. A long-term sustainable development is needed to ensure that the investment maximizes the value for communities, businesses, owners and users."*

Studies made by Advice AS in 2011 on behalf of The Danish Association of Construction Clients show that some of the most common barriers against increased activity and development in energy renovation are:

- Lack of economic incentive
- Lack of total financial overview



- Missing guaranties of energy savings
- Connection to and timing of other improvements and renovations

Within new constructions there has been a radical development of requirements by building code development class 2015 and 2020 in Denmark, which has given rise to much of new social housing are being built by class 2015. There is a similar need for existing buildings to develop a comparable model for energy efficient renovation. A holistic renovation model for energy optimization of existing buildings can provide a clear and realizable roadmap for the conversion of the existing building stock.

Energy efficient renovation must therefore bring together all those possibilities which can create most value for the building and its residents. By starting with the objectives and conditions of the building, there can be produced a variety of possible solution supporting the chosen objectives to improvement of the existing building.

To optimize the long term economic impact of the suggested solutions, an action plan proposing the order of the implementations must be carried out taking into consideration remaining life expectancy, accessibility of needed technologies and financial profitability. The proposal should collectively provide a detailed overall picture of the social, environmental, economic parameters such as for instance; energy engineering, architectural and functional parameters including accessibility, each of which can help to transform the existing building through a step by step renovation.

### 1.1. RESEARCH QUESTION

The aim of the project is to explore *“How to perform a holistic oriented and future proofed renovation of social housing in an environmental, economically and socially sustainable way.”*

## 2. Methodology

Methodologically theoretical principles will be used from Gate 21's/Plan C's *“Total Value Model”* (Original Danish *“Totalværdimodel”* from now on *“TVM”*) will be used for the purpose of adding a holistic structure to our approach and adapt our model with the relevant features this tool offers. Moreover, the strategy within the economically long-term investments has foundation in "BELOK Total Project, Energy efficiency av befintliga lokalbyggnader, Ekonomisk bedömning" by Enno Abel, November 2010. Finally we will use some of the elements from SAVE (Survey of Architectural Values in the Environment) in order to meet and improve the existing architectural values as a condition for the intervention.

The sustainable TVM has a new and holistic approach to renovation with the focus on energy and total value. In the construction process the professional consultants has traditionally put emphasis on the design and construction phases; although there may be retrieved greater value through integration of the operational phase. TVM aims at

- Prioritization of all registered values of the building
- Documented decision-making processes
- Increased value of the investment
- The operation phase of the buildings is included in the decision
- Visibility of the total environmental, economic and social value
- Specific tools for calculating the total economy

Municipalities and public clients often perceive energy renovations without a more holistic approach. Expensive renovations which are only intended in the short term, does not always give the benefit they could generate if they had been done in the long term and thus give the investment the full value. TVM is a tool which can control the building process of thinking holistically and increase the value of energy renovations.

A study of existing energy strategies for holistic approaches has been conducted and experiences and tools such as "*Renprocess.dk*" and TVM (Plan C, 2012), "*Energimål.dk*" (Esbensen, 2012) and "*Task Force Netværk for energirenovering*" (Sbi 2012) has been analyzed to be merged with Belok's long term investment strategy within energy renovation. The result is the following methodological approach to the development of a common renovation strategy in Horsens, which consists of a sequence of the following phases

1. *Recognition* of the relevance in developing a strategy
2. *Definition* of goals and ambition with the renovation
3. *Registration* and analyze of the preconditions by screening tools
4. *Conducting* an interdisciplinary process qualifying ideas/solutions
5. *Prioritization* of a list of objectives from the results above
6. *Transforming* a step by step approach into an action plans

### **3. The development of a common strategy in Horsens**

The 2<sup>nd</sup> of November 2011 the Association of Sustainable Cities and Buildings (FBBB), Horsens Municipality and VIA University College went together and arranged the workshop for energy renovation of housing and municipal institutions in Horsens.

### 3.1. BACKGROUND

The workshop was the result of an action proposed by the Climate Council of Horsens Municipality in 2010 as one of a series of recommendations, which later were finalizing into the Climate Action Plan 2 of Horsens Municipality. In Horsens housing is responsible for 27% of the total electricity consumption and about 30% of the total consumption of natural gas and heating oil, which is equivalent to the national average, and therefore represents a significant potential for reductions in total CO<sub>2</sub> emissions.

A consortium consisting of Rambøll, Energy Midt and VIA University College was therefore instructed to prepare a process for developing a model for the cooperation between the housing associations based on a common strategy for energy efficient renovation and future proofing of the multi-storey buildings. The following objectives were the basis of cooperation between the housing associations

- To reduce energy consumption for heating and mechanical systems in the buildings by developing new methods of network collaboration, bedding and project financing
- Conducting screenings of the social housing stock
- To provide an overview across the housing associations to gain a benchmarking tool that can qualify and quantify energy efficient renovation potentials without taking into account the various housing associations different opinions and ambitions in the field
- Fostering collaboration across existing housing organizations in finance, bedding, operations and maintenance
- Develop renovation projects supporting typical residential properties in the area
- Develop a replicable bedding concept to enhance competition/costs

### 3.2. THE PROCESS

The process were build up around a case study carried out at the workshop where the participants were divided up into interdisciplinary groups and invited to a planned screening visit in a nearby building, which has an urgent need for a thorough renovation, which are comparable to about 3000 dwellings in the town of Horsens.

#### *3.2.1. Recognition of the relevance*

Before starting the process the housing associations must recognize the relevance of this action. In order to create a common understanding of the strategy behind the renovation model, it is important that the housing associations cooperates and involves the necessary stakeholders for the

holistic approach to become a reality. To get all the parties together around a positive innovation process in the project like this, a triple helix were selected in a dialogue-based tripartite cooperation between Horsens, VIA University College and the Housing Associations, all of which are represented by the Housing Associations national organization.

So far, written agreements with Housing Association *Beringsgården* and *Odinsgård*, has been signed and it is expected to make similar agreements with the rest of the housing associations in Horsens in the future so that they can participate in a common strategy for renovation. This allows the tenants to look towards a future proofing of their housing more than what could be expected from what the lowest hanging fruit will throw off.

### 3.2.2. *Definition of ambition*

Each housing association must make ambitious objectives for their buildings beneficial to the clients and the building as well as being a profitable to renovation.

An energy efficient renovation can provide huge savings in these buildings and at the same time achieve a better building for the users concerning indoor climate, architecture, functioning and the social environment.

In this particularly case study the definition of ambition wasn't preselected due to the main purpose of the case study was to find out

- How is it most appropriate to define level of ambition and launched full scale renovation projects
- How practical screenings can be catalytic for social and physical improvement in housing
- The importance of communication to residents and owners in implementation of energy retrofitting

### 3.2.3. *Registration and analysis*

When the objective of an energy renovation is clear the building will undergo a technical registration and analysis and its architectural and historical potential will be defined. This analyze examines the building properties such as energy conditions, technical services, constructions, functionality, structure, material, climate and lighting conditions. The means to achieve a better building is those properties which are worth preserving and implement in the final result of the renovation.

A full screening of a building also takes social factors into consideration, such as user behavior, function, climatic and physical conditions. Great savings can be achieved if potentials from use of the building will be taken into account and thereby create a balance between building aesthetics, functionality and energy consumption.

### 3.2.3.1 Energy screening

The energy consumption of the building *Beringsvænget* is 150 kWh/m<sup>2</sup>/a from which heating is 127 kWh/m<sup>2</sup>/a and electricity is 23 kWh/m<sup>2</sup>/a in primary energy. This is about 3 times higher than the maximum energy consumption of new buildings under the Danish Building Regulation BR10.

The result of the first energy screening shows

- Wooden windows from 1993 can be replaced within 5 to 10 years
- Windows has a negative effect on the indoor climate due to overheating and can if replaced reflect the heat
- Possibility of skylights to improve the natural light in top dwellings
- Use of natural ventilation in some of the apartments
- Infiltration is causing draught. New ventilation with heat recovery
- Heating installations is out of balanced
- Outside insulation of facade
- Common lighting; outside, stairs and basement etc.
- Solar energy - common plants adapted to the surroundings

The Danish construction and civil engineer company MT Højgaard has developed a so-called “energy calculator” that can be used from the company homepage. The “energy calculator” is a free online tool to be used for figuring out how to finance particular renovation project. By entering data on the building, a fast overview of the options to choose energy-efficient solutions appears. A preliminary screening of 10% of the total heated floor area of “*Beringsgården*” results in the following economy of an energy efficient renovation (table 1).

### 3.2.3.2 Building physics

The housing area *Beringsvænget* was constructed in the early 70'ties (1973-1974) and consists of 318 dwellings and has a floor area of 26.114 m<sup>2</sup>. The construction is clearly inspired of the 70's main architectural visions and was a state of art building at the time.

The close, low urban dwellings were the main trend. The dwellings areas were made like small towns in the town with pedestrian streets and squares inside the areas. The inhabitants could then meet protected from the traffic. This was quite new compared to the 60'ties multi-story housing with open areas between the blocks, which did not give any intimacy or solidarity in the areas. *Beringsvænget* was arranged with a pedestrian street structure and a big square in the southern part of the area.

TABLE 1. Energy calculations

| <i>Energy action</i> | <i>Energy savings</i><br>€/year | <i>Total invest.</i><br>€ | <i>Energy invest.<sup>1)</sup></i><br>€ | <i>Value of Energy invest.<sup>2)</sup></i><br>€ | <i>Simple payback time</i><br>Year |
|----------------------|---------------------------------|---------------------------|---|--|------------------------------------|
| 1. Facades           | 2990                            | 232185                    | 33630                                   | 118070   | 11                                 |
| 2. Roof construction | 560                             | 27840                     | 27840                                   | 22150  | 50                                 |
| 3. Basement wall     | 0                               | 0                         | 0                                       | 0  | 0                                  |
| 4. Windows           | 4530                            | 369600                    | 76800                                   | 179200   | 17                                 |
| 5. Sky-lights        | 0                               | 0                         | 0                                       | 0  | 0                                  |
| 6. Heat installation | 3390                            | 34670                     | 10400                                   | 133880   | 3                                  |
| 7. Light system      | 2200                            | 17330                     | 5200                                    | 86980  | 2                                  |
| 8. Ventilation       | 2840                            | 156000                    | 17330                                   | 112270   | 6                                  |
| Sum                  | 16510                           | 837625                    | 171200                                  | 652530   | 10                                 |
| 9. Solar heating     | 4810                            | 57600                     |   | 190280   | 12                                 |
| 10. PV panels        | 2560                            | 28000                     |   | 101200   | 11                                 |

<sup>1)</sup> Energy investment is the part of the overall investment involving only energy savings

<sup>2)</sup> The value of the investment is the cumulative discounted value of 30 years of savings

### 3.2.3.3 Social capital

The population in this district is about 6500 people. The district is characterized by the many benefits of a small town as grocery stores, senior centers, day care centers, primary school and higher educations.

There are residential areas and a large number of public housing. A large proportion of them are multi-storey buildings. In the two largest public housings in the district, "Beringsvænget" and "Sundbyparken" has approx. 2700 people. It is mainly children and young people and families, as well as refugee and immigrant family residents of the two estates. The proportion of foreigners is approx. 1/3 of the residents.

The areas has for many years been characterized by great inequality in social and cultural sustainability compared to Horsens in general. This has meant that there has been a potential marginalization by social and cultural exclusion of people and from this a high degree of crime, vandalism, violence and degradation of the physical environment.

For years, there have been focused on, how to break the negative social development through targeted interventions, interdisciplinary cooperation, district projects and neighborhood advisory etc. Renovation of the physical environment and new development opportunities in the open space is well underway and at the turn of the millennium there was a new community

center in *Sundbyparken* ready for use. Over the years there has been a tradition for the formation of different culture networks in the area where residents in many different contexts involves as volunteers and the district's residents in sustainable social and cultural life in an interaction between organized residents democracy, private and public organizations.

TABLE 2. Social values

| <b><i>Building physic</i></b> | <b><i>Tenants</i></b> | <b><i>Locality</i></b> |
|-------------------------------|-----------------------|------------------------|
| Skylights / indoor climate    | Social capital        | Logistic               |
| Natural ventilation           | Security, safety      | Activities in the area |
| Functional apartments         | Self-support          | Way finding            |
| Flexible building area        | Tenant composition    | Accessibility          |
| Varied architecture           | Payment capability    | Green areas            |
| Openness                      |                       |                        |
| Identity                      |                       |                        |

#### 3.2.4. Interdisciplinary process

The interdisciplinary process is based on a holistic approach involving all relevant key actors thus recognizing the complexity of the energy efficient renovation and the need for all stakeholders to be involved.

The initiated workshop had participation of all stakeholders' such as civil engineer, architect, contractor, craftsmen, owner, tenant, municipality and higher education researchers. The purpose of this workshop was to present the project to the stakeholders including unfold project's perspectives so that all stakeholders were aware of their role. One important outcome of this workshop was to share important information of social values, interests, ideas, solutions etc. to create ownership amongst the stakeholders especially the tenants who plays a major role in the democratic organization amongst Danish social housing.

The experience of the workshop was good and especially initiatives focusing directly towards the tenants as mentioned by Andreas Kragh from MT Højgaard (Blyt, H., 2011):

*We need to improve decision-making, so tenants know what they get out of the investments. Knowledge from the users must be involved from the start of the planning - what is it residents can expect? What should they be prepared for in the renovation process? What they get out of it eventually? Tenants must have explained what a difference a renovation will do. They should*

*have explained that the money is being spent on renovation, will be saved on energy consumption, and therefore it is benefit themselves. Tenants must to be consulted and informed in a regular basis in a building process. They must always know the next step in a project from start to finish.*

It was also the objective of this workshop to identify opportunities and conditions in the project. The aim is to see opportunities and conditions in the energy retrofit projects that can contribute to the establishment of a common framework for understanding key concepts like "renovation".

#### 3.2.4.1 Catalogue of ideas

The outcome of the interdisciplinary process was a catalogue of ideas and solutions within the building physic, the surrounding of the building area, the architecture of the building design and the technical solutions.

TABLE 3. Catalogue of ideas

| <i>Building physic</i>      | <i>Locality</i>            | <i>Design/Architecture</i>   |
|-----------------------------|----------------------------|--|
| Insulation of balconies     | Safe community – no walls  | Proportions and scale:<br>Reduce the numbers of<br>different materials, details<br>and flashings |
| Visual energy measures      | Row buildings              |  |
| New insulated gables        | Opening of gardens         |  |
| Ventilation / heat-recovery | Meeting places             |  |
| Natural ventilation         | Shelters with green plants | Update the visual look   |
| Displaced balconies         | Variation of path ways     | Cut through wing building  |
| Sky-lights                  | Deposit room in basement   | Windows in gables  |
| Tight and well insulated    | Light outdoor areas        | Less window area   |
| Low energy windows          |                            | Sky-lights   |

#### 3.2.4.2 Ideas for technical solutions

- Possibly use of solar energy
- Use of the stairwell as "chimney" in combination with a heat pump
- Use of the stairwells as pathway for ventilation ducts. Distributed of ducts through the ceiling in the hallway, which can reach all room.
- Renovation and balancing of the heating systems
- "Solar-prism" on the roof with solar heating, ventilation, heat pumps and solar cells



### 3.2.5. Prioritization and transformation

The prioritization of the objectives from the catalogue of ideas and solutions will relay on the specific housing associations chosen goal and ambition with the renovation. Transforming a step by step approach into an action plan will be determined by the following factors

- Goal and ambition in the energy renovation strategy
- Back log of the building components in the individual building
- Financial resources in the housing association
- Availability of alternative/extra finance

#### 3.2.5.1 Total value tool

The financial consequences of the prioritization can be seen when using the tool called Belok. The tool has been chosen because of its ability to show different scenarios graphically. It is easy to combine the scenarios with the planned Operation and Maintenance and see the consequences for the tenants like the need for temporary housing depending on the nature of the step. A financial plan is derived from the program and can be matched with available finance and trace the deficit. If the scenario is not financed, then it is fast and simple to make another scenario. The process of Belok is divided into the following 3 scenarios based on the state of the building

1. Calculation of cost for the different components from the screening
2. Analyzing if there is a deficit compared with the finance needed
3. Continuing analyzing if there still is a deficit

As Belok is a tool based on economy, there is still a need to valuate and compare the environmental, economically and social parameters of sustainability. Such a tool is developed by the Danish Research Centre SBi together with the other Nordic countries. The tool SURE (*Sustainable Refurbishment of Buildings*) is integrating indicators from all three parameters and has been tested on several renovation projects in the Nordic countries.

## 4. Results

The result is based on 3 different solutions depending on the goal and ambition of the renovation for a multi-storey block in the social housing of “Beringsvænget” and calculated by the MT Højgaards energy calculator.

TABLE 4. Result

| <i>Low energy class of today</i>   | <i>Low energy class 2015</i>  | <i>Low energy class 2020</i>   |
|--|---|--|
| 1. Facades<br>33.000 kWh/y<br>- new ext. gable wall<br>- insulation of facade                                | 1. Facades<br>38.000 kWh/y<br>- new ext. gable wall<br>- insulation of facade<br>- replacement of balconies                     | 1. Facades<br>38.000 kWh/y<br>- new ext. gable wall<br>- insulation of facade  |
| 2. Roof construction<br>0 kWh/y  | 3. Roof construction<br>0 kWh/y<br>- new sky-lights   | 4. Roof construction<br>6.000 kWh/y<br>- insulation of roof  |
| 3. Windows<br>95.500 kWh/y<br>- replacement for low energy windows   | 3. Windows<br>95.000 kWh/y<br>- replacement for super low energy windows  | 3. Windows<br>95.500 kWh/y<br>- replacement of super low energy windows  |
| 4. Installations<br>37.000 kWh/y<br>- optimize of heat system<br>- optimize of extraction<br>- heat recovery | 4. Installations<br>65.000 kWh/y<br>- optimize of heat system<br>- common light system<br>- establishment of hybrid ventilation | 4. Installations<br>65.000 kWh/y<br>- optimize of heat system<br>- optimize of light system<br>- hybrid ventilation with solar prism |
|  |   | 4. Solar energy<br>76.000 kWh/y<br>- solar-prism with solar heating, ventilation and heat pump                                       |
| Savings<br>165.000 kWh/y   | Savings<br>198.000 kWh/y  | Savings<br>280.000 kWh/y   |

## 5. Conclusion

The project is the first of three phases, which involves a full screening with participation of preselected stakeholders and housing associations, from which the interdisciplinary groups are established.

From the studies of already carried through holistic renovations the housing associations are joined in a common energy efficient renovation strategy for Horsens. A similar project has never been implemented in Horsens.

In the next phases the housing associations carries out full scale trials, which are evaluated and forms the basis of the model for the next renovations. The whole process are followed and monitored by the project group, thus the

knowledge generated can be shared between the housing associations, construction industry and educations beyond the borders of the municipality. From this paper investigation the aim was to explore *“How to perform a holistic oriented and future proofed renovation of social housing in an environmental, economically and socially sustainable way.”*

The results from the workshop carried out last year shows that there are visible evidence in the form of the qualitative feedback from the stakeholders involved, that traditionally physical screening of the buildings with little interdisciplinary involvement has low or no added value for the housing association due to inconsistency between the social, economic or environmental context. The Director of the housing association *“Beringsgården”* Gunnar Sorensen, quoted in a following questionnaire after having the result of the final workshop output (Blyt, H., 2011):

*“I was very excited about the workshop, and what we got out of it. The best thing was the participants got to see a home on “Beringsvænget”, so we had the same platform for a discussion of the opportunities that are in the developing of a strategy for energy renovation. We got good concrete suggestions for the actions we can embark on, and it was great to get some external opinions on the possibilities and fresh ideas to the actions, which we can do something about.*

*We cannot implement all the measures that were suggested in one step, but it was a great help that many of the various proposals were discussed and perspective. If at any time, we have this process of energy renovation in other departments, I hope that we can participate in a similar workshop for I was really impressed with the quality of the proposals we received. I can only recommend other house owners, which is facing a mayor renovation of their departments, to do the same.”*

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# REVIEWING THE EXTENT TO WHICH 3D PRINTING MAY OFFER AN ACCESSIBLE, UBIQUITOUS AND AFFORDABLE TECHNICAL DESIGN TOOL FOR ARCHITECTURAL TECHNOLOGY UNDERGRADUATES AND PRACTICE?

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## **Abstract**

Gibbs (1988) described a pedagogy of “learning by doing” which embodies phases of action, evaluation, analysis and reflection. In design education, the studio invariably sets the context in which academic objectives are developed and realised. The design studio may also be used as a teaching model for professional practice (RIBA, 2004). Stuart Pugh (1991) developed a methodology at Strathclyde University promoting collaboration and integration within design development as key precepts underpinning successful detail (technical) design. Through the ascendancy of information and communications technologies (ICTs) physical models of virtual components, assemblies and whole buildings can be generated and transposed from virtual environments at various stages during the design process. (Rheingold 1991) There may be value in incorporating knowledge and understanding of these techniques into undergraduate education as an aspect of sustainable design and construction. (Kouider et al., 2006)

3D printing enables the automated production of physical objects from virtual CAD models. Initially used as rapid prototyping tools for industrial design/manufacture, 3D printers are becoming embedded in design education. Within teaching institutions, hardware tends to be centralized, requires technical support and not affordable for own-use by undergraduates and small practice. This paper will discuss the premise that 3D printing may offer potential as an accessible and affordable technical design tool. Reference will be made to the authors’ ongoing research and collaboration with industry.

## **1. Overview**

This project has been undertaken from a perspective which encompasses architectural education, practice and associated industry where the use of

# **REVIEWING THE EXTENT TO WHICH 3D PRINTING MAY OFFER AN ACCESSIBLE, UBIQUITOUS AND AFFORDABLE TECHNICAL DESIGN TOOL FOR ARCHITECTURAL TECHNOLOGY UNDERGRADUATES AND PRACTICE?**

71

physical modelling to test ideas and represent buildings and their component parts is implicit in the design and development process.

Historically, the teaching and learning of design skills has developed from pedagogies which promote “learning by doing”. Typically these methodologies have embodied phases of action, evaluation, analysis and reflection within structured and planned educational activities. In design education, the studio invariably sets the context in which academic objectives are developed and realized and the design studio may also be used as a teaching model for professional practice. In the 1990s, Strathclyde University’s School of Engineering developed a methodology for teaching “total design” in an environment which promoted collaboration and integration as key precepts underpinning successful outcomes for technical design development.

Within that broad context, Petroski (1996) reviewed the process of design as it morphs from the conceptual to the physical in evolving from thought to thing. A relatively recent addition to the technical designer’s toolkit is the 3D printer which enables physical objects to be made from CAD models via a software interface. Initially used as a rapid prototyping tool for industrial design/manufacture, digital fabrication is increasingly becoming a mainstream component of built environment design education. Currently there may be barriers to the more widespread uptake of 3D printing as a ubiquitous and affordable tool for education and practice. For example, within educational institutions, 3D printers tend to be centralized, require support technician input and with high entry level costs, not affordable for undergraduates and/or small commercial organisations.

A number of studio based initiatives (Fab Lab, MAKLab et al.) have sought to make 3D printing technology affordable and more widely accessible to individuals, small organisations and built environment education providers. In that context, Anderson (2012) recorded and analysed the roots and development of that Maker Movement in the United States and internationally. This project was predicated on the view that there may be value in shaping an holistic knowledge of evolving technologies into a frame of reference for architectural technology education shaped by the need to embed sustainability into a process which develops from a given brief towards practical outcomes such as drawings, visualisations and physical models.

## **2. Research Question and Methodology**

The project tested the hypothesis that entry level 3D printing could offer a useful and affordable tool for undergraduates and small architectural practices; also as a low cost prototyping tool for companies designing and

manufacturing building components. There was an aspiration from within the project team, to review the idea that along with a PC and/or laptop and internet connectivity, a budget 3D printer could become a component of the architectural technologist's tool-kit. To develop and review the premise, a commercially available 3D printer evolved from the Rep Rap family. (Bowyer et al., 2011) was built and tested during 2012.

The printer build utilised a kit of parts costing in the region of £1k. Affordability was defined in relation to capital cost of the printer kit being significantly below typical costs for fully assembled 3D printers at the time the project was initiated. The price threshold was set around the cost of a mid-level gaming specification laptop. No allowance was made for the time and labour costs for building the kit. It was agreed that both the build process and output from the printer would be logged and evaluated by the project team to test perceived effectiveness of the printer, both in relation to predefined criteria and also in the round.

The research team comprised project manager, research assistant and nominated consultant with previous experience of 3D printing. Points of contact were established with architectural practice and industry to facilitate consultations and gathering appropriate feedback. That interaction was formative in shaping the way that the project was structured and developed. The team all had significant professional practice experience in architecture and/or a direct association with the teaching and learning of architectural technology through undergraduate degree delivery in Further and Higher Education. That range of experience proved useful in developing a methodology which bridged between academia and professional practice.

Following, preliminary brainstorming within the team, a methodology was defined to address the research question through data gathering and review. The methodology was sub-divided into six inter-connected phases ranging from a scoping study at the outset to reflection on the need for further work at the conclusion of the study. The scoping study was intended to identify and map an appropriate domain within which the work could realistically be developed given time and resource constraints. Arksey and O'Malley (2005) argued that scoping studies could facilitate the rapid mapping of key concepts underpinning a research area. In that context, it was the research team's intention to identify and benchmark attitudes and current practice by sampling from both the architectural profession and industry. Also, from within each of these sectors, to target specific instances which might offer appropriate case studies for testing and evaluating output from the experimental 3D printer.

A review of literature was embedded into project development to define both a specific context for the work and also to inform/underpin relevant decision making and actions. Additionally, to facilitate tapping into current

## **REVIEWING THE EXTENT TO WHICH 3D PRINTING MAY OFFER AN ACCESSIBLE, UBIQUITOUS AND AFFORDABLE TECHNICAL DESIGN TOOL FOR ARCHITECTURAL TECHNOLOGY UNDERGRADUATES AND PRACTICE?**

73

knowledge, understanding and practice associated with entry level 3D printing. Key objectives from the literature search were to:

- increase breadth of subject knowledge to underpin the research
- identify information, ideas and methodologies relevant to developing experimental aspects of the project
- ascertain if work in the subject area has already been carried out by others
- to facilitate the development of new knowledge by building on existing ideas and research
- identify key developments in the subject area
- provide an intellectual context for the research in relation to work done by others

While rapid prototyping and digital fabrication are well established in a range of sectors including medicine, automotive engineering, aerospace and product design, technology transfer to the built environment is in its infancy. (Steadman, 2013) Consequently a significant body of published literature does not exist. Online sources were used to identify chronology, ongoing empirical research, the current state-of-play with 3D printing and new/emerging developments which might assist shaping and steering the project. Self-building, calibration and testing of the printer was intended to develop deeper knowledge and understanding among the research team through direct engagement with observation of the build process. (Reigeluth, 2009)

### **3. Literature Review**

The literature suggested that 3D printing has primarily developed as a commercially viable additive manufacturing process since the 1980s and followed three separate strands. These pioneering streams of activity were linked to concurrent developments in three technologically rich processes, stereolithography, selective laser sintering (SLS) and fused deposition modelling. (FDM)

Bourell et al. (2009) noted that in 1972, Matsubara of Mitsubishi Motors proposed a topographical process to build up layers using refractory particles such as graphite powder or sand coated with a photopolymer and heated to form a coherent matrix. By using a projected light source, a defined area of the matrix could be hardened into a mass and the unhardened part dissolved away using solvent. The thin layers formed using that technique was stacked together to form a casting mould.

Charles Hull, an American inventor, the founder of 3D Systems and holder of over 60 US patents in the fields of ion optics and rapid prototyping is generally acknowledged to have instigated commercially viable 3D printing techniques from around 1984 (Anon., 2011). In his patent for the “Apparatus for Production of Three-Dimensional Objects by stereo lithography”, issued on March 11, 1986, Hull described stereo lithography as a method for making solid objects by successively depositing thin layers of an ultraviolet curable material one on top of the other.

Selective laser sintering (SLS) is another additive process which uses a laser source to fuse small particles of plastic, metal or ceramic in powder form into a 3 dimensional object. The laser selectively fuses the powder source by scanning a series of cross sections generated from a 3D digital description of the object (usually a 3D CAD model) on the surface of a powder bed. SLS was developed and patented by Dr Carl Deckard at the University of Texas at Austin in the mid 1980s (CSE, 2012) although a similar process was patented by RF Housholder in the late 1970s.

The third strand of activity was the introduction of fused deposition modelling (FDM) developed around 1988 by Scott Crump in the United States. In 1993 Massachusetts Institute of Technology (MIT) added to the development of this field by patenting 3D printing techniques based on modifications to extant 2D printer bubble jet printer technologies (Anon., 2012) These developments were subsequently licensed and led to the commercial availability of 3D machines marketed by companies like Z Corp from around 1996. Over the following decade, there was evidence both of an uptake of 3D printers by large architectural practices, for example Foster Associates in the UK, and of intense competition between manufacturing companies driving printer research and development.

In the broad context framed by questions on mass availability and affordability of evolving 3D printer technologies, Dr Adrian Bowyer an mechanical engineer and academic invented and developed the RepRap printer at the University of Bath as a viable open source printer for construction from a kit of parts. The RepRap used the FDM technique, thus avoiding the incorporation of expensive laser technology and claimed to be capable of replicating many of its components. The first version of the RepRap, the Darwin, was finalised in 2007 followed by the Mendel, an evolutionary model.

One useful facet of low cost 3D printing is that a significant amount of open source help and support is provided via wikis and social media including Twitter linked feeds and blogs. That information ranges from help with assembly instructions to publication of test results, information about the performance of different materials and software/hardware configurations/modifications. Moilanen and Valden (2012) published the



## REVIEWING THE EXTENT TO WHICH 3D PRINTING MAY OFFER AN ACCESSIBLE, UBIQUITOUS AND AFFORDABLE TECHNICAL DESIGN TOOL FOR ARCHITECTURAL TECHNOLOGY UNDERGRADUATES AND PRACTICE? 75

first online survey of the 3D printing community and generated a significant cache of data from 358 respondents spread across three pre-defined categories of “developers” “early adopters” and “end users”.

### 4. Printer Build

The RapMan V3.2 model built by the project team to evaluate and test the research question is a commercially available model evolved from the RepRap printer family (Fig. 1)



*Figure 1. RapMan V3.2 3D printer.*

The team was conscious that given limited resources, time would be most effectively spent on the build and gathering/analysing raw data, rather than for example, learning software packages. It was agreed that navigation through the software suite necessary to test and prototype with the RapMan machine would be developed through combining prior knowledge with trial and error. The build was supported by a comprehensive notes package provided by the supplier. The build sheets included detailed parts inventories, interactive online help and 3D PDF files which could be manipulated on screen to view and review sub-assemblies in three dimensions. (Fig. 2)

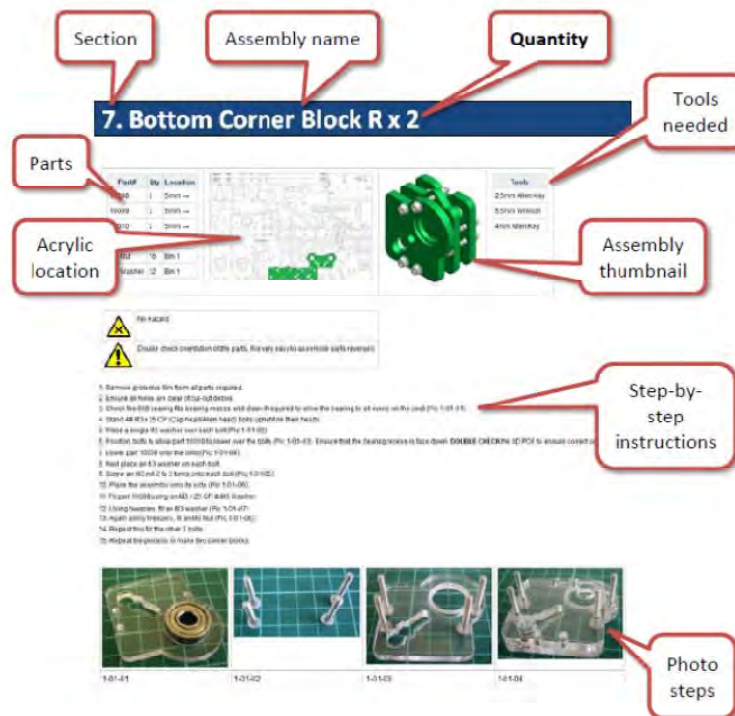


Figure 2.. Sample from RapMan V.3.2 assembly instructions

A number of issues arose during the build process. None of these proved to be insurmountable, perhaps more indicative of aspects of the kit and assembly instructions which could be evaluated for possible future improvement.

Once the initial build had been completed, software calibration was undertaken. This exercise proved to be time consuming. Calibration tests and aligns the configuration of the printing heads by making sample prints which are used to measure and benchmark the distance between the two extruders. Essentially, the test print is a measuring tool designed to check the distance between the 2 extruders and take that dimension into account when the printer is in service. It was found that to make a test print, then enter the corresponding numerical values into the control panel took around 45 minutes. The team repeated that cycle four times in attempting to set up the RapMan correctly. A calibration print is recommended prior every instance of use in service.

There were a significant number of variables embedded in the build process. The team thought the difficulty experienced with calibration might have highlighted an issue with the z-height setting which adjusts the distance

## REVIEWING THE EXTENT TO WHICH 3D PRINTING MAY OFFER AN ACCESSIBLE, UBIQUITOUS AND AFFORDABLE TECHNICAL DESIGN TOOL FOR ARCHITECTURAL TECHNOLOGY UNDERGRADUATES AND PRACTICE? 77

between the extruders and the horizontal base board. After several attempts to calibrate the extruder, the settings did not seem to save, and a manual temporary fix was incorporated to complete the set-up procedure. This fix allowed testing to continue, but was not ideal.

One negative characteristic which the printer demonstrated intermittently (and continues to do so) during set-up/calibration process was a tendency for the moving printer head carriage to seize temporarily on its guide rails. This phenomenon caused the machine to “lock-up” and vibrate until the issue had been resolved. The most significant effect from the vibration was that it caused nuts securing sub-assemblies to loosen. It is not known whether this issue was associated with the build or is endemic with the printer family.

A total of 45 hours was recorded for the RapMan V3.2 build. Of that, around 33% was attributed to reinstating abortive work, troubleshooting at various stages and the like.

### 5. Testing

As is typical for a CAD/CAM process, source 3D CAD files migrate through a series of file-type conversions before being exported to the RapMan’s Axon software which controls the printer. The extent of that migration process depends on the source file type. In the case of SketchUp files (.skp extension) these were saved as .dxf files and converted to the .stl format which makes a triangular representation of surface geometry from the source object. The .stl format is a commonly used file protocol for 3D printing. The Axon software transposes from .stl format to G-code to drive the printing process. (Fig. 3)

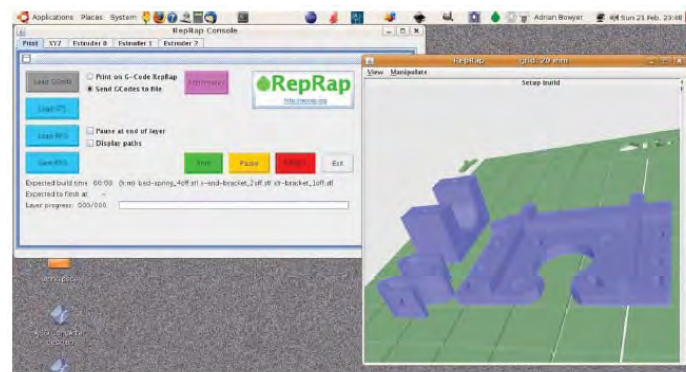


Figure 3. RepRap control display for transposing from .stl file format to G-code. After Bowyer et al. (2011)

Before setting up the RapMan to print off prototypes, the research team ran a brainstorming session to consider the range of variables which might impact on printer speed and quality of output. These factors included, size of printer head, printer speed, layer thickness, fill density, fill pattern and geometry of the source object.

Some variables, for example size of printer head can be controlled by the operator, while others are determined by the Axon software as a correlation with the nature of the source object being printed. Due to the limited scope of the project, it was not possible to carry out a detailed analysis of cause and effect with these variables and the research team agreed to validate factors thrown up by the brainstorming session through observation of printed test pieces. A number of test pieces were then printed. Some of these were sourced from pro forma 3D files provided by the printer supplier, others were generated by the research team. Test pieces were compared by observation and results noted.

The printer offered three different extrusion thicknesses, 0.5mm, 0.25mm and 0.125mm. The 0.5mm extrusion was the fastest of the three, but tended to result in rough and poor quality finishes. As a compromise between quality of output and speed of model production, the 0.25mm provided a reasonable mean from observation of the test pieces made. The 0.125mm extrusion produced the highest quality of surface finish but took much longer to produce. As a reference point, the time taken to print out test pieces of comparable size to widget 1 ranged from 18 minutes with the 0.5mm extrusion head to 30 minutes with the 0.125mm nozzle. In comparing characteristics of extrusion filaments, ABS seemed to provide more robust support for models under construction whereas PLA could be extruded in thinner sections and demonstrated higher quality of surface finish. PLA seemed to be more sensitive to variations in extrusion thickness than ABS.

The default setting for fill density is 20% and from observation, this seemed to be an optimum figure. The higher the fill density setting, the longer the model takes to print. The team did experiment with density settings less than the default (down to 10%). It was noted however, that as the fill density was reduced, the inclination of the model under construction to sag increased with a consequent impact on quality.

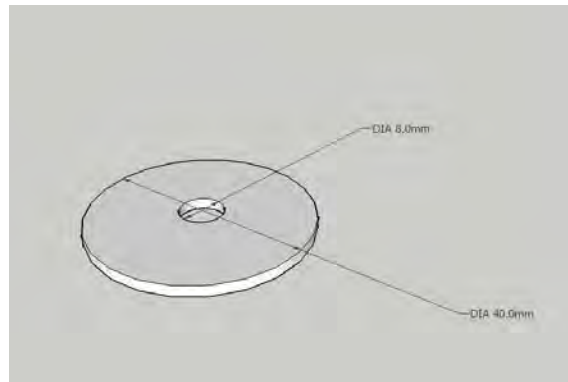
## **6. Prototyping**

The final stage of the investigation was to designate control models to test the quality of printer output against perceived industry and professional practice needs as sampled from the scoping study. Two model types were designed as control widgets. That selection was based on information drawn

**REVIEWING THE EXTENT TO WHICH 3D PRINTING MAY OFFER AN ACCESSIBLE, UBIQUITOUS AND AFFORDABLE TECHNICAL DESIGN TOOL FOR ARCHITECTURAL TECHNOLOGY UNDERGRADUATES AND PRACTICE?** 79

from the industry organisation and the architectural practice which had contributed to the formative work.

Widget 1 (Fig. 4) was drawn in 3D using Trimble SketchUp software as a 40mm external diameter pressed steel flat spreader washer. For printing and testing purposes, this component was deemed equivalent to the type of mild steel timber connector produced by the manufacturing company consulted during the scoping study. Widget 2 (Fig. 5) was also generated in SketchUp using an ISO standard steel shipping container as a template. Note that Widget 1 described a flat solid object while Widget 2 comprised a box-shaped volume enclosed by six sides. These geometric configurations provided different instances for comparison.



*Figure 4. Digital model of control widget 1: spreader washer*



*Figure 5. Digital model of control widget 2: shipping container*

## 7. Output

The team were able to print widget 1 successfully as a full size model from the 3D CAD source using both PLA and ABS filaments (Fig. 6). Both configuration and thickness of the mock-up could be replicated using the RapMan V3.2 machine. That outcome suggests that with more time available, mock-ups of pressed steel timber connectors as designed and manufactured by the collaborating industry partner could have been usefully prototyped for evaluation in the field. If these prototypes were produced in quantity, the fact that PLA is a biodegradable material could be deemed to be a positive by-product of the process.



*Figure 6.* Prototype pieces printed from control widget 1 using recyclable PLA filament. Best to poorest quality resolution reading from left to right.

Replicating the shipping container was more problematic. As noted in the scoping study, architectural practice has a particular requirement for high quality general arrangement physical models. It was not possible for the team to respond to that need using the RapMan V 3.2 printer. As an alternative, It would have been possible to reproduce the container as a series of flat sides and these could have been fitted together. Typically that could have been achieved at a scale of 1:200 and printed test pieces suggested that good quality of surface and detail finish could have been attained. This idea was interesting, but project constraints limited further development. It proved viable to print from the source model for the shipping container at a smaller scale, typically 1:500. The downside of that outcome was that as the geometry of the test piece necessitated the printer generating a supporting structure, a solid model was generated. The desired form was achieved, but with overuse of source filament.

## **8. Summary and conclusions**

During 2012, the research team developed a study to investigate the affordability and usefulness of entry level 3D printing for architectural technology undergraduates and practice. The team assembled, and tested a 3D printer from a commercially available kit of parts costing around £1k. In framing the broad context of the study, the researchers consulted with architectural practices and an industry company designing small components for building construction applications. The purpose of that dialogue was to link academic research to real world practice and the business needs of SMEs

The literature suggested that 3D printing is a fast moving technology which has not yet reached maturity. Since the project began, low cost machines which are closing the price gap between entry level and medium priced printers are beginning to come on to the market. It is likely that the cost of fully assembled stereo-lithographic printers may soon drop below £1k.

Following testing, it was observed that quality of resolution with printed objects was variable using the self-built 3D printer. In terms of the addressing the needs of architectural technology education and practice, it was concluded that printer output could be useful for making small components, for example for prototyping purposes. Replicating larger objects such as architectural models where high quality surface finish was a prerequisite proved to be more challenging and would require additional research.

For manufacturers of small non-complex building components, it was concluded that printer output as sampled could make a useful contribution both to product development and enhance links between design and manufacturing processes, possibly within the broader context of building information modelling. (BIM)

One particularly significant trait of printer output was observed. There seemed to be a symbiotic relationship between the geometry of the virtual model being reproduced and the ability of the printer to replicate the source object. Organic forms tended to be viable, while objects with non-complex orthographic configurations were less so. Further work would be required to evaluate this characteristic in relation to cause and effect

A positive by-product from the study was the identification of fresh research strands which could be investigated and developed by architectural technology students in the studio. These themes include using 3D printing to prototype and test buildability, fit and recyclability of components/assemblies and similar exercises where engaging with physical objects could add value to the teaching and learning experience. To follow

up on the interaction with practice which helped shape the study the researchers ran CPD workshop on digital fabrication for architectural technology practitioners in central Scotland.

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**REVIEWING THE EXTENT TO WHICH 3D PRINTING MAY  
OFFER AN ACCESSIBLE, UBIQUITOUS AND AFFORDABLE  
TECHNICAL DESIGN TOOL FOR ARCHITECTURAL  
TECHNOLOGY UNDERGRADUATES AND PRACTICE?** 83

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# **A COMPARATIVE ANALYSIS OF ARCHITECTURE AND ARCHITECTURAL TECHNOLOGY UNDERGRADUATE DEGREE PROGRAMMES IN THE UK**

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**Abstract.** The complexity of the architectural profession is constantly increasing, which makes it difficult to be handled by only architects. The need for help about that complex process resulted in the evolution of new professions all over the world. Universities are either trying to develop their architecture programmes or set up new architecture related programmes, such as architectural technology. The UK has a great diversity in architecture related undergraduate degree programmes, with architectural technology increasing in popularity since its launch in the 1990s. Two subject benchmarks statements (2000) and (2006) help to demonstrate an evolving subject area, both in terms of the profession the education of architectural technologists. There are thirty three CIAT accredited degree programmes in Architectural Technology and forty five RIBA validated architecture programmes in the UK. Analysis of these programmes was undertaken with the aim of highlighting the differences between architecture and architectural technology. From this the authors identify a number of factors that could be explored further in regard to the further development of architectural technology education.

**Keywords:** architecture, architectural technology, education, evolving profession

## **1. Introduction**

One of the oldest architecture schools is the Architectural Association in the UK, which dates from 1847. The foundation of the AA is usually accepted as the reason for the rise of architecture education as it is understood today (AA History, 2013). Over time several different professions have evolved from architecture, such as architectural technology, architectural engineering and

more recently design management. Architecture is still accepted as an umbrella discipline for all of those professions but it is impossible for an architect to be knowledgeable in all areas, hence the specialisation and fragmentation to be found in education and in industry. In the UK during the 1990s a new phenomenon emerged in the education of built environment professionals. That was the introduction of an undergraduate degree in Architectural Technology, first introduced at the University of Luton and quickly adopted by other institutions in the UK and the Republic of Ireland (see Emmitt, 2002; Alexander & Orr, 2013). Up until this breakthrough in the education of architectural technologists, it was only possible to undertake Higher National Certificates and Higher National Diplomas in architectural technology. This new undergraduate programme offered students an alternative to design orientated programmes in Architecture or more technical/managerial programmes in Building, Construction Management or Building Surveying. Table 1 illustrates the architecture related undergraduate degree programmes in the UK.

TABLE1. Architecture related degree programmes in UK.

|  |  |
|--|--|
| Architecture                               | Property Development and Arch. Design    |
| Architectural technology                   | Building Services Engineering            |
| Building survey                            | Architecture Studies                     |
| Construction management                    | Architectural History                    |
| Quantity Surveying                         | Landscape Architecture                   |
| Interior Architecture and Design           | Lighting Design and Technology           |
| Civil and Architectural Engineering        | Building Studies                         |
| Architectural Visualisation                | Structural Engineering with Arch. Design |
| Construction and the Built Environment     | Building Production Technology           |
| Project Management for Construction        | Arch. Engineering and Design Management  |
| Architecture and Environmental engineering | Architectural Environment Engineering    |
| Architectural Engineering                  | Architecture and Environmental Design    |
| Building Surveying                         | Environmental Construction Surveying     |
| Civil Engineering with Architecture        |  |

The architecture profession is concerned with the production of a conceptual creative idea for a building and other related works for realization in a physical form. These are usually combined and referred to as the architectural design process. Both the demands about the conceptual creative design idea and the performance of the realized physical form of the buildings are increasing day by day. The realization of an architectural idea is the most time consuming and complex sub-process of the architectural

design process. And this sub-process is a key factor affecting the success of an architectural design idea. The complexity of this sub-process lies within the nature of the modern construction industry as firstly, there are lots of different building materials, components and elements and secondly there are lots of different construction techniques and methods. Architects are usually too busy dealing with the creative conceptual studies, which is why there is a need for a different professional who will be the link between the creative idea and the realisation of design intent. In the UK it is the architectural technologist who forms the link in the architectural design process.

Architectural technology, as a creative link, is also being recognised in a growing number of countries, such as Canada, South Africa, Republic of Ireland, Sweden, Denmark, Hong Kong and UK. The UK is a significant example, as architectural technology is accepted as a different and separate, profession to architecture. In the other countries the term 'architectural technology' is usually used in a similar way to the term architectural technician or to refer to a 'constructing architect' in, for example, Denmark (Barrett, 2011).

In the UK architectural technology education is controlled by the Chartered Institute of architectural Technologists (CIAT). There are currently 33 architectural technology programmes in UK. 23 of these are CIAT accredited and 10 are accredited in principle. 16 of these programmes belong to a university that also has an architecture programme. The aim of this paper is to compare and contrast these schools' architectural technology and architecture programmes in an attempt to better understand the contemporary borders between the education of architectural technologists and architects.

### 1.1 METHOD

The method adopted for this research consists of two main parts. The first part is the data collation, drawn from the UCAS, programme specifications, the chartered bodies of architecture and architectural technology, and programmes' curricula. The second part is the analysis of that data.

In the data collation part the programmes are examined in four steps:

1. analysis of the entry requirements,
2. analysis of the Faculties and Schools that the programmes belong to,
3. analysis of the accreditation principles for architecture and architectural technology,
4. analysis of the subject areas (topics) of each programme.

In the comparison part, data derived from the above steps are used for the comparative analysis of architecture and architectural technology programmes, comprising the:

1. entrance requirements,
2. type of Faculty and School that oversee these programmes,
3. accreditation principles,
4. subject areas (topics).

## 2 Architecture Programmes

In this paper, 49 honours degree architecture programmes of the UK are studied (Table 2). 47 of them use UCAS for electing candidate students. 43 of the programmes are RIBA Part 1 validated. 47 of them use UCAS and 2 of them use their own systems for electing the candidate students. These programmes were analysed in terms of entry requirements to find out the level and attributes of the students who want to study architecture. Secondly, faculties/schools to which the programmes belong were analysed to identify the educational atmosphere (creative or technical or otherwise). Thirdly, validation principles are analysed to find out the level and attributes of new graduate architects. And lastly, the modules of the programmes are analysed to find out the subject topics of their curricula.

TABLE 2. Architecture honours degree programs in the UK.

| #   | University                              | validation status | election type | curriculum | #   | University                                 | validation status | election type | curriculum |
|-----|---|-------------------|---------------|------------|-----|--|-------------------|---------------|------------|
| 1.  | The Arts University of Bournemouth      | RIBA              | UCAS          | obtained   | 26. | Northumbria University                     | RIBA              | UCAS          | obtained   |
| 2.  | University of Bath                      | RIBA              | UCAS          | obtained   | 27. | The University of Nottingham               | RIBA              | UCAS          | obtained   |
| 3.  | Birmingham City University              | RIBA              | UCAS          | obtained   | 28. | Nottingham Trent University                | RIBA              | UCAS          | obtained   |
| 4.  | University of Brighton                  | RIBA              | UCAS          | obtained   | 29. | Oxford Brookes University                  | RIBA              | UCAS          | obtained   |
| 5.  | University of Cambridge                 | RIBA              | UCAS          | obtained   | 30. | Plymouth University                        | RIBA              | UCAS          | obtained   |
| 6.  | Cardiff University                      | RIBA              | UCAS          | obtained   | 31. | University of Portsmouth                   | RIBA              | UCAS          | obtained   |
| 7.  | University of Central Lancashire        | RIBA              | UCAS          | obtained   | 32. | Queens University of Belfast               | RIBA              | UCAS          | obtained   |
| 8.  | University for the Creative Arts        | RIBA              | UCAS          | obtained   | 33. | Robert Gordon University                   | RIBA              | UCAS          | -          |
| 9.  | De Montfort University                  | RIBA              | UCAS          | -          | 34. | The University of Sheffield                | RIBA              | UCAS          | obtained   |
| 10. | University of Dundee                    | RIBA              | UCAS          | obtained   | 35. | Sheffield Hallam University (Architecture) | RIBA              | UCAS          | obtained   |
| 11. | The University of East of London        | RIBA              | UCAS          | obtained   | 36. | The University of Strathclyde              | RIBA              | UCAS          | obtained   |
| 12. | The University of Edinburgh             | RIBA              | UCAS          | -          | 37. | University of Ulster                       | RIBA              | UCAS          | obtained   |
| 13. | University of Glasgow (the Glasgow Scho | RIBA              | UCAS          | obtained   | 38. | University of Westminster                  | RIBA              | UCAS          | obtained   |
| 14. | University of Greenwich                 | RIBA              | UCAS          | obtained   | 39. | University of the west of England, Bristol | RIBA              | UCAS          | -          |
| 15. | The University of Huddersfield          | RIBA              | UCAS          | obtained   | 40. | University of the Arts of London (Central  | RIBA              | UCAS          | obtained   |
| 16. | The University of Kent                  | RIBA              | UCAS          | obtained   | 41. | Hull College                               | RIBA              | UCAS          | -          |
| 17. | Kingston University                     | RIBA              | UCAS          | obtained   | 42. | The Bartlett School of Architecture        | RIBA              | -             | -          |
| 18. | Leeds Metropolitan University           | RIBA              | UCAS          | obtained   | 43. | Architectural Association                  | RIBA              | -             | -          |
| 19. | University of Lincoln                   | RIBA              | UCAS          | obtained   | 44. | Anglia Ruskin University                   | -                 | UCAS          | obtained   |
| 20. | The University of Liverpool             | RIBA              | UCAS          | obtained   | 45. | Coventry University                        | -                 | UCAS          | obtained   |
| 21. | Liverpool John Moores University        | RIBA              | UCAS          | obtained   | 46. | Norwich University College of Arts         | -                 | UCAS          | -          |
| 22. | London Metropolitan University          | RIBA              | UCAS          | obtained   | 47. | Ravensbourne                               | -                 | UCAS          | obtained   |
| 23. | London South Bank University            | RIBA              | UCAS          | obtained   | 48. | University College London                  | -                 | UCAS          | -          |
| 24. | The University of Manchester (and The M | RIBA              | UCAS          | -          | 49. | British Ins. of Tech. and E-Commerce       | -                 | UCAS          | -          |
| 25. | University of Newcastle Upon Tyne       | RIBA              | UCAS          | obtained   |     |  |                   |               |            |

## 2.1 ENTRY REQUIREMENTS

47 architecture programmes, which use UCAS system, are analysed about the entry requirements. There are three main factors related with the entry requirements to architecture programmes. The first is A-levels, the second one is the applicant's portfolio of work, and the last one is an interview.

The General Certificate of Education Advanced Level, commonly referred to as the A-level, is a qualification offered by educational institutions in England, Wales and Northern Ireland. A-levels are studied over a two-year period and are recognised as the standard for assessing the suitability of applicants for higher academic courses in English, Welsh, and Northern Irish universities (OFQUAL, 2013). Almost all of the architecture programmes in the UK (79%) demand or prefer 3 A-levels, Slightly less than a sixth of the programmes (15%) demand 2 A-levels, and a minority of programmes (6%) demand 3,5 A-levels. The grade range of the A-levels varies from AAA to ABC (BBB). And finally, the range of the tariff points demanded by the programmes varies from 280 to 340 (average 300), collected from A-levels and other qualifications (UCAS, 2013).

A portfolio is a selection of work compiled over time to showcase the artistic and creative abilities of an individual (Merriam-Webster, 2013). The portfolio is developed by the student during their A level studies, and is commonly required for entry into creative undergraduate programmes covering the arts and architecture.

The academic interview is a conversation between the applicant and academics during which questions are asked by the interviewer to elicit facts or statements from the interviewee. In education interviews are usually used to evaluate qualifications of a prospective student (Merriam-Webster, 2013).

An examination of the portfolios and an evaluation of the qualifications of the applicants by interviews are usually used in the election process of students to architecture programmes. More than half of the programmes (54%) demand the applicant to attend for an interview and present a portfolio. Almost a quarter of them (22%) demand the applicant to present only a portfolio, and slightly more than a tenth of them (12%) demand the applicant to attend for an interview. Slightly more than a tenth of the programmes (12%) do not require the applicant to attend for an interview or present a portfolio (UCAS, 2013).

## 2.2 FACULTY/SCHOOL

A faculty is a division within a university comprising one subject area, or a number of related subject areas which are usually represented by the related programmes. The programmes in a faculty form a scientific environment

which may affect how the programmes are managed and also influence their content. For architecture programmes the Faculties can be categorised as:

- I. Art, design and architecture – 27%
- II. Science, technology, engineering and humanities – 18%
- III. Architecture – 16%
- IV. Technology, engineering, design and architecture – 14%
- V. Built and natural environment – 8%
- VI. Art, social sciences and communication – 8%
- VII. Art, environment and technology – 2%

### 2.3 ACCREDITATION/VALIDATION

RIBA validation is an evidence-based, peer review system working internationally as a critical friend to schools of architecture, monitoring courses to improve median achievement, encourage the excellent, and ensure a positive student experience (RIBA, 2011). There are 11 general criteria for validation of architecture programmes, and these criteria can be categorized into five topics:

- I. Design
  - a- Ability to create architectural designs
  - b- Knowledge of fine arts
  - c- Understanding the relation of people and buildings
  - d- Understanding the methods for design brief preparation
- II. History & Theory
  - a- Knowledge of history and theory
- III. Urban Design
  - a- Knowledge of urban design
- IV. Professional Practice
  - a- Understanding the profession of architecture and role of architect in society
  - b- Knowledge of the industries, organisations, regulations and procedures in translating design into buildings
- V. Architectural Technology
  - a- Understanding structural design, constructional and engineering problems
  - c- Knowledge of physical problems, technologies and the function of buildings
  - d- Necessary design skills to meet users' requirements

## 2.4 TOPICS OF ARCHITECTURAL EDUCATION SUBJECTS

The curricula of 38 architecture programmes were analysed considering the following headings: ‘architectural project’, ‘architectural representation’, ‘supportive modules’, and ‘final project’.

### 2.4.1 *Architectural Project*

Modules, which can be called with the keyword ‘architectural project’, are central parts of architecture related education. All aspects of the student’s education are structured and the links with the practical life are developed around these modules (Demirbas and Demirkan, 2003). The topics of these modules may give clues about how programme comprehend this module. The distributions of the programmes according to the topics are:

- I. Architectural design – 30%
- II. Design studio – 16%
- III. Studio – 16%
- IV. Design – 8%
- V. Architectural / Design project – 8%
- VI. Project – 6%
- VII. Architectural design studio – 4%
- VIII. Other – 12%

Architectural project modules are usually sequential in the architecture programmes, increasing in size and complexity as the student progresses. Almost half of the architectural programmes (45%) use the same topic for architectural project modules for all of the semesters. Slightly more than a fifth of the programmes (21%) use different topics for architectural project modules in the first two semesters. These are usually structured to be a foundation to the later on architectural project modules. Almost a sixth of the programmes (16%) use different topics for architectural project modules in the final year which is usually related with the integration of different architectural subjects. Almost a sixth of the programmes (16%) structure the architectural project modules with a thematic approach. This results with different thematic topics for the architectural project modules in each term. The topics of architectural project modules are transformed to different topics for the final two semesters in the minority of the programmes (2%). These are usually related with the integration of different architectural subjects.

### 2.4.2 *Architectural Representation*

Different architectural representation techniques are used to exchange ideas by the specialists of the architectural design process (Yazicioglu, 2007). Architect is one of the most important specialists of the architectural design



process, nevertheless more than half of the architecture programmes (60%) in the UK do not provide any specific architectural representation modules in their curricula. Less than half of the architectural programmes (40%) in the UK have modules which are related with architectural representation techniques. The topics of these modules may give clues about how programmes comprehend this module. They can be categorized under three main groups according to their subjects: communication, presentation, and computer applications.

#### *2.4.3 Supportive Modules*

The role of an architect in architectural design process has become to be mainly about the design idea (Latham, 1994; Egan, 1998). Hence, the content of architectural education programmes shift towards conceptual design (Emmitt, 2005; Cole and Cooper, 1988; Carpenter, 1997). However, architects should be equipped with some other knowledge and abilities to support, shape and configure design related issues (Yazicioglu and Kus, 2011). The modules which support these issues are essential parts of the curricula in architecture related programmes. They are called as the supportive modules in this paper. Almost all of the architecture programmes in the UK have several supportive modules in their curricula. The topics of these modules may give clues about how programmes comprehend this module. They can be categorized under three main groups according to their subjects: architectural technology, professional issues, and history and theory.

#### *2.4.4 Final Project*

In higher education institutes, modules which are used to assess the suitability of the students for graduation are commonly used. There are also similar modules in architecture programmes. As the main subject of architecture education is architectural design activity, these modules are usually structured to be like an architectural project module from which the decision for a student to graduate is decided. They are called as the final projects in this paper. Slightly more than a quarter of architecture programmes in the UK (28%) have final project modules in their curricula. The topics of these modules may give clues about how programmes comprehend this module. These modules are usually referred as; thesis, research project, design thesis, and main project report.

### **3 Architectural Technology programmes**

In this paper, 33 honours degree architecture programmes of the UK and the Channel Islands are studied (Table 3). 23 of the programmes are CIAT accredited and 10 are accredited in principle. 27 of them use UCAS, and 5 of

them use their own systems for electing candidate students. These programmes were analysed in terms of entry requirements to find out the level and attributes of the students who want to study architectural technology. Secondly, faculties/schools to which the programmes belong were analysed to identify the educational atmosphere (creative or technical or otherwise). Thirdly, validation principles are analysed to find out the level and attributes of new graduate architectural technologists. And lastly, the modules of the programmes were analysed to find out the subject topics of their curricula.

TABLE 3. Architectural technology honours programmes in the UK.

| #   | University                       | validation status | election type | curriculum | #   | University                                 | validation status | election type | curriculum |
|-----|----------------------------------|-------------------|---------------|------------|-----|--|-------------------|---------------|------------|
| 1.  | Anglia Ruskin University         | CIAT              | UCAS          | obtained   | 18. | Edinburg Napier University                 | CIAT              | UCAS          | obtained   |
| 2.  | Birmingham City University       | CIAT              | UCAS          | obtained   | 19. | University of Derby                        | CIAT              | UCAS          | obtained   |
| 3.  | University of Brighton           | CIAT              | UCAS          | obtained   | 20. | University of The West of England, Bristol | CIAT              | UCAS          | obtained   |
| 4.  | University of Central Lancashire | CIAT              | UCAS          | obtained   | 21. | University of Northampton                  | CIAT              | UCAS          | -          |
| 5.  | Coventry University              | CIAT              | UCAS          | obtained   | 22. | Southampton Solent University              | CIAT              | UCAS          | obtained   |
| 6.  | The University of Huddersfield   | CIAT              | UCAS          | obtained   | 23. | University of Wolverhampton                | CIAT              | UCAS          | obtained   |
| 7.  | Leeds Metropolitan University    | CIAT              | UCAS          | obtained   | 24. | The University of Bolton                   | CIAT              | UCAS          | obtained   |
| 8.  | Liverpool John Moores University | CIAT              | UCAS          | obtained   | 25. | Cardiff Metropolitan University            | CIAT              | UCAS          | -          |
| 9.  | London South Bank University     | CIAT              | UCAS          | obtained   | 26. | Glyndwr University                         | CIAT              | UCAS          | obtained   |
| 10. | Northumbria University           | CIAT              | UCAS          | obtained   | 27. | University of West London                  | CIAT              | UCAS          | obtained   |
| 11. | Nottingham Trent University      | CIAT              | UCAS          | obtained   | 28. | Highlands College (Jersey)                 | CIAT              | -             | -          |
| 12. | The University of Plymouth       | CIAT              | UCAS          | obtained   | 29. | De Montfort University                     | CIAT              | -             | -          |
| 13. | Robert Gordon University         | CIAT              | UCAS          | -          | 30. | Guernsey College for Further Education     | CIAT              | -             | -          |
| 14. | The University of Salford        | CIAT              | UCAS          | obtained   | 31. | Pembrokeshire College                      | CIAT              | -             | -          |
| 15. | Sheffield Hallam University      | CIAT              | UCAS          | obtained   | 32. | Waterford Institute of Technology          | CIAT              | -             | -          |
| 16. | University of Ulster             | CIAT              | UCAS          | obtained   | 33. | Carlow Institute of Technology             | CIAT              | -             | -          |
| 17. | University of Westminster        | CIAT              | UCAS          | obtained   |     |  |                   |               |            |

### 3.1 ENTRY REQUIREMENTS

27 architectural technology programmes, which use UCAS system, are analysed about the entry requirements. The most important factor related with the entrance to an architectural technology programme in the UK is the A-levels. Some of the programmes also demand a letter of intent from the students, but the demand for a portfolio or an interview is rare.

More than half of the architectural technology programmes (56%) demand or prefer 3 A-levels, and the remainder of them (44%) require 2 A-levels. The grade range of the A-levels varies from BBB to CCC. And finally, the range of the tariff points demanded by the programmes varies from 200 to 300 (average 260), collected from A-levels and other qualifications (UCAS, 2013).

Almost three quarters of the architectural technology programmes (74%) do not require the applicant to attend for an interview or present a portfolio. Slightly more than a tenth of the architectural technology programmes (11%) require the applicant to attend for an interview and present a portfolio. Slightly more than a tenth of the programmes (11%) only require the

applicant to attend for an interview and a minority of the programmes (4%) require the applicant to present a portfolio.

### 3.2 FACULTY AND SCHOOL

For architectural technology programmes the Faculties can be categorised as:

- I. Technology – 27%
- II. Art – 27%
- III. Engineering – 23%
- IV. Architecture – 12%
- V. Built environment – 8%
- VI. Development and planning – 4%

### 3.3 ACCREDITATION/VALIDATION

“CIAT Accreditation (including Accreditation in Principle) implies that an educational establishment’s Architectural Technology Honours degree level programme has been assessed in terms of content, structure and resources and has met the required standards. It also provides assurances that students will be able to develop their academic, analytical, communication and employability skills” (CIAT, 2012). CIAT evaluates the architectural technology programmes’ curricula according to the criteria listed in the 2007 dated Architectural Technology Benchmark Statement (QAA, 2007). Accordingly, there are 19 criteria for accreditation of architectural technology programmes which are categorised by QAA and CIAT into four topics.

- I. Design
  - a. Client requirements
  - b. Evaluate resources and environmental impacts
  - c. Manage health and safety
  - d. Legal and regulatory control
  - e. Develop brief and design programmes
  - f. Project design and detail design
  - g. Design documents
  - h. Project feedback
- II. Technology
  - a. Condition of the property
  - b. Construction methods and plan of work
  - c. Technical and performance requirements
  - d. Detailed design solutions

- e. Survey requirements, technical information and developments factors
- III. Procurement
  - a. Control contract quality, progress and costs and manage project handover
  - b. Procure and evaluate estimates, bids and tenders and agree contracts
  - c. Select and agree procurement procedures and forms of contract
- IV. Professional practice
  - a. Operate in a professional manner
  - b. Work with teams and other people
  - c. Form design teams and establish their responsibilities and methods of working

### 3.4 TOPICS OF ARCHITECTURAL EDUCATION SUBJECTS

The curricula of 24 architectural technology programmes could be obtained for this study. These curricula have been analysed considering the following headings: 'architectural project', 'architectural representation', 'supportive modules', and 'final project'.

#### 3.4.1 *Architectural project*

The distributions of the programmes according to the topics are:

- I. Architectural design project – 33%
- II. Architectural technology project – 30%
- III Interdisciplinary project – 30%
- IV Professional practice project – 7%

Architectural project modules are usually not sequential in the architectural technology programmes. A variety of names are used at different stages of the programme to describe the project module. More than half of the architectural technology programmes (54%) use different topics for architectural project modules each year. These programmes usually structure the first year's modules to be preparation to design, second year's modules to be introduction to design, and final year's modules to be the actual architectural project modules. Slightly more than a fifth of the programmes (21%) use the same topic for architectural project modules for all of the semesters. Slightly more than a sixth of the programmes (16%) use different topics for architectural project modules in the final year which is usually related with the integration of different architectural subjects. Almost a tenth of the programmes (8%) use different topics for architectural project modules in the first two semesters.

### *3.4.2 Architectural Representation*

Almost all of the architectural technology programmes in the UK have modules which are related with architectural representation techniques. The topics of these modules may give clues about how programmes comprehend this module. They can be categorized under three main groups according to their subjects: communication, design and survey abilities, computer applications.

### *3.4.3 Supportive Modules*

The role of an architectural technologist in the architectural design process is about the works for realization in a physical form of the design idea. Thus, architectural technology students should be equipped with design, technology and management skills (Emmitt, 2001). Architectural technology students are equipped with general design related abilities and integration of different gathered knowledge and acquired abilities in the architectural project modules. Besides, the knowledge and abilities about detail design, technology and management are gathered and acquired in the modules which support the architectural project modules. These kinds of modules are called supportive modules in this paper. All of the architectural technology programmes in the UK have; architectural technology, legal and regulatory framework, and reuse and restoration in their curricula.

### *3.4.4 Final Project*

Almost half of the architectural technology programmes (42%) have final project modules in their curricula. The topics of these modules may give clues about how programmes comprehend this module. These modules are usually referred as; dissertation, research project, technical report, special – independent study and final year project in the architectural technology programmes in the UK.

## **4 Comparative Analysis of Architecture and Architectural Technology Programmes**

Currently there are more institutions offering architecture than architectural technology, with 49 programmes in architecture and 33 in architectural technology (see Table 2 and 3). This may well represent the historical development of the subject areas, with architectural technology being a relatively new academic discipline, and it may be interesting to see what these figures look like ten years hence. However, this may also reflect the more creative (and potentially more attractive) nature of architectural programmes and hence a larger market. It is also interesting to note that all of the architectural technology programmes are offered in the ‘new’ universities. These institutions were known as polytechnics and technical

colleges prior to the 1990s, after which time they had the right to apply for university status. This is relevant because the polytechnics and technical colleges were always more vocational related compared to the traditional universities. This means that the architectural technology programmes may still be influenced by a more vocational rather than academic focus and may go some way to explain the differences in entry requirements for architecture and architectural technology.

#### 4.1 ENTRY REQUIREMENTS

Entry requirements for the architecture programmes are higher than that for architectural technology programmes. And, the majority of architecture programmes require a portfolio of work and an interview whereas architectural technology programmes do not. The average entry requirements in terms of UCAS tariff points are; 300 for architecture and 260 for architectural technology programmes. This implies that the architecture students are more academically gifted than the architectural technology students.

##### *4.1.1 Faculty/School*

Over half of the architecture programmes (57%) are provided by architecture faculties. Almost one third of the architecture programmes (32%) are provided by technology and/or engineering related, and almost a tenth of them (8%) is art and/or social sciences related faculties. A minority of programmes (3%) are provided by faculties which hold both art and technology as main subjects.

Half of the architectural technology programmes (50%) are provided by technology and/or engineering faculties. Slightly over a quarter of the programmes (27%) are provided by art related faculties. Slightly more than a tenth of the architectural technology programmes (12%) are provided by architecture related, and almost a tenth of them (8%) are provided by built environment related faculties. A minority of programmes (3%) are provided by development and planning related faculties.

There are 16 universities which offer both architecture and architectural technology programmes. Architecture and architectural technology programmes are in different faculties in a quarter of these universities.

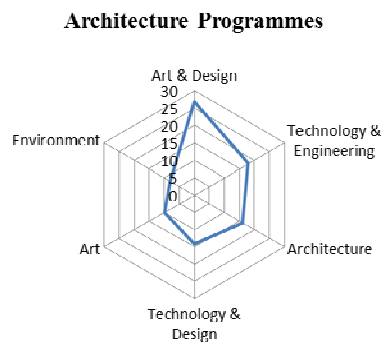


Figure 1. Distribution of architecture faculties among different subjects oriented faculties.



Figure 2. Distribution of architectural technology faculties among different subjects oriented faculties

Table 4. Universities which offer architecture and architectural technology programmes in different faculties

|    | Univesity - Programme                      | Faculty / School                                       |
|----|--|--|
| 1. | Birmingham City - Architecture             | Birmingham Institute of Art and Design                 |
|    | Birmingham City - Architectural technology | Faculty of Technology, Engineering and the Environment |
| 2. | Leeds Met - Architecture                   | Art, Architecture & Design                             |
|    | Leeds Met - Architectural technology       | Built Environment                                      |
| 3. | Brighton - Architecture                    | Faculty of Arts  |
|    | Brighton - Architectural technology        | The Faculty of Science and Engineering                 |
| 4. | John Moores - Architecture                 | Faculty of Arts, Professional and Social Studies       |
|    | John Moores - Architectural technology     | Faculty of Technology and Environment                  |

Table 5. Universities which offer architecture and architectural technology programmes in same faculties

|    | Univesity - Programme | Faculty / School  |
|----|-----------------------|---|
| 1. | Nottingham Trent      | School of Architecture, Design and the Built Environment      |
| 2. | Sheffield Hellam      | Faculty of Development and SocietyArchitecture and Planning   |
| 3. | Plymouth              | Faculty of ArtsSchool of Architecture, Design and Environment |
| 4. | Westminster           | School of Architecture and the Built Environment              |
| 5. | Huddersfield          | School of Art, Design and Architecture                        |
| 6. | Northumbria           | Faculty of the Built and Natural Environment                  |
| 7. | London Southbank      | Faculty of Engineering, Science and the Built Environment     |
| 8. | Ulster                | Faculty of Art, Design and the Built Environment              |
| 9. | Uclan                 | School of Built and Natural Environment                       |

## 4.2 VALIDATION / ACCREDITATION

The topics of the validation / accreditation criteria of both professions are found to be appropriate for the definitions of the professions. But architecture criteria are found to be better structured, especially in pedagogic means, as they are divided in terms of ‘knowledge’, ‘understanding’, ‘ability’ and ‘skills’. CIAT accreditation criteria are categorized in four headings: design, technology, procurement, and professional practice. RIBA’s validation criteria can be categorized into five headings: design, history & theory, urban design, professional practice and architectural technology. Table 6 demonstrates the differences and similarities of these categories.

Table 6. CIAT and RIBA headings of the criteria

| CIAT accreditation criteria | RIBA validation criteria    |
|-----------------------------|-----------------------------|
| 1. design                   | 1. design                   |
| 2. architectural technology | 2. architectural technology |
| 3. professional practice    | 3. professional practice    |
| 4. procurement              | 4. history & theory         |
|                             | 5. urban design             |

The headings of the categories of the accreditation and validation criteria show that both professional bodies wanted their future member students to be equipped about design, architectural technology and professional practice related subjects. The differences between them are:

- CIAT expects the architectural technologists to be equipped with procurement related knowledge and/or abilities.
- RIBA expects the architects to be equipped with history and theory related knowledge and/or abilities.
- RIBA expects the architects to be equipped with urban design related knowledge and/or abilities.

Differences relating to procurement are to be expected because architectural technologists are more related to construction, whereas architects are usually focused on the conceptual design. Urban design is a specific specialist area which architects, as conceptual designers, need to be acquainted with, whereas architectural technologists do not. When it comes to history and theory one could be excused for asking why it is not included within the architectural technologist’s curriculum. History & theory is an important resource that feeds creativity in architecture and architecture related subjects. The importance of precedents in detail design is a crucial factor that should underpin the architectural technologist’s knowledge and skills set, and this should be included within the architectural technology curricula.



#### 4.3 TOPICS OF ARCHITECTURAL EDUCATION SUBJECTS

##### 4.3.1 Architectural Project

Architectural project modules are the fundamental components of both architecture and architectural technology programmes. Figure 3 and 4 demonstrates the keywords used in architectural project modules in architecture and architectural technology programmes:

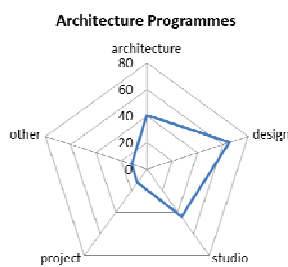


Figure 3. Keywords of architectural technology projects in architecture programmes.

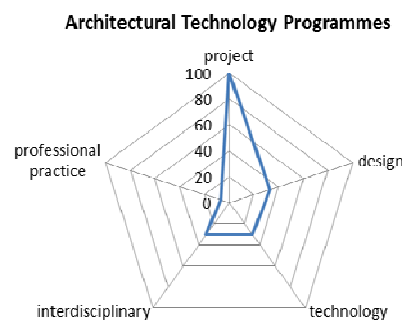


Figure 4. Keywords of architectural technology projects in architectural technology programmes.

In architectural technology the architectural project modules are more descriptive in terms of the keywords used in their names. Architecture programmes use generic names for the modules, appear to be structured more loosely and are less prescriptive; thus allowing for greater creativity. These modules in architecture are also sequential, increasing in complexity, whereas similar modules in architectural technology are not. While this may reflect the different tasks undertaken in practice, there appears to be an opportunity to make the project aspects of architectural technology programmes more cohesive.

##### 4.3.2 Architectural Representation

More than half of the architecture programmes (60%) do not have any architectural representation related modules in their curricula whereas almost all of the architectural technology programmes do. Related modules in architecture programmes can be categorized in 'communication', 'presentation', and 'computer applications' topics. Related modules in architectural technology programmes can be categorized in

‘communication’, ‘designing and surveying abilities’, ‘computer application’ topics. Table 7 demonstrates the differences and similarities of these categories.

Table 7. Representation related modules in architecture and architectural technology programmes

| Architectural technology programmes |                                   | Architecture programmes |                      |
|-------------------------------------|-----------------------------------|-------------------------|----------------------|
| 1.                                  | communication                     | 1.                      | communication        |
| 2.                                  | computer application              | 2.                      | computer application |
| 3.                                  | designing and surveying abilities | 3.                      | presentation         |

Architectural representation issues are mostly handled in architectural project modules in architecture programmes whereas there are mostly separate modules in architectural technology programmes. The reason for that is probably related to the depth level expected from the two specialists’ representations. The representation technique of a creative design may also be generated by the architect creatively and freely, whereas an architectural technologist deals with designs which are more complicated and detailed.

#### 4.3.3 Supportive Modules

Supportive modules in architecture programmes relate to ‘architectural technology’, ‘professional issues’, and ‘history and theory’ topics. In architectural technology programmes the supportive modules are in ‘architectural technology’, ‘legal and regulatory framework’, ‘reuse and restoration’ topics. Table 8 demonstrates the differences and similarities of these categories.

Table 8. Headings of supportive modules in architecture and architectural technology programmes

| Architecture programmes |                          | Architectural technology programmes |                                |
|-------------------------|--------------------------|-------------------------------------|--------------------------------|
| 1.                      | architectural technology | 1.                                  | architectural technology       |
| 2.                      | professional issues      | 2.                                  | legal and regulatory framework |
| 3.                      | history and theory       | 3.                                  | reuse and restoration          |

Architecture and architectural technology programmes’ supportive modules differ in four areas. These are professional issues and history & theory

related modules in architecture programmes, and legal & regulatory framework, and reuse & restoration modules in architectural technology programmes. These differences help to give some identity to the two professions. The need for history & theory related modules in both architecture and architectural technology programmes is discussed in section 6.3.

#### *4.3.4 Final Project*

Almost a quarter of architecture programmes (23%) have final project/thesis modules in their curricula compared to almost half of the architectural technology programmes (42%). The distribution of the topics of the modules is similar in both architecture and architectural technology programmes, 'dissertation', 'research project', 'technical report', 'special – independent study' and 'final year project'. These modules help to develop a student's research skills and further research is required to establish the nature of these differences and the impact on the education of the students.

## **5 Discussion**

Analysis of architecture and architectural technology curricula has been instrumental in helping to highlight similarities and differences between the two subject areas. The difference in entry requirements of architecture and architectural technology programmes, in terms of UCAS tariff points and A-levels indicate that architecture programmes are more popular than architectural technology programmes. This may simply be related to the newness of the discipline, but it may also be that:

- Student (and career advisors') awareness about architecture programmes and the role of the architect may be higher than their awareness of architectural technology,
- Architecture may be perceived as a more creative undergraduate programme than architectural technology. Hence it may be more appealing than the built environment alternatives that are more science and/or management orientated
- The status of the architect may be perceived to be higher than that of the architectural technologist, and hence more attractive than architectural technology
- Students may think that it is easier to find a job as an architect, or better understand the role of the architect.

Architecture programmes require a portfolio from candidates whereas architectural technology programmes do not. The main reason for this is the need for selection of the students, as more students want a place in architecture programmes. The portfolio is a concept which is mainly related to art and architecture, artistic and creative activities. Thus one could conclude that architecture programmes demand students whose creative cognitive abilities are high, whereas architectural technology programmes do not. This is, however, somewhat contradictory as one of the most important parts of architectural technology is about detail design. Detail design activity also needs creative cognitive abilities which are related with more variables than an architectural concept design activity. Choosing students whose design abilities are at a good level is important in the success of educating architectural technologists. Therefore, a portfolio of work should form part of the assessment of the applicants for all architectural technology programmes.

## 6 Concluding recommendations

Architects and architectural technologists are two essential actors in a contemporary architectural design process. Both need each other in order to do their job effectively. From our analysis it is evident that the undergraduate degree programmes for both professions are well organised, but there are some significant differences. The architecture programmes are more advanced than the architectural technology programmes considering the entry requirements, the number of programmes available and the accreditation/validation criteria. The length of time that architectural education has been around may well have something to do with this, but given that architectural technologists aim (or even claim) to be on a par with architects, there would appear to be some areas that need to be addressed. Tentatively we can propose that;

- Architectural technology degrees need to develop a more distinct identity with clearly stated boundaries that complement architectural programmes. Being hosted in a variety of faculties with differing academic (scientific) cultures may help in this regard and may also add an element of uniqueness.
- History and theory should be integrated into architectural technology programmes to give the subject more relevance to the built environment. Similarly, the importance of historical precedents and design theory should be applied to detail design.
- Entry to an AT undergraduate programme should be on a par with architectural programmes to help address issues of status. A

portfolio should form part of the interview requirements given the importance of design to the architectural technology profession.

Architectural technology is still evolving as an academic discipline and it is highly likely that the undergraduate degree programmes in architectural technology will develop a stronger identity over the next decade. We might also expect that the entry requirements move closer to those in architecture as the programmes mature and the discipline's status rises. These changes are linked not only to the development of the discipline in industry, but also to the development of a research culture in architectural technology. In terms of further research it may be insightful to research the attitudes of architects and architectural technologists at the start of their undergraduate studies and on completion of their studies. Programme preferences of the architectural technology students enrolling on to masters programmes may give some clues about how the perceptions of them about the discipline change. It may also be insightful to research the modules of the programmes more detailed. Surveys, observations and interviews may be done to understand why and how the modules are structured and related with the programmes as a whole. These may also help to propose more advanced curricula for architectural technology programmes.

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## FROM ELEARNING TO ILEARNING

### *Transforming the Teaching Environment for Architectural Technology Students*

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**Abstract** Whilst traditional lectures can have benefits in terms of delivering key information to many students, there is a growing scepticism about their ability to aid student learning and understanding. In many lecture theatres notes are simply recorded in the file of the student, only to be regurgitated in examinations without any real learning taking place. In Architectural Technology (AT) education this is far from ideal, as an opportunity needs to be provided for the student to apply the information to real world scenarios, reflect and engage in meaningful discussion. Oblinger (2006) stated “Today’s students – whether 18, 22 or 55 have attitudes, expectations and constraints which differ from those of students even 10 years ago...Many of today’s learners favour active, participatory, experiential learning – the learning style they exhibit in their personal lives.” The recent development of the Apple iBook has the potential to assist with this transformation in student learning. For Architectural Technology & Management (ATM) students, the integration of 3D models, quizzes and video has the ability to bring real world scenarios into the classroom, encouraging dialogue and presenting information in a way that genuine learning and understanding can occur. This paper will focus on how the iBook is being used at the University of Ulster as a method of teaching first year ATM students and will offer a preliminary insight into their creation and impact on student attitudes.

## 1. Introduction

Year one of the ATM course at the University of Ulster is aimed at providing students with a fundamental understanding of the AT discipline.

In order to achieve this, they study a range of modules, one of which is Architectural Technology A. This is a module that is primarily delivered via a series of lectures, and as outlined in the module booklet, is aimed at providing learners “with knowledge of the principles and application of building technology.” The content covers a range of subject areas including construction techniques and materials, architectural detailing, Computer Aided Design (CAD) and legislation governing the design and construction of buildings.

The entry routes onto the course are quite varied. Some students will have studied for a National Diploma in Construction giving them a basic understanding of construction operations, methods and techniques. The remainder of the cohort will have taken a more traditional route studying A-Levels, but will not necessarily have any background knowledge of design or construction. Consequently, a significant proportion of first year students tend to struggle with the module, as it is their first exposure to construction detailing and legislation. An additional problem is the constant difficulty in keeping first year students focused during lectures. Many subconsciously tend to disengage for spells of time, often coinciding with the delivery of key learning outcomes. Teaching methods within the module have always encouraged student engagement and aimed to use real life projects to provide a realistic context for study, however, there is still the underlying challenge of maintaining an active interest for prolonged periods when delivering key concepts of information that are essential for learning and understanding to take place.

A 2012 report by the Pew Research Centre entitled “How Teens do Research in the Digital World”, indicates that a substantial proportion of teachers surveyed believe “today’s digital technologies are creating an easily distracted generation with short attention spans” whilst 64% were in agreement with a statement suggesting that “today’s digital technologies do more to distract students than to help them academically.” While the above may be true when students are using technologies without guidance, there is an argument that the popularity of such technologies amongst students should be harnessed and used for their advantage. Consequently, it was decided to trial the use of lecture material, created using iBook Author software and delivered via an Apple iPad, as an alternative presentation technique on the Architectural Technology A module. The iBook format and iPad delivery method were seen as having the greatest potential to differ from the traditional lecture experience. The aim of the study was two-fold;

- To determine if using the iBook/iPad increased interactivity and student engagement within the lecture.



- To ascertain if there was a marked difference in feedback between those students who used an iPad in class and those who relied on the PDF version of the presentation.

A tripartite approach was considered key to the delivery of the project, with input from staff, students and practitioners essential in ensuring the content aligned with the learning outcomes for the module, was engaging for students and included content which mirrored real world activities.

## **2. The iPad in Education**

There are now four generations of full-sized iPads, the first appeared in April 2010 with the latest, along with the iPad Mini, being released in late 2012. The second, third and fourth generation iPads, along with improvements in the operating system have given academics and students in education the opportunity to exploit computing power in the palm of their hand. When it was launched, Steve Jobs told the world the iPad would be “blazing a path to the future of computing” (Levy 2010) and it is difficult to argue with his prediction. They are simple to use and usually focused on a singular purpose. The iPad has created an entirely new niche within computing, a niche it continues to dominate in spite of the growing success of similar products such as the Android tablet. Whilst initially a product for individual consumption of media content online, the iPad has morphed into a sophisticated platform which has become prevalent in both business and educational spheres. Indeed, it has been claimed the iPad has seen a greater rollout in primary and secondary education at much higher rates than almost all previous technologies (Alberta, 2011).

Whilst research into the use of iPads in education is understandably in its infancy, the benefits it can bring to the educational sphere have started to be identified and explored. The iPad can help to individualise learning (Alberta 2011), shifting responsibility for learning from the teacher to the student, and thus enabling the learner to become a more active participant, rather than a passive recipient of information (Sinelnikov 2012). In this way, the student can learn to construct their own knowledge, using the iPad to help them study in their preferred way, at their preferred pace which best suits their own learning style. In addition, the learner is no longer bound by the limits of the physical classroom environment. Students can access course materials, videos, research data and core texts, or even connect with peers or experts in the field, without having to leave the classroom. Data is available immediately, via Apps, websites or social media (Geist 2011). In this way, the iPad can also easily facilitate social construction of knowledge, as multiple participants can collaborate in real-time to work on the same material (Bruce et al, 2012). Apps such as Google Docs, Facetime, Evernote,

DropBox and Good Reader enable individuals to make best use of the iPad for their own best practice. Digital iBooks offer users the ability to take notes, manipulate text and images; complete quizzes and other activities, thus making their reading experience more interactive, engaging, and individualised than it could be with a physical textbook (Eagleton & Dober 2007; Larson 2010; Hutchison et al 2012).

This is perhaps the unique benefit of the iPad over other educational technologies such as the Interactive Whiteboard and Virtual Learning Environments. The students can find tools and resources that meet their needs quickly and effectively, in a platform that is user-friendly, lighter than a laptop and thus more mobile and portable. When the user encounters something they can't do with their current features, they can simply search the App store to find an App that will meet their needs, quickly and in many cases, cheaply, compared to the cost of PC applications. It is thus unsurprising to note how, at the launch of the latest iPad in October 2012, Apple CEO Tim Cook outlined that the number of downloaded Apps had reached 35 billion (CNET, 2012).

This is not to say the iPad is without its criticisms. The cost of the hardware is expensive when compared to rival technologies such as a Windows laptop or Android tablet. The iPad devices cost from £380 (approximately), which does not account for the additional expense of a protective cover, connection cables and other accessories. In addition, there are some enforced limitations with the operating system, such as the inability to use Adobe Flash content – though there are ‘workaround’ Apps such as Puffin browser. Others have asked the question, does the iPad enhance the learning experience, or distract from it? Rolling out iPads in the educational sphere should, like any technological implementation, be grounded in pedagogic theory, rather than simply offering the user a means of accessing content or engaging with the technology rather than the learning materials (Melhuish and Falloon 2010). In this way, the teacher can ensure the learning experience does not simply focus upon a surface approach, whereby the student simply learns to find information, rather than constructing an understanding of it.

In spite of these concerns, initial studies continue to find the iPad to be a beneficial tool for education (Heinrich, 2012; Melhuish and Falloon 2010; Geist 2011; Alberta 2011). For this reason, the authors decided to embark on this pilot study, to see whether using the iPad, and in particular, iBook resources, could indeed benefit the teaching and learning experience of participants on the Architectural Technology A module.

### 3. The Study

The Architectural Technology A module is delivered in the second semester of year one on the ATM programme. In the 2012/13 academic year 30 students are enrolled on the module. A one-day workshop was held in the first semester, which attracted a number of students, practitioners and academics. The workshop was used to provide an overview of the study and gain feedback and ideas on the content, presentation and delivery of the iBooks.

The free iBook Author App (only available for the Apple Mac computer platform with OS Lion or Mountain Lion) was used to create each iBook. This format allowed quizzes to be included along with other interactive features such as images, videos and 3D CAD models. Some of the practitioners involved in the workshop and steering group provided case studies that were used within the iBooks.

Two distinct types of iBook were created. The first (iBook A) contained detailed written content with supporting video, images, quizzes and 3D interactive models. The second (iBook B) contained much less text, but the other interactive elements remained. As the study also wanted to determine which presentation method would prove most beneficial, iBook A, iBook B and PowerPoint were used to present in alternate weeks. The proposed teaching schedule can be seen in the Table 1.

TABLE 1. Weekly Lecture Schedule

| Week | Content                                     | Method     |
|------|---|------------|
| 1    | Module Introduction & Background            | Various    |
| 2    | Resistance to Moisture & Building Structure | PowerPoint |
| 3    | Substructure, Soils & Foundations           | iBook (A)  |
| 4    | Roof Design & Construction                  | iBook (B)  |
| 5    | Glazing & Access into Buildings             | PowerPoint |
| 6    | Stairs in Domestic Buildings                | iBook (A)  |
| 7    | Fire Design & Protection                    | iBook (B)  |
| 8    | Lighting Design & Ironmongery               | PowerPoint |
| 9    | Sustainable Design                          | iBook (A)  |
| 10   | Drainage Layout & Design                    | iBook (B)  |
| 11   | Group Activity                              | Various    |
| 12   | Review & Revision                           | Various    |

Once each iBook was complete it was uploaded onto the teacher's iPad and this was the medium used to teach the class. The students with access to an iPad (20% of the cohort) downloaded the iBook to the iBook App. This

allowed them to read it prior to the lecture, annotate the book in class and even produce revision cards. An essential criteria in the selection of this presentation medium was the fact that the iBook authoring tool allowed for the creation of a PDF version of the presentation to accommodate students without an iPad. The University's content management system was used to host the lecture material whilst the multimedia resources were stored in web-linked files for the user to select while reading the PDF.

To present the first 'iPad' lecture in week three, the iPad was wirelessly connected to the data projector using the Reflector App installed on an Apple MacBook Pro. However, when videos and synchronised audio were played there were issues with quality. This was due to the requirements of the video on the limited Wi-Fi bandwidth. To overcome this issue for all subsequent lectures, a VGA adapter cable was used to connect the iPad to the data projector directly.

The hour long lectures were purposely broken into ten-minute segments of information to try and maintain attention levels, with an active learning method (Quiz, Video, App) employed before the next key snippet of information was delivered.

#### **4. Early Findings**

Although this project is not yet complete, feedback received to date from the staff, students and external practitioners has been extremely positive. A student focus group and a steering group consisting of students, academics and practitioners were established to provide feedback throughout the project on elements such as presentation, content and design. An online discussion area was setup to enable the entire cohort to offer feedback throughout the semester. The tutor also recorded his thoughts and observations in a weekly diary in order to critically reflect on the success of the project at the end of the semester. End of semester surveys and module marks will also be used as a method of gauging success. Feedback from individuals within the focus group to date indicates that students are favouring the integration of 3D models, CAD details and video clips. Comments have included:

*"Reading about the foundations then viewing real foundations in the video is a great way to make things clear. Again the 3D models are good to use and easy to use, enabling me to view different areas as I need to"*

*"The use of CAD details is excellent because as a student it is essential to know what the details are showing and how to draw these details...."*

*“In the EBook you can link to other design software such as Google Sketch Up which provided the students [with] a better idea of what the lecture[r] was talking about....”*

A big advantage, which a number of students commented upon, was the fact that there was no buffering period when playing videos. Individuals indicated that this was beneficial in maintaining levels of concentration and focus. The general feeling from members of the focus group, which included students without access to an iPad, was that although the PDF version of the presentation was professional, the ability to view the iBook content (especially video and 3D models) so effortlessly, whilst listening to a live lecture and having the option to create revision cards, would transform their learning experience. Individuals also suggested that it was superior to PowerPoint in terms of a presentation method. One student commented:

*“The use of these iBooks during class would be a massive gain to the students, they would be able to interact with the lecture/lecturer and they would feel more involved rather than flicking through a PowerPoint...Having access to these iBooks in class means that the student can also use the 3D models within the iBook to give them a better understanding of what the lecture and iBook is saying”*

The tutor noted that levels of interaction in class appeared to be greater when the iBook/iPad was used to deliver the lectures. Apps, especially Paper and Bamboo Paper, proved popular with students as a way of presenting building details. Positive feedback was also received from practitioners involved in the steering group. One stated that the iBook presentation and the use of interactive 3D models, video clips and CAD details within, made the delivery look “*extremely professional*” and helped to make some rather mundane subject areas “*engaging*”. The diary entries from the tutor focused on the ease and speed of setup for the lecture. When the VGA adapter was used to connect the iPad to the projector, the only equipment required to be taken to the lecture theatre was the iPad and VGA adapter cable. This was much more compact and lightweight compared to carrying a laptop. A second noteworthy point was that the creation of the iBook (type A) did take longer than expected, but becoming more familiar with the software has helped reduce production times.

## **5. Conclusion**

Although this project is in its infancy, early signs suggest that this is a teaching technology that has considerable promise. To the tutor, it seems students are indeed engaging more in classes and initial feedback suggests

they appear to favour this over PowerPoint as a teaching method. In addition, the use of the Architectural related Apps has been an unexpected success, with students finding them beneficial in understanding difficult elements of detailing. The study has also raised unexpected operational and logistical issues which educational establishments will need to address such as the requirement for more bandwidth and access points as more staff and students use Wi-Fi to access and present resources in class. There are still questions to answer, such as students' comparison of the PDF output against the iBook, and further analysis will take place at the end of the current semester. This study is a single snapshot of the experiences of a small group with the technology, and while it is clear there are benefits being raised by both the tutor and students in this particular module, further research over a longer period and with greater numbers will be required in order to gain a fuller understanding of the impact of this new teaching resource.

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## QUANTITATIVE MATERIALS, DYNAMIC QUANTITIES

### *Material Libraries*

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**Abstract.** Materials play a key role in construction and by definition should also have a key role in BIM. By mentioning a particular material to a competent craftsman, implicitly implies the scope of work to be done, by whom, for how long and at what cost. Bringing this level of detail to modelling can be accomplished by creating a comprehensive material library where all the information is embedded in the model, and in so doing, reduces the opportunity for human error. Instantly, after sketching a foundation there is the opportunity to create a schedule and an estimate, complete with all the information needed for a specification. This is a good example of the dynamic, bi-directional proper use of BIM.

Costs start out with calculating the unit price of a material. This is then combined with a cost factor for the assembled component, where the total cost can be shown including the labour cost, material cost, hire of external equipment, soft costs, fees, and even a cost index for where the work is being performed. Labour and material costs are calculated with an exponential value so that when the volume of the work increases the price per square meter decreases.

Similarly, other properties allow the calculation of u-values of the component, using the heat transmission of the material. Even the density of a material can be used for load calculations, meaning the whole process of information searching can be shortened. Even fire and acoustic information can be right at your fingertips. The material can be linked to a data catalogue from a supplier or in most cases the information can be just embedded in the material. The most assuring thing about the material library is that there is no information loss in any part of the process and the component description and the component itself match, making the project flawless.



## 1. Introduction

When constructing a building, it can be said that there are two main physical resources involved; the *materials* necessary to form the various parts, and the *technical* ability to assemble the parts into an enclosure (Osbourn 1985). The raw materials for a building are rarely used in their basic form, but are treated or processed in some way to suit their purpose (Stroud Foster 1979). They become the elemental pieces of the building and together with functional requirements and performance criteria form components which can be deployed in the project. Renzo Piano, as a lifelong sailor and designer of yachts, used his '*a priori*' approach to explore different materials, ranging from marine plywood to ferro cement (Frampton 1997). But this is an iconic individual, exhibiting a large element of accumulated experience.

When looking at the performance of buildings, the demands placed on building components can be said to include load bearing capacity, climatic envelop, insulating qualities, fire ratings, moisture control, ventilation, wind stopping, maintenance and acoustics. This list is not exclusive or comprehensive, but provides an insight to some of the requirements to be met. Others could include aesthetics, cost, quality, ease of manufacture and erection.

A technologist's role is to affect this choice in the best manner possible (Emmitt 2012). Traditionally this was accomplished with a body of knowledge built up by experience from tried and tested methods. It lead to conservative decisions being made in component development and lead to building failures where innovative methods were misunderstood with dire consequences.

Previously, materials like brick or masonry could make a brave attempt at satisfying all or most of these requirements, whereas modern assemblies invariably use sandwich constructions which comprise of several materials all doing a single job from the list (Selck 1974). They therefore need to exist together with correct sequencing and tolerances, allowing them to breathe and perform appropriately. A second point that can be noted from this, is that accurate methods of measuring that performance are relatively recent, suggesting that the demands made on the building stock were not robust or comprehensive previously. Being unable to measure something means that it cannot be dealt with adequately or methodically (Harty 2012).

## 2. BIM

### 2.1. INTRODUCTION TO BIM

Building Information Modelling also called BIM is a new way of working and thinking that starts at the design stage and stretches all the way to the

demolition of the building and in some cases even to the reuse of materials from the decommissioned building. The idea of BIM is to gather as much relevant information in one place so that it can then be accessed by the widest possible array of different programmes (Eastman 2009). This makes it possible for all parties involved to access the latest information. That creates a new level of collaboration where the loss of information is limited to an absolute minimum, thereby offering greater accuracy in estimation and avoidance of error, which results in saving time and costs through all stages of the project.

To gain all the benefits of BIM all the stakeholders must work with the same fundamental mindsets that not only changes the way the information is stored but also the way it is archived and how it is handled through all stages of the project (Bernstein 2013). This means BIM is not only a new technology but also a new way of working at a strategic level. The opportunities that BIM creates, to store the information in the 3D model, is a huge advantage when all the parties are working with BIM.

By having all the information in one place, makes the model the primary tool for document generation, and moves away from conventional parallel world involving word-processing and CAD drawings (Pittard 2012). It creates a workflow where specifications and reports (that are both time consuming and hard to update if changes are made) are an integrated part of the model and automatically updated as the project evolves.

To insure the effective sharing of the information pool, BIM related software must be compatible with the 3D model so the required information can effortlessly be transferred from model to calculation, simulation and analysis. So essentially, BIM combines the technologies that we work with on a day-to-day basis (Kennerley 2013).

The most often used expression of the level of BIM used is 3D (Building Design in 3D with Quantities), 4D (3D + Time), 5D (4D + Cost), 6D (5D + Facilities Management) and 7D (6D + Physical Performance). These levels are obtained by using the information from the model in a variety of different software programmes combining the results. BIM improves both the quality of the work and the delivered product. This creating easy access to project time planning, budget estimates, energy consumption, solar studies, construction timeline animation, visualisation, animation, and so on, by having all the information accessible from one place.

## 2.2. PROBLEMS WITH BIM

One of the things that make BIM so hard to implement on a full scale, is if one or more of the stakeholders does not use BIM. All the information that is loaded in to the model then needs to be extracted and filed into conventional documents and reports. This means that the information is processed more than once, which is time consuming and to some extent not properly

integrated into the BIM model. The importance of the information inside the BIM software then becomes less important than the documents extracted. The way BIM works today is that all the information loaded into the model comes from an external source, which is sometimes easier to place directly in to the conventional documents rather than loading in to the model and extracting it afterwards.

Another relevant point is information loss that can occur between software programmes. BIM works impressively by exporting information to other programmes but the information obtained in the external programmes often cannot be imported back into the model. This creates problems that can in some cases become overlooked, and can result into huge errors.

### 2.3. SOLUTION TO BIM PROBLEMS

BIM has many working tools, which are becoming more and more integrated into one overarching programme that is more open and easier to use. From whence the project starts until the construction is completed, users load information from external sources into the model. But would it not be better to make the model itself into the main source of this information? If the model becomes a container of all the information from the start of the project, the user can then select the relevant information from the project through a process of filtering.

All the selected information can easily be passed on to the parties that need it. There is no need to handle the same information more than once, reducing double work. If we accept that the main information which is loaded into the model is material information, by having all the material information in the model or a model library solves the problem.

## 3. Material Library

### 3.1. INTRODUCTION TO MATERIAL LIBRARY

Materials play a key role in construction and by definition should also have a key role in BIM. By mentioning a particular material to a competent craftsman, implicitly implies the scope of work to be done, by whom, for how long and at what cost. Bringing this level of detail to modelling can be accomplished by creating a comprehensive material library where all the information is embedded in the model, and in so doing, reducing the opportunity for human error. Instantly, after sketching a foundation there is the opportunity to create a schedule and an estimate, complete with all the information needed for a specification (Bowers 2012). This is a good example of the dynamic, bi-directional proper use of BIM.

The same key information should be standard information in any BIM related software. By creating or using a library you are sure that all the information is therefore in the model, meaning there is no need to add additional (parallel) information, opening up the opportunity of human error. With a fully updated material library the benefits are huge in the start of the project (Autodesk 2012). Instantly after drawing a foundation there is the opportunity to create a schedule with all the information needed to construct it. Then the engineer can access it and any changes made are automatically updated in the entire documentation. While the concept is being made the architect has cost calculation for every component that is made.

The process for compiling a personal price book, setting up an external price book such as V&S (DK) or Spons (UK), or making a new one is essentially the same, although the fastest way is to use a system with a database that is compatible with a programme like Autodesk Revit thereby importing most of the material information. The biggest advantage with a material library is shown when it is combined with schedules where all the required information for the different components are automatically updated when a material is chosen which thereby saves loads of both time and effort. As an example, material trade scheduling works by having the different trade's information of the materials, and a list with the salaries of the different trades for easy updating. When the exponential decreases of worked time are calculated, the amount of work hours is multiplied by the salary.

### 3.2. WORKING WITH MATERIAL LIBRARY

Scheduling in Revit together with material information can contain all the information required in a project. The opportunities for information export will be things like labour time that is shown in hours or days, the construction time for the different materials the amount of workers and even specific salary for the labour time.

The cost shows the price of each material in the construction and a combined price for the entire component where it is shown through labour cost, material cost, hire of external equipment, soft cost, fees, and even price index for what contrary the work are being performed. Labour and material cost calculated with an exponential value so when the volume of the work increases the cost per meter squared decreases.

Detailed descriptions are often used on the component to easily setup type tagging, but the information is typically entered manually and is specific for each individual component, consisting only of the specific information about the materials in the component. By having the information predefined in the detailed material libraries, there is a better chance that the component tag automatically updates with the latest information. By using this workflow a description in standard constructions is made by a click of a button which insures the user that the information is accurate and always up-to-date.

The assembly description is information that is specific for each individual component and to some extent does not involve the material library but if the materials are detailed enough then it becomes a possibility. Sometimes creating a new material, it must be related to another similar material in order to determine the trade and price. Of these materials, an assembly description is used which has an influence on the price and must be altered. Similarly, the assembly description can be added to all the materials in the library, it is only limited by the level of detail required.

Trade information is usually restricted to the material's trade component. As the component is assembled with different materials the different trades involved in the process of constructing are shown in the component list, giving a clear overview of the work and the resources involved. This information can then be used for a more detailed quantity take-offs and all the relevant information needed for a workspecification.

In Autodesk Revit 2013, there is a new feature that can calculate the u-value of the component using the heat transmission of the material. By having the information directly in the material library, insures the user that the correct information is always used which saves time, not having to search separately for an external document.

Likewise, the density of the material is often required for load calculation so in the same way as with the u-value the process of information search is shortened. In the process of finding the right material for the component, material information like the span on the material according to sizes can help determine the total size of the component in the concept stage and thereby minimizing the chances later in the project where it can be more time consuming. Even fire and sound information is right at the end on your fingertips so when the right material has been selected, the user is sure that aspects like fire resistance and sound obscuration are part of a better informed design decision.

In green projects, where the focus is on the carbon emissions of the construction and the carbon imprint of the materials it is a long process to calculate the carbon used to make the materials for the entire project but having the information in the library the user will only have to set up a schedule that shows the entire calculation for the project. The schedule properties can also be saved as a template, so it becomes a standard calculation for all future projects making designers think more about the environment and the use of materials. Schedules can also show lifetime cycle analysis of materials so if any of the materials far exceed the lifetime of the project it creates the opportunity to look into the reuse of the material as in a cradle-to-cradle project.

Making sure that all of the materials have the full lifetime operation and maintenance information can also be added to the material so the owner of the project can extract the information and know when to do what. Everything required to make an entire project specification including health

and safety information can be placed in the material library making it one of the most timesaving and secure tools that BIM can offer.

#### **4. Material Research**

##### **4.1. THE BENEFITS WITH MATERIAL LIBRARY IN REVIT**

Like all other BIM related processes, using a fully updated and well maintained material library means the user must create a new mindset and workflow. The research for materials can no longer happen on the Internet, but in the model itself. The material can link to the data catalogue from the supplier but in most cases the information lies in the material properties. The most assuring part about a material library is that there is no information loss in any part of the process, and if the wrong material is selected by the user the component description and the component match flag this making the project flawless.

##### **4.2. PROBLEMS WITH MATERIAL LIBRARY**

Currently, use of external software programmes is limited, because the typical calculations needed to calculate everything correctly require experts to setup the schedules and make test calculations before they can be implemented in the template.

The timesaving of a fully intergraded material library could be up to an estimated 10% of the entire project, 40% of the design stage and 80% of the written documentation. Information handling is limited to specialists where the descriptions and performance information is divided either to in-house specialists and or external sources that have experience in the subject.

Therefore the material library is difficult and time consuming to establish, so for small companies the investment in making the library might be too expensive. The way that materials work in Revit at the moment also gives some minor complications, one of them is that two materials cannot be placed in the same layer. As an example, insulation and rafters occupying in the same space in a roof, but there is way to come around the problem.

##### **4.3. CONSULTATION**

The material library requires a lot of work to begin with, but when it is up and running it is a huge advantage both in the implementation of BIM and in all the subsequent work stages

Main suppliers of materials for construction have a great opportunity to make a material library in the collaboration with their suppliers that would

be a huge advantage with BIM users, where the template could produce a shopping list with quantities that can be send directly from the customer. It also opens the doors for specialist companies to make libraries schedules and templates and leases the entire package with material, material price and service updates. Companies like V&S or Spons who have their own price book could make a material library as an alternative to their regular price books giving them an advantage with BIM users.

The material library is a great investment for medium and large architect and construction companies but for small companies the work effort to create their own material library is too costly. In the near future there will be companies to correct the complications with Revit and the construction industry will have the opportunity to buy or create material libraries with the help of specialists.

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## ARCHITECTURAL TECHNOLOGY AND THE BIM ACRONYM:

### *Critical Perspectives of Evangelical and Evolutionary Paradigms for Technical Design*

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**Abstract.** The United Kingdom Government's intent to embed collaborative Level 2 BIM into publicly procured building projects from 2016 (BIM Task Group, 2012) trails the General Services Administration's (GSA, 2012) earlier and similar initiative to require the adoption of BIM protocols in the USA from the 2007 fiscal year. The built environment scene is currently awash with a panoply of initiatives sharing a mission to disseminate the BIM message via around 350 organisations which represent built environment professional interests in the UK. These developments raise challenging and complex agendas for an industry which historically (Latham, Egan et al) has been perceived as being fragmented and lacking in the research and development resource base necessary to introduce and effectively disseminate new knowledge, understanding and practice. Race (2012) has noted that engagement with the BIM agenda should be tempered by the critical perspective which Shon (2009) argued is a key component of the reflective practitioner's skill set.

Technical design has been perceived as a core skill for the architectural technologist. Making reference to a range of theoretical models, this paper will critically assess the technologist's contemporary engagement with BIM related paradigms. The paper will also review BIM in historical and broader contexts of object oriented technical design, both within the built environment and across other design and manufacturing industries. In considering how the architectural technologist may move forward as key built environment player, reference will also be made to relationships with co-professionals and BIM futures including digital design/fabrication.

**Keywords:** BIM, evangelical, evolutionary, context, technical design, architectural technologist



## 1. Introduction

The UK construction supply chain consists of around 300,000 companies, (LEK, 2009) 90% of which have ten or less employees. (King et al. 2011) The industry is largely dominated by smaller SME's (Small and Medium Enterprises). In addition, no less than 350 organisations represent the industry and its interests (professional, statutory and regulatory bodies, associations and similar groups). These statistics suggest a majority representation of small and very small firms within the sector and the clear potential of opposing interests given that the construction industry is not a professionally homogeneous unit. The interests of a surveyor are not always the same as an architect or architectural technologist.

This paper is a snapshot of a process of investigation, information gathering, critique and evaluation of an ongoing research being undertaken by the authors. The focus of this research is a critical perspective of Building Information Modelling (BIM) and its impact on technical design, particularly in the context of the UK government proposed legislation mandating the use of building information modelling from 2016. Given the constantly evolving debate on BIM and its application, the information flow for this study involves an ongoing dialogue with academic developments and innovation on the one hand and professional practice and its responses to practical and implementation issues. The paper is intended to be critical and shed the spotlight on evangelical and evolutionary paradigms that the authors feel are not being subjected to rigorous scrutiny in the current debate.

Within the UK construction sector, BIM propaganda (the evangelical model) with all its facets and mantras (collaboration, communication, project efficiency, carbon reduction, whole life asset management etc) has focused on implementation in large design and construction companies, for example HOK and Skanska. These organisations operate at a much larger business scale than the SMEs representing the majority interests in the sector (certainly by numbers, if not financial clout). For large organisations, engaging with BIM may offer competitive advantages which can be easily afforded, not only to maintain leadership in the market but also to harvest business benefits BIM may bring to the table. In that context, where does the debate leave the SME's in the sector? Where is the polemic on BIM; the argument and counter-argument necessary to feed informed decision making, particularly for small companies (the so called micro-SMEs)?

It seems that until recently, this 90% majority stakeholder interest has been left on the margins of the debate. With the cut-off date for the UK Government's mandate now just over a couple of years away, will there be a gradual awakening, realisation and actions in respect of how BIM may impact on UK construction in the round (the evolutionary model) From the sub-groups set up to deliver on the Government's BIM agenda, BIM4SME,

has developed as a cross discipline grouping of interests championing BIM and promoting, in particular, the interests of construction sector SMEs.

*BIM4SMEs is a working group made up of individuals from SME organisations that have a passion for BIM and desire to help SMEs in their understanding and engagement of the BIM process. Its primary and only focus is to support the SME community in its understanding and use of BIM, whether they be consultants, contractors, specialists, suppliers or manufacturers.* (BIM4SME, 2013)

As BIM paradigms continue to emerge, develop and evolve across construction disciplines, the idea of BIM requiring new business models has become more established and is challenging traditional methods of delivering building projects. Typically, in a traditional model, the overall process consists of two interlocking sub-processes or activity nodes, design/construction activities and policy and codes. Technology is normally embedded within the activities of each node with limited cross over. In a BIM business model, Razvi (2008) noted that a third technology node which interlocks with the other two has become critical to process development (Fig. 1)

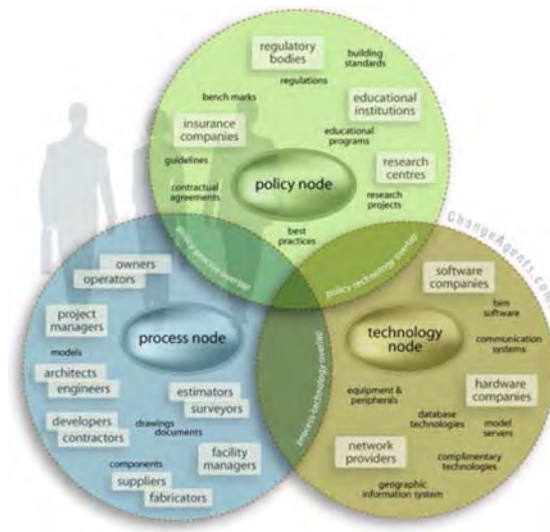


Figure 1. The 3 Interlocking nodes of BIM

The IT infrastructure and expertise required to support a BIM model are sufficiently complex that they need to be run and managed often by external

network agencies. A number of these companies are already active in the market including Asite, BIW Technologies and similar providers of web and cloud based construction collaboration technologies. Such a business model could be considered imperative for an organisation in the construction sector to capitalise on the benefits of implementing BIM, (efficient workflow, collaborative working, building partnerships, good communication etc) and add value to their business.

## **2. Context and Government Objectives**

### **2.1. DRIVERS**

It is important to remember the drivers and critically the objectives sought behind the legislation mandating BIM by 2016 on all government projects above £5 m. (Cabinet Office, 2011) The principal objectives include:

- Achieve 20% savings on the overall cost of projects
- Build up a reliable and effective data sets for the efficient management of assets using COBie (Construction Operations Building Information Exchange)
- Carbon reduction to meet international and local targets
- Improving competitiveness of the construction industry

One can only speculate that the impact of the policy will reverberate beyond the state to the private and charity sectors, possibly an intended consequence.

### **2.2 CAPACITY OF BUILT ENVIRONMENT PROFESSIONS TO COPE**

A latent and lingering question central to the BIM debate is quite simply can the industry cope? In migrating to BIM, it seems reasonable to suggest that UK construction will travel through a transition phase in relation to current work practices and may challenge the capacity of education and training to support change in the workplace . A number of key issues need to be seriously considered, particularly for SMEs. Firstly, the timescale i.e. 2016 is very short given the practical and cultural issues involved. Secondly the fast moving pace of Information and Communication Technologies (ICT), in particular the constantly evolving BIM systems software and the inevitability of change will impact on any organisation trying to introduce and implement a new business model. And thirdly the human, financial and expertise resources needed to effect change may put a considerable strain on the industry; in particular, micro-SMEs, defined in EU terms as having less than 10 employees. (EC, 2013) In addition, with the ongoing economic recession predicted to continue beyond the 2016 UK Government BIM

deadline will continue to impact heavily on the capacity of the built environment professions to cope with significant change.

### 2.3 IMPACT OF THE BIM MATURITY INDEX

The BIM Maturity Index (Fig. 2) assumed that all built environment professionals should be aiming to be operating at the top end of Level 2 by 2016. What is the level of progress towards this goal? It has been noted that some, but not all reference standards are in place (Snook, 2012) although a key document (PAS1192-2) was published in the spring of 2013 (CE, 2013). The reality is less certain and predictable, particularly amongst the majority of small organisations operating across built environment design, development and facilities management.

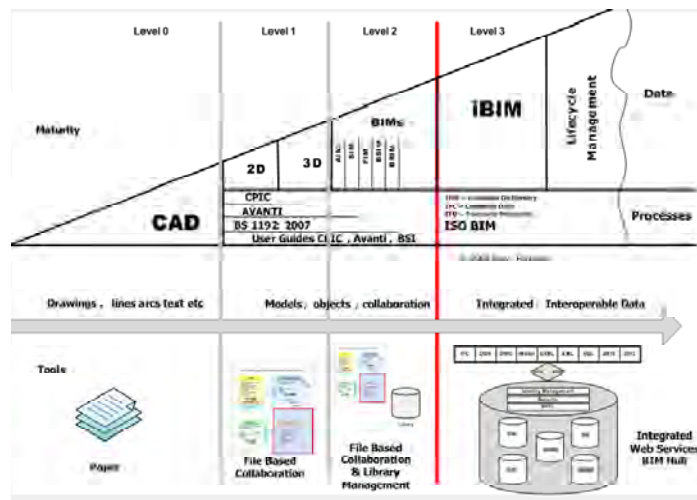


Figure 2. BIM Maturity Index

The reality of BIM engagement, particularly amongst the majority of small built environment organisations is and remains an unknown quantity in the

UK. Protocols used for communication and data handling form a wide spectrum of activities. For example, anecdotal evidence suggests that some small contractors do not use e-mail and a recent straw poll of surveyors in Ulster suggested that under 40% of listed organisations have a website. The range extends through organisations sharing data electronically via Word files, Excel spreadsheets and 2D dwg or pdf formats towards file management, for example set up by a contractor, local authority or corporate commissioning client. It could be argued that at best most of these repositories are there to achieve compliance, for example with tender pre-qualification requirements and at best provide a level of passive data exchange which may assist coordination, primarily during design and construction phases. In practical terms, achieving Level 2 BIM by the 2016 deadline may not be within the reach of all.

### **3. Construction industry response**

Following the Latham report (Latham 1994) and the Egan report (Egan 1998), the construction industry as a whole attempted to implement the various recommendations and improve its performance, shake off the silo culture and exploit new Information and Communication Technologies (ICT). Sample Key Performance indicators (Fig. 3) demonstrate the relatively low performance and the improvements that still need to be achieved.

The adoption of ICTs, in particular BIM authoring and ancillary software along with associated data management systems, has accelerated in recent years in the UK. Associated commercial interests may be significant and large design and construction companies have taken the lead and continue to dominate. The debate on BIM and collaborative working has been fuelled by publication of the Government construction strategy (Cabinet Office, 2011) and subsequent BIM Task Group initiatives.

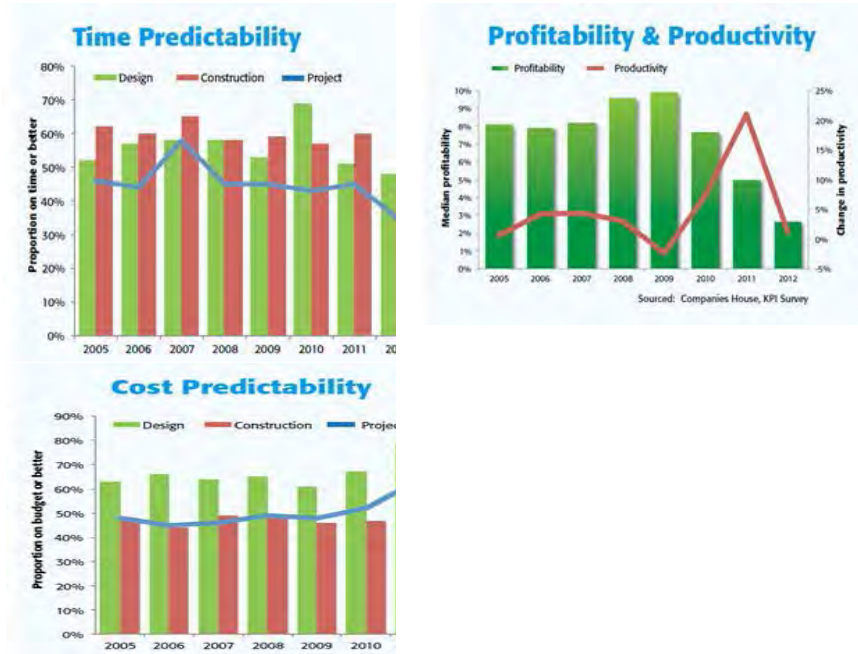


Figure 3. Economic KPIs 2012 – All construction. After Glenigan (2012)

In the lead in to full implementation of the Government's objectives per the 2016 threshold for Level 2 BIM uptake, it remains difficult to form a complete and realistic picture of levels of engagement with BIM across built environment organisations in the UK. To some extent, individual professional bodies are on the case, but there is little evidence of concerted and collaborative effort across disciplines. In that respect, the picture painted by Latham, Egan et al. has not changed significantly. A lack of representative and reliable data does not help. For example, although one 2012 cross-discipline survey (NBS, 2012) gathered feedback on BIM from around 1000 respondents that level of data return was equivalent to just 2% of combined CIAT/RIBA membership, to name just two from many representative organisations. As further points of reference, from other professional bodies, RICS has around 140,000 members, CIOB 39,000, IStructE 27,000 and so on.

As a consequence, whatever the Government's will to effect change, UK construction is currently subject to many challenges in relation to BIM uptake and more widespread implementation. These include:

Mixed messages on BIM:

- Lack of objective advice and critique across the industry

- The evangelical few and the great silent majority, primarily smaller organisations
- Research and development culture not prevalent in construction
- The current fiercely competitive economic situation suggests that those with knowledge and experience (e.g. early adopters) may be reluctant to share it
- A certain degree of BIM Delusion Syndrome: e.g. UK can lead the world with BIM; an evangelical message as promoted by some given the fact that other countries may have at least equivalent, if not more advanced knowledge
- Downstream dissemination of UK Government strategy relying on volunteer effort in the lead-in to Digital Britain: BIM 4SME, CIC BIM Hubs etc

Lack of specificity:

- Some but not all industry standards extant
- Unclear legal framework (are risks perceived or real?)  
Absence of rule based protocols for online submission of statutory approvals. Planning Department and Building Control services could act as a catalyst for change but lack a clear mandate for BIM implementation
- Parallel information flows on BIM from Government bodies, construction industry organisations (CIC, CIRIA, CPIC, NBS, BRE etc.) and professional bodies
- BIM overload Syndrome leading to an Anti-BIM backlash particularly from micro-SMEs
- Little evidence of exemplars for collaborative working, particularly with small projects

These factors highlight a number of pressing issues including lack of effective coordination across UK construction, mixed and sometimes ambiguous information and perhaps some conflicting interests. What the industry needs is an authoritative and reliable message based on evidence and experience which could help to lead the way for BIM uptake in a clear and unequivocal fashion.

#### **4. Macro versus Micro built environment organisations**

#### 4.1 TECHNOLOGY GAP

It is argued that a significant technology gap exists between large companies and micro-SMEs in UK construction. Amongst the former, ICTs are pervasive and have become a key element of enabling infrastructure covering all aspects of business including design, construction, whole life asset management, life cycle, marketing, cost management etc. Amongst the latter however, ICT use is in the main limited to traditional 2D drawings, perhaps some static 3D visuals, email and possibly a symbolic internet presence. The 2012 NFB survey suggested that among large contractors (250 or more full-time equivalent employees) 54% recorded experience of working with 3D drawings while for SMEs the figure dropped to 25%. (NFB, 2012) That perceived status quo creates a divide and may result in a Macro versus Micro effect that will certainly hamper efforts for collaboration on BIM within the industry. One dares to challenge those large organisations with experience and expertise in BIM to match their marketing discourse with a similar level of actions by providing reliable and credible case studies and even collaborate with SMEs to raise industry awareness and help to achieve faster and smoother transition towards a consistent approach to BIM uptake across UK construction.

#### 4.2 SME'S ACCES TO BIM

SME's and in particular micro-SME's may lack the ICT infrastructure to be able to cope with a quick deployment of BIM. Working in a dynamic and collaborative IT-centric environment may represent major shift in working practices and extend beyond acquiring expensive hardware and software. A radical change of attitude and business model may be an additional prerequisite. Furthermore, the learning curve is lengthy and may demand sustained training and up skilling of personnel, (Miller, 2013), including graduates who may have already have undergone up to five years of full-time university education. A recent study examining BIM as a collaborative tool concluded that

*“contrary to the literature review, the case study has shown that the present investment, in terms of time, cost, and effort required to implementing the technology means that BIM is unlikely to be adopted on small simple projects or by SME's where conventional CAD is adequate”* (Kouider, 2008)

The burden of the additional expenditure is not insignificant in the current economic climate in which small businesses are struggling to stay afloat. When asked in a conference how much does it cost to install a full BIM station, the HOK BIM manager replied £30 to £70 k. And in the absence of a



clear and coherent national/professional strategy on BIM on the one hand and the lack of clarity on the level and time scale of return on investment makes it even more difficult to make substantial financial commitments as highlighted by BIM4 SME working group.

*“Moreover, as the group are SMEs themselves the equation of cost is foremost In our minds, but perhaps the more important question is ‘what do I get for my money, what are the benefits and how long before my investment is paid off’” (BIM4SME, 2013)*

The lack of explicit engagement by clients is a feature of the debate. If the push /pull concept as described in the BIM Industry Working Group (BIS, 2011) is to be effective, a much greater more and more explicit presence of clients at all levels of project value would be needed. Who owns the model/s? Who pays for it/them? Who initiates it/them? All are well documented questions in the literature and will remain vague and not fully represented without client involvement.

## **5. Technical design and BIM:**

### **5.1 EDUCATION**

“Technical design” is the terminology utilised by the Chartered Institute of Architectural Technologist (CIAT) and its practitioners (Wienand, 2007) to characterise the specialist skills of their members and is, to a large extent, reflected in contemporary undergraduate training for technologists. In the UK, unlike his/her counterparts in Europe, a practising architectural technologist may be commissioned to design and build any type of building and he/she is expected to possess the appropriate design and related skills. Furthermore, there exists the expectation that any building designer will deliver a product that not only meets the requirements of the client’s brief but also meets, in addition to the technical, the socio-cultural expectations of society as a whole.

The technologist’s educational curriculum, with a focus on technology and management (QAA, 2007) falls short of the historical and philosophical aspects of architecture compared with an architect’s training (RIBA, 2003). For technologists, this subject emphasis is arguably what provides specialism and identity to their discipline. But there is also the issue of balance between subjects and the educational experience in the round in relation to workplace expectations. Is there a mismatch between professional and societal expectations on one hand and the architectural technologist’s contemporary education in the UK?. From that perspective, the following question may be raised. Is technical design still a valid representation of the

architectural technologist's specialism? Or, would the term "design" be more appropriate? A robust and consistently applied outline syllabus for architectural technology undergraduate education would be helpful.

Being technically focused, the architectural technology curriculum covers various aspects of ICTs. In recent years many undergraduate courses extended their programmes to include 3D modelling, environmental analysis and some aspects of BIM. The latter would naturally be expected to feature more prominently in the curriculum throughout built environment courses in anticipation of the 2016 government deadline. On that point, there is an view that developing projects using data rich architectural software packages is not in itself BIM. (Rosenbloom, 2011) Being able to demonstrate evidence of collaboration across disciplines in developing workflows is an essential ingredient of the mix.

Currently, there is a lack of clear educational standards for BIM despite a number of recent initiatives. For example, the UK Construction Industry Council (CIC) published a BIM protocol targeted at built environment professionals and their clients. (CIC, 2013) The BIM Academic Forum (BAF: a grouping of a number of academics from UK Universities) in conjunction with the Higher Education Academy (HEA) recently produced a document outlining proposed level learning outcomes for BIM education and training. (HEA, 2013) In addition, a number of Master courses dealing directly or indirectly with BIM (Glamorgan, RGU, Northumbria, etc) are being offered together with a plethora of short courses and CPD events provided by software houses, professional bodies and other agencies. All these initiatives seem to lack a solid point of reference in terms of clear benchmark standards or national guidelines on which academic and training programmes could be based. This lack of clarity has the potential to create confusion amongst practitioners and the industry as a whole in identifying the skills to meet the 2016 challenge and beyond.

## 5.2 PROFESSIONAL ASPIRATIONS

It is generally acknowledged that in the digital age there is a generational skills gap within the construction industry. First, a new young generation of graduate professionals well trained and versed in ICT tools and working methods has been entering the construction industry professions next to a well-established older generation whose knowledge of these technologies may be limited. Also for micro-SMEs in particular, there may be a resistance to looking beyond tools required to do the job, (MacKay, 2013) particularly in the current economic climate. Small, medium sized and large organisations may not share the same attitudes and values regarding the potential of these technologies. Second, the managerial power within the industry dominantly resides with the older generation; often sceptical and

reluctant to adopt unfamiliar technologies and working practices in which are perceived to embody high risks. Clearly the industry is going through a major transition and the BIM Task Group's push/pull strategy may help to firm up minds, shorten the transition period and open the doors wider for the aspirations of younger professionals.

### 5.3 GRADUATE SKILLS AND IMPACT ON PROFESSIONS

Graduate architectural technologists are entering an industry in which traditional working methods are in the process of being replaced by a new order based on multi-disciplinarity, collaboration and fast communication all primarily driven by ICTs. With a technically focused education and training, architectural technologists are perceived as well positioned to take a significant role in a changing construction industry. Hard evidence from practising technologists is limited to support this assumption but a number of useful initiatives exist. Some of these have been identified by the authors as part of this study. One could argue that the architectural technology profession should take a lead in promoting its members and further developing its accredited education and training programmes in order to meet a changing and developing market. A number of specialist titles are developing with the spread this technologically driven process of change include Design Manager, Information/Data Manager or consultant and BIM Manager. The latter is well established in the USA, increasingly in the UK and has evolved from the historical CAAD manager role. Execution of these roles may be enhanced by extended professional education and development at Masters level. Undoubtedly more specialist course and bespoke training will appear to prepare for a new skills market and the architectural technology profession may exploit its position and capitalise through further diversification of programmes and professional scope.

## 6. Practical Experiments: BIMtoolkit

### 6.1 RATIONALE AND DESIGN

As a practical consequence of the discussion, BIMtoolkit is an experimental project set up to develop and encourage collaboration between architectural technology academics, undergraduates and small practices across built environment professional disciplines. A sub-text of the principal objective is to challenge some of the norms being propagated by evangelical BIM paradigms. The rationale for following that path is grounded in the observation that while there is some evidence that micro-SMEs may be receptive in principle to migrating to BIM, there may be difficulty in understanding the language of BIM and resistance to engaging with some of

its mantras; data rich architectural models, COBie data drops, adoption of IFC file format, use of proprietary 3D BIM objects and the like.

There is also the key issue highlighted in this paper of clients being on board, both when projects are commissioned and in facilitating decision making as workflows progress over a project's whole life development and use. Challenges and opportunities are well documented and populated with useful dialogue via authoritative social media sites such as the NBS Objects forum on LinkedIn. (NBS, 2013) In the context of the global economy, tapping into the online dialogue also raises the paradox of BIM standards being framed and applied locally and internationally. Simultaneous propagation of the Uniclass and OmniClass schemas for construction classification is a case in point which may impact on, for example, the forthcoming EU procurement directive (CIOB, 2013) which will may lead to fresh and interesting pan-European conversations on BIM.

BIM toolkit was defined by setting out a series of precepts and pointers for experimentation and testing using freeware and/or low cost software. These included:

- achieving collaborative working online using 3D tools as one of the underpinning principles of BIM
- for BIM to work effectively and universally, the skills to facilitate collaboration need to be embedded across the construction industry. From large multi-disciplinary organisations, through micro-SMEs to sole practitioners. Clients also need to be included in the mix. Without commissioning clients, there would be no buildings. Clients also have a key role to play in decision making, reviews, approving budgets etc as workflows progress
- even for a small domestic scale development, a typical team could include client/s and a range of built environment players to steering the project from design through costing, project, planning, construction, occupation and maintenance in use
- it is reasonable to assume that each of the players would have different skills. As a starting point for BIMtoolkit, it would be a useful exercise to filter out the attributes which all participants need to have from the skills which might be considered to be more discipline specific, eg cost planning, or carrying out detailed energy calculations
- In that context, and as a shared entry level skill, a prerequisite was that participants should be able to engage with and manipulate 3D models using a viewer at a basic level. For example, to suit a client who could use a PC or laptop and was familiar with basic graphic

software like photo editing, computer games and the like. As a starting point for developing BIM toolkit, familiarity with 3D AEC data rich authoring software was not required. The issue of alphanumeric data flow was not considered at this stage, beyond information which could be accessed, modified and shared within the viewing environment.

## 6.2 PRESENTATION OF EARLY FINDINGS

Preliminary work identified a range of 3D model viewers available online. These are all available as freeware, although there may be qualifications. For example software houses may tempt users with a free download but limit full functionality to subscription versions. Viewers sampled are listed below. It was found that some downloads are much larger than others eg SketchUp viewer is around 11Mb whereas Autodesk Navis Freedom 2013 has a file size of around 500Mb. There may be a relationship between resident file size and functionality, but it is too early to confirm at this point in time. Listed alphabetically, the model viewers reviewed and/or software which incorporating 3D viewing capability were:

- Adobe Acrobat Reader XI (3D functionality claimed from Adobe Acrobat 9)
- Autodesk Navisworks Freedom 2013
- DDS-3D CAD viewer
- SketchUp viewer
- Softplan Review 3D
- Solibri Model Viewer V7.1
- Tekla BIMsight

Each of the viewers tended to demonstrate key features. One of the most significant is that some, for example SketchUp, will only upload one model at a time, while others like Solibri or Tekla BIMsight will allow multiple 3D models to be loaded for simultaneous viewing and manipulation.

SketchUp viewer in particular was found to be very easy to use. The next stage of enquiry would be to test functionality, particularly feedback from clients on the effectiveness of the viewer to navigate and read 3D concept and preliminary design models online. SketchUp also interacts well with Google Earth, (Fig. 4) so linking with site specific data is also a possibility; site location, topography, site context etc.

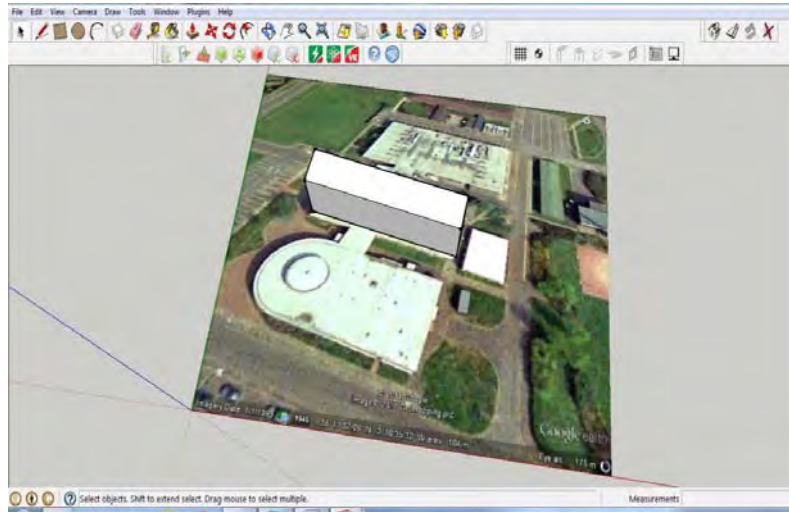


Figure 4. Site model with embedded GIS information. Native file source .skp

From the multiple model viewers sampled, Tekla BIMsight, for example, offered extended functionality including the possibility to combine federated models, (Fig. 5) read/write, scaling, markup and potential for dialogue/data exchange across disciplines via a browser environment. (Fig. 6) One feature noted from the more sophisticated model viewers was a sensitivity to imported file type and, even with very limited sampling, a perceived loss of geometric data in migrating from a native file source to, for example, the IFC format. Possibly single and multiple model viewers could work in tandem. That premise has not been tested to date and the work continues.

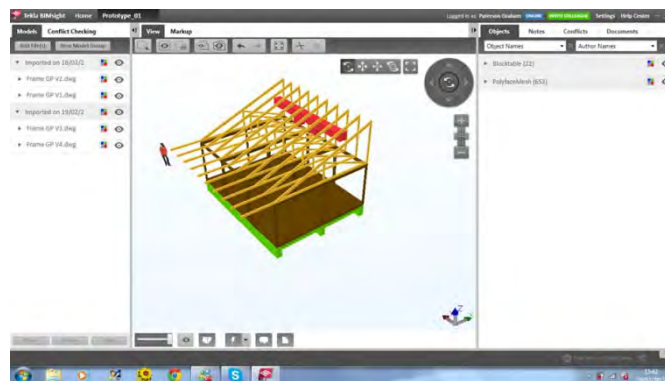


Figure 5. BIMtoolkit: federated model combining four separately designed instances in the Tekla BIMsight viewer. 1) Substructure + floor slab, 2) superstructure general arrangement, 3) specialist timber roof trusses, 4) Heat Recovery Ventilation (HRV) ducting.

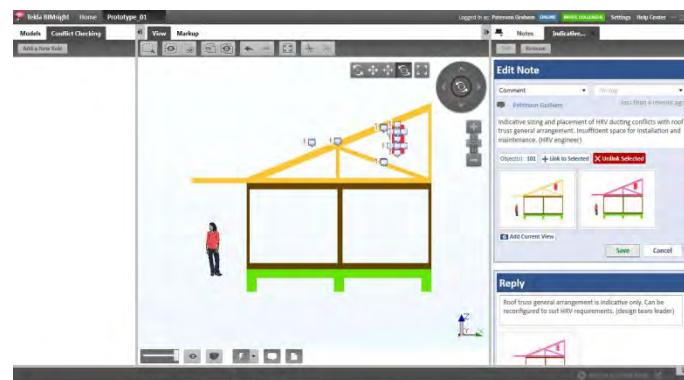


Figure 6. BIM toolkit: orthographic view of suite of federated or reference models showing markup and “first steps” identification and resolution of potential conflicts between building structure and mechanical, electrical + plumbing (MEP) services.

## 7. Conclusions

This paper has discussed BIM in relation to the UK Government’s intent to embed Level 2 BIM into publicly procured projects from 2016. Associated issues have been reviewed including perceived models for implementation, identified as *evangelical* and *evolutionary* paradigms. A range of challenges has been raised, highlighted and evaluated. These include the structure of the UK industry as it may relate to BIM uptake, and consideration of whether the evangelical paradigm may be appropriate to effectively reach and modify the behavior of the SMEs representing the industry’s majority stakeholders. The need to identify, review and apply a range of business models relevant to BIM uptake has also been appraised in relation to best fit with organizational cultures, discipline characteristics and requirements. These issues relate primarily to the use of ICTs as process enabling tools. In the UK, the spectrum of organisations across construction characteristics across construction is very broad in relation to size, characteristics etc and raises questions as to whether or not a *one size fits all* approach is likely to be effective, or indeed desirable if the message is likely to inhibit rather than encourage BIM uptake among micro-SMEs in particular.

Drivers for BIM uptake have been examined raising the key issue of whether or not the UK built environment professions will be able to cope with significant change to culture and work practices by the Government's 2016 deadline. Consideration of macro versus micro organizational typologies has identified a perceived technology gap in relation to the need/ability of SMEs to engage with the ICT infrastructures prevalent among larger organisations.

Technical design has been discussed in relation to architectural education in general and architectural technology in pedagogy in particular. The need for a robust and consistently applied outline syllabus embodying BIM has been raised as a question for the architectural technology profession to consider. In that context, maintaining connections between undergraduate education, research and professional practice is critical. Industry studies have consistently demonstrated a dearth of R+D in construction. One key facet of an evolutionary paradigm for BIM uptake is that it should follow a reasoned, evidenced based and consensual pathway towards implementation. Collaboration across disciplines and the involvement of clients is thought to be key to achieving that objective.

BIMtoolkit has been initiated and developed as an experimental project to propose and test methodologies for facilitating collaboration across disciplines, possibly by-passing the need to engage with data rich AEC software authoring tools to achieve more universal engagement with UK Government Level 2 objectives. That work continues into 2014.

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## PREPARING ARCHITECTURAL TECHNOLOGY STUDENTS FOR BIM 2016 MANDATE

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**Abstract.** This paper presents a challenging stand for architectural technology (AT) students, and roles. What roles are AT graduates going to play before and after the 2016 Building Information Modelling (BIM) mandate and how academia is preparing them for such roles. All these questions and others have been debated since the mandate, speculation more than any other tangible knowledge or experience is the basis for most changes to the AT curriculum. AT student expectations have been explored and the different opportunities that a graduate might have, in the light of the suggested roles. A survey was designed and emailed to third year students in the second semester of their study. The purpose was to understand students' perception on BIM within the context of professional practice (s) this included both; work placement and Simulated Professional Practice. The results suggest that BIM as a practice in context still lacking, however AT graduates feel confident for the mandate. But to overcome the current transitional stage academia needs both; contextual teaching and training of BIM, and stronger ties with the industry. Achieving that would provide well-trained and confident AT graduates to take up the transitional change competently and innovatively in AEC practices.

### 1. Background

With the government Building Information Modelling (BIM) 2016 mandate, the construction industry is faced with changes in practices, processes and roles. Consequently, Architectural Technology (AT) as a profession has the ability to gain versatile opportunities to complement the gap between the architect and other construction parties, but this can only be accomplished if AT graduates have the technical skills to support both, knowledge of building design and BIM workflow.

The BIM strategy has added another technological responsibility for AT - to bridge the different attitudes of interdisciplinarity. This responsibility comes mainly from Information Technology (IT) and its new ways of doing things. The current shortage of trained BIM personnel is a barrier to BIM implementation.

This study considers the effect of work placement on contextual learning possibilities for full-time curriculum of Architectural Technology education. It discusses the approaches adopted in the Scott Sutherland School of Architecture and Built Environment at Robert Gordon University, which we believe will be of interest to colleagues and educators in other schools who are concerned with a lack of opportunity to undertake practical training allied to the built environment.

The study employs a questionnaire survey to look at the effect of undertaking work placement and attendance at a professional practice studio on the participants' skills development. This survey examines the current position with regard to the balance between education and work in practice. A detailed account is provided with a focus on professional studies, where some issues and opportunities were highlighted for improvement.

## **2. BIM Current Messages for Education**

Encouraging the development of Information Technology (IT) skills is a key part of the UK Government's strategy to improve the construction industry productivity and performance. Recently the Government's Construction Strategy complemented this with its mandate for *'fully collaborative 3D BIM as a minimum by 2016'*, and the need for efficiency and industry reform to realise a *'cost reduction of 20% during the term of the current parliament'* (National BIM Report, 2012 p.04). This has already encouraged many firms to revise their *"technology assessment and training programmes, to make sure that they can measure the skills of key personal"* or new graduates.

At the same time, it is necessary to understand the changing needs of the industry and these must be communicated to be able to develop governance that supports UK students to acquire the right skills in the field of Architecture Technology and Built Environment. This can be achieved through a centrally co-ordinated collaborative approach to monitor skills development of final year architecture technology students, and architecture design students.

Therefore, an investigation into the influence of placement from an industrial context on students' skills is required. Bearing in mind that until now there has been no consensus on how best to address this aspect of students' development (Salman, 2011), this research focuses on the practical skills of students in both AutoCAD (CAD) and Revit (BIM). Other studies focused on skills that are more generic and their impact on students' professional capacity. Taking into consideration the potential benefits for architectural technology programmes, this research will help set the agenda for professional training and BIM integration – areas that have to be set

properly to maintain our educational role and impact for the 2016 BIM mandate.

The focus of this study is on one aspect of employability - that is graduate's confidence in using BIM (3D CAAD based design processes) within a placement as opposed to University (Salman, 2011). How would placement change students' engagement in learning and using CAAD (2D and 3D) while the context is different? How this might enhance their confidence and employability after graduation? Remarkably, this is an under-researched area and requires more efforts by scholars to understand how teaching programmes can bridge the technical/professional aspects of students' development: that is, how undergraduates are using BIM principles and 3D skills rather than learning new skills and other attributes through the higher education process. This will have a positive impact on student's professional preparation.

## 2.1 TERMINOLOGY

One aspect of our teaching is the terminology that we use to express concepts and relations. Adopting new technologies brings new terminology, when BIM is mentioned the wording used implies that all parties are present in one way or another.

*"It makes designing fun again. We are not drawing lines, we are building a building"* (Downs, 2009).

Active and experiential learning of BIM have changed terminology in two ways. The language has become more active in the sense that it carries with it collaborative meanings and shared values. Table 1 shows some of the differences between the terms of yesterday (then) and tomorrow (now or tomorrow).

Table 1. Terminology and BIM.

| THEN            | NOW and<br>TOMORROW |
|-----------------|---------------------|
| Disconnected    | Integrated          |
| They            | We are..            |
| 2D drafting     | 3D, 4D, nD          |
| Sketching ideas | Building ideas      |
| Print           | Digital             |
| CAD skills      | Modelling           |
| Drawing         | Prototype           |

While they differ, they share similar aims and qualities. The adapted terms aim at placing emphasis on the exploration of 3D qualities and

information extraction whilst also emphasising information transmission in an integrated approach.

## 2.2 CAAD VS BIM

When BIM is mentioned CAD also mentioned, even if implicitly, and the question of whether BIM is CAD or CAD is BIM comes to the forefront. Based on teaching BIM, Eastman et al. (2008) recognised clearly that *“students are able to grasp the concepts and become productive using BIM tools more quickly than they were with CAD tools”. BIM appears fairly intuitive to students and it more closely resembles their perception of the world.*” Because BIM requires different ways of thinking about how to develop designs and manage construction of buildings, the industry sought to retrain those employees who are more familiar with CAAD (Eastman, et al., 2008). This training needs to balance old ways of thinking (primarily 2D-based) and working habits with different processes and work flow. New graduates, who are influenced by their familiarity with BIM and use it for a full range of undergraduate projects, are likely to have a profound effect on the way that companies will deploy BIM.

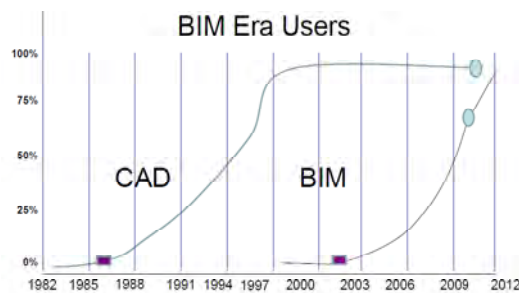


Figure 1. BIM adoption vs. CAD adoption (Deutsch 2011)

In the literature, the term CAAD is treated as an inclusive term of all CAAD systems that may be used for the architectural design process (Salman, 2011). However, it is not inclusive or generic from students' point of view. In Salman's (2011) study, all participants agreed that when CAAD is mentioned they associate it with the most used CAAD package AutoCAD (no mention of ArchiCAD, although it has been taught in parallel, and it is a CAD compound term). Briefly, the study suggests three things: 1 - defining the term CAD or CAAD as a meaning was based on a practical context in relation to the way it was used by students during their university education; 2 - introducing CAAD in a detached manner from its historical evolution and philosophies, and 3 - to reflect on the differences between different

CAAD software programs such as AutoCAD and SketchUp, which are totally different in the way they work.

BIM implementation does not mean employing another CAAD software program, or a particular software program, even if that software program is 3D based. Implementing BIM involves both technology and process, as the existing processes will evolve with the implementation of BIM technology (Deutsch, 2011).

### 2.3. BIM IN THE EDUCATIONAL CONTEXT

Most schools consider the integration of computer literacy and CAAD as one concept (Mark, Martens and Oxman, 2003), which involves the teaching of two types of computer systems: social and professional. In recent years, Garcia et al. (2007) challenged professional (commercial) systems by proposing an educational system that has the same aspects of AutoCAD commercial software, but with an easier learning curve. The results showed that students preferred to learn and use AutoCAD even though it is more difficult than the new system. This preference was based on two reasons: CAAD's advanced *technical* aspects, and its role in their future career (Garcia, et al., 2007). This also reflects the common perspective of why these systems are important in design schools and design teaching.

AEC industry requirements change with time, e.g. the BIM 2016 mandate, and all careers are subject to such changes (Soltani-Tafreshi, Twigg, and Dickens, 2009). It is imperative that students are able to handle the uncertainty that comes with such changes. Academia tries to highlight potential roles and the accompanied changes as these requirements are not always aligned with the curriculum.



Figure 2. BIM transferrable change

With a mandate from the UK government, BIM adoption is inevitable. However, its implementation may manifest in two opposite directions suggesting that change needs a wider base; this wider base may be presented by new graduates coming BIM ready to industry, or by industry technological reformation. The most likely is that graduates will take the



lead to bridge the identified gap between industry and academia, between technology and multidisciplinary teams.

#### 2.4. EFFECT OF THE WORKSPACE

The term design workspace refers to the tools that are available to designers in a shared workspace; either studio or practice, such as CAAD software programs and paper-based, and the designers' interpersonal communication channels (Maziloglou, Scrivener and Clark, 1996). In the workspace, one can observe both interpersonal interactions between designers and other construction specialists, and their interaction with the various workspace tools and media. These two interactions are responsible for giving the design workspace its richness and complexity. The flow of work may change to accommodate a new technology or approach to design processes. Workflow has changed in the industry to suggest new experiences and problems. However, collaboration and cooperation are the most appraised by employers and professional practices.

The interaction between students and tools and their ability to be critical of the used tool also depends on the level of skill in using this tool and, to a certain extent, how confident they feel interacting with a tool in the academic context of the studio. If the skill is available, then interaction will take place and as a result, the student's ability to be critical will mature.

Universities in the UK promote the merits of vocational degree programmes that combine academic rigour with periods of placement within industry. At Scott Sutherland School third year AT students have to select one option from the following professional contexts: Industrial Placement, Simulated Professional Practice, or Exchange Programme.

#### 2.5. NEW ROLES

BIM means different things to different professionals, working with BIM means a profession has more specific roles than an AT, CAD manager or IT coordinator. Some of the research on BIM comes from a particular discipline or professional perspective. Specific literature has been written to help professionals and graduates to understand the benefits of BIM and the changes in roles. This change can be categorised under new emergent professions as outlined below (Oxman, 2008; Salman, 2011; Simpson, 2012):

- *The Technology Manager*: An AT who is responsible for setting up information, communication and modelling strategies for the whole project team (s), from start to operation.
- *The Modeller*: An AT who is responsible for creating geometry based models, and any detailed components required for the BIM model.

- *The Toolmaker*: An AT who is responsible for tailoring tools, apps and interfaces to allow exchange of ideas, information and data between different project team members and software programs.
- *The Researcher*: Anyone who wants to bridge the gap between theory and practice to speed up implementation and solve problems.

### 3. Data Collection

The interaction between research, practice and education is important in producing and revealing necessary knowledge. Through this interaction, the applicability of CAAD from one context to another can be observed and applied through design practices. Thus, the investigative (physical) setting is a significant factor in the overall research approach to design processes, which affect the research methods used. For example, work placement as a setting provides a reliable indication of the applicability of student's transferable skills.

This study methodology aims to monitor the effects of professional context (under simulated or real conditions) on undergraduates' skill development, which also supports the "process" point of view of research methodology as an explorative methodology. Consequently, the current research involves a questionnaire survey to monitor students' development during their second semester professional practice.

The research started with a literature review focusing mainly on the following keywords; work placement and skills acquisition, employability and attributes, professional context and BIM adaption. The search included both literature on general employment skills and literature specific to architecture technology and architecture disciplines. The goal of the literature review was to find out the main skills of the discipline and develop a questionnaire that is explorative in nature. The questionnaire focuses on how undergraduates comprehend their generic skills, specifically CAAD skills development, through work placement and simulated professional practices, and how their CAAD/ Revit skills were perceived by the employer.

#### 3.1. SURVEY

The questionnaire survey was exploratory in nature, but also evaluative, which was critical in two respects. Firstly, it describes the contemporary student from the student's perspective by reflecting on their experiences and the application of CAAD and BIM (if any), in order to support the study with contextual propositions. In addition, it further informs what needs to be changed or modified in subsequent year(s) of study.

Data from the targeted sample was collected for the following research objectives:

- To describe the targeted sample in terms of their skills, knowledge and contextual learning in the professional context, and
- To know how students measure their learning preferences and needs.

### 3.2. METHOD

A questionnaire survey was designed and circulated using an online tool (dotsurvey.com) to gain an understanding of the professional context within which students operate and interact. This study was able to clarify the effects (if any) of their professional practices on skills acquirement and employability expectations and helped to gain understanding of how context would affect CAAD's future integration in the architectural technology curriculum.

The targeted sample consisted mainly of third year students who have been studying Architecture Technology at the Scott Sutherland School of Architecture and Built Environment for at least two years, with an average of one-year industry experience (taking a placement).

## 4. Results

Twenty-five responses (representing a 50% sample of the cohort 2012-2013) were received. The questionnaire took approximately 3 minutes to complete. Results are presented in the same sequence as the main survey. Descriptive analysis was carried out to provide a general overview of the sample to be presented in percentages. Survey responses were analysed using an Excel spreadsheet. Survey responses were analysed using the MS Excel package by performing descriptive statistics, and presented in percentages.

### 4.1. PROFESSIONAL CONTEXT

In response to what the participating students (third year) had to do in their semester-two studies, work placement and professional practice simulation were cited equally, with a percentage of 43%. This is shown in Figure 3. Only 14% cited none of the two options.

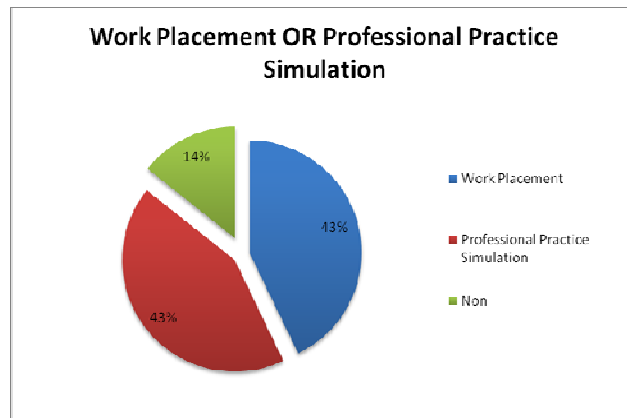


Figure 3. The survey participants

#### 4.2. DESIGN SKILLS

Students' self-assessment of their design skills (architectural design, and CAAD) was highlighted in the following manner. Students' skill "self-assessment" was measured on a five-level scale from poor (1) to excellent (5). The results are shown in Figure 6. The results showed that students ranked their design skills as follows: architectural design skills mean score is good (mean score of 3.4 out of a possible 5), and CAAD skills mean score is good (3.8); slightly higher compared to their design skill.

The chart in Figure 4 provides a visual indication of the students' self-assessment scores showing the lowest and the highest score.

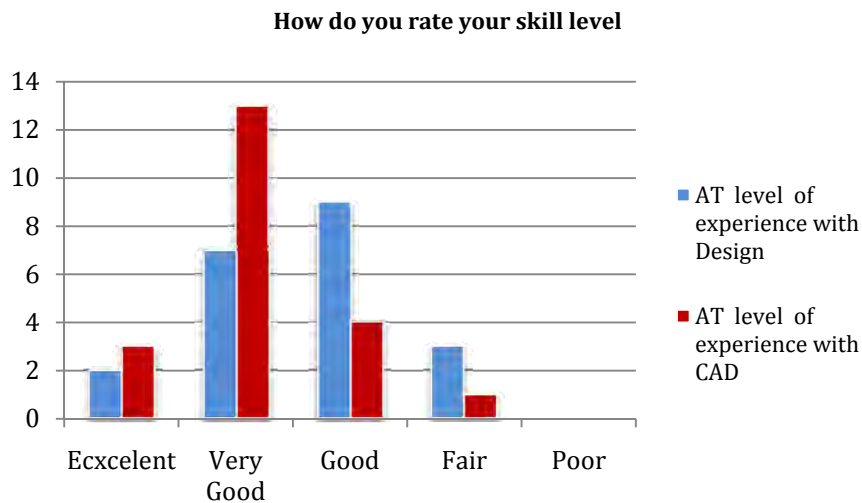


Figure 4. Participants' skills Self-assessment

It is obvious that third year students were consistent in assessing their design skill and extremely inconsistent in assessing their CAAD skill by scoring various levels of CAAD experience within the same studying stage. This should be taken into consideration when designing any CAAD related modules. Normally, students at earlier stages of education have various levels of skill, something that is less likely to be noticed when they are in the final stages of their education. Therefore, access to various levels of CAAD tutorials is essential for AT students.

#### 4.3. THE USE OF 2D AND 3D

Figure 5 shows the differences between the main two contexts in terms of CAAD use in relation to work placement and professional simulation. In the workplace context, more than half of the students (53%) tend to use CAAD for 2D drawings with a lower percentage (29%) of them using it for simple 3D drawings (without rendering). Only 18% of them use it for 3D modelling (with rendering).

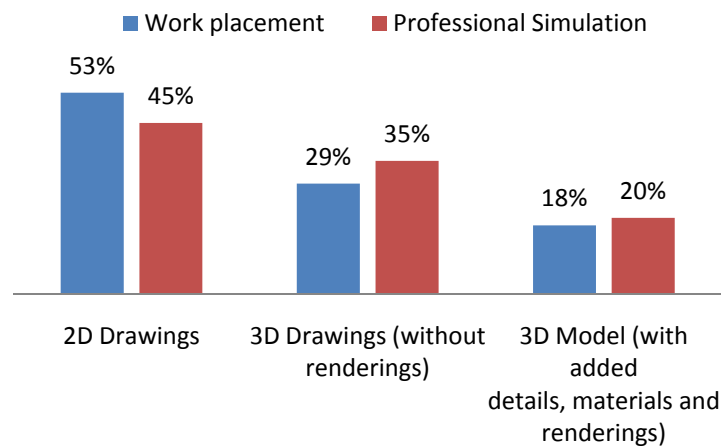


Figure 5. Participants' use of 2D and 3D in both contexts

On the other hand, the results in relation to professional practice showed a different trend, CAAD use in a professional simulation studio. Figure 5 shows that less than half of the participating students tend to use CAAD for 2D drawings with a lower percentage (35%) of them using it for 3D drawings. Only 20% of them use it for 3D modelling (detailed and rendered).

In general, the results show that the use of CAAD for 2D drawings is significantly higher than 3D use in the workplace context. The use of CAAD for 3D drawings is significantly higher than 2D use in the professional simulation studio. This could suggest that academia has enhanced the use of 3D within its curriculum compared to industry, and potentially demonstrates how academia might be quicker to adapt BIM practices/principles.

#### 4.4. 3D MODELLING SKILLS

The responses of students to whether knowing that you are skilful in 3D modelling is an important aspect to your work placement are shown in Figure 6. More than half (56%) of the sample found it very important that their employers knew that they were skilful in 3D modelling. Forty four percent of the sample reported that having 3D modelling skills is not important for their employers.

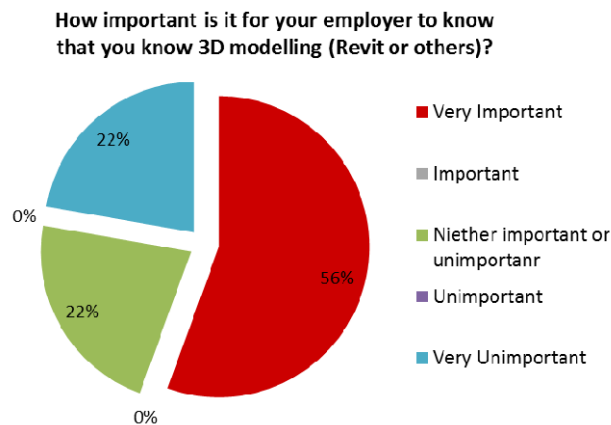
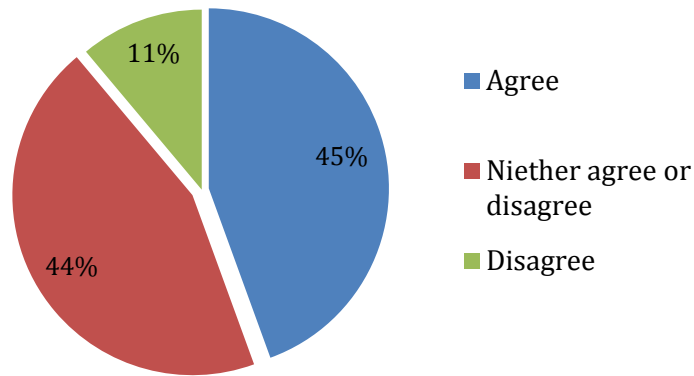


Figure 6. 3D modelling and employers

Based on the sample's background and skills, Figure 7 shows that less than half of them (45%) believe that using 3D modelling in the workplace has influenced their working capability in general, and 44% neither agree nor disagree with the same statement, with 11% disagreeing. This suggests that the sample's views regarding 3D modelling impact on design related issues and capabilities are divided, although they share the same level of knowledge as they are at the same stage of education.

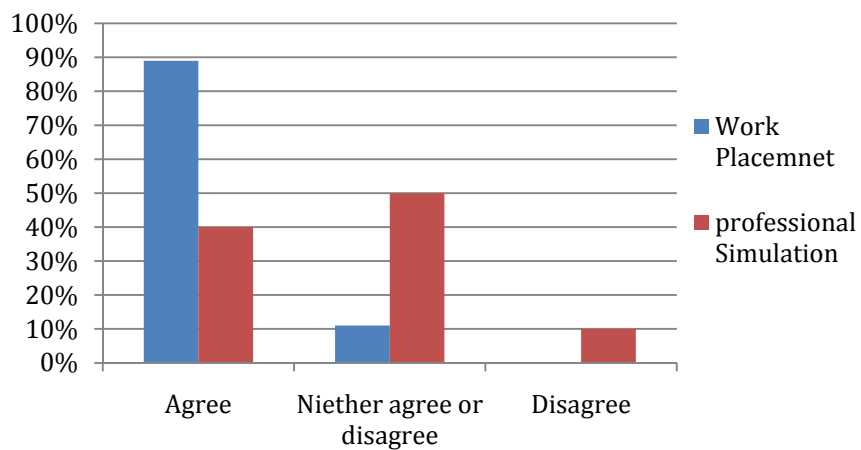
**Using 3D CAD modelling within placement affects my work experience positively.**



*Figure 7. 3D modelling and experience gained.*

#### 4.5. WORK PLACEMENT

The students were asked if either their placement or professional simulation have validated the skills and knowledge of their undergraduate studies. The majority (89%) of the sample completely agreed that work placement validated their studies, and 11% neither agreed nor disagreed. This data is shown in Figure 8.



*Figure 8. Work placement and Knowledge validation*

In the context of professional simulation, 40% percent felt that professional simulation practice has validated their knowledge. Fifty percent of students neither agreed nor disagreed with the statement, while 10% of the sample disagreed. These differences suggest that students relate knowledge validation with work placement rather than a professional simulation studio. Students still believe that work placement acts as a real industrial context and as such would validate their skills in a tangible way.

#### 4.6. OTHER SKILLS

Results also showed that while students recognise the contribution that the course had offered them so far, they still feel that there is a lot to learn from a professional context. The importance of teamwork, being given responsibility, and collaborative learning emerged as the most important factors for effective learning in the two professional contexts under consideration. They also felt that they needed to learn about other principles and relations in their final year taking into consideration integration of the following skills (Figure 9):



*Figure 9 Skills Development*

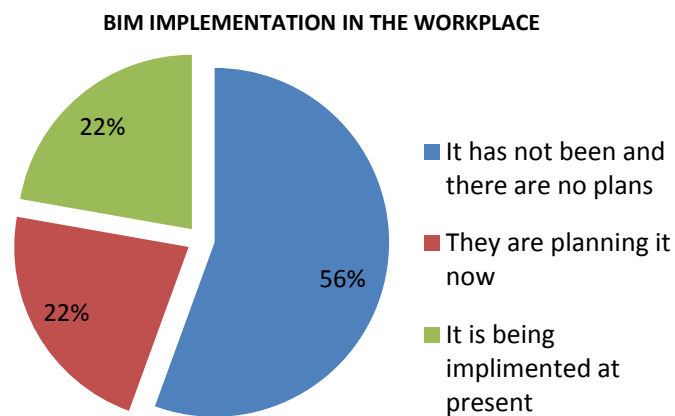
All participating students involved in the survey had experienced work placement or professional simulated practice as a formal part of their undergraduate studies. Results showed that while graduates recognised the contribution university had made to their generic skills development, they greatly valued the experience of learning in the workplace during placement and, subsequently, in employment.

#### 4.7. BIM IMPLEMENTATION

Students who were in the workplace were asked if BIM was implemented yet or not. The results show that 22% of them indicated that they had not implemented BIM yet, and a similar percent indicated that their employers were planning it presently. More than half (56% percent) indicated that they



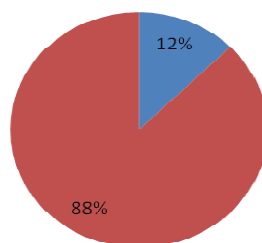
have no plans for implementing BIM in the near future. On the other hand, 22% of them indicated that they are planning for implementation at present. Another 22% indicated that they have already implemented BIM, demonstrating that industry is providing students with little opportunity currently to gain full experience and benefits. How industry is going to deal with BIM and how these contextual experiences are conveyed to industry is still unclear as this loop is very weak at present.



*Figure 10 How has BIM implemented in your workplace?*

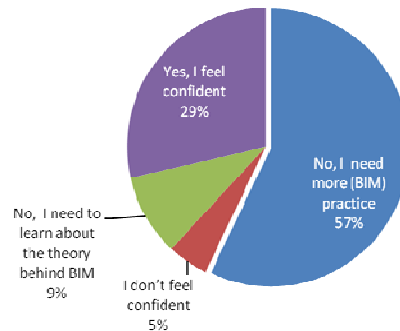
#### 4.8. CONFIDENT WITH BIM

Those students whose employers had implemented BIM were asked whether they had experienced BIM in the workplace context. The majority indicated that they had not. However, a low percentage (12%) had experienced BIM in the work place. This result is very dependent on the answer to the previous question relating to BIM implementation in the construction industry.



*Figure 11 Had you experienced BIM at the workplace context?*

Finally, third year students were asked if they feel confident that they have the skills required for the BIM 2016 mandate. More than half of them (57%) felt that they need practical experience with BIM to feel confident about the mandate.



*Figure 12 BIM Mandate*

However, 29% felt confident that they already have the skills required for the mandate. Nine percent felt that they needed to learn about the theory and 5% felt that they were not confident in doing so.

## **5. Conclusion**

All students involved in the survey had experienced either work Placement or Simulated Professional Practice as a formal part of their third year undergraduate studies. Results showed that while graduates recognised the contribution university had made to their generic and technical skills development, they greatly valued the experience of learning in the workplace during placement and, subsequently, in professional simulated. The importance of teamwork, being given responsibility, and collaborative learning emerged as the most important factors for effective learning in the two contexts under consideration.

BIM awareness should be raised to include the many facets of the emerging roles for AT graduates. The curriculum should be complemented by BIM through integration and contextual learning and teaching projects, which would enhance programs accreditation.

BIM practice is evolving rapidly in the industry; academia should be clear about defining graduates' role after 2016 to establish the confidence needed to start their career. On the other hand, the industry should push its opportunities by enhancing BIM practices for our graduates and the AEC industry.

In light of the 21st Century challenges for higher education, 3D CAAD and BIM principles become much more critical as a knowledge base. The professional context is the most vital medium for BIM learning and knowledge integration. Recent claims emphasised trans-disciplinary knowledge integration into the studio context (Salama, 2008), taking students' needs as the main criterion because it would be more effective to channel students' efforts toward their professional needs.

### 5.1. FUTURE RESEARCH

An extended study to emphasise and inform long-term (professional) development should be considered. Therefore, future studies should include how undergraduates' skills are developed through work placement, and to what capacity, and how their abilities and skills are enhanced or modified through professional work placement.

### Acknowledgements

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## CPD AN EXTENSION OF THE DEGREE IN ARCHITECTURAL TECHNOLOGY

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**Abstract.** Every qualified Technologist has to prepare a plan of their needed CPD requirements for any given year, so a period of sustained continuous professional development can take place. For most it is a haphazard leap from month to month looking for anything that can resemble CPD, relying upon manufacturers and some web presentations.

This paper is all about the way any plan should be put together, the tools you should use to develop your plan year on year, and how information should be stored for future retrieval. How and where your information should come from and the role Universities can play a major part in this.

How your plan is put together and your subject matter can and should be directed by both your work place and personal interests. A newly qualified technologist will have a slightly different requirement from that of a seasoned professional. Coaching and development could easily be part of the universities role in this, advising, teaching, and coaching a technologist, bringing in valuable fees.

What tools are used depends upon you, there are several paid for subscription programs available, the CIAT paper log, or there are several internet-based free methods of both record keeping and storage.

Should manufacturers take such a leading role in this, they, after all have a vested interest in giving their view of technology, which is not always the correct one. It is my belief that the Universities can and should play a more prominent role in this as a trusted source of knowledge, but also as an Alumni of Professionals.

This paper aims to outline this in detail.

### 1. Introduction

Every qualified Technologist has to prepare a plan of their needed CPD requirements for any given year so he or she may obtain at least 35 hours of sustained continuous professional development - CPD.

For most it is a haphazard leap from month to month looking for anything that resembles CPD, relying almost entirely upon manufacturers for their

entire CPD needs, dotted with the odd organised events from a number of professional institutes and the odd paid for lecture.

Almost no forward planning in engaged, instead, so often it's down to who ever comes through the door, that can offer a CPD presentation, at best it is a subject relating to your current work load, at worst, it is nothing to do with it, or your current project.

The need for continuing professional development (CPD) in the UK and for that matter, the rest of the globe, has been recognised by most professional bodies, and in particular the construction sector.

CPD, or to call it by a common name "Lifelong learning" is vital to individual and organisational success, keeping up practice knowledge with an ever increasing portfolio of law and material use.

All individuals learn in different ways from listening, watching, questioning, doing and helping other to learn. Lifelong learning programs aimed at people in the work place must be suited to their particular needs, in both the professional and personal parts of their life.

## 2. The Need

Planned, structured and mentored learning should be organised to allow any individual to update and add to his or her own portfolio, and thereby add to the workplace knowledge base. To add a certain quality or core theme for Architectural Technology, a core of fundamental subjects should be mandatory learning. Most professional organisations recognise that 35 hours is a normal minimum requirement, although this can easily be increased when complex or new legislation is added to the workplace. The RIBA have published a core list that includes:

Being Safe - Health and Safety

Climate - Sustainable Architecture

External Management - Client users and delivery of service

Internal Management - Professionalism, practice, business and management

Compliance - Legal, regulatory and statutory framework and progress

Procurement and contracts

Designing and building IT - Structural design, construction technology and engineering

Where people live - Communities, urban and rural design and the planning process

Context - The historic environment and its settings

Access for all - Universal or inclusive design

They suggest that the 10 core curriculum topics be weighted and be a prerequisite of 2 CPD hours for each subject giving 20 study hours per year.

The adoption of a similar list maybe bias towards a more technical approach, but the core subjects of the RIBA are also applicable to any. The list of core subjects should be laid out, together with a list of relevant subjects attaining to current and proposed projects the Technologist is going to need in the forth coming year.

The core subject list should be augmented by a personal list in common everyday use, this could easily be mostly building regulation oriented, together with some day to day practice tools like CAD and specification use. Any list should be live, in that it needs constant attention and updating as the Technologists needs and career develop, with the goals in terms of time added to give some idea of ranking or need.

Research of any topic should be done via research on the web or existing technical libraries, specific manufacturers and some via specialist presenters or specialists in their field.

The reliance on manufacturers is a somewhat one sided approach to any subject, good manufacturer presenters will provide a balanced view of that particular subject, but it is always in their own interest to present their company and their company first, after all it is why they spend time attending a practice for free, and so often paying for lunch, so they can secure only their materials in any specification.

Internet research is often the most popular way forward, but it is thwarted with problems, of none verified data and manufacturers literature spin, not giving a complete or accurate picture. By far the best way is to pay for lectures, but even here, Technologists often pay for attendance at a lecture, only to find it given by a manufacturer. This is not to say that manufacturers' presentations are in any way flawed, as long as it is made clear from the start that it is specific to that company.

External verification of any presentation is a way to give credence to a manufacturer's presentation, and who better to review and approve manufacturers' presentations for technical content and use to the Architectural Technologist than a University peer review. Surely this is an area that can easily be supported by any University alumni, and backed by current lecturers writing and researching presentations. Bringing in valuable fees and even more valuable is links to industry. The RIBA currently has its

own approval system, but the University Alumni, would be more the stronger method, linking internal research to manufacturers research Data.

The idea that manufacturing could link into Academia is not new, but the links and peer review of material would give the office presentation a new lease of life. Instead of just one manufacturer, there might be a comparison of several.

A natural extension to the Academia review system could be a CPD alumni also offer any university a chance to offer specialist courses to Technologist's wishing to add specialist credentials to their expertise. Ancient building or monuments, SAP or other, discussed later. A yearly fee could be applied to this attendance bringing in valuable fees and also keeping their current student within the university, far better to support our university Technologist courses than private companies.

Another extension to this might be a web site specific to the University, which would allow student papers to be viewed, and discussion promoted within the Alumni. The idea of a University alumni web site offers a chance to add links to papers presented to the site and a current CPD activity which can only enhance the job application, when used within a graduates CV.

### **3. The best storage method**

Back to the need to carry out 35 hours of CPD, current CIAT, record needs are met by a simple A3 two sided paper record, that has limited record space, and allows hardly any room for notes and links, is flat and offers no external interrogation.

Record keeping for the purposes of any CPD activity, consisting of research, or lectures attended, should be carefully recorded, on a system that allows for accurate, searchable notes from simple electronic text notes to audio recordings to video and photographs. I might add that even paper is useful, if neatly written and scanned into an electronic format i.e. PDF, that can be tagged, linked and shared, with an OCR scan added.

Research and papers might be stored in a system that allows current search engines to interrogate the personal archive, as part of any day to day research. It is this personal archive that adds to the performance of any technologist giving transferable skills that will enhance and technologist looking for work.



The Evernote App that plugs into so many of the current browsers allows just this net and private archival of search. It soon proves an invaluable source of research to the Technologist. Why spend all that time and effort into researching a subject just for that moment, any notes and research material should be live for the future, constantly updated.

Evernote and its suite of programs and apps are an excellent example of “Personal knowledge base”, archive system, free is an industry standard cross platform cloud resource. That allows vast, almost unlimited record keeping, and most of all, allows easy sharing of data.

Specific tags to Evernote documents allow cross pollination of documents that might contain alternative sources and subject matter, available for search. OCR or optical character Recognition, allows further refinement of the search and document classification.

The use of Tags on any document allows external search engines to find and classify documents in much the same way, but with the added benefit of other researchers finding and citing the work, hence my comments on the University Alumni site for student papers.

#### **4. A simple spreadsheet**

Recording CPD activity can be done via an online database, within the Alumni site, or simple personal spreadsheet stored with Google Docs to record the hours spent, together with simple notes on each subject with formulas that add up hours and apply then to specific project activities allowing an instant overview of my CPD and highlighting areas to be picked up on. Links to any specific Evernote record completes the spreadsheet record allowing easy access to the research.

The use of a Google doc spreadsheet, allow easy sharing to mentors, without the need to program and maintain expensive sites, there is also a simple share embed facility to allow records to be displayed on a personal page within the University Alumni.

Not all presentations are equal, hours spent on any subject, should be subject to a weighting, was it good CPD and did I achieve the goal I set, perhaps weighting the hours spend for online V's actual attendance and discussion. A personal attendance being seen as a bigger commitment, but time to attend is often cited as one of the main problems in attending any CPD lecture, Office pressure, family life all eat into the time anyone can give to creating and maintaining any ones personal CPD.

## **5. The rise of the MOOC**

Online courses should offer the professional chance to study at a time convenient to him or her. Massive Open Online Courses, (MOOC) currently being rolled out by a number of institutes offer the solution to the real time problem of “time to learn” i.e. the lecture or presentation not being at a convenient time. They allow own time viewing 24/7/12, are extremely cheap to set up and offer easy access for both student and content creator.

But Self Directed Learning is so often thwarted with the idea I can do it later, and when later comes only find there is little or no time left. In a traditional classroom, the lecturer and institute are so often responsible for the time scale. Candidates operating their own self directed learning CPD, take responsibility for the organizing and implementation of their own time table.

But a balance between the two can be achieved, with the augment of modern communications, such as VOIP (Skype or Google) where a lecturer or Mentor, might be available to help discuss and motivate the distance learner. Each Technologist being appointed a tutor to not oversee but guide, comment, mentor on the year's activity, perhaps even maintaining the CPD documentation for the Technologist giving both credence to the research and the way it has been applied.

## **6. The role of the office mentor**

Local cells might be formed within a local Architectural practice, where a Mentor might attend to give a lecture and take time to speak to the cell. The inclusion of current practices close to the University offers more exciting development of the practice CPD, allowing development of the link in reducing PI fees and establishing live project access for younger students. A further development of this would be in placement for summer or year out students.

At what age does CPD end, the simple answer is never, with the age barrier of 65 being ignored by so many men and women, who rightly feel they have still a few more years of active contribution left?

Legislation and construction techniques so often need constant updates, giving the problem of older and obviously more experienced Technologists the problem of being assigned a mentor who might be less qualified both in years of experience and qualification. The MOOC partly removes this problem, but more mature lecturers would be needed who can be seen as on

par or more senior to the older student, perhaps giving a different style of mentorship.

Currently post graduates have to apply for Charter-ship of the Chartered institute of Architectural Technologists, CIAT, and develop and maintain what is known as a POP record, this currently is external to the University system, being almost self motivated and often mentored by the current membership, with any University involvement only at the end as peer reviewer of the documents before being sent to CIAT. The University Alumni could offer a more specialist system for monitoring the path and development of the POPS record or other system, rather than waiting to the end of the two year so often spent in its creation, only to find it being refused.

Might this be considered as a Post graduate award, even replacing POPS, currently undergoing a lot of change, which would be taken into the University. Giving some parity to the current School of Architecture course structure and allowing further development of the discipline with a final three year course leading to specialist accreditation post qualification.

For more mature candidates who are already chartered it would be easy for a tutor to spot research of note and encourage taking it to a higher level, perhaps a masters or PhD. The CPD base and perhaps Alumni would add the base for this, and allow natural information progression, with the technical social sharing of information, lectures and notes, being encouraged, highlighting areas of research that might prove valuable to other Technologists, methods of working, construction details, material performance, and would give Technologist's proof of their expertise in certain areas.

## **7. Sharing and social networks**

Although a University Alumni is advocated, the existing batch of social networks and their spread across the globe should not be ignored therefore links to sites like twitter, Facebook and LinkedIn should be a prerequisite to any Alumni site.

New methods of giving papers might also be explored, fitting in with so many peoples' need to watch lectures and do their own research at times often not suitable for most; with video now being so easy to generate and disseminate. With the likes of YouTube, Viddler and others, this medium is most suited to the personal lecture or MOOC. Even live hosting of personal

presentations of papers via sites like Google+/hangout, giving direct feed to YouTube for storage and retrieval.

Research is so often done with the aid of both written text, but increasingly photographs and video are providing valuable insights to details that help promote and prove good detailing and as a way to avoid bad practice.

The use and development of this new media should not be overlooked, modern tagging of media now allows easy search of items, and sites like YouTube remove the need for expensive storage. The use of private tags allows video use to be kept to small dedicated groups if needed. Sites like Google's Web Picasa allow for almost unlimited storage of photos and video. But so do specialist sites like Flickr, YouTube and Vimeo.

## 8. Conclusions

It's clear there is much to do in the way we as professionals continue our learning, and also in the way we store that research for future retrieval. Current paper is not acceptable, and the one sided approach by manufacturers should be controlled. The rise in the almost unlimited internet give rise to many of the answers such and University involvement and MOOC learning, and almost free iCloud repositories for research notes. Plus the encouragement seen via social networks sites should not be overlooked.

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