EDeR

Educational Design Research

Volume 6 | Issue 3 | 2022 | Article 54

Contribution Academic Article

Title **Design-based research as a research methodology in teacher and social education – a scoping review**

Authors **Astrid Lasthein Lehrmann**
Design School Kolding
Denmark

Helle Marie Skovbjerg
Design School Kolding
Denmark

Simone Jessen Arnfred
Design School Kolding
Denmark

Abstract As a methodological approach, design-based research (DBR) has been widely applied within research on educational systems. Nevertheless, the question of how DBR is used as a research method in specific educational environments remains. This scoping review focuses on DBR as a research methodology in teacher education and social education. Such a review can productively map a research area and can guide further research within a field. For this scoping review, 27 articles were selected, and the results showed that DBR is used as a research method in teacher education and social education; however, there are differences in how strictly the articles apply the approaches that are found and are well-known as important features within the DBR methodology. The main finding is that although the selected articles outline their research according to DBR, they do not

strictly use the methodology in practice. In most studies, participants are considered co-designers, and the research is conducted in iterative cycles. Because these are the fundamental core features of DBR, it would be relevant to suggest a stronger emphasis on the guidelines within the methodology and insist that future research follows these guidelines to remain within the design-based methodology and thereby strengthen the epistemology of the methodology.

Keywords design-based research, scoping review, pre-service teacher education, teacher education, social education, research methodology

DOI The DOI will be added when the issue is published.

Citation Lehrmann, A. L., Skovbjerg, H. M., Arnfred, S. J. (2022). Design-based research as a research methodology in teacher and social education – a scoping review. *EDeR – Educational Design Research,* 6(3), 1-32.

The DOI will be added when the issue is published.

Design-based research as a research methodology in teacher and social education – a scoping review

Astrid Lasthein Lehrmann, Helle Marie Skovbjerg, Simone Jessen Arnfred

1.0 Introduction

The question of the role of active participants seems more important than ever. Traditional instruction as an approach to education is being criticised because there is a request for new and broader skill sets to meet the challenges of the future (Sylva, Melhuish, Sammons, Siraj-Blatchford, & Taggart, 2010; Ananiadou & Claro, 2009; OECD, 2018). Educational attempts to change traditional teaching approaches have focused on inquiry-based learning, problem-based learning, playful learning and game-based learning (Jørgensen, Schrøder, & Skovbjerg, 2022; Jensen, Pedersen, Lund, & Skovbjerg, 2020; Boysen, Jensen, von Seelen, Sørensen, & Skovbjerg, 2022; De Freitas, 2006). Consistent with these approaches, there seems to be a changing ethos in teacher and social education, one that is moving away from the role of the professional as a transmitter of knowledge for knowledge acquisition and heading towards active student-led approaches that facilitate knowledge construction (Beetham & Sharpe, 2013; Wright, 2011).

For approaching the changes in education Design-based research (DBR) is a well-known and established research method within teacher education and social education[1], in which we have a specific interest, as these candidates will educate children in the future (Anderson & Shattuck, 2012; Kelly, Lesh, & Baek, 2008), and also within the broader educational context as a way through research and development.

In a DBR process the participants are considered 'co-participants in both the design and even the analysis' (Barab & Squire, 2004, p. 3). Anderson and Shattuck (2012) also suggested this feature as one of the key characteristics for a DBR approach and emphasise the approach as: taking place in a real context, emphasising a particular intervention, consisting of a number of iterations and having a close relationship between participants in the specific real context and the researchers (Stokes 1997; Schoenfeld 1999; Lester, 2005).

[1] The formal educational system in Denmark have a 3,5-year bachelor degree in social education which gives the professional work title pedagogue. The bachelor degree in social education is separate from the Danish teacher education since a pedagogue works within contexts such as youth clubs, day cares, preschools, primary schools, and institutions for people with special needs and does not work in relation to curriculum-oriented learning as teachers do.

Previous studies have analysed the progress and interventions within education to obtain an understanding of the qualities of DBR (McKenny & Reeves, 2012); however, few studies have attempted to understand the intervention in depth, specifically in terms of how or if the participants are participating or are positioned as collaboration partners and what type of roles they play when the intervention is carried out. Zheng (2015) highlighted different types of interventions and found that the instructional method is one of the least used; this could indicate different roles and positions for the participants, but the author did not focus on that question.

The current scoping review (Arksey & O'Malley, 2005) explores the role of participants involved in a DBR approach in teacher and social education. The main contribution of the present article is to show that the core feature of DBR, which involves collaborators with participants, is not consistent in trying to develop the future of teacher education and social education as being participant driven. The importance of being able to do this mirrors the overall goal of active students for now and for the future of education. If DBR as a methodology should have the impact to meet the future challenges of education, from merely transmitting knowledge into facilitating knowledge, the claim here is that we need to strengthen that epistemological reflection in the methodological approach and take practical implications of that approach upfront.

The current paper is structured as follows: First, we introduce the methods of the scoping review; then, we present a thematic analysis, which points to the types of participation when performing DBR. Finally, we provide the discussion and conclusion.

2.0 Methodology

In the following sections, we present the methods used for conducting a scoping review according to Arksey and O'Malley (2005). A scoping review aims to create an overview of a research area, thereby identifying the gaps within this area. Therefore, a scoping review was considered appropriate. A scoping review consists of five stages: 1. identifying the research question; 2. identifying relevant studies; 3. selecting studies; 4. charting the data; and 5. collecting, summarising and reporting the results.

2.1 The research question

This scoping review examines the methodological approaches applied when using DBR as a research method in teacher education and social education and the participation of students and researchers within the studies. We have phrased the research question as follows:

How is DBR methodologically used within research in teacher education and in social education, and what characterises the

participation of students and researchers within the literature in this research area?

According to Arksey and O'Malley (2005), the initial database literature search must be broad; thus, further search parameters were added later in the process. DBR has similarities with other research methodologies (Barab & Squire, 2004; Anderson & Shattuck, 2012). Therefore, the initial search was expanded to include, for example, 'action-based research' and 'formative research' to maintain a broad approach. The search terms were modified because the number of articles was extensive.

Different terms can be used depending on the country, as well as how the education is labelled. The term ´social education´ is not the label used in Denmark, but instead the term ´pedagogue education´ is used. Thus, we needed search terms embracing both a Danish and an international context. We needed additional search terms within this particular group and used various terms such as 'early childhood education', 'social education' and 'preservice teacher education'. However, because we did not want to narrow the search from the beginning, we also used the search term 'pedagogue education'. By including several terms, we maintained the broad scope of the search.

2.2 Identifying relevant studies

The studies for this scoping review were identified through systematic literature searches in selected electronic databases. Electronic databases allow the user to access international research literature and set the search parameters, for example, the language or year of publication (Arksey & O'Malley, 2005), which was done for the current scoping review as well. The first step was to choose the relevant databases. For the present scoping review, we chose the databases ERIC, JSTOR and Idunn. The ERIC and JSTOR databases provide international literature in relevant areas such as learning, teaching and education in general. Idunn was chosen because it is a Scandinavian database, and the scoping review is in a Danish research context. The following search parameters were set to narrow the scope and because of practical reasons, for example language barriers. We included articles that were peer-reviewed to ensure high quality, articles written in English, Danish, Swedish and Norwegian and articles published between 2010 and 2021. The time limit was set to access the most recent research because DBR is a relatively new approach that was established in the beginning of the twenty-first century (Anderson & Shattuck, 2012).

The literature search was conducted in iterative cycles in the year 2021 and refinements were made throughout the process. Additional search terms collected during the first iterations were used in various combinations in the following iterations. The search terms or keywords used were applied to strings consisting of two blocks: one containing keywords about the methodology, for example 'design-based research', and another block containing the target group, for

example ‘preservice teacher’. The exact same search string could not be applied in the ERIC, JSTOR and Idunn databases because there is a word limit in JSTOR and the initial searches were carried out in ERIC, which has no word limit. Idunn ended up with zero results when the initial search string was applied. Therefore, we used the same keywords in both ERIC, JSTOR and Idunn, but the keywords were shorter and various combinations were used. Specifically, for Idunn, we used options to search ‘in the exact expression’, which is the same as phrase search, to focus and narrow the scope of articles when searching for ‘design-based research’. Subsequently, we applied the option ‘in some of these words’ to broaden out the scope in an additional search string. The process is outlined in Table 1.

Database:	Search string:	Results:
ERIC		
Search 1:	((preservice teacher* OR "preservice teacher* education" OR "teacher education" OR “preservice pedagogue” OR "pedagogue education") AND (DBR OR "design based research" OR design experiment* OR "research through design" OR "formative research" OR "design experiment research"))	772
Search 2:	(("early childhood education" OR "social education" OR "kindergarden teacher" OR "pre-service kindergarden teacher*" OR "pre-service teacher*" OR "teacher education" OR "teacher student" OR "teacher students" OR "pedagogue student") AND (DBR OR "design based research" OR "research through design" OR "formative research" OR "design-based research" OR "design experiment"))	162
Jstor		
Search 1	((("Design-based research" OR "design based research") AND (("pre-service teacher*")) OR ("pedagogue educa*")))	392
Search 2:	(((("early childhood education") OR ("social education")) OR ("pre-service kindergarden teacher")) AND ("design-based research")) OR ("design based research"))	340
Idunn		
Search 1:	“design based research” (in the exact expression)	23
	Design-based-research, design based research, preservice teacher	20
	Design-based-research, design based research, pedagogue education	0
Search 2:	Design-based-research, design based research, pedagogue	2

	"Design research" "pre-service teacher" (in some of these words)	43

Table 1: Search strings

2.3 Study selection

To select articles, we developed inclusion and exclusion criteria based on the research question. The inclusion and exclusion criteria were not firmly decided from the beginning of this phase but were created and adjusted during the process based on Arksey and O'Malley (2005). In addition, study selection was conducted according to the PRISMA guidelines (Preferred Reporting Items for Systematic Reviews and Meta-analyses) because it provides a systematic and transparent view of the process in the PRISMA flowchart, which is depicted in Appendix 1. The flowchart comprises four phases: identification of articles; screening based on title and abstract; reading full-length articles and considering eligibility; and the number of studies included (Moher, Liberati, Tetzlaff, & Altman, 2009).

One of the authors screened all the articles based on title and abstract and created inclusion and exclusion criteria while reading, and corresponding and discussing with the co-authors. Articles were excluded because of the following reasons:

- The title or abstract does not reflect the study's objective.
- The articles use a different methodology, for example 'art-based learning'.
- The articles focus on quantitative data, such as randomised control studies.
- The articles do not reflect the research question.

The inclusion criteria for selecting the articles were, in the beginning, articles using DBR or a research methodology similar to this, for example 'formative research' or 'action based research'. Subsequently, it was clear that the research literature contained enough literature to include only articles using DBR, and articles using 'formative research' and 'action based research' was left out. A total of 196 articles were read for full eligibility by one author, and the selection process was discussed with the co-authors. At the end of this process, we had a total of 27 articles for analysis. During study selection, the target group in the studies only contained pre-service teachers, which are students enrolled at the teacher education. In the international research literature, teacher education is broader than that in the Danish context, so the representation of this target group was accepted. From this point on, we refer to pre-service teachers as PSTs.

2.4 Charting the data

The data can be charted by 'charting and sorting material according to key issues and themes' (Arksey & O'Malley, 2005, p. 15). We

conducted a coding process and thematic analysis. For this, we combined the work of Charmaz (2006) and Braun and Clarke (2006).

A double coding process was employed to sort the articles. The 27 articles were coded individually by one of the authors and then coded again by another author to ensure agreement with the codes; this was performed on the electronic platform Dedoose, which is used for analyses in qualitative and mixed methods research (Salmona, Lieber, & Kaczynski, 2020). Coding data is one method for categorising data, and to do this, we used the method employed by Charmaz (2006). This author has worked within grounded theory and stresses that codes are defined by data but are constructed based on the researcher's comprehension (Charmaz, 2006). The coding process was guided by the research question, but an open approach was maintained. Thematic analysis by Braun and Clarke (2006) follows five stages, which begins by familiarising oneself with the data, coding, searching for themes, reviewing themes and defining and naming the themes. This process led us to create four themes: *DBR as a research method within research in teacher education, Researchers as educators and designers, PST Participation,* and *Participation through design tools*. In Appendix 2, all 27 articles are presented by title, author, year and intervention.

2.5 Collaring, summarising and reporting the results

During this phase, according to Arksey & O'Malley (2005), the results must be collected and summarised. The next section will be presented through analysis divided into four themes. Because of the iterative process of characterising DBR, the themes identified are entangled and difficult to separate completely.

3.0 Thematic analysis

3.1 Theme 1: DBR as a research method within research in teacher education

In line with the DBR methodology, all selected studies were performed through an iterative process. Often, this process was described in terms of phases, as in Esteve-Mon, Adell-Segura, Llopis Nebot, Valdeolivias Novella, and Pacheco Aparicio (2019). First, the literature was analysed, and the PSTs' perceptions were explored. Second, a process of design and refinement was conducted, and 'finally, the effectiveness of the intervention (…) was evaluated' (Esteve Mon et al., 2019, p. 143). In addition to these phases, some studies conducted multiple cycles of iterations (e.g., Thompson Long & Hall, 2015; Zeng & Blasi, 2010). For example, in their study regarding digital storytelling, Thompson Long and Hall (2015) conducted 1) a small-scale exploratory pilot followed by 2) a mainstream intervention, and finally implemented 3) a capstone intervention 'to help verify the process overall' (p. 574). As in the study of Cetinkaya, Kertil, Erbas, Korkmaz, Alacaci, and Cakiroglu (2016), a course 'was developed through several

iterations over three teaching semesters; each iteration served to enhance the content of the course and/or incorporate new components within the course' (p. 295). In these cases, refinements were implemented based on the data collected from previous cohorts. Other studies describe the iterative cycles in which refinements were implemented regarding a single cohort (e.g., Stroupe & Gotwals, 2018).

Meetings held within the research team to discuss the progress and content of the interventions were a common way of assessing the need for modifications (e.g., Stockero, Rupnow, & Pascoe, 2015; Cetinkaya et al., 2016; Campbell & Elliott, 2015). For example, Cetinkaya et al. (2016) assessed the need for refinements within the research team at the end of each class session. Thus, 'meetings were held between the instructor and research assistants to discuss any issues that may have emerged and to consider appropriate adaptations in terms of pace and content' (Cetinkaya et al., 2016, p. 295). Similarly, in their didactic design, Campbell and Elliott (2015) modelled a series of instructional activities (IAs) for the PSTs to enact. Subsequently, analyses were conducted within the research team, assessing the need for refinements based on the researchers' sense of progress, which was partially informed by the data collected from the PSTs, such as interviews and video recordings of the enactments. In contrast, the iteration cycle in the study by Stroupe and Gotwals (2018) was less systematic. Rather than simply prescribing learning opportunities for the PSTs to enact, the researchers introduced the concept of macroteaching as an overall framework, in which learning opportunities emerged 'as the instructors and PSTs made sense of pedagogical moments' (Stroupe & Gotwals, 2018, p. 300). Thus, the iterative process became a continuous cycle permeating the enactment of the design because 'PSTs and instructors had opportunities, both in-the-moment during instruction and in assignments, to articulate emerging and shifting learning needs and to advocate for solutions' (Stroupe & Gotwals, 2018, p. 300). Thus, in addition to the researchers reflecting on the proposed solutions and making modifications during the following class sessions, the process of evaluation also took place during instructional episodes. In this sense, Stroupe and Gotwals (2018) served as an example of a DBR process in which the design was developed over the course of enactment instead of introducing a set of instructional techniques designed in advance for the PSTs to perform.

Several of the selected studies primarily focused on the outcome of the interventions rather than on the interventions as an outcome itself (e.g., Esteve-Mon et al., 2019; Caughlan, Juzwik, Borsheim-Black, Kelly, & Fine, 2013; Kharade & Peese, 2014). For example, in one of the studies regarding the development of PSTs' technological, pedagogical and content knowledge (TPACK), PSTs completed pre-/post-surveys to map the potential differences in their scores on TPACK before and after intervention (Kharade & Peese, 2014). Here, the function of the evaluation became a question of whether the intervention was successful in developing TPACK: 'the statistical analysis helps us to

conclude that there is a significant difference between the pre-survey and post-survey TPACK scores' (Kharade & Peese, 2014, p. 267). Similarly, in Caughlan et al. (2013), the PSTs videotaped their teaching sessions during practicum periods. The research team then used these video recordings to analyse the relationship between the PSTs' use of dialogic tools and student participation. In this case, the researchers designed the intervention with the intent to examine their 'underlying hypothesis (…) that dialogic tools led to student participation' (p. 233).

Besides the study of Kharade and Peese (2014), several of the selected studies applied pre-/post-surveys as a tool in the process of evaluation but for different purposes (e.g., Zeng & Blasi, 2010; Beyer & Davis, 2012; McMahon, Yeh, & Etchells, 2019; Esteve-Mon et al., 2019; Chesler & Chang, 2019; Zha, Jin, Moore, & Gaston, 2020). Thus, Beyer and Davis (2012) described how lesson plans were used as pre-/post-tests to identify changes in the beliefs and ideas of PSTs regarding analysis of the curriculum materials. The same lesson plan was analysed at the beginning and end of the intervention, 'so the preservice teachers would be able to directly compare their analysis ideas from pre to post' (Beyer & Davis, 2012, p. 393). In contrast to Kharade and Peese (2014), this way of applying pre-/post-tests served as a way of evaluating in terms of 'what if' rather than 'what works': What if a set of criteria were implemented mediating the interaction between the PSTs and the curriculum materials, then what might happen to their pedagogical design capacity? This line of inquiry is in opposition to measuring the differences in this capacity from the pre- to post-period. In other words, in their evaluation, Beyer and Davis (2012) were not as focused on the learning outcome as they were on the learning experience embedded in the design. This focus was evident in several studies: What might happen to reflectivity if a technological tool is implemented in sessions of supervision during practicum periods (Mathisen & Bjørndal, 2016)? How might PSTs experience the implementation of a flipped classroom (Egbert, Herman, & Lee, 2015)? How might the implementation of a mapping tool create meaningful connections between professional and practical knowledge (Kulild, 2020)? What might happen if the concept of microteaching is replaced with that of microteaching in a method course (Stroupe & Gotwals, 2018)?

The studies used DBR for two purposes: 1) to examine what happens when a design is implemented and 2) to examine whether the implemented design works. These studies described working in a process of identifying a problem in practice, using the literature to reinforce this underlying construct, designing and implementing an intervention in practice and evaluating the intervention. This process was conducted in multiple iterations in several studies, while other studies did not explicate this feature.

3.2 Theme 2: Researchers as educators and designers

As with any research process, the identification of a phenomenon that calls for further investigation marks the starting point of the DBR process, a point from which researchers will start to explore and develop principles derived from prior research guiding the design. Thus, conducting literature reviews and deciding theoretical frameworks seemed to be an important part of this process in all of the selected studies. However, as teacher educators and curriculum designers, the researchers came into their contexts as informed experts and, therefore, were considered part of the context themselves. Therefore, for observing the context from within, they turned to their own experiences when identifying challenges and developed design principles. Thus, in the selected studies, the authors often carried out the roles of researcher, designer and educator/instructor (e.g., Beyer & Davis, 2012; Brown & Thomas, 2020; Chesler & Chang, 2019; Campbell & Elliott, 2015; Egbert et al., 2015; Kennedy, Newton, Heines, Walther-Thomas, & Kellems, 2012; Zha et al., 2020). For example, Brown and Thomas (2020) described how they 'conducted the research and taught sections of the course. One author was also the course coordinator and was responsible for designing the learning activities in the syllabus, including the group assignment used for all sections of the course' (p. 4). Thus, the researchers were often in charge of teaching the PSTs, for example, demonstrating the functions of a technological tool and/or introducing a theoretical framework required in the enactment of the designs (e.g., Koh & Divaharan, 2013; Petersen & Henning, 2010; Kharade & Peese, 2014; Kulild, 2020; Stockero et al., 2015). In their study on mathematical modeling, Chesler and Chang (2019) further described how they, as mathematics educators and applied mathematicians, 'co-taught the Mathematical Modeling for Teachers course from the joint perspective of [their] disciplines' (p. 2). In addition to teaching PSTs, Cetinkaya et al. (2016) described how the instructor served as a role model in terms of PSTs acquiring the pedagogical principles required to teach mathematics through modeling. During in-class modeling activities, the PSTs 'directly observed how a teacher would evaluate different ways of thinking by asking questions, and how to listen, understand, and guide students' (Cetinkaya et al., 2016, pp. 307-308).

As informed experts, the researchers often initiated the research process based on educational concerns experienced during their practice as teacher educators and/or education researchers (e.g., Horn & Campbell, 2015; Petersen & Henning, 2010; Egbert et al., 2015). Thus, Horn and Campbell (2015) stated that 'we too often watched novices from our program transform ambitious teaching practices into pedagogies-as-usual (…) thus inspiring our redesign' (p. 150). Similarly, Petersen and Henning (2010) described how they used numerous analytical tools, revealing that PSTs, against their expectations as curriculum designers, 'separated theory and practice and could not practise what they had learned theoretically, nor theorise what they had practised' (p. 63). The researchers further stated that these findings left them with a shocking sense of failure regarding the

curriculum, and thus, '[the researchers] had to go back to the drawing board' (Petersen & Henning, 2010, p. 63). These cases illustrate how educational challenges can be identified by researchers through the actions of PSTs. Because teaching is an interactive practice, the process of problem identification will most likely be intertwined with experiences of both teacher educators and PSTs. This is a process in which, however, the experiences of PSTs can be directly involved in general. Thus, in some cases, the process of problem identification was based on more student-centred approaches, such as the use of student debriefings (Stroupe & Gotwals, 2018; Kulild, 2020).

Researchers acting as designers were an apparent aspect of the DBR process in all of the selected studies. However, the degree of the structure characterising the designs varied across studies. The structural framework could include researchers deciding in advance the number of products to design during the intervention, such as in the case of Celik (2020), 'in order to enable each group member to work actively in the process, 4 course designs were requested from each group' (p. 215). The framework could also consist of what Zha et al. (2020) referred to as step-by-step instructions, in which the PSTs were instructed to perform tasks such as reading articles and watching the video tutorials of a programming tool, which was followed by hands-on experience in terms of developing digital stories using this tool. In this sense, the researchers envisioned learning activities and prescribed them for the PSTs to enact. Similarly, in the study by Campbell and Elliott (2015), in which a series of IAs were modelled, PSTs were given a planning protocol with which to plan their own rehearsals. Afterwards, IAs were enacted by the PSTs, and their enactments were discussed collectively with their peers. Thus, 'they [PSTs] were not involved in the design or the research analyses of a given IA but were participants in the various phases of work around each of the three IAs' (Campbell & Elliott, 2015, p. 152). This quote exemplifies the possible positions of both researchers and PSTs in the process of design and enactment. Furthermore, it illustrates the dominating role of the researchers in analysing the data. In the selected studies, the researchers collected or generated data both qualitatively and quantitatively through different sources such as interviews, surveys, observations, reflection papers, written field notes and audio/video recordings. When analysing data, the researchers often used theories such as constant comparative methods or thematic analysis (Esteve-Mon et al., 2019; Kennedy et al., 2012; McMahon et al., 2019; Zeng & Blasi, 2010). At other times, a theoretical framework was used for analysis (Thompson Long & Hall, 2015; Stockero et al., 2015). In the study by Stockero et al. (2015), the PSTs recorded videos of mathematics lessons in a real-life classroom. Afterwards, the PSTs analysed these videos, marking mathematically important moments, which, in their opinion, a teacher should notice. The markings of the PSTs were based on the analytical framework 'Mathematically Significant Pedagogical Opportunities to Build on Student Thinking' (MOST). Then, 'the researchers met weekly to agree on instances that were MOST in the video and to discuss the instances [PSTs] had identified as important' (Stockero et al., 2015, p. 822). In

the study by Thompson, Long and Hall (2015), the intervention was evaluated based on a framework referred to as R-NEST (reflection, narrative, engagement, sociality and technology). The researchers used this framework through three iterations, and the changes were implemented both in the intervention and theoretical framework itself.

In summary, the researchers possessed multiple roles across the selected studies. The various ways in which they participated were often outlined by whether they functioned as the educator, designer or researcher, along with the specific tasks related to the role. In most cases, the educator was also the researcher in practice; they have broad knowledge of the research context based on their own experiences as educators.

3.3 Theme 3: PST participation

Although the researchers are considered part of the educational context, they are not the whole context. On the contrary, they share an educational setting with the PSTs. In the third theme, PST participation in the selected studies is presented through two identified subthemes: *PSTs as co-designers* and *testing the interventions*.

3.3.1 PSTs as co-designers

The PSTs were involved throughout the various phases of the research process, which involved problem identification, development of design principles and/or changes made during intervention, but this was only the case in some of the selected studies (e.g. Kennedy et al., 2012; Petrosino & Mann, 2018; Horn & Campbell, 2015; Kenyon, Davis, & Hug, 2011; Stroupe & Gotwals, 2018; Kulild, 2020). These studies differed in terms of which of the phases the PSTs were involved in. Regarding problem identification, both Stroupe and Gotwals (2018) and Kulild (2020) described how the use of student debriefings guided the re-designs of their teacher preparation programs. In the study by Stroupe and Gotwals (2018), the PSTs raised criticisms against the concept of microteaching. In part, the PSTs experienced microteaching as being inauthentic because the methods course 'permitted only 20 min for them to enact part of a lesson, rather than allow for entire lessons or a unit of instruction' (Stroupe & Gotwals, 2018, p. 295). Considering this critique, the authors decided to introduce the concept of macroteaching, which provided the PSTs with the opportunity to teach an entire unit from start to finish instead. They described this as follows:

> We did not want our methods class to merely reproduce the critiques of teacher preparation as inauthentic and separate from classroom reality; rather, we wanted to actively address the needs of our PSTs while investigating if, how, and why a

> new learning opportunity, macroteaching, benefited them (Stroupe & Gotwals, 2018, p. 295).

As previously mentioned, the researchers decided on macroteaching as a framework that would allow PSTs and researchers to co-design learning opportunities together, which involved agreeing on names for each learning opportunity as these emerged during enactment, such as time out/time in, real-time instructional coaching, rewind and so forth (Stroupe & Gotwals, 2018). Similarly, in the study by Beyer and Davis (2012), the participating PSTs and one of the researchers, who also served as the instructor of the intervention, collaborated to develop a product. In this case, a set of criteria for critiquing and adapting curriculum materials for science lessons was introduced in a methods course. The class sessions were dedicated to learning about each criterion through activities and discussions. Then, at the end of each class, PSTs recorded their ideas for analysing the curriculum materials on exit slips. In subsequent classes, the instructor introduced a list of indicators framed as questions to use when applying the learned criteria in analysis work of curriculum materials. Thus, the instructor developed a product by transforming the PSTs' own ideas into 'a set of questions to consider, rather than as structured analysis forms' (Beyer & Davis, 2012, p. 408).

The researchers made changes during iterations based on the reactions and/or responses from the participating PSTs or analysis of the research findings (Stroupe & Gotwals, 2018; Kenyon et al., 2011; Kennedy et al. 2012; Kulild, 2020; Horn & Campbell 2015). The PSTs participated in these changes by writing reflection papers after each class and engaging in semi-structured interviews and final assignments on student performance to determine if the implemented design tool was useful. In the study by Kennedy et al. (2012), in which a content acquisition podcast (caP) was implemented as a design tool, authors described how written reflections from the PSTs guided them through the iterative process of the intervention:

> Researcher analyses of student reflections resulted in immediate changes to various facets of instruction as per design experiment methodology (...) Students reported that they wanted the caPs to be available for a longer window of time than just the day before class. In response, the research team produced caPs for the remainder of the semester and posted them on the course management site (pp. 264-265).

The above example illustrates how written reflections can be used as a strategy when identifying the need for refinement. This strategy was deployed by Horn and Campbell (2015), who encouraged PSTs to write reflections regarding a weekly theme of activities when participating in a hybrid learning environment because 'instructors wanted to better assess all of the novices' sensemaking and provide a place for them to air questions or thoughts that they might not want to share in front of the partner teachers [PSTs]' (2015, p. 163).

3.3.2 Testing the interventions

In most studies, PSTs were not involved in problem identification or analysis and were primarily testing interventions. They played a role in which they tried out the researchers' designs and navigated within this intervention or design (e.g., Campbell & Elliott, 2015; Egbert et al., 2015; Caughlan et al. 2013; Herrington & Parker, 2013; Thompson Long & Hall, 2015). In one of these studies, PSTs had to perform tasks within the design:

> In all cases, [PSTs] had the IA modelled for them, were given a planning protocol with which to plan their own rehearsals, rehearsed in the methods course with their peers and with coaching from the teacher educator, enacted the IA with classroom students, and collectively discussed and analysed the enactments (Campbell & Elliott, 2015, p. 152).

The PSTs also had to test digital solutions to enhance the reflection processes. In the study by Thompson Long and Hall (2015), PSTs participated through three phases/iterations, with an increased number of PSTs per phase and in which changes made were implemented from each phase into the next. PSTs had to develop their own 'digital storytelling' (DST), which is a short video of one's personal experiences. In this case, PSTs had to reflect on their learning, goals, transformations and improvements, which was a positive experience for the PSTs: Students found 'that the DST enabled them to reflect more deeply than they had done in other reflective assignments on the teacher education programme' (Thompson Long & Hall, 2015, p. 586). During the second phase, the process was expanded, and PSTs also had to hand in reflective feedback essays (Thompson Long & Hall, 2015). This study is an example of PSTs acting out a researcher-outlined intervention.

The PSTs not only had to engage in numerous tasks when testing the interventions but also had to generate data in the selected studies. Besides pre-/post-surveys, the studies included questionnaires with open-ended questions for qualitative replies, participation in in-class sessions, working individually or working in groups with peers, individual and focus group interviews, reflection papers and working with technology or another digital solution (e.g., Zeng & Blasi, 2010; Beyer & Davis, 2012; Güler & Altun, 2010; Cetinkaya et al., 2016; Celik, 2020; Kulild, 2020; Brown & Thomas, 2020). When testing the interventions, PSTs often completed surveys both before and after the intervention. The use of surveys was widely used as a tool for the PSTs to participate and as a method for gaining knowledge of their experiences and outcomes from participating in the intervention (e.g., Esteve-Mon et al., 2019; Kharade & Peese, 2014; McMahon et al., 2019).

In summary, the PSTs participated according to their roles. When participating as a co-designer, the PSTs were highly involved in the creation of the intervention, but as participants merely testing the intervention, they played a much more passive role.

3.4 Theme 4: Participation through design tools

The participation of PSTs was often facilitated through technological or digital tools, or by participating in authentic learning environments, which has implications for their participation. This will be presented in the following subthemes: *Using technological solutions as design tools* and *Participation in authentic learning activities.*

3.4.1 Using technological solutions as design tools

Technology seems to be a way of expanding or enhancing student participation by offering novel ways to reflect on their own learning processes. Tools changed the ways the PSTs participated in their learning processes because the PSTs were actively engaged with the tools and, as a result, were involved to a larger extent than before, which enabled deeper reflection (Mathisen & Bjørndal, 2016; Celik, 2020; Thompson Long & Hall, 2015; Campbell & Elliott, 2015; Caughlan et al., 2013; Stockero et al., 2015). A common feature of the aforementioned studies was the use of various forms of video recordings. The researchers described how they used video recordings of PSTs teaching lessons in classrooms, either using a video camera or tablets, as a method for deeper reflection of their learning outcome. The PSTs often recorded their own teaching lesson, individually chose a clip from their teaching session and received group feedback from peers and instructors or supervisors (Caughlan et al., 2013; Celik, 2020; Campbell & Elliott, 2015; Mathisen & Bjørndal, 2016; Stockero et al., 2015). In the study by Stockero et al. (2015), PSTs visited a local secondary classroom, observed an experienced mathematics teacher and videotaped these lessons. The videos were used for analysing what aspects of the teaching lesson the PSTs especially paid attention to and why, with the intention of enhancing the PSTs' ability to be aware of the differences in pupils' thinking and, thereby, the kind of instruction they need to provide in future teaching.

Technological solutions seemed to enhance the PSTs' reflection processes, which was significant for the ways the PSTs participated. For example, Mathisen and Bjørndal (2016) illustrated how the use of a tablet functioned as a shared memory during feedback situations in supervision. The PSTs made video recordings of their teaching during practicum periods and shared these with their peers and supervisors. The video recordings made it possible for the PSTs to reflect on their performance as it actually played out, rather than how they remembered it: 'For example, one student, contrary to the supervisor's opinion, thought she had performed rather poorly in her handling of a teaching situation. When watching the video recording, however, the student concluded that she actually handled the situation well' (Mathisen & Bjørndal, 2016, p. 233). In earlier supervision situations, the PSTs tended to remember the negative episodes and leave out the successes. In these cases, the video recordings became a strength for the PSTs.

3.4.2 Participation in authentic learning activities

Designing using authentic learning environments was used multiple times in the selected studies (e.g., Horn & Campbell, 2015; Luo, Murray, & Crompton, 2017; Campbell & Elliott, 2015; Mathisen & Bjørndal, 2016). Luo et al. (2017) applied an authentic learning approach to teach the PSTs the process of solving problems that could potentially arise in their future teaching practice. In this particular study, the PSTs had to use an online learning application and design an online course or curriculum for an imaginary pupil who could not attend class because of illness. The authenticity of this issue motivated the PSTs because it made them feel like a real teacher: '… the real-life scenario was helpful because it made the assignment more practical and made me want to invest more in the project because I could see how I may be in a similar situation at some point in the future' (Luo et al., 2017, p. 150). Horn and Campbell (2015) developed a hybrid learning environment in which mathematics PSTs attended a methods course and visited a high school class; they were asked to observe this class to gain an understanding of what was happening in a high school mathematics class. The authors expressed that the knowledge the PSTs gain should come from both universities and field placements to improve the learning experience and make it authentic (Horn & Campbell, 2015). Both Celik (2020) and Campbell and Elliott (2015) employed a simulated classroom where the PSTs played the role of pupils when 'rehearsing' their teaching. Campbell and Elliott (2015) approached the need for authentic learning environments in teacher education by designing a course with the aim of maintaining knowledge from the university into the PSTs' future classrooms.

In summary, the PSTs often participated through the use of technology or in a real-life or simulated authentic learning environment. Both scenarios were used as methods to increase learning for the PSTs and expand their skills and readiness for future teaching.

4.0 Discussion

In the following sections, we discuss the 27 studies in connection to the values of the DBR methodology and specifically how students and researchers participate in the activities given within the DBR methodology. With regards to the DBR methodology, we use the definitions by Anderson and Shattuck (2012), McKenney and Reeves (2012), and Cobb, Confrey, diSessa, Lehrer and Schauble (2003). These authors stressed on the importance of a real situated educational context when conducting research through DBR. In this process, an intervention or design tool is implemented in practice, which is tested to not only improve the practice but also to understand the complex learning environments. Problem identification takes place in the research context, and this process includes assessing the relevant literature and theory in the research area. DBR is a pragmatic methodology and involves multiple methods for data generation, collaboration and involving researchers and participants. DBR is conducted in several iterations to refine and adjust the intervention or design. Iterations consist of three phases, here described by

McKenney and Reeves (2012) as follows: 1) analysis and exploration, 2) design and construction and 3) evaluation and reflection. This process will lead to the development of design principles, which aim to enhance implementation in particular contexts. In the following sections, we discuss how the studies meet the above-mentioned values in order for us to point to epistemological challenges and issues that the studies do not seem to explore.

It seems that not all the selected studies conducted their research in multiple iterative cycles, as stated above, as one of the core features in the DBR methodology (Barab & Squire, 2004; Cobb et al., 2003; McKenney and Reeves, 2012; Collins, 1992). Both Stroupe and Gotwals (2018) and Thompson Long and Hall (2015) stated that iterative cycles were used to refine and adjust their intervention in practice, while Mathisen and Bjørndal (2016) did not describe iterative cycles in their study, although the research period was from 2012 to 2014 and contained multiple sources of data, for example interviews and surveys. The studies were primarily testing an intervention before and after implementation using pre-/post-tests and did not conduct multiple iterations. This runs against the broader scope in DBR that seeks to go 'beyond perfecting a particular product (…) and refine generative or predictive theories of learning' (Design-Based Research Collective, 2003, p. 7), and not just testing whether an intervention is successful and ´works´. The consequences of testing and not conducting multiple iterations, or conducting multiple iterations without descriptions within a study, could be that the implementation will not be sensitive to the context. The learning design will be implemented and not flexible to the need of the context, just as the studies to some extent do not document the feedback of the context for implementing the learning design. The iterations are time consuming and cost energy and hard work from the researchers and the practitioners; on the other hand, the quality of DBR is also a way to gain knowledge about the learning design, context and methodology (Ejsing-Duun & Skovbjerg, 2018).

This is also related to the next tendency. In most of the selected studies, PSTs played a passive role, not meeting the key characteristics of DBR stated in McKenny and Reeves (2012). They were not involved in problem identification or in analysis following an intervention, which is also a core feature of DBR. Anderson and Shattuck (2012) described that research within the DBR methodology should occur in collaboration between researchers and practitioners. In the currently reviewed studies, the PSTs often acted as participants, testing a design tool or intervention implemented in practice. Indeed, the studies were aiming at examining if the implemented design worked, for example, if the implemented design or intervention improved the PSTs' learning outcome. However, this is not enough in the DBR methodology, which is outlined by Cobb et al. (2003): 'Design experiments are conducted to develop theories, not to merely empirically tune 'what works'' (p. 9). Here, DBR aims to not only improve the educational contexts, but also develop theories and design principles that can be of guidance for educational research and practice (Design-Based Research Collective,

2003; Anderson & Shattuck, 2012). Furthermore, the PSTs should be recognised as participants who are highly involved in the identification of problems and ongoing analysis of an intervention or design tool. As stated by Barab and Squire (2004), 'participants are not subjects 'assigned' to treatments but instead are treated as co-participants in both the design and even the analysis' (p. 3). When approaching PSTs as passive doers, the practical implication might be that we end up continuing traditional educational practices, not aiming at engagement and active learners, both for PSTs and for the future students that they will end up teaching. There is also a risk of us only creating knowledge relevant to what researchers might think is important, whereas the context-sensitive push at knowledge creation can be missing. We would state that epistemologically this is serious and can potentially be lacking trustworthy DBR, underlining the importance of context-sensitive knowledge creation, but doing something which could be characterised as more conservative research practices. There is a need for future studies to emphasise the importance of shared knowledge creation and to show how we have supported and created the opportunity for the knowledge creation to be possible.

The researchers in the selected studies were often the instructors or educators (e.g., Chesler & Chang, 2019; Herrington & Parker, 2013), which can pose problems in terms of developing new theory and design principles that can be implemented in other contexts (McKenney & Reeves, 2012; Anderson & Shattuck, 2012). As stated earlier, one of the core features of DBR is a close collaboration between researchers and practitioners (Collins, 1992). In addition, the researcher was also considered the designer, implementing an intervention (Barab & Squire, 2004). In the current scoping review, the instructor or educator was considered the practitioner. However, what are the implications for the research when the researcher is acting as the researcher, designer and educator/instructor? One feature of DBR is the inclusion of both an educator and researcher to work as partners and supplement each other during the process (Anderson & Shattuck, 2012). The practitioner is situated in the context under investigation and has a greater understanding of the problems occurring. Researchers outside of the context could add new perspectives and impact the creation of the intervention, thereby broadening the scope when developing theory and design principles, and not letting research disappear within the particular context (McKenney & Reeves, 2012; Anderson & Shattuck, 2012). According to DBR's core features, educators and researchers should be two separate entities, not one and the same, to improve the quality of research. In contrast, Cobb et al. (2003) stated that 'the size of the research team and expertise of the members vary depending on the type and purpose of the experiment' (p. 11). The determinant is that the research team has the knowledge and skills to conduct 'an initial design, conducting the experiment, and carrying out a systematic retrospective analysis' (Cobb, 2003, p. 11-12). If these competencies are fulfilled by the educator/instructor, they could also act as both the researcher and designer.

In some cases, studies involved the PSTs in both the design and analysis and setting possibilities for future DBR practices. One example is Stroupe and Gotwals (2018), who changed the scope of the inquiry mainly because of the critiques from PSTs because the initial learning model did not 'provide them with all of the opportunities they needed to learn ambitious instruction' (Stroupe & Gotwals, 2018, p. 295). In most of the selected studies, PSTs were not considered as practitioners and, therefore, were not involved in the degree DBR prescribes. Several studies seemed to base their research on the emphasis that PSTs need tools and knowledge to prepare them for future teaching placements. Sometimes, PSTs lacked knowledge of specific pedagogical skills for how to incorporate, for example, technology in classrooms, and in other cases, the knowledge they gained within teacher education was 'forgotten' and not transformed into skills in their future teaching (Kharade & Peese, 2014; Campbell & Elliott, 2015). If this is the underlying construct, PSTs should be considered active practitioners and should influence the research process, thereby affecting their learning process. Continuing this discussion, what implications could it potentially have for the DBR as a methodology if the participants within the research are not considered co-participants, or if participants are considered as co-participants on a theoretical level, but are not as involved in the practical intervention? Following the core features within the DBR methodology, collaboration is crucial to create changes in practice that make sense to the participants involved (Design-Based Research Collective, 2003). The involvement of PSTs can be of significance because it might have implications for their future as teachers. In one of the studies, the authors state a problem: '… novice teachers tend to teach based on their experiences as students' (Egbert et al., 2015, p. 3). If we take that statement seriously, there is a need for the PSTs to experience participation, remain active and show active involvement and engagement in their own education. If not, we will end up with the same conservative education system as DBR wanted to leave and change.

Overall, the discussion emphasises that the studies often follow a basic model as an argument for performing a DBR study. The studies explain the values when describing the research approach, but in the realisation, the studies could be strengthened in terms of the role and position of the PSTs and the collaboration with them. We encourage future research on design-based approaches to be careful regarding the realisation and also to write about it when writing up their research to make sure that we discuss and explore the epistemological implications of the values of DBR with the aim for the field to develop further. There is a need for taking the discussions about the epistemological implications seriously, if the research field is going to influence the changes in future education for teacher education and social education.

5.0 Conclusion

The current scoping review has provided an overview of the available literature within the research on PST education when using DBR as a research methodology. We asked how DBR is used within research in PST education and social education and focussed on the role of the participants within the DBR studies. First, it seems that additional research is required to cover research concerning the use of DBR in social education. Second, from our analysis, all the studies worked within DBR but were not conducting their research according to all of the core features of DBR. One of the main points is that the research needs to be conducted in multiple iterations and in close collaboration with the participants; these aspects are not consistent across the selected studies and could be of importance for future research within the area of research in teacher education using DBR. Furthermore, when PSTs interact within the intervention or with a design tool, it has a positive effect on their learning outcomes, but PSTs must be able to experiment within the process and not merely test an intervention for its effectiveness. When experimenting, and doing this in iterative cycles, the PSTs form a part of the whole research process, participate in analysis and evaluation of iterations and are included in the research, as the DBR methodology prescribes. For the sake of future education, values coming from design-based approaches seem to have a high importance, and potentially, design-based approaches can have an impact on the education for the future if we are not only imagining the values but also realising the values.

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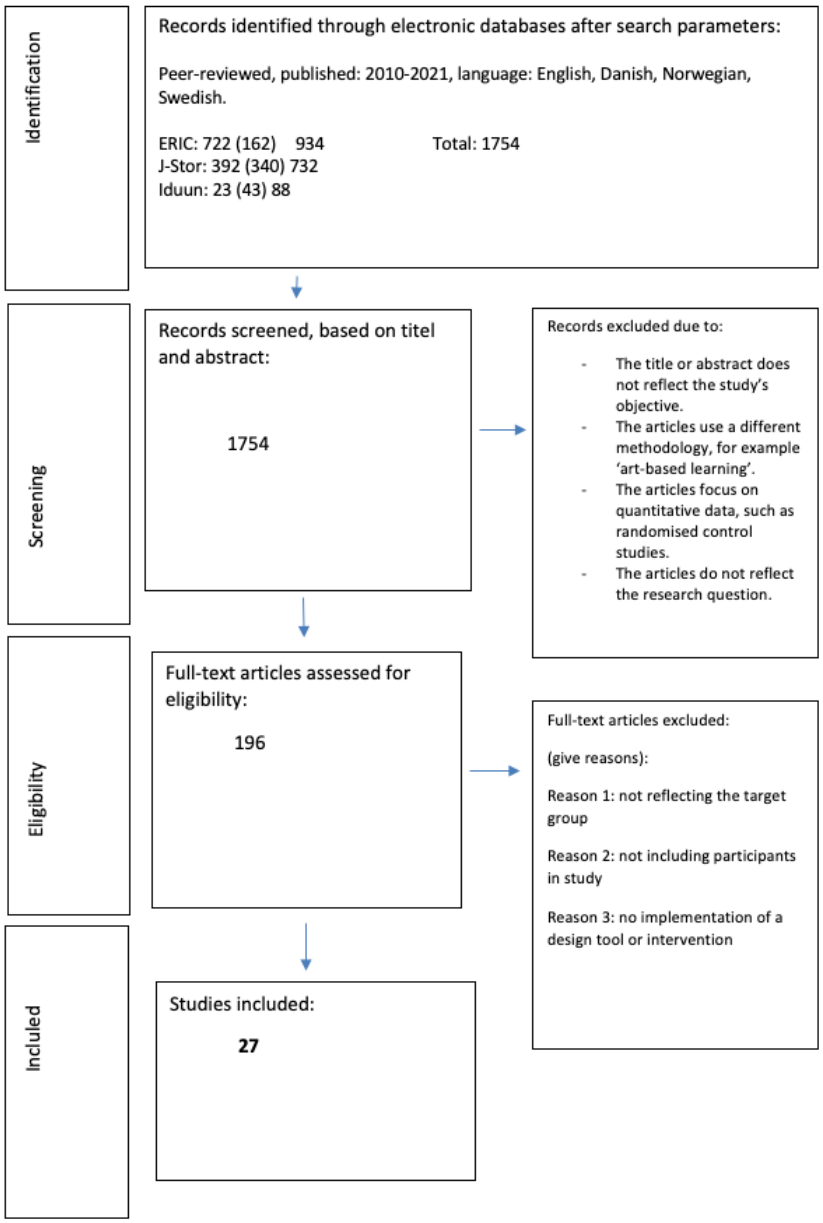
Appendix 1: *PRISMA flowchart*



Appendix 2: *Selected articles*

Title:	Author/s:	Year:	Intervention:
Technology Used to Support Learning in Groups.	Brown, B. & Thomas, C.	2020	This study is a part of a larger DBR project and presents results from the second and last years of research. Working in groups is pivotal when working as a teacher, and therefore, this project wanted to improve the design of group assignments in teacher education. This study focuses on how the PSTs used technology in groups and in problem solving.
Developing Preservice Elementary Teachers' Pedagogical Design Capacity for Reform-Based Curriculum Design.	Beyer, C. J. & Davis, E. A.	2012	Development of the pedagogical design capacity of PSTs for reform-based curriculum design. Use of curriculum materials is important for novice teachers, and therefore, this study was undertaken for this purpose. This research draws largely on DBR.
Designing Approximations of Practice and Conceptualising Responsive and Practice-Focused Secondary Mathematics Teacher Education.	Campbell, M. P. & Elliott, R.	2015	This study is framed as an ongoing design-based research project and is trying to solve problems concerning teacher education and the practice they experience as future teachers. In the intervention, instructional activities (AIs) were designed and implemented in a methods course with the purpose of creating approximations of practice. This study specifically focusses on secondary mathematics teacher education.
English Teacher Candidates Developing Dialogically Organized Instructional Practices.	Caughlan, S., Juzwik, M. M., Borsheim-Black, C., Kelly, S. & Fine, J. G.	2013	In this DBR project, an intervention concerning scientific modeling was implemented at three university sites with teacher education programs. The intervention was conducted in four iterative phases about water movement in plants.

Examination of sample course design studies performed by pre-service social studies teachers by using digital technologies.	Celik, T.	2020	Design and implementation of a social studies course with pre-service social studies teachers, which integrated digital technologies. DBR was used as the research method, and PSTs had to work on their course projects and use digital technologies in the solving process. They had to present and implement their course projects with peers, as in a real classroom. The researcher evaluated the course projects based on usefulness.
Pre-service Teachers' Developing Conceptions about the Nature and Pedagogy of Mathematical Modeling in the Context of a Mathematical Modeling Course.	Cetinkaya, B., Kertil, M., Erbas, A. K., Korkmaz, H., Alacaci, C. & Cakiroglu, E.	2016	Implementation of a modeling course for PSTs to investigate their conceptions of mathematical modeling. The study is considering "real-life" problems, to develop a connection between solving problems in real-life scenarios and mathematical skills. The study was conducted through design and experimentation processes.
A course in mathematical modeling for pre-service mathematics teachers.	Chesler, J. & Chang, J.-M.	2019	A course in mathematical modeling was implemented in a teacher preparation program because modeling is widely used within the K-12 curriculum. The study is the first iteration of a design experiment.
Flipped Instruction in English Language Teacher Education: A Design-based Study in a Complex, Open-ended Learning Environment.	Egbert, J., Herman, D., & Lee, H.	2015	Implementation of a flipped classroom to gain more time for inquiry-based and experimental learning in teacher education. DBR was used to investigate the process of implementing the flipped classroom.
The development of computational thinking in student	Esteve-Mon, F. M., Adell-Segura, J., Llopis Nebot, M. Á.,	2019	This study was conducted to improve the PSTs computational thinking through an intervention with educational robots. Using

teachers through an intervention with educational robotics.	Valdeolivas Novella, G. & Pacheco Aparicio, J.		DBR, the PSTs were involved in several activities containing unplugged devices and robotics.
Teacher trainees as learning object designers: problems and issues in learning object development process.	Güler, Ç. & Altun, A.	2010	Re-design of a course to investigate problems when PSTs design learning objects (LOs). This article presented the results from the first cycle of two using the DBR methodology.
Emerging technologies as cognitive tools for authentic learning.	Herrington, J. & Parker, J.	2013	The study investigated the use of technologies as cognitive tools in problem solving. This was done in the context of an authentic learning environment in the bachelor of education. DBR was used as the research methodology in four iterative phases.
Developing pedagogical judgment in novice teachers: mediated field experience as a pedagogy for teacher education.	Horn, I. S. & Campbell, S. S.	2015	This is a design experiment conducted in a timeframe of 6 years. A methods course was redesigned such that it considered field experiences. Students had to observe a high school mathematics class and pay attention to difficulties experienced by a selected pupil at the high school. The goal was to create an understanding of a classroom and enhance future teaching and not continue pedagogies as usual.
A triarchic model for teaching "Introduction to special education": Case studies, content acquisition podcasts, and effective feedback.	Kennedy, M. J., Newton, J. R., Haines, S. J., Walther-Thomas, C. S. & Kellems, R. O.	2012	Implementation of content acquisition podcasts (caPs) to gain more instructional time in class because the PSTs use caPs prior to class and implement case-studies as learning materials. This took place at a course in pre-service teacher education called *teaching exceptional children in the general education classroom.* The

			research team used DBR to continuously test and design the practical applications of case studies and caPs.
Design Approaches to Support Preservice Teachers in Scientific Modeling.	Kenyon, L., Davis, E. A. & Hug, B.	2011	This DBR study took place at three different university sites and over several years. The PSTs participating in this study hardly had experience with scientific modeling, and the researchers designed instructional approaches through four iterative design phases.
Problem-Based Learning: A Promising Pathway for Empowering Pre-Service Teachers for ICT-Mediated Language Teaching.	Kharade, K. & Peese, H.	2014	Design and implementation of a problem-based learning model to enhance ICT-mediated language teaching and enhance TPACK in PST language teachers using DBR methodology.
Towards a TPACK-fostering ICT instructional process for teachers: lessons from the implementation of interactive whiteboard instruction.	Koh, J. H. K. & Divaharan, S.	2013	This article is a part of an ongoing DBR project and takes place in two implementation cycles. The purpose of this study is to support PSTs development of TPACK as they use an interactive whiteboard or ICT tools in general.
Korleis tenkte du no?» Frå øving til gjennomføring i grunnskulelærar-utdanninga.	Kulild, M.	2020	Design and implementation of a mapping tool which can be used by PSTs to gain knowledge of their pupils' accounting strategies. The overall purpose of the study is to support the professional development of PSTs. The researcher used educational design research and continued the process in iterative cycles to create motivation and guidance for future work.
Designing authentic learning activities to train pre-service	Luo, T., Murray, A. & Crompton, H.	2017	A DBR project conducted in two macro cycles with smaller cycles within. The purpose of this study was to implement a teaching

teachers about teaching online.			intervention with authentic learning activities. The PSTs within the study had to design a curriculum in different authentic activities.
Tablets as a digital tool in supervision of student teachers' practical training.	Mathisen, P. & Bjørndal. C.	2016	This study tested tablets as a tool for supervision in practicum periods for PSTs. In the supervision period, PSTs had to upload text, videos and pictures and the supervisor would provide feedback on specific situations the PST chose. The study used educational design research and the article presented the early perceptions from PSTs and supervisors in terms of quality of the project.
The impact of a modified initial teacher education on challenging trainees' understanding of neuromyths.	McMahon, K., Yeh, C. S.-H. & Etchells, P. J.	2019	As a way of bridging the gap between neuroscience research and educational practice, DBR was used within the initial teacher education to map the student's beliefs of neuromyths. The goal was to reflect on teaching/learning resources within the educational environment. Researchers conducted pre-/post-surveys when implementing workshops concerning neuromyths in children.
Design refinement tools for a teacher education curriculum: the example of a service learning course.	Petersen, N. & Henning, E.	2010	Re-design of a curriculum in service learning for PSTs. A divide between theory and practice was observed, meaning that PSTs were not able to convert the knowledge gained in the teacher education into their teaching practice. The researchers used DBR to revise the curriculum.
Data Modeling for Preservice Teachers and Everyone Else.	Petrosino, A. J. & Mann, M.	2018	A curriculum was designed to help PSTs develop skills to teach science through experiments. They had to try out and experiment to be able to enhance their future

			teaching. Using DBR, the PSTs and researchers co-designed questions about the quality of measures and challenges related to this topic. Different items were measured by PSTs, and problems were investigated and discussed. The PSTs were experimenting in an iterative process.
Noticing Student Mathematical Thinking in the Complexity of Classroom Instruction.	Stockero, S. L., Rupnow, R. L. & Pascoe, A. E.	2015	In this study, an intervention was implemented in a field experience course with prospective mathematics teachers. The students had to videotape teaching lessons at a local secondary mathematics class and afterwards pay attention to important mathematical issues that a teacher should be able to notice. The study is a design experiment and through several iterations, the students instead had to focus on 'Mathematically significant pedagogical Opportunities to build on Student Thinking' (MOST).
R-NEST: design-based research for technology-enhanced reflective practice in initial teacher education.	Thompson Long, B. & Hall, T.	2015	This article presents digital storytelling (DST) as a tool for deeper reflection within PSTs. DST was implemented using a DBR methodology in three iterative cycles. Each cycle consisted of phases of analysis and exploration; design and construction and evaluation and reflection.
"It's 1000 Degrees in Here When I Teach": Providing Preservice Teachers With an Extended Opportunity to Approximate Ambitious Instruction.	Stroupe, D. & Gotwals, A. W.	2018	Implementation of a concept called "macroteaching" in a PST methods class framed as a design experiment. The purpose was for the PSTs to learn ambitious science teaching, and macroteaching was implemented and co-designed with researchers and PSTs.
Learning through web-based	Zeng, R. & Blasi, L.	2010	Implementation of digital case studies with the purpose of investigating the effect on

multistoryline case studies: A design-based research.			student's knowledge acquisition in a measurement and evaluation course. DBR was used to refine and guide design through multiple iterative cycles.
Hopscotch into Coding: introducing pre-service teachers computational thinking.	Zha, S., Jin, Y., Moore, P. & Gaston, J.	2020	This study implemented a flipped learning module to teach PSTs about computational thinking and gaining skills within this topic. This study is the first iteration of a project using DBR.

Author Profile

Astrid Lasthein Lehrmann is a research assistant and works within the research LAB for design and play at Design School Kolding.

Helle Marie Skovbjerg is professor and Ph.d at Design School Kolding at the masters programme Design for play, and the research LAB for design and play.

Simone Jessen Arnfred is an intern at the research LAB for design and play at Design School Kolding.

Author Details

Astrid Lasthein Lehrmann
Design School Kolding
Aagade 10
6000 Kolding
Denmark
0045 22480031
astridlehrmann@gmail.com

Helle Marie Skovbjerg
Design School Kolding
Aagade 10
6000 Kolding
Denmark
0045 91333000
skovbjerg@dskd.dk

Simone Jessen Arnfred
Design School Kolding
Aagade 10
6000 Kolding
Denmark
simonearnfred@gmail.com

Editor Details

Prof. Dr. Tobias Jenert
Chair of Higher education and Educational Development
University of Paderborn
Warburger Straße 100
Germany
+49 5251 60-2372
Tobias.Jenert@upb.de

Journal Details

EDeR – Educational Design Research
An International Journal for Design-Based Research in Education
ISSN: 2511-0667
uhh.de/EDeR
#EDeRJournal (our hashtag on social media services)

Published by

Hamburg Center for University Teaching and Learning (HUL)
University of Hamburg
Schlüterstraße 51
20146 Hamburg
Germany
+49 40 42838-9640
+49 40 42838-9650 (fax)
EDeR.HUL@uni-hamburg.de
hul.uni-hamburg.de

In collaboration with

Hamburg University Press
Verlag der Staats- und Universitätsbibliothek Hamburg – Landesbetrieb
Von-Melle-Park 3
20146 Hamburg
Germany
+49 40 42838 7146
info.hup@sub.uni-hamburg.de
hup.sub.uni-hamburg.de