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CV

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Peter Gundersen holds a Master in Pedagogical Philosophy and has been affiliated with the Department of Learning and Philosophy (L-ILD) at Aalborg University, Copenhagen, during his PhD studies.

ENGLISH SUMMARY

The dissertation is a meta-study on Design-Based Research (DBR). The purpose of the study is to explore the potentials and challenges of performing design-based activities when researching through interventions in educational arenas. Through a historical literature review, the author identifies four key characteristics that, despite the broad spectrum of ways to conduct DBR, over time have remained recognisable from the first experiments in the early 90s and until now. The four characteristics and their related activities are:

- DBR is based on interventions,
- interventions progress in iterative cycles,
- interventions are carried out in collaboration with practitioners and
- interventions are often based on initial design principles that are tested in practice and ideally refined at the end of a project.

Based on the four design-related research characteristics and activities, the dissertation aims to answer the following research questions:

- How does the field of DBR understand activities tied to working design-based?
- Which challenges do the reported enactments of design activities in DBR projects entail?
- How can perspectives from less represented voices in DBR and other fields of design help accommodate these challenges and potentially improve the methodology of DBR?

In four separate parts, the dissertation dives into first the understanding of the activity in question, then the challenges such understandings hold and, finally, one or more areas that have the potential to meet the challenges.

The questions are examined using a multimethod approach in which literature reviews are combined with data from interviews. The review approach in the four parts mentioned above is inspired by a previous review in which the authors have selected the five most cited articles in the literature on education and DBR to draw a picture of the development of the approach in recent years. In the dissertation, the articles of the last five years are added and the entire body of the 77 articles is coded rather than, as in the original review, only abstracts. Each of the four research activities has its own research questions and analytical approach, based on the findings from the historical overview.

The findings from the reviews are nuanced, challenged or solidified through interviews with four researchers who during their PhD studies have worked with or

are inspired by DBR. The researchers were interviewed in two consecutive rounds, the first of which focused on the four identified design-based research activities and the second on the discussion of potentials to meet the identified challenges. The potentials stem from a series of interviews and workshops that were conducted during the author's visits to the Department of Design and Communication at The University of Southern Denmark in Kolding and the Umeå Institute of Design.

Across the four activities, three sets of challenges are presented. The first set relates to developing solutions to practical problems, the second set is concerned with the implementation of intended interventions and the third set deals with challenges of generalising knowledge on the basis of completed interventions.

Firstly, examples of iterations before an intervention is implemented are not reported in any significant detail. Initial investigation of the problem and the subsequent exploration of the solution space either remain undisclosed for scrutiny or simply do not take place. Furthermore, practitioners are only in 1 out of 4 reported cases involved in activities of problem investigation and ideation for solutions. In some cases, the iteration term seems to be confused with the intervention term or deliberately understood as having similar meanings.

Bearing in mind that early iterations are highly valued across all design disciplines, mostly in the form of various sketching activities, the lack of reported tangible materials to spark branching idea processes presents a serious challenge for the quality of solutions pursued in DBR studies. Additionally, the absence of representations of ideas complicates the inclusion of other collaborative partners such as practitioners of teaching and learning, in activities related to problem setting and solving.

The interview data suggest a lack of skill among DBR researchers in terms of generating such materials and setting up situations where tangible objects can play a mediating part among collaborative actors. On a concrete level, researchers express no proficiency in terms of sketching activities in general and point to the additional challenge specifically concerning teaching and learning in which conveying the temporal aspect and complexity of educational situations in a meaningful manner have proven to be difficult.

A challenge for researchers of DBR is thus how to generate early iterations that can help raise the quality of proposed solutions in ways where practitioners are involved in a collaborative manner.

The second set of challenges is concerned with the implementation and testing of solutions. Some challenges related to implementation are inherited by the previous problem set. The quality of interventions is thus expectedly lower if only one problem and one solution have been explored before the actual implementation. Furthermore, the sense of ownership from practitioners might also diminish in cases where

practitioners only play the part of implementers and have no agency of the setting and solving of the problem that the interventions seek to mitigate.

The data, however, also point to a challenge regarding interventions in terms of the methodological nomenclature of DBR. DBR studies tend to be described via traditional research design terms such as case studies, longitudinal studies, cross-sectional studies, etc. whereas a fitting vocabulary for describing the overall design intervention strategy remains absent throughout the selected studies. The consequences are a lack of transparency regarding the intentions of researching through interventions, a black boxing of potential divergent routes taken during a project period to accommodate adversities and arbitrary intervention setups leading to poor design processes.

Another set of challenges appears when researchers of DBR seek to generalise knowledge on the back of their interventions. First, very few studies generate refined design principles when reporting on their studies. The continuum of identified existing knowledge, over conjectures to conclusive principles thus appear to be broken. This in time leads to a situation where no new principles are generated and the existing pool of knowledge from which researchers draw upon as a result become outdated.

Additionally, no consensus seems to exist in terms of how to formulate design principles, both guiding and conclusive principles, although attempts to generate heuristic formulas have been proposed.

The interviewed researchers, especially those who primarily intervene through a change in teaching setup and not via a specific technology, express a reluctance towards formulating principles for two reasons; one rests on the uneasiness of generating abstract best practices based on highly situated experiments. The second reason is that the knowledge they produce is not prescriptive in nature. According to the researchers, principles are too bold or not cut for the kind of knowledge they produce.

As only researchers, according to data, are involved in the generation of theory, a danger emerges as for the ambitions of DBR to ensure that the knowledge is usable for and applicable by practitioners. In other words, if the practitioners are not involved in the evaluation of the generated principles, how do researchers know if principles are recognisable and applicable for them?

Challenges thus remain as to how researchers of DBR formulate principles that are useful for practitioners and at the same time not too presumptuous in terms of claims between cause and effect. Furthermore, the revision processes of principles throughout a DBR study should, ideally, be transparent in order for practitioners to apply them both in early development activities and when implementing them in practice once refined.

In order to accommodate the three problem sets laid out above, two areas of potentials are presented. The first relates to the nomenclature of DBR and the second to practices, both of which hold potential to lead to more novel and efficient design solutions.

At present, few studies describe the way planned interventions are linked throughout a study or what characterises the researchers' pursuit of knowledge. Five intervention strategies or ways of drifting offer a starting point for making these methodological considerations transparent. Additionally, different paths to clarify the form of the knowledge output generated through DBR are mapped out, whether it is researchers seeking to refine a known set of existing principles via conjecture mapping or attempts at describing untrodden turf via design narratives to form the beginning of a design pattern.

Drifting strategies, conjecture mapping and design patterns together form a set of potentials to describe DBR projects of vastly different foci and approaches. The set of potentials in time could be part of a larger and more proven vocabulary for researchers within DBR to be able to explain their intentions of why and how they seek to benefit from doing interventions or, in other cases, why they chose to divert from the intervention strategy they initially described.

Secondly, in relation to conducting DBR, the data suggest that in terms of being able to iterate when setting and solving problems in the beginning of a project and to collaborate with practitioners at all stages of a study, DBR researchers are struggling to meet their own standards. Specifically to overcome the lack of drawing skills among DBR researchers and the difficulties of representing teaching and learning situations, the activity of enacted sketching is proposed. The purpose of enacted sketching is quickly and inexpensively to create scenarios as a way of exploring ideas for interventions, which during the enactment can foster alternative routes, mutations and a shared communication reference. The activity is characterised by immediacy and minimal effort. The design research team, which ideally include practitioners, create and play with scenarios with minimal use of props and without any roleplaying. The aim is to generate dialogue, questions and the possibility for the participating parties to sense potentials and redirect the enactment on the fly.

The shared communication reference is also a key ingredient in inviting collaborative partners on board the design processes. Open-ended co-design processes such as enacted sketching or similar activities within the categories of conversation subjects, conversation prompts or experience enablers represent a set of potential ways to engage with practitioners while making proposals visible and tangible.

Together the two areas form a path to explore in order to accommodate the three identified challenges. In their current forms, the sets are purely theoretical and would need testing in practice as well as further research. They are, nonetheless, a starting

point for the continuous advancement of ways of conducting research that strives to be relevant and grounded at the same time.

DANSK RESUME

Afhandlingen undersøger de forskningsaktiviteter, der er kendetegnende for at arbejde designbaseret inden for forskningstilgangen *design-based research* (DBR). Gennem et historisk literaturreview identificerer forfatteren fire nøgleaktiviteter, der på trods af det brede spektrum som forskningstilgangen rummer, over tid er forblevet genkendelige fra de tidligere eksperimenter i starthalvfemserne og frem til nu. Disse fire aktiviteter er:

- Planlægning og gennemførelse af de interventioner forskningen er baseret på,
- Udvikling af disse interventioner i iterative cyklusser,
- Samarbejde med praktikere om disse interventioner, og
- Test og forfinelse af design principper på baggrund af data fra interventioner

Med udgangspunkt i disse fire design-relaterede forskningsaktiviteter stiler afhandlingen efter at besvare følgende overordnede forskningsspørgsmål:

- Hvordan forstås design-baserede forskningsaktiviteter blandt DBR-forskere?
- Hvilke udfordringer er forbundet med de rapporterede forståelser af design-baserede forskningsaktiviteter?
- Hvordan kan perspektiver fra andre designrelaterede discipliner samt mindre repræsenterede DBR-stemmer imødekomme disse udfordringer og potentielt forbedre den eksisterende DBR-metodologi?

I fire separate dele dykker afhandlingen ned i først forståelsen af den pågældende aktivitet, dernæst de udfordringer sådanne forståelser rummer og slutteligt et eller flere potentialer, der kan imødekomme udfordringerne.

Spørgsmålene undersøges ud fra en multimetode-tilgang hvor litteratur-reviews kombineres med data fra interviews. Review-tilgangen i de fire ovennævnte dele er inspireret af et tidligere litteratur-review, hvor forfatterne har udvalgt de fem mest citerede artikler inden for uddannelse og DBR for at tegne et billede af tilgangens udvikling i nyere tid. I afhandlingen tilføjes de seneste fem års artikler frem til 2017 og i modsætning til det originale review kodes hele artikel-korpusset og ikke kun abstracts. Hver af de fire identificerede forskningsaktiviteter har sine egne specifikke forskningsspørgsmål og analysefremgangsmåde, baseret på fundene fra det historiske overblik.

Reviewene nuanceres, udfordres og mættes gennem interviews med fire forskere, der i forbindelse med deres Ph.d. har arbejdet med eller er inspireret af DBR. Forskerne er blevet interviewet af to omgange, hvoraf den første havde fokus på de fire

identificerede design-baserede forskningsaktiviteter og den anden på diskussion af potentialer til at imødekomme identificerede udfordringer. Potentialerne er tilvejebragt gennem en række interviews og workshops, der blev gennemført i forbindelse med forfatterens miljøskifte til Institut for Design og Kommunikation ved Syddansk Universitet i Kolding og Designhøjskolen ved Umeå Universitet.

På basis af analyserne i de fire kapitler omkring design-baserede forskningsaktiviteter identificeres der i afhandling tre sæt af udfordringer. Det første sæt af udfordringer omhandler de tidlige stadier i DBR-projekter, hvor eksempler på iterationer før interventioner er implementeret i praksis sjældent beskrives på et detaljeret niveau og i visse tilfælde er interventioner forvekslet med eller i andre tilfælde bevidst forstået som identiske med iterationer. Praktikere er desuden kun i 1 ud af 4 tilfælde involveret i problem- og idé-generering. Det lille fokus på tidligere iterationer står i kontrast til den værdi de tillægges på tværs af etablerede designdiscipliner og manglen på håndgribelige repræsentationer af idéer komplicerer inklusionen af samarbejdspartnere såsom lærere og andre undervisere. Data fra informanterne peger i retning af manglende kompetencer blandt DBR-forskere inden for skitsearbejde og forskerne peger yderligere på de udfordringer, der er forbundet med at indfange kompleksiteten i undervisningssituationer ikke mindst i forhold til temporale aspekter. En udfordring for forskerne er dermed, hvordan de skal generere tidlige iterationer af idéer, der kan hjælpe til at øge kvaliteten af de realiserede interventioner på måder, der også kan involvere praktikere.

Et andet sæt af udfordringer omhandler selve interventionsdelen af DBR-studier og ikke mindst den manglende terminologi. Først og fremmest arver dette problemsæt en udfordring fra det ovennævnte sæt, idet det må forventes at kvaliteten af interventioner er lavere i de tilfælde hvor problemidentifikationen og rummet for mulige løsninger kun sparsomt har været udforsket. Afhandlingen peger imidlertid også på en anden udfordring idet et vokabular for projekternes interventionsstrategi er fraværende i de udvalgte studier. Studierne beskriver godt nok deres forskningsdesign og i visse tilfælde de revisioner der er blevet udført mellem to interventioner. Der er til gengæld ingen terminologi, der direkte giver indsigt i den overordnede strategi ved at udføre en række interventioner og ikke mindst hvordan disse indbyrdes opnår synergi. Konsekvensen af dette er en uigennemsigtighed i forhold til forskernes intention med at udføre interventioner og en potentiel blackboxing af grunde til at forskerne i andre tilfælde har valgt at afvige fra deres strategi.

Et sidste sæt af udfordringer centrerer sig om måden hvorpå DBR generaliserer viden. Ideelt beskrives viden i DBR-projekter som en bevægelse fra tentative principper hentet fra litteraturent, over afprøvninger af dem i konkrete praksisser, til forfinede og generaliserede principper gennem analyse af data fra interventionerne. Imidlertid genererer kun meget få studier forfinede principper og det før beskrevne kontinuum knækker således på midten. Dette stiller DBR-feltet over for den udfordring, at den eksisterende pulje af viden som forskerne i feltet kan trække på, når de søger i

litteraturen for eksisterende principper, bliver forældet. Desuden eksisterer der ingen konsensus i forhold til at formulere principper, hverken tentative eller forfinede, på trods af eksempler i litteraturen om DBR på sådanne guidelines. Blandt de interviewede forskere udtrykker særligt den gruppe, der ikke intervenerer gennem en bestemt teknologi to grunde til ikke at formulere generaliserede principper. For det første anser de deres egne interventioner som så situerede, at de tøver med at generere, hvad de anser som abstrakte bedste praksisser. For det andet er den viden deres studier genererer ikke præskriptive af natur. Endelig er praktikerne sjældent involveret i teorigenereringen og den ambition som DBR stiler efter at opnå, at gøre forskningsbaseret viden brugbar og omsættelig for praktikere, er dermed i fare for at forblive uopfyldt. En udfordring er dermed hvordan principper kan formuleres på baggrund af DBR-studier, så de på den ene side er brugbare for praktikere og på den anden side ikke i overdreven grad anviser forsimplede handlemåder for best practices.

For at imødekomme disse udfordringer identificeres der i afhandlingen 2 områder, der rummer potentiale til at forbedre kvaliteten af design-baserede forskningsaktiviteter.

Det første område omhandler potentialer til at udvide og forbedre det eksisterende metodologiske vokabular til at beskrive DBR-projekter. Projektets data viser at måden hvorpå viden udvikler sig på i DBR projekter og gennemsigtigheden i den metodiske tilgang især i forbindelse med interventionsstrategier rummer potentiale til forbedring. I afhandlingens fremlægges fem interventionsstrategier, som kan udgøre et udgangspunkt for at udvikle et vokabular for den intenderede sammenhæng mellem planlagte interventioner i DBR-studier. Strategierne giver et sprog for at beskrive en overordnet vidensindsamlingsstrategi i relation til interventioner. Er der fx tale om et veldefineret problem, der undersøges i samme eller meget lignende kontekster og er målet derfor at skabe viden i dybden? Eller er det et mere eksplorativt studie hvor målet er skabe viden i bredden om en problemstilling vi på forhånd har sparsom viden om? Disse strategier påvirker også formen på den viden, der løbende revideres igennem et DBR-studie. I visse studier kan en række identificerede principper forfines løbende sådan som det ideelt set er beskrevet i meta-tekster om DBR-tilgangen, hvorimod i andre studier kan det være mere fordelagtigt i stedet at beskrive narrativer, der er kendetegnede ved at være mindre præskriptive og som i stedet kan medvirke til at forme mønstre i uudforskede undervisnings- og læringssituationer. Et vokabular som det ovenfor beskrevne er for nuværende stadig i DBR-sammenhænge et teoretisk potentiale og vil kræve yderligere empiriske studier og iterativ udvikling før det kan blive et mættet metodologisk referencepunkt.

Det andet område, der I afhandlingen peges på har potentiale til at imødekomme de identificerede udfordringer på, omhandler samarbejde med praktikere og måder for DBR-forskere at distribuere designkompetencer. Forskere i et DBR-projekt kæmper i flere tilfælde med at opretholde de standarder de sætter for deres egen faglighed inden for alle de områder de potentielt set kunne være eksperter i. Disse tæller udover didaktisk viden på ekspertniveau og naturligvis forskningskompetencer, viden inden

for designprocesser og oftest også teknologi. Især i de tidlige faser af et projekt ved processer omkring problemidentifikation og idegenerering, som er særligt vigtige for et vellykket design-baseret projekt, oplever informanterne at være udfordret. I afhandlingen udfoldes i første tilfælde et potentiale der imødegår forskernes manglende skitsekompetencer, der yderligere kompliceres af hvor svært det er at repræsentere undervisnings- og lærings-situationer i skitseform. Her præsenteres handleskitser som et bud på en forskningsaktivitet, der kan medvirke til at skabe delbare repræsentationer af idéudkast blandt et hold forskere og praktikere. Formålet med handleskitser er at opstille hurtige og billige scenarier, der kan generere dialog, spørgsmål og mulighed for at fornemme nye potentialer og hvor idéer, alternativer, mutationer kan behandles via en fælles referenceramme. Aktiviteten er karakteriseret ved umiddelbarhed og minimal indsats. Den fælles referenceramme er også en nøgleingrediens til at invitere samarbejdspartnere ombord i designprocesserne. I halvdelen af interventionsstudierne behandlet i afhandlingen er praktikere med i rollen som dem der implementerer interventioner, der på forhånd er udviklet af forskergruppen. Denne praksis står i kontrast til en af de indledende ambitioner der ledte til udviklingen af DBR til at starte med, nemlig at gøre didaktiske løsninger mere relevante og nemmere at implementere ved at invitere praktikere med i hele designprocessen. Inddragelsen af åbne processer i DBR-projekter såsom handleskitsering og lignende aktiviteter med håndgribelige skitseartefakter har potentiale til at imødegå udfordringen ved manglende designkompetencer blandt DBR-forskere og lede til bedre kollaborative praksisser med praktikere. I sidste ende vil det medvirke til, at DBR-forskningen i endnu højere grad kan producere didaktisk viden, der er relevant og brugbar for praktikere, der skal anvende den.

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CHAPTER 1. INTRODUCTION

1.1. PURPOSE OF STUDY

The dissertation you are about to read is a meta-study on a particular approach to educational research most commonly labelled *Design-Based Research* (DBR). The purpose of the study is to explore the potentials and challenges of performing design-based activities when researching through interventions in educational arenas.

In this chapter, I start out by describing how I got involved with questions on DBR. Next, I move on to explaining how I chose to single out the concept of design in DBR and the difficulties I encountered when I started working with it. Lastly, I present the leading research questions followed by a reading guide to the full dissertation.

1.2. ENCOUNTERING DBR

The notion of design is currently finding its way into a whole array of disciplines not traditionally associated with the field of design. Burdick (2009) points out a striking fact concerning the expansion of design and its seemingly many purposes by arguing that design:

> 'is variably a value-add, an everyday event, a working method, a byproduct, a literacy, and a complete abstraction. And frequently designers are nowhere to be found.' *(Burdick, 2009, p.1)*

This peculiar observation echoes the experiences of my own initial encounters with design in educational research.

Back in 2012, I started working in a research programme at a university college, which was heavily inspired by DBR and concerned with designing educational interventions on all levels of education. The projects I became involved in were, for instance, a cross-national programme on video-supported teaching in mother tongue in Denmark, Sweden and Norway. The idea was to create virtual classrooms where the pupils could get experiences with having dialogues with peers in their related Nordic languages (which is a part of the curricula in these countries). Another project was concerned with developing a regional MOOC in the Region of Zealand (Denmark) for overcoming barriers in getting access to education due to distances or personal conditions limiting the individual's opportunities to study. A third project involved heads of primary and lower-secondary schools across Denmark and focused on findings ways in which we could support them in implementing digital strategies at their schools. For all of the projects, Design-Based Research was the chosen methodological approach and the primary aim was to improve practice.

Throughout my years of working there, I raised many questions regarding the use of the term 'design' in DBR. I could not grasp *what* we were designing and thus *how* we were actually designing it. When I asked my senior colleagues, the responses I received were often in the lines of 'the design is everything' or 'you cannot pinpoint the design'. None of these answers satisfied me, and I began to pay much attention to the use of the term in academic discussions and texts concerned with educational interventions. It seemed to me at the time that *design* was put in front of everything to instigate a certain value. Design intervention, design process, design principle, design workshops… what made all these things designerly? What set them apart from other interventions, processes, principles and workshops?

I became intrigued about how expert designers perceive design or the processes of designing. I had the feeling that designing educational interventions entails great promise and researchers conducting DBR can benefit from learning from traditional disciplines of design.

From these initial empirical data, I generated two hypotheses:

- Key terms referring to the design-based aspects of DBR are not well defined within the field
- Educational researchers can design better interventions by knowing about and by practising design activities from more established design disciplines.

Similar concerns regarding the shortcomings or potential for the growth of DBR as a research approach have previously been raised (Dede, 2004; Dede, 2005; Rowland. 2007; Easterday, Lewis & Gerber, 2017). Especially concerning the latter hypothesis, Rowland (2007) points to the apparently missing competencies of the designer in DBR projects. In his view, the DBR literature either does not recognise the importance of design competence or implies that it is a natural possession of researchers.

One reason for this might be the previously mentioned elusive character of design as a concept. A challenge I at the earliest stages of my project had to face in an attempt to pinpoint the object of my study.

1.3. THE PROBLEM OF DESIGN AS A TERM

'…the problem is, when a word means almost anything or everything, it actually means nothing. It is not precise enough to be useful...'

'…if you are expecting me to give you a clear definition of design as I use the term, I am afraid that I am going to

disappoint you. Smarter people have tried and failed. This is a slippery slope on which I do not want to get trapped.'

(Buxton, 2007, p. 95-96)

When Buxton, a principal researcher at Microsoft Research and pioneer in the human-computer interaction field, is reluctant to give a definition of design, strategies to try to bypass such a challenge might be in place. Design has so many levels of meanings as Heskett (2002) humorously illustrates in his seemingly nonsensical, yet grammatically correct sentence:

'Design is to design a design to produce a design.' (Heskett, 2002, p. 3)

In the sentence, design can thus both refer to a general concept, an action, a plan (or an intention) and an outcome. As a means to overcome this plurality of meanings, Buxton (2007) suggests looking for activities across disciplines of design. In other words, to simply look for what designers do.

My own initial reflections concerning the contribution of my study held the ambition of not wanting to end up in a position where I would lecture fellow colleagues on how to conduct DBR based on an external understanding of design. In other words, I did not want to force an understanding from other fields of design upon DBR and the researchers working with the approach.

Thus, I decided to abandon the path of predefining an understanding of design to look for in DBR. Instead, I chose to identify how the field of DBR itself describes and distinguishes research activities as design-based.

These main characteristics and activities form the basis of how I decide to explore the above-mentioned two hypotheses. The historical overview in chapter 2 forms the scope by which I look at design in the DBR literature and when interviewing researchers within the field. Perspectives to help further advance the approach are provided partly by lesser-represented voices in the field, expert opinions and theoretical contributions from other design disciplines.

To sum up, the study at hand is a meta-study. I study how people within DBR understand activities tied to working design-based when reporting on their projects and when asked directly on their opinion of them. Secondly, I look for areas where knowledge on design might have the potential to improve the practice of design activities in DBR.

1.4. RESEARCH QUESTIONS

The purpose of the project is based on existing literature and interview data to identify understandings of different practices related to design activities and point to challenges and potentials in working design-based when researching through design interventions in education.

The project thereby aims at answering the following questions:

- How does the field of DBR understand activities tied to working design-based?
- What challenges do the reported enactments of design activities in DBR projects entail?
- How can perspectives from less represented voices in DBR and other fields of design help accommodate these challenges and potentially improve the methodology of DBR?

This will be carried out by:

- Mapping different key characteristics and activities of working design-based in DBR texts
- Analysing the way design activities are described by researchers involved in DBR
- Identifying challenges related to these activities
- Pointing at potentials for the development of the DBR methodology either from a design disciplinary perspective or from the approach itself.

1.5. READING GUIDE

This dissertation is a monography and can as such be read from the first page to the last. However, distinct parts of it are perfectly suitable to read on their own. If for example, you are particularly interested in the potentials and challenges related to design principles, reading chapter 7 only should not cause problems of understanding. There are, obviously, synergies between the chapters, and references to other parts of the dissertation do occur frequently. Apart from the introduction and the conclusion, the dissertation consists of six chapters, which address the following.

Chapter 2 is a historic overview of how Design-Based Research has been conducted since the early 1990s. For the readers who are unfamiliar with DBR, the chapter provides a starting point for becoming familiar with the approach from its initiation to recent times. The chapter is divided into different tentative periods starting with the initial ambition of design experiments as put forward by the main protagonists of DBR Ann Brown (1992) and Allan Collins (1992). The next period in time covers the influential thoughts from mainly curriculum research in The Netherlands stressing the

important characteristics of working with design challenges and generating principles. Next, I describe the golden age of DBR, a period at the beginning of the millennium where DBR reached a peak in academic interest as several notable journals devoted special issues to DBR (Barab & Squire, 2004a; Dede, 2005; Kelly, 2003; Sandoval & Bell, 2004). Larger studies based on DBR were also conducted and reported on in this period of time (e.g. Barab, 2005; Ketelhut, 2007; Laferrière et al., 2010). Lastly, I finish the overview with the latest development concerning the overall maturation of the approach and discuss findings from the meta-studies on DBR that began to appear around 2010.

Chapter 3 explains the overall approach and the methods I have applied throughout the study. The literature review approach I apply is inspired by a previous review authored by Anderson and Shattuck (2012) with the aim of assessing the progression of DBR in the decade leading up to the publication of the review. In this chapter, I present the reasons for building upon their previous work and the way I applied it to my study. The chapter also provide insights on exclusion and inclusion criteria.

Interviews, and especially thoughts on interviewing experts, is the other major part of chapter 3. In this part, a technique developed in collaboration with colleagues at Aalborg University, Professor Rikke Ørngreen, and PhD students Birgitte Henningsen and Heidi Hautopp, labelled *videosketching* is also introduced. The framework for videosketching was developed through three papers published in the proceedings of the conferences *Association for Visual Pedagogy*, *European Conference on e-learning ECEL* and *EAI International Conference on Design, Learning & Innovation in 2018*. Elements from these papers are included in chapter 3. Along with this approach, I discuss considerations in relation to interviewing experts of DBR and expert designers.

The two methods, interviews and reviews, are put into a methodological frame of a multiple methods approach, which in the case of this study is inspired by the archipelago metaphor put forward in mixed methods literature. Problems of triangulation and the interdependence of the data components are also covered in this chapter. Finally, the chapter covers reflections on the overall coding strategy of the study, which is based on in vivo coding and abductive reasoning.

The four activities related to working design-based that are discussed throughout the rest of the dissertation are identified based on the overview presented in chapter 2. The activities include researching through interventions, working iteratively, collaborating with practitioners and generating design principles. Each of the four activities are discussed in separate chapters starting from chapter 4 to chapter 7.

The first of the chapters, on intervention, discuss on what theoretical basis the notion is described and how interventions relate to each other within a DBR study. It points to the challenge that there is a lack in terminology when researchers of DBR explain

their strategy of intervention. Lastly, the chapter explores the potential of using different ways of drifting (Krogh, Markussen & Bang, 2015) as a possible starting for developing a framework of intervention strategies.

The next chapter, on iterations, explore different purposes of working iteratively tied to development, refinement and theory-generation. Cycles, a key term related to iterations in DBR, is also discussed in-depth. The chapter point to the challenge of iterations in DBR mainly being associated with refinement, which overlook the importance of early iterations in much design work often seen in conjunction with sketching activities. In the later parts of the chapter, the idea of implementing sketching activities in DBR is explored and the theoretical foundation of what I label *enacted sketching* is presented.

The third activity, collaborating with practitioners, is analysed in chapter 6. Here, the roles of practitioners are analysed in the intervention studies among the selected review articles revealing three broad types of roles: co-designers, implementers and co-researchers. These roles are discussed along with along with the role, skills and responsibility of the designer, which in many cases of DBR appear to be viewed as inherently covered by the researcher. The chapter tackles this assumption and explores the potentials of inviting more people to take part in the design processes in DBR as well as distributing design competency among all participating parties by making the processes more tangible.

Lastly, the way in which DBR-projects generalise knowledge through design principles is treated in chapter 7. The first part is a rework of an article currently under submission written in collaboration with Professor Rikke Ørngreen and Professor Thorkild Hanghøj both at AAU, where the focus is to point to the challenges of the use of design principles in DBR. These include the lack of coherency in the way principles are formulated as well as the absence of refined principles in much published DBR literature. Oftentimes, studies present guiding principles for their interventions without returning to them when concluding on them. On the challenge of creating coherence, the potential of conjectures (Sandoval 2004; 2014) is explored in an attempt to formulate a more systematic way of working with design principles. Additionally, through interviews with researchers, a reluctance towards procedural principles when intervening through a learning design is identified. Thus, an attempt to broaden the palette of generalised knowledge in DBR via a continuum including narratives, patterns and languages is suggested.

The dissertation ends with a conclusive chapter where three sets of challenges across the four activities are put forward. These challenges are related to how to develop solutions to practical problems, how to implement intended interventions and how to deal with challenges of generalising knowledge on the basis of carried out interventions. In order to accommodate the three problem sets laid out above two sets

of potentials, researchers conducting DBR might find to be useful starting points are presented.

CHAPTER 2. AN INTRODUCTION TO DESIGN ACTIVITIES IN DESIGN-BASED RESEARCH

In this chapter, I seek to identify activities related to working *design-based* in Design-Based Research (DBR). Later, I study these practices in depth through literature reviews and interviews (see chapters 4-7). Instead of forcing an external understanding of design upon the field, I wish to generate the main characteristics and their related activities from key texts of the DBR approach itself. For this reason, I lay out a rough timeline of the state of the art, which I present in the following.

Based on seminal articles, handbooks, special issues and other grey literature, I create a broad foundation which the reviews presented later are based on. This overview covers a variety of positions and the history of why DBR came to be in the first place. In this way, the activities I explore are to a lesser degree skewed by the selected scope of the study comprising only the five most quoted articles pr. year. Rather, the later analyses are informed by history while still representing the mainstream understanding of DBR and what characterises design-based activities in DBR.

Lastly, the chapter helps the reader get a broad understanding of how DBR can be characterised before jumping into the more detailed analysis of different aspects of how design is conceived and the challenges and potentials that are explored in this study.

In *Out of the lab into the classroom* I start by introducing design experiments as put forward by Brown (1992) and Collins (1992) in the early 1990s. Next in *Solving problems and generating principles*, I introduce a range of similar approaches primarily rooted in Dutch research such as development research (Richey, Klein & Nelson 2004), formative research (van den Akker, 1999) and educational design research (McKenney, van den Akker, Nieveen, Gravemeijer & Plomp, 2006). The third period in time, *The Golden Age of DBR*, focuses on design research and Design-Based Research centred on the highly cited seminal articles, special issues and handbooks published from approximately around the beginning of the millennium and ten years forward. Lastly, in *Maturation and meta-studies*, I wrap up by discussing key characteristics from the previous sections, such as iterative progression and collaboration with practitioners, in relation to findings from the meta-studies that began to appear around 2010.

2.1. OUT OF THE LAB INTO THE CLASSROOM

In the early 1990s, Ann Brown (1992) and Allan Collins (1992) introduced the term *design experiments* to educational research. Design experiments were a reaction to traditional psychological experimentation, which at that time was the dominating research paradigm within the field of teaching and learning (Collins, 2010). Two overall purposes sparked the motivation for moving towards this evolving methodology: the first was the ambition to increase the relevance for practitioners and policy makers of the research carried out (Collins, Joseph & Bielaczyc, 2004; van den Akker, 1999), and the second was to develop more empirically grounded theories when moving from highly favourable lab settings to more naturally occurring test beds (Barab & Squire, 2004b; Brown, 1992). This new wave of interest in design experiments came on the backdrop of criticism from numerous researchers, practitioners and policy makers regarding the fact that extant educational research had little impact on practice (Lagemann, 2002; Heartel & Means, 2003).

In relation to these ambitions, Brown (1992) reflects:

> 'Gradually over the years I have increasingly situated my study of learning in classrooms, first in such lab-like settings as pull-out time (for reading groups, etc.), then in socially sanctioned settings in the classroom (reading group), and finally orchestrating, some might say disrupting, the entire classroom activity for at least one hour a day. Making this shift involves an increasing trade-off between experimental control and richness and reality. The classroom is not the natural habitat of many experimental psychologists, and our methods did not evolve to capture learning in situ.' (Brown 1992, p. 152)

Brown contrasts her research to prior, primarily psychological, educational research. Moving experimentation into the messy settings of everyday classroom life and away from more controllable lab settings addresses the issue of how much of the contextual detail is necessary in a particular study. As researchers piece together their theoretical accounts, some lay more focus on generalisability, while others attend to matters of particularisability. This continuum of methodological and theoretical possibility represents a reoccurring compromise made by researchers, as they constitute an empirical/analytical stance adequate for the study at hand (Bell, 2004, p. 24). The conceptual dyad is also discussed later within the DBR community as Dede (2005) presents two extreme stances on the epistemology of educational research. At the objectivistic end, the complexity of human interaction is viewed as solvable in terms of generating predictive theories comparable to biological sciences. At the subjectivistic end, no objective reality exists to be collectively measured or predicted; rather, it is a process of individual construction (Dede, 2005). In the end, Dede concludes that few DBR investigators are at either end of the spectrum, but that the range of viewpoints in the middle is quite broad.

Dede's analysis underpins the variety of interpretations on how research is optimally carried out while still qualifying as research involving design experiments. Disregarding one's epistemological position, however, the overall purpose of engaging in design experiments was, and still is in DBR today, prompted by the aim of better understanding how to orchestrate innovative learning experiences among people in their everyday educational settings as well as to simultaneously develop new theoretical insights about teaching and learning. This dual orientation has been described manifold from the infancy of Design-Based Research. For instance, Cobb, Confrey, diSessa, Lehrer and Schauble (2003) state:

> 'Design experiments have both a pragmatic bent -"engineering" particular forms of learning - and a theoretical orientation - developing domain-specific theories by systematically studying those forms of learning and the means of supporting them.' (Cobb, Confrey, diSessa, Lehrer & Schauble, 2003, p. 9)

Later in this chapter, I will return to more elaborate models explaining the double role of being both a designer and researcher. For now, I would like to turn the attention to three key characteristics related to the design process of design experiments. The characteristics each relate to the motivation for doing design experiments mentioned previously and are part of Collins' (1992) initial eight ideas for a methodology for design experiments, which has since been rephrased and refined by various design experimentalists.

The first is the interventionist nature of the design approach, which entails the idea that proposed solutions will have a higher degree of relevance for practitioners and - as opposed to experimental psychology - are more grounded in practice (Bell, 2004). Design studies are typically test-beds for innovation, where the intent is to investigate the possibilities for educational improvement by generation new practises of learning in order to study them. For this reason, there is often a significant incoherence between typical forms of education, which could be studied naturalistically, and those that are the focus of a design experiment (Cobb, Confrey, diSessa, Lehrer & Schauble, 2003, p.10).

The second is collaboration with practitioners in the particular area you as a researcher are aiming to improve. In the context of primary and secondary schooling, Collins (1992) argues that in order for design experiments to be successful, they must work within the constraints defined by the teachers and must address their questions. Again, the issue of relevance is here the key motivation for changing the research approach. Teachers become co-investigators providing their expertise in many phases of the design process such as formulating questions, making refinements to each successive intervention and evaluating the effects of different aspects of the experiment. The idea is that, in the end, the findings from a study will bear increased relevance through such a process.

The third characteristic is the iterative manner in which design experiments are developed and tested. This approach of progressive improvement in design involves putting a first version of a design into the world to see how it works. The real life experimentation of initial theories answers the call for more empirically grounded theories developed by educational research. The interventions are constantly revised based on experience, until all the bugs have been fixed (Collins, Joseph & Bielaczyc, 2004, p. 18). The revision process can be seen as both prospective and reflective. The implementations of design experiments are from a prospective side carried out with a hypothesised learning process in mind. The levels of analysis from a reflective side lead to the strengthening or refutation of initial conjectures. Together, the prospective and reflective aspects of design experiments result in an iterative design process; as conjectures are generated and perhaps refuted, new conjectures are developed and subjected to test (Cobb, Confrey, diSessa, Lehrer & Schauble, 2003, p.10).

In summary, the first wave of design experiments was a reaction to psychological educational research carried out in closed lab settings. The main purpose was to increase the relevance of educational research and develop empirically grounded theories. The interventionist nature, collaboration with practitioners and the iterative manner in which experiments were developed and tested constitute three main characteristics regarding the design process of the experiments carried out. To some degree, the three characteristics provide answers to the criticism of previous educational research that sparked the motivation for design experiments in the first place.

According to the strong Dutch educational design community, the ideas of design experiments can be traced back even earlier to the works of Freudenthal, Janssen and Sweers (1976) and Streefland (1991). Within this community, a wide variety of terms has been put forward to capture the essence of Design-Based Research. A selection of these will be discussed in the following section.

2.2. SOLVING PROBLEMS AND GENERATING PRINCIPLES

Centered around the educational design milieu at the Institute for Curriculum Development at the University of Twente in the Netherlands, several researchers have contributed to further refinements of design-based educational research. Van den Akker, Gravemeijer, McKenney and Nieveen (2006) primarily use the label *educational design research*, but they remark that the following terms of research approaches are to be understood as the same:

- Design studies, design experiments
- development/developmental research
- Formative research, formative evaluation
- Engineering research
  (Van den Akker, Gravemeijer, McKenney and Nieveen (2006, p. 4)

The different approaches share similar characteristics as the ones identified in the first wave of design experiments; most prominently, the features of aiming at intervening in the real world and incorporating an iterative cyclic approach to design. One major differentiation, however, is introduced between *validation studies* and *development studies* (Nieveen, McKenney & van den Akker, 2006). Validation studies feature the design of learning trajectories in order to develop, elaborate and validate theories about the process of learning and the implications for learning. According to the aforementioned authors, design experiments tend to fall in the first category, as do the highly influential design researchers within the domain of mathematics, Gravemeijer and Cobb (2006).

In development studies, the fundamental aim is to develop design principles (van den Akker, 1999) for use in practice. Research is problem driven, situated in the educational field, and involves close interaction between practitioners, researchers, experts and other stakeholders. Developmental researchers integrate knowledge from prior research in the design process and fine-tune educational innovations based on piloting designs in the field. By unpacking the design process, design principles that can inform future development and implementation decisions are deduced (Nieveen, McKenney & van den Akker, 2006, p.153).

Collaboration with practitioners is thus also a major part of the Dutch way of understanding what it means to be design-based in educational research. Additionally, design principles are put forward as a domain-specific way of informing and influencing the work of practitioners by making the findings relevant and immediately applicable.

To visualise the key differences between the two types of studies mentioned earlier, I present this slightly modified model from (Nieveen, McKenney & van den Akker, 2006):

	Validation studies	Development studies
Design aim	To elaborate and validate theories	To solve educational problems
Quality focus of design	Theoretical quality of design	Practicality of intervention
claim / scientific output	Iterative design with small scale testing (cf. alpha testing with classroom focus)	Iterative development with formative evaluation in various user setting (cf. beta testing in various contexts

Practical contribution	Specific learning trajectory for a specific classroom	Implemented interventions in several contexts / classrooms

Table 2-1. Slightly simplified model from Nieveen et al. (2006) fig. 10.2 Educational engineering research cycle, p. 155. In the original model, effectiveness research is also included, but here I want to highlight the difference between validation and development studies exclusively.

In terms of aims and foci, the two types of studies differ quite substantially. With regards to validation studies, theories on teaching and learning are tested in their natural habitats in order to validate their effectiveness. Development studies, on the other hand, aim at solving real world problems often identified by practitioners to not only test the implemented design but also to improve the practice it is implemented in, which can eventually spread to several contexts through beta and gamma trials. Development studies, therefore, also tend to have a broader scope than validation studies and importantly do not necessarily focus on contributing to knowledge regarding theories on learning. The problems identified by educational practitioners might have several other characteristics expanding on the notion of how effective a given teaching strategy might be. Both the practical contribution and the knowledge claim following a development study might therefore surpass the specific classroom and encompass a school, a curriculum or an educational format.

Engeström, when launching his ideas on formative intervention, put forward the critique that DBR suffers from the exact same weaknesses as the the initial design experiments were a reaction to (Engeström, 2011). He claims that:

> '...the main difference between "gold standard" interventions and design experiments seems to be that the former expects the design of the intervention to be complete at the outset while the latter, recognizing the complexity of educational settings, expects the design to proceed through multiple iterations of "refinement".' (Engeström, 2011, p. 4)

In his view, DBR tacitly assumes that researchers make the design and teachers implement it. His claim is that a researcher-driven design that only needs refinement associates itself with notions of perfection, completeness and finality, thereby ignoring the agency of practitioners, students and users. While this critique certainly has its merits concerning design experiments and DBR validation studies, it seems dubious whether the same can be said about development studies (at least the way they are presented theoretically). In development studies, practitioners ideally play a part in each of the crucial phases of the research process including problem identification, idea generating new solutions, testing out prototypes, analysing the data and even developing new theory. Ironically, Engeström (2011) does refer to literature where these distinctions are made (i.e. van den Akker, Gravemeijer, McKenney & Nieveen, 2006). However, he maintains that these contributions mainly enrich and elaborate the basic assumptions already put to question.

A methodological contribution by Dutch curriculum research on DBR is the persistent focus on design principles as a specific kind of knowledge different from other types of findings within the field of educational research. In terms of defining what a design principle is, one of the most prominent voices in educational design research is van den Akker (van den Akker, 1999; van den Akker, Gravemeijer, McKenney & Nieveen, 2006). He suggests that design principles can support design researchers in their task through heuristic statements where the intention is not to guarantee successful interventions, but to generate principles that allow depiction and discussion of the currently most appropriate knowledge for specific design and development tasks. There are two types of principles: 1) procedural design principles, which are characteristic of the design approach 2) substantive design principles, which are characteristic of the design itself (Nieveen, McKenney & van den Akker, 2006, p. 153). Substantive design principles can partly be extracted from prototype testing, which is one of the reasons why it is profitable early in the design process to analyse already existing interventions to generate ideas for new design tasks (van den Akker, 1999). The development of knowledge through Design-Based Research can thus be seen as a continuous refinement of conjectures (Sandoval, 2004; Sandoval 2014) to be tested in local settings and generalised principles that have proven effective across various contexts.

Although the Dutch influence on Design-Based Research has been labelled in many different ways as mentioned earlier, the contribution of distinguishing between validation studies and development studies as well as clarifying the knowledge claim of educational design research, are distinct features of how this branch of research operates. The methodological considerations from the Dutch community are easily recognisable in the multitude of seminal works from the beginning of the millennium and ten years forward, which I have labelled *the golden age of Design-Based Research.*

2.3. THE GOLDEN AGE OF DESIGN-BASED RESEARCH

At the beginning of the millennium, the notion of Design-Based Research was beginning to gain significant traction. An abundance of literature suggests a continued and growing interest in the research approach. Four notable journals devoted special issues solely to the approach or related approaches (Barab & Squire 2004a; Dede, 2005; Kelly, 2003; Sandoval & Bell, 2004), Routledge printed a handbook of design research methods in education (Kelly, Lesh & Baek, 2008), and a series of key seminal articles discussing the nature and rigor of Design-Based Research found their ways to well-esteemed journals (Edelson, 2002; Reeves, Herrington & Oliver, 2005). Furthermore, major design-based projects with substantial funding saw the light of day, such as the Quest Atlantis project (Barab, Thomas, Dodge, Carteaux & Tuzun, 2005), the River City project (Ketelhut, 2007) and the KBIP (Knowledge Building International Project (Laferrière et al., 2010).

The growing popularity of DBR also led to a widening in the range of objects of study as well as the scales of interventions. From being primarily concerned with learning processes through minor design experiments, researchers now began studying identity formation, moral growth, perceptual learning, gender development, etc. (Bell, 2004). Similarly, educational design work now also focused on the development of novel learning technologies, refinement of a semester-long curriculum sequence, the design of a teacher education program or even on the creation of a multifaceted exhibit space broadening DBR to learning settings at museums or other similar cultural institutions (Ibid.). In sum, complex interventions in education related to Design-Based Research began to take many forms some iterations were scaled up dramatically compared to the early classroom interventions.

From this evolution of the approach grew attempts to capture defining descriptions of what DBR is or should be. Barab and Squire (2004b) offered the following very broad definition:

> 'Design-based research is not so much an approach as it is a series of approaches, with the intent of producing new theories, artifacts, and practices that account for and potentially impact learning and teaching in naturalistic settings.' (Barab & Squire, 2004b, p. 2).

Similarly, models aiming to capture how processes in DBR leading up to fulfilling this intent in meaningful ways were developed. This development development can be explained by the expanding funding landscape of DBR as bigger projects were proposed, so the need for describing complex design processes in a simple and comprehensible way increased.

Bannan-Ritland (2003) proposed a framework that positions Design-Based Research as a socially constructed, contextualised process for producing effective interventions with a high probability of being applied in educational practices (Ibid.). The framework draws on theory from product design, usage centred design, innovation development and educational research and entails the following four stages: 1) Informed exploration; 2) Enactment; 3) Evaluation: Local impact; and 4) Evaluation: Broader impact (Ibid., p. 21). The first phase typically involves the identification of a learning or educational 'problem', which ultimately results in a design plan that entails a proposed way of solving the identified problem. The plan is enacted or tested through phase two and evaluated in terms of local and global impact in phase three and four. Simpler, yet still rich in information, is Reeves' (2006) representation of the Design-Based Research model:

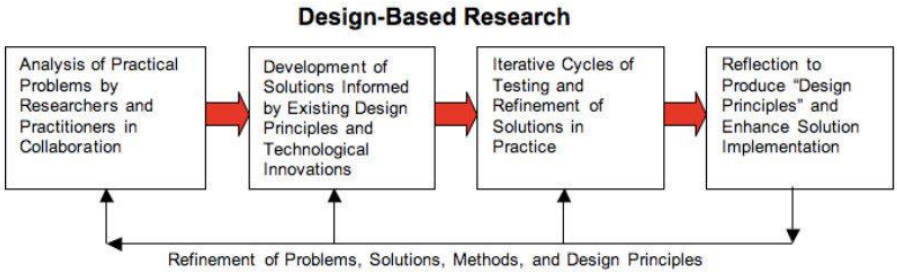


Figure 2-1. Representation of the design-based research model (Reeves, 2006, p. 59).

Although phase models in design have been subject to much critique (see e.g. Gedenryd, 1998), the model succeeds in capturing a large proportion of the elements touched upon in this overview. Problem identification, close collaboration with practitioners, development of solutions, testing in practice, iterative refinement and reflection to produce design principles are all distinctive features previously accounted for as essential throughout the history DBR.

It can be argued that the model encompasses a process much closer to developmental studies than validation studies, with its focus on problem identification in collaboration with practitioners rather than theory testing. The model thus seems to support a trend of moving away from researcher led validation towards collaborative development within the field of DBR. A trend that is echoed by Barab and Squire (2004b) in the introductory text to the special issue devoted to DBR in the Journal of the Learning Sciences, stating that participants are not 'subjects' assigned to treatments but instead are to be treated as co-participants in both the design and the analysis.

Philips and Dolle (2006) cautioned that the close collaboration with practitioners grappling the complex variation of real-world educational challenges makes the simultaneous pursuit of practical innovation and theory building both ambitious and difficult. Acknowledging the difficulties in balancing design and theory when designing educational innovations, Ejersbo et al. (2008) generated the 'osmotic model' in order to show the give-and-take between designing artefacts and developing theoretical insights in DBR projects. In the model, artefacts are not necessarily understood as material objects, but also as learning strategies, organisational changes, or other intangible process descriptions.

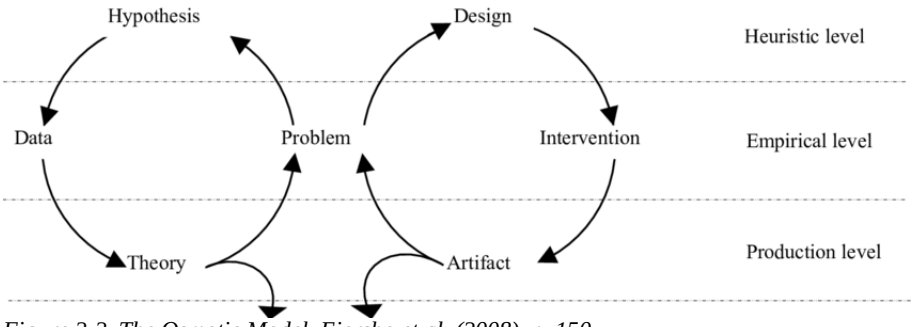


Figure 2-2. The Osmotic Model. Ejersbo et al. (2008), p. 150.

The model refers to the process of osmosis because there is an inherent fluctuation between focusing on designing and reflecting on theory. The osmotic model is not to be understood as an instruction manual for how to do proper research; rather it is a simplification for piloting between various aspects of the research process. The arrows are meant to show that there is a flow - a dynamic osmotic force - and do not indicate any sort of chronology (ibid, p.151). They represent stages of a process that are deemed necessary by the authors for the maturity of a design research project.

The centre of the model is the problem area or the theme that a 'problem owner' wants to study and solve. It could also be referred to as an area of opportunity in case a researcher aims at taking a less problem-based stance. Ideally, the challenge or potential is investigated by a cross-disciplinary research team who, in the cycle to the left, conducts research that can be referred to as traditional in terms of defining the problem, creating hypotheses, collecting data and analysing data. The circle on the right, however, represents the production cycle where developed artefact prototypes are tested and validated by test groups and target users. Ideally, a DBR project starts in the middle and then moves in synchronous, circular movements.

Other models of the general research flow do exist, but the main consensus seems to be that a DBR project starts with a design challenge, tries to develop solutions, tests them in practice and from these interventions aims at generating theory. This is - to a higher or lesser degree - done in collaboration with practitioners and, ideally, in a continuously iterative manner.

Needless to say, discussions of the boundaries and potentials of DBR were still very much part of the academic discourse as primarily internal criticism called out for more systematic scientific rigor. A critique from within the community itself was put forward by Dede (2004; 2005) who claimed the majority of DBR studies are 'under-conceptualized and overmethodologized'. Concerning under-conceptualised studies, Dede's rationale was that the results generated by such studies were simply common sense for anyone with experience in educational settings. His second claim is based on his observations that DBR studies generate an unmanageable amount of data, while at the same time only the first five percent or so of the data collected were needed to

induce the findings. In his seminal work on what we learn when we engage in design research, Edelson (2002) provides a simple yet useful differentiation on the type of theory researchers engaging in Design-Based Research should strive to produce. Whereas the goal of ordinary design is to use the lessons embodied in a design procedure, problem analysis and design solution to create a successful design product, Design-Based Research adds the additional goal of developing useful, generalisable theories when constructing the above, similar to what was earlier described in the osmotic model. The theoretical output can either be of a descriptive nature in the form of domain theories, design methodologies or prescriptive design frameworks. Domain theories relate to problem analysis and entail, in very general terms, the generalisation of how a researcher understands a problem. A design methodology provides guidelines for the process rather than the product and hence relates to the procedural aspects of design. A design methodology thus describes the process for achieving a class of design challenges, the forms of expertise required to solve them and the roles of the individuals representing those forms of expertise. Lastly - and of greatest interest to this study - are the prescriptive design frameworks that are generalised design solutions in Edelson's (2002) categorisation. They describe the characteristics that a designed artefact in the broadest sense of the word must have to achieve a particular set of goals in a particular context. Building on van den Akker's (1999) work, a design framework is a collection of coherent substantive design principles. Edelson's (2002) contribution relates directly back to the initial motivation for introducing design to educational research as design frameworks can be seen as an advance in making the knowledge output more relevant to practitioners and policy makers. Due to the objective of Design-Based Research and the nature of the theoretical output, Edelson (2002) stresses that the lessons learned from design experimentation should not be judged by the same standards as traditional empirical research (Ibid.). Two unique and important evaluation metrics for design research are in his view novelty and usefulness. Furthermore, the strength of theories developed through design research comes from their degree of explanatory power and their grounding in specific and recognisable experiences. Again, we see how useful, recognisable and degree of explanatory power are keywords that relate to the increased relevance of educational research.

The golden age of DBR solidified the approach as an important player in the educational academic discourse. Debates on procedural rigor, scope and theoretical output continued to have a dominant position, but as the decade came to an end, more and more studies focused on the findings of the studies rather than the methodological implications of them. This shift in perspective also led researchers to assess the knowledge contribution of design-based approaches to educational research and, as the approach grew more popular; more books explaining and describing its core elements were published. This most recent period in the history of DBR, I describe in the following section using the label *Maturation and meta-studies*.

2.4. MATURATION AND META-STUDIES

Along with the growing popularity, reviews exclusively analysing DBR literature began to pop up at the beginning of the past decade (Rowland, 2007; Anderson & Shattuck, 2012; Zheng, 2015). Anderson and Shattuck (2012) aimed at assessing DBR and the trends within this particular field during the period 2002-2012. Zheng (2015) reviewed research papers related to DBR from 2004 to 2013. The review carried out by Rowland (2007) has a more philosophical approach, bringing together strands from DBR and other sources. In relation to this study, it excels in focusing sharply on the relation between design and research in DBR.

The latest reviews provide insights into two main characteristics of design in DBR: Interventions and iterations. Zheng (2015) looks into the number of iterations and the length of the studies. She concludes that the studies involve between one to five iterations lasting from a month to more than 3 years (Zheng, 2015, p. 407) and later that in terms of iteration frequency, 50% of the DBR studies conducted in the past decade comprised only one cycle (Zheng 2015, p. 408). Anderson and Shattuck (2012) point to the variety of terms used to describe iterations, e.g. *year*, *site*, *phase*, *iteration*, *cycle*, *phase* and *case study*, which makes it difficult to depict a comparison of multi-iteration projects. They do, however, provide an infographic showing the amount of iterations the different projects have gone through at the time of article submission.

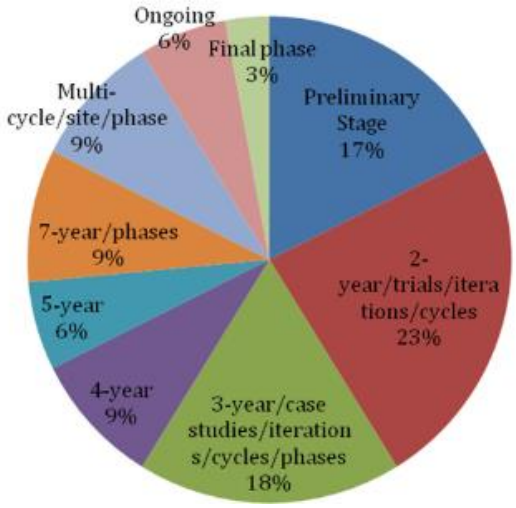


Figure 2-3. Iteration and phase sequences (n=34) Anderson and Shattuck (2012, p. 23).

The figure above shows that over half of the DBR projects discussed in the empirical studies focus on projects that have progressed through three or more iterations (Anderson & Shattuck, 2012, p. 21). Zheng's (2015) analysis hints that there is a

trending tendency towards not providing the details of how interventions are revised and, furthermore, that most of the studies included in her review only tested the intervention by one cycle (Zheng 2015, p 408).

The reviews thus reveal that DBR studies iterate between two and seven times in cycles ranging from a few months to years and that the details on the revision process moving from one intervention to the next are not always reported on. A careful conclusion on the back of this might suggest that the initial strive for more grounded theory and empirically based improvements of practice are pursued, but that the design efforts set in motion to achieve this goal to some degree remain unaccounted for.

Rowland (2007) raises quite a few salient issues concerning the nature of DBR. One point in particular concerning the partnership between practitioners and researchers in DBR studies is worth highlighting when pursuing what might constitute design-based activities in DBR. He writes:

> 'It seems reasonable to expect benefits from bringing together people with different perspectives and expertise (Barab & Squire, 2004b). However, taking roles at face value and not inferring the possession of additional skill sets, this represents a partnership between only two of the three professional roles - researcher and practitioner - that Schwen (1977) described as being "characterized by different expectations, contexts, and particular outcomes" (p. 6). Missing is the third role of developer or designer, ironically the one with competencies most directly related to educational innovation.' (Rowland, 2007, p. 17)

Rowland concludes that at least in his scope of review, DBR literature does not appear to recognise the importance of design competence or implies that it is a natural possession of researchers. He - along with Dede (2004) - suggests that rigorous scholars and creative designers might have limited overlap in skills and that teachers are likely to have more experience with activities related to design.

As part of the maturation of DBR, the continuous publication of books explaining and developing the approach continued to flourish (e.g. McKenney & Reeves, 2012; Bakker, 2018). To a large degree, the publications confirm what is stated previously in this chapter, although some new aspects of particular interest to this study concerning design blur and design principles did arise. The manner in which designs tend to mutate or blur during design processes has been the subject of theoretical interest in recent educational design research literature (e.g. Hung, Lim & Huang, 2010; McKenney & Reeves, 2012; Dohn & Hansen, 2018) as DBR continued to grow in popularity and publications. This mutation can be referred to as design blur where the blur refers to the difference in what was intended and what was implemented.

More than a decade ago, van den Akker (2003) introduced a tripartite of how to perceive design and theoretically grasp the concept of design blur in design research (primarily related to his studies in curriculum design). He introduced a lens for viewing interventions as either intended, implemented or attained. This way of defining design in different phases of a project was taken up by McKenney and Reeves (2012). The intended form of the intervention refers to what it sets out to do. The implemented form of the intervention is that which is actually used in practice. The outputs and outcomes of an intervention constitute its attained form. The authors provide this example:

> 'For example, a primary school physical activity program could intend for children to experience three 1-hour periods of team sports per week, with the goals of improving children's attitudes toward cooperative work and lowering the school's average body mass index (BMI). Due to inclement weather and teacher illness, the implemented program might consist of two 1-hour periods of team sports per week. The attained intervention may then be an increase in children's attitudes toward cooperative work but no change in BMI.' (McKenney & Reeves 2012, p. 139)

The lens provides a first step to differentiate between interventions at different stages of a DBR project. It does not, however, clarify the revision processes moving from one intervention to the next or to a very great extent in what way a series of planned interventions are intended to inform each other from a design research perspective.

Dede (2005) found that DBR studies are victims of design blur when using a strategy of expanding the design to include conditions for success that seem problematic. This leads to processes in which unpromising designs are never abandoned or studies evolve into full-scale systemic reform initiatives. As a consequence of his reasoning, Dede (2005) pleads for standards to evaluate the effectiveness of DBR interventions. Responding to the call for standards and the measurements of effectiveness, McKenney and Reeves (2012) provide an overview where initial alpha testing measure the soundness and feasibility of the intentions, beta testing explore the local viability and gamma testing measure the actual impact and effectiveness of the intervention (McKenney & Reeves, 2012, p. 140) as shown in the figure below.

Table 6.2 Phase and focus of evaluation for different forms of intervention

Phases	*Forms*		
	Intended intervention	*Implemented intervention*	*Attained intervention*
Alpha testing (Internal structure)	Test design intentions: • soundness • feasibility	Test assumptions about implementation; what will render: • local viability • institutionalization	Test assumptions about success: • what will render effectiveness and impact • how will these be measured
Beta testing (Use in context)	Explore alignment and conflict between intervention attributes that boost viability and institutionalization, and those of: • soundness • feasibility	Explore: • local viability • institutionalization	Measure: • potential effectiveness and impact • (prevalence of) fostering and hindering conditions for success
Gamma testing (Effects)	Reflective assessment of intentions and ideals; were they: • sound and feasible • appropriate and sufficient	Study how factors contributing to: • local viability, and • institutionalization influence effectiveness and impact	Measure actual: • effectiveness • impact

Figure 2-4. Phase and focus of evaluation for different forms of intervention (McKenney & Reeves, 2012, p. 140)

To an even greater detail, Easterday, Lewis and Gerber (2017) introduce seven iterative phases to avoid two opposing scenarios: 1) that researchers early on in design-based studies focus too much on controlled testing and thereby waste resources verifying potentially bad designs, or 2) that researchers never advance beyond theory building and radically different designs and therefore are unlikely to provide solid evidence for the efficacy of an intervention or principle (ibid, p.19).

The authors argue that previous attempts to define the phases of DBR have conflated goals with time and phase with implementation, leaving the presented models analytically indistinct (Ibid.). Defining phases using, for instance, terms like 'early' and 'final' prototyping leads to multiple phases with the same goal (i.e. prototyping). The same problem occurs when accounts of the process conflate phase with implementation, for example, phases using 'evaluation of local impact' and 'evaluation of broader impact' (both of which have the goal of testing) (ibid. p.3). In this case, the analytical distinction is not clear as both phases refer to the level of spread of the intervention. Lastly, they argue against sequential models because they

often result in a time-based perspective, which ultimately obscures the iterative nature of DBR. The model they suggest is presented in this way:

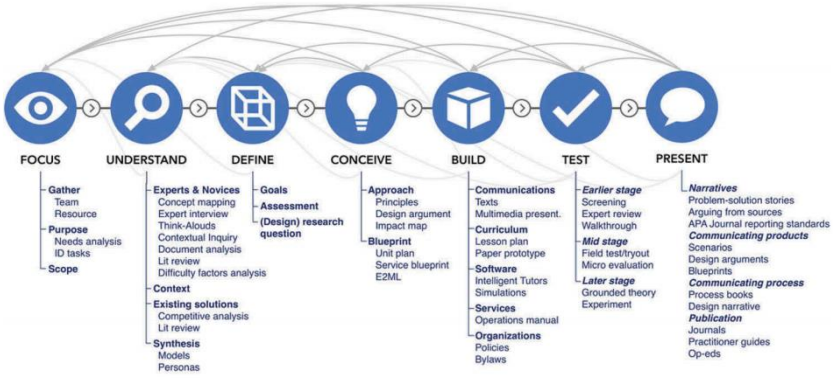


Figure 2-5. Model of seven iterative phases by Easterday, Lewis and Gerber (2017, p. 8).

In the phases to the left, researchers should concentrate on low-fidelity prototyping and collecting the minimal amount of data needed to rapidly reject failure and identify possible successes. In cases where researchers identify promising prototypes, they can start to focus on generating theory with different research methods to understand the issues a given design might address. At the stage where researchers have a credible, well-grounded theory and an implementation has been carried out with some evidence of success, it is time to begin conducting randomised controlled experiments to verify the effectiveness of the theory and intervention (Ibid.).

The last phase, present, is actually a further refinement of the model as this phase was not part of the model presented in an earlier paper (Easterday, Lewis & Gerber, 2014). In the present phase, the idea is for designers to communicate to relevant stakeholders whether and why the design solves a challenge that addresses their interests. It requires design researchers to explain the challenge at hand, a solution that addresses the problem, evidence showing that the design works and how, and in some cases the process and insights that led to the design. In this perspective, more emphasis is put on the actual solution rather than on the theoretical conclusions to be drawn from a DBR project. Design principles are nonetheless still present in the model as they are part of the conceive phase. Here, researchers propose new design models in the form of principles, although the authors argue that, in general, design researchers use many methods to describe the theoretical products of design research (Easterday, Lewis & Gerber, 2017). Through this model, we see a very different design approach than presented by the first wave of design experiments; it is more about improving practice and less about refining theory, more about communicating to practitioners and policy makers than fellow learning theorists or researchers trying to implement technology

in classroom settings, and it is far more explicit in relation to concrete activities to explore the initial problem setting when compared to the early design methodologies.

In the continued vein of making the theoretical output of DBR relevant to practitioners, McKenney and Reeves (2012) maintain the importance of design principles and state that they are:

> 'Probably the most prevalent term used to characterize the kind of prescriptive theoretical understanding developed through educational design research.' (McKenney & Reeves, 2012, p. 34)

Design principles are also mentioned as a pivotal part of DBR in the Anderson & Shattuck's (2012) review in which the authors devote a section to discuss 'the evolution of design principles' (Anderson & Shattuck, 2012, p. 17). Here, designs both evolve from and lead to the development of practical design principles, patterns, and/or grounded theorising. Design principles help researchers understand and adjust both the context and the intervention itself and are compared to conceptual models that reflect the conditions in which they operate. The development of design principles is considered a strength by the authors, and it is argued that it puts the types of research that unilaterally descend for testing in a classroom and then disappear with the researcher once the experiment has been concluded at a disadvantage. Design principles are hereby maintained as a distinct way in which knowledge drawn from interventions can be captured and distributed within the field of DBR.

Despite the maturation of the approach, calls for fundamental clarifications and more rigorous definitions are repeatedly put forward by key proponents of DBR (Dede, 2005; O'Neill, 2012; Anderson & Shattuck, 2012; Easterday, Lewis & Gerber, 2017). These challenges include, but are not limited to, the definition, form and role of design principles, the understanding of what constitutes design interventions at different stages, the detailed reasoning when iterating from one intervention to the next and why, when and how practitioners are involved in the design processes.

2.5. SUMMARY

DBR started as a reaction to psychological lab experiments and aimed at creating more impactful, relevant and useful knowledge for practitioners that was also empirically grounded in real life settings. Mainly concerned with the development of learning theory and the implementation of technology in classroom settings, DBR evolved into dealing with much larger scale interventions with a variety of foci and scopes. The growing popularity of the approach also led to a shift in view from theory development to problem-based improvement of practices.

To sum up the development of DR as described in this chapter, the model below offers a visual overview of the focus points of DBR since the beginning of the 1990s. The

model highlights the four periods I have presented with the spots of colour indicating that the relation between the periods and the timeline is indicative rather than definitive.

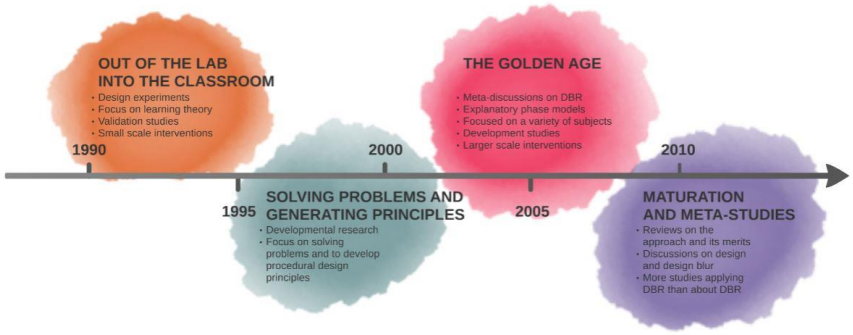


Figure 2-6. Periods in DBR.

As DBR has progressed, less attention is paid to debating the methodological rigour of the approach and more energy is put on carrying out actual interventions. This has sparked the debate of how initial solutions change over time, on what grounds they are refined and when ideas to improve practice should be abandoned.

Despite the numerous unresolved questions, a series of key characteristics that relate to what is conceived within the field itself to be design-based have remained constant and recognisable even since the beginning:

- DBR is based on interventions,
- interventions progress in iterative cycles,
- interventions are carried out in collaboration with practitioners and
- interventions are often based on initial design principles that are tested in practice and ideally refined at the end of a project.

Furthermore, important theoretical distinctions in relation to these characteristics can be identified:

- DBR interventions can be conducted either as a part of validation studies or development studies.
- Ideally, there are different phases in a DBR study and different levels (heuristic, empirical, production and validation) in which collaboration with practitioners can take place
- As a way of avoiding design blur, one can distinguish between intended, implemented and attained designs

- Either design principles can be guiding principles (also called conjectures) or they can be conclusive (refined principles)
- A set of coherent design principles can form a design framework.

The four main characteristics and the activities tied to them form the body of this dissertation. I explore the challenges and potentials of each of the characteristics one by one. The theoretical distinctions help inspire and ground the way I analytically tackle the different reviews presented in each part as I move through understandings and uses of *intervention*, *iteration*, *collaboration* and *principles*.

CHAPTER 3. METHOD

In the introduction, I discussed the immediate challenge of working with activities related to design as an object of study. I have found that acclaimed designers from established design disciplines are very reluctant to define design, and as stated earlier I do not wish to force an understanding from other fields of design upon DBR and the researchers working with the approach. My ambition with this study is to uphold a curious and explorative attitude when uncovering ways to act out design-based activities in DBR.

Methodically, I therefore face the challenge of pinpointing what design activities entail in the relatively diverse field of DBR. To be clear, this poses two challenges. One is to identify a definition of design-related activities that can function as an object of study throughout the dissertation derived from DBR itself. The second is to find a way to represent the broad range of DBR practices to further study this notion of design. In other words, once I have defined what design activities look like in DBR, how do I single out a mainstream body within DBR to investigate these activities on a deeper level?

My ambition of taking a curious and explorative approach resonates well with the original work of Glaser and Strauss (1967) on grounded theory and the further development by Glaser (1978, 1998, 2001, 2005) where the researcher is kept as free and open as possible to discover theory derived from data. In this perspective, the researcher attempts to avoid forcing data into pre-existing concepts by delaying the common strategy of doing an initial literature review. In the heart of the argument lies the fear of supporting what is already known from a constructed theory, rather than providing new insights through emergent theory (Heath, 2006).

Thornberg (2012), however, deems this position problematic for several reasons in his advocacy for what he labels informed grounded theory. If, for instance, a researcher wants to conduct studies in fields of his or her own expertise, that person would effectively have to either unlearn prior knowledge or alternatively pretend to be a ‘theoretical virgin’ (Clarke, 2005). Both strategies seem counterintuitive and conflict with researchers admitting their theoretical understandings from the outset of a study (Bruce, 2007). In this case, I have already made clear that I have several years of experience working with DBR. Failing to make this prior experience transparent, or actively putting it in play when conducting the study for that matter, would be to hamper the efficiency of the work purposefully. Thornberg (2012) lists five additional reasons as to why delaying literature reviews is a counterproductive strategy. These include pragmatic reasons (the researcher has to prepare proposals in which literature reviews are often mandatory in order to receive funding) as well as avoiding reinventing the wheel by being unaware of what has already been discovered.

Instead, Thornberg proposes, along with Strauss and Corbin (1998) that literature reviews are used actively in grounded theory research as long as these initial findings do not block creativity or narrow the paths of exploration. In order to facilitate this, the researcher applies abductive reasoning where comparisons and interpretations are carried out by constantly moving back and forth between data and pre-existing knowledge.

On the basis of these reflections, I decided to initiate two types of literature reviews. From a historical perspective, the first review aims at establishing what characteristics of design and design-related activities can be identified from studying historical key texts of DBR. The second set of reviews specifically targets the most quoted seminal articles published within the last 15 years concerned with Design-Based Research and education. Focusing on the most quoted articles serves the purpose of narrowing down a manageable body of literature, while at the same time preserving the idea of it representing a mainstream attitude held by researchers of DBR. Both reviews are described in detail later in this chapter.

Immediately, concerns related to publication biases, such as the constraints of reporting on DBR projects in the format of seminal journal articles or the types of studies that attract high quotation scores, spring to mind. Specifically in relation to the matter of design research and journal constraints, McKenney and Reeves (2012) point to the struggles of researchers having too much story to tell and stress that few formats allow detailed descriptions of how interventions are designed. Furthermore, it could be argued that if I truly wanted to uphold a curious attitude, I would need to engage in a dialogue with the researchers in question as well. I therefore decided to supplement the literature analyses with interviews with researchers from the field. I chose researchers who were either in the midst of working on their PhD dissertations based on DBR or had recently completed their dissertation. The reason for doing so is twofold; firstly, I figured that this group would be willing, accessible and interested in discussing their recent work. Secondly, I wanted to ensure that the people I interviewed had worked intensely with the methodology, as is often the case when working on a dissertation.

Lastly, to fulfil the second ambition of mine, to point at ways of potentially improving the DBR approach, rather than just point to a series of challenges, flaws or discrepancies, I wanted to gain insight into both an internal and an external view on potentials for moving forward. I interviewed the researchers again with this outcome in mind, but I also wanted to supplement their contribution with perspectives from established fields of design. The struggles to find such appropriate voices are described later in this chapter as well as how to get access to design perspectives.

Subsequently, I end up with a research design containing two methods: literature reviews and interviews. The literature reviews help define my object of study and represent a “mainstream voice” of DBR. The interviews help yield a fuller picture

than what can be extracted from the articles alone and allow me to investigate the specific aspects of design activities relevant to this study through the means of dialogue. In this way, the dissertation speaks only of how researchers of DBR report and understand design-based activities as part of their research and not, for instance, how they actually practice it. Such a study would indeed be of interest to the field, but it would at the same time require a larger scope than a PhD study, should the ambition be to cover more than just a few cases. By choosing the multimethod approach of reviews and interviews, I intend to author a research study that raises a methodological debate within the full scope of the approach and addresses all fellow colleagues who have experienced and struggled with conducting DBR.

The chapter follows a simple structure in which multimethod in relation to mixed methods is discussed, including considerations related to triangulation. Next, I describe the two methods in detail. I start with literature reviews, explain the types of literature I have applied, provide critical perspectives on my approach, and lastly I present the selected body of literature. Following this, I introduce my informants as well as my struggles to gain access to relevant design perspectives from traditional disciplines of design. I also present a framework for working with video sketching, which is a result of working closely with a small group of researchers at Aalborg University. I end the chapter by describing how the data from the two data collection methods are integrated in the study and account for my overall coding strategy.

3.1. A MULTIMETHOD APPROACH

I define my overall methodological perspective of my study as a multimethod approach. I use the term as an alternative to the more commonly used 'mixed methods', which for some researchers only apply to studies where both qualitative and quantitative methods are integrated (Creswell, 2015; Mark, 2015). Instead, I opt for the term multimethod research, along with Johnson and his fellow colleagues (Johnson, Onwuegbuzie and Turner, 2007) to indicate that different styles of research are combined in the same research project.

It has been pointed out that the distinction between mixed methods and multimethod research tends to narrow the range of possibilities for multimethod work (Brewer and Hunter, 2006). The argument is that if a multimethod approach does not cross the number-word divide, it will be ignored and papers based on the approach will have a slim chance of being published in a journal of mixed methods research. Vogt (2008), however, argues that even though research that mixes numbers and words is perfectly acceptable, the research community should be equally excited when work links interviews and document analysis or ties together laboratory experiments with numerically coded observations. He therefore presents the following recommendation:

> ‘We should not be limiting ourselves to combining research in which the data are coded with words and numbers. Rather we should also be mixing designs (e.g., experiments, interviews, participant observations, document analyses, and surveys) and methods of sampling (e.g., snowball sampling, random sampling, and case studies).’ (Vogt 2008, p. 23-24)

According to Vogt (2008), focusing on ways of coding data is too limiting, and he finds this way of organising how we think about research methods unsatisfactory. Instead, he urges researchers to combine designs and sampling techniques, not only coding and analysis techniques.

As the object of my study, i.e. activities related to conducting design-based research in education, is elusive in its character, I found the multimethod approach appealing as an attempt to capture the complex problem I am dealing with. I present these considerations in further detail in the following sections.

3.1.1. THE ARCHIPELAGO METAPHOR AND THE PROBLEMS WITH TRIANGULATION

In mixed methods theory, the metaphor of the archipelago has been put forward to illustrate how a group of datasets can be both separate and at the same time connected (Lawrenz & Huffman, 2002). An archipelago is a set of islands connected by an underwater peninsula so they loosely form a group. In an archipelago, the vast majority of the structure is underwater and hence out of sight. The islands are in plain sight, but they only represent a relatively small portion of the entire archipelago. From a mixed methods perspective, the image portrays different data (the islands) as fundamentally linked, while not revealing all that is still hidden (beneath the surface). One can collect multiple types of data and use various analysis procedures, but in the end, it is difficult to completely uncover the truth.

When I first heard about the metaphor, it struck me how the elusiveness of design is captured in this image. Uncovering how people understand and practice design in DBR felt (to me at least) like standing on small islands, learning the customs of one particular culture, tradition or work ethos, well aware that the neighbouring island might have different views and that most of what I was trying to seek out would remain hidden underneath the water.

Stringing together different kinds of data on the same object of study is often associated within the literature of social science with checking the validity through triangulation (Hammersley, 2008). Reviewing the literature, Hammersley (ibid.) identifies four different meanings of the term: triangulation as validity checking, indefinite triangulation, triangulation as seeking complementary information and, finally, triangulation as epistemological dialogue or juxtaposition.

Triangulation as validity checking ideally arises from the mutual validation of measurements from two separate sources of data collecting methods. The different methods compensate the known weaknesses in each of them and thereby raise the validity of the collective results derived in the study (Denzin 1978). In cases where the data contradict one another, it can either be viewed as a flaw in one of the applied methods or a sort of falsification of the hypotheses in a study (Brewer and Hunter 2006).

A number of questions, however, have been raised about checking validity through triangulation. Erzberger and Kelle (2003) point to the logic of methodological triangulation in social research (and therefore also in education) as being different from that of triangulation in navigation and surveying. Hammersley explains:

> 'In the case of navigation, the second measurement does not provide verification or validation of the first, but rather is a necessary complement in order to identify relative location. By contrast, in methodological triangulation what is unknown, or at least sufficiently uncertain to need checking, is the validity of the first 'bearing', the first source of data. A complementary difference is that while in navigation a single bearing can tell us that we are on a line in a particular direction from the landmark, though not where we are located on that line, in the case of social research a single source of data can in principle tell us all we want to know: whether a particular knowledge claim is true. In short, potentially, it gives us the whole answer, we do not necessarily have to combine it with something else. Or alternatively, if it is wrong, it tells us nothing in itself.' (Hammersley 2008, p. 24).

Therefore, in this first concept of triangulation, the reason behind researchers engaging in triangulation is for them to check an answer, not to gain further information in order to produce an answer.

The most fundamental question raised about this interpretation of 'triangulation' is not concerned with checking validity, but the assumption that there is a single reality and that its characteristics can come to be known via the use of different data sources, methods, approaches, etc. This has led to advocacy of other forms of triangulation. The most common meaning of 'triangulation' employed by researchers has been outlined by Erzberger and Kelle (2003) who state that:

> 'The use of different methods to investigate a certain domain of social reality can be compared with the examination of a physical object from two different viewpoints or angles. Both viewpoints provide different pictures of this object that might not be useful to validate each other but that might yield a fuller and more complete picture of the phenomenon concerned if brought together.' (Erzberger & Kelle 2003, p. 461)

The authors offer the metaphor of the jigsaw puzzle to clarify their point. 'Empirical research results obtained with different methods are like the pieces of a jigsaw puzzle that provide a full image of a certain object if put together in the correct way' (Erzberger & Kelle, 2003, p. 461). It seems that this understanding of triangulation does not escape the issue of the first definition because how are we to know which data sources will provide the most desirable kinds of complementary information? Furthermore, the perspective implies that there is a correct way of putting together pieces of data, which points to a stance where we can have complete or 'the right' knowledge of a phenomenon.

A key problem in discussions of triangulation is that only in rare cases distinctions are drawn between combining data from different sources, using different methods and integrating different methodological approaches. This is due to the result of triangulation not solely being a matter of debate between quantitative and qualitative research traditions, but also at the same time of clashes among rivalling qualitative traditions (Hammersley 2008).

In the present study, triangulation refers to different viewpoints that provide different pictures of the same object, which may not be useful to validate each other, but might yield a fuller and more complete picture of the phenomenon concerned if brought together. I do, however, in this way inherit the problem of answering the question: how do I know which data sources will provide the most desirable kinds of complementary information? As I seek to explore the most popular understandings of working design-based in DBR, I opted to look at the most commonly used seminal works related to education and DBR. Acknowledging that the data do not provide a true picture of what researchers within the field perceive design to be, and that the majority of knowledge is hidden beneath the murky water surface, I find that the texts that researchers refer to the most are excellent starting points (islands) to visit when trying to piece together popular understandings of a given phenomena within a field. The highly quoted articles are complemented by two additional sources. The first is the historical overview of DBR, which aims to ensure that the analysis of design characteristics is indeed relevant to the field. Staying within the archipelago metaphor, I might say that the overview provided me with a lens to understand the culture of the islands and thus tighten my perspective. The second data set is the series of interviews and workshops I held with researchers and designers. I still maintain that the viewpoints expressed by these informants are not meant as a way to uncover the truth about how design is understood, but rather that they serve to create richer and fuller descriptions of the understandings previously identified in the popular texts. In this sense, the approach I choose can be viewed as a multimethod approach that seeks complementarity (Greene, 2007), where one qualitative set of data helps elaborate, illustrate and clarify the results from another.

Another important distinction when designing a mixed methods study, and therefore also in multimethod research, relates to the timing of two (or more) components.

Often, mixed methods research designs are either concurrent or sequential (Morse, 1991). Simultaneity forms the basis of the distinction between the two and is the one-half of the two defining aspects of timing, the other being dependence (Guest, 2013). In a sequential design, one component precedes another, as opposed to being executed simultaneously, because it is performed in concurrent designs (Schoonenboom & Johnson, 2017).

A second aspect of timing is dependence. Dependency between two research components occurs if the implementation of a component depends on the results of data analysis in the component that came before. In the opposite case, two research components are independent, in instances where the implementation of one component does not depend on the results of data analysis in the component in succession of it (Schoonenboom & Johnson, 2017). In my study, data sets are highly dependent and influenced by the previous set. The historical overview of DBR forms the key characteristics of designs that I choose to explore in my literature study. The findings from the literature study are what form the basis of how I analyse the interview data. In the analysis, I look specifically for illustrative statements that can enrich previous findings or contrasting viewpoints that go against what has been drawn from the texts. Additionally, I analyse the interviews with the overall aim of the study in mind: to explore challenges and potentials in relation to how research activities related to design are understood by the informants.

In order to illustrate this multi-method research design in a simple way, I present the following model:

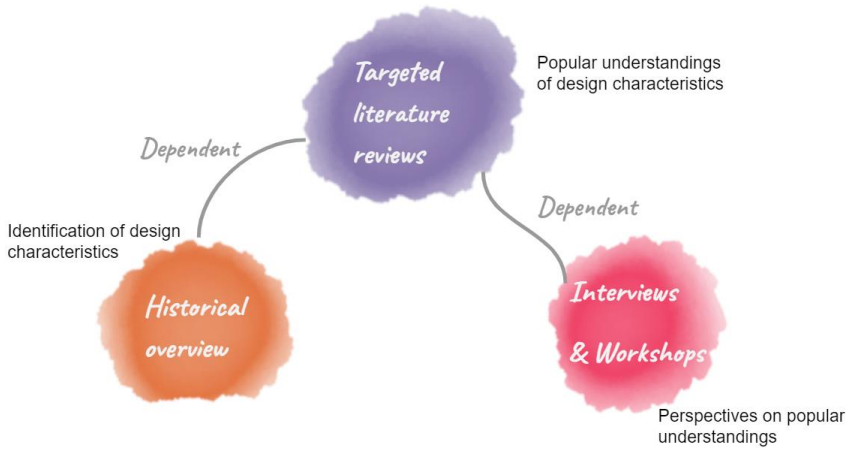


Figure 3-1. Dependency of data sets

The model illustrates how the historical overview feeds into targeted literature, which again is nuanced by the subsequent interviews and workshops with researchers from the field of DBR and various design experts. The way I sat up my research design is recognisable in the structure of the dissertation. The dependency of the various data sets supports the logic I attempt to impose on the object of study. The purpose of the first literature review is to map out key characteristics of working design-based in DBR. Next, building on these characteristics I establish how these characteristics have been described in mainstream DBR literature through four different targeted reviews using the same body of texts. In order to nuance those descriptions four interviews with researchers of DBR provide lengthier opinions to the specific areas of interest in this study and help settle the most prominent challenges of carrying out research activities when operating design-based. Lastly, based on these challenges design experts are brought in to point at potentials to overcome such obstacles from their experience in dealing with the delicate matters of design processes.

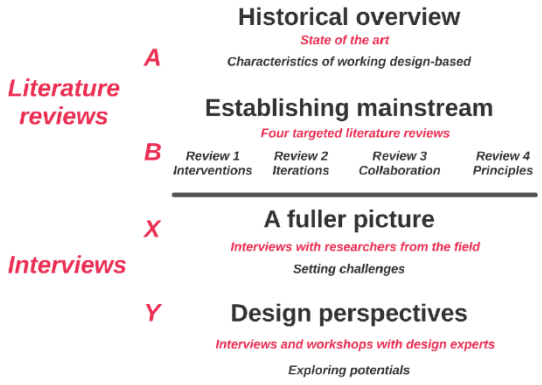


Figure 3-2. Overview of dissertation and related data sets

The figure to the left is a way of capturing both the main methods applied to collect data, the purposes and outcomes of each individual part and lastly if read from top to bottom a very condensed introduction to how the dissertation is sat up.

In the following, I lay out on a more detailed level which data and methods are mixed in my project and how. I start by introducing my approach to the different literature reviews and then move on to my reflections on how I decided to interview my informants.

3.2. LITERATURE REVIEWS

As it is evident from the initial introduction to the overall multimethod research design introduced above, the dissertation contains two different types of literature review data sets of which the last set is further divided into four different reviews, each with their own purpose and research questions. Both sets can generally be described as methodological reviews, as their main purpose is to identify key variables, methodological strengths and weaknesses, and illuminate how research practices differ across groups, times or settings. In relation to the last purpose, the reviews also bear resemblance to studies focused on how people (in this case researchers) tend to

carry out a certain practice (i.e. DBR in this case). This type of review can help identify a practical need not currently met in the current field.

Literature review A (fig. 3-2), the historical overview, is an attempt to identify the key characteristics of activities related to working design-based in DBR, thus both focusing the rest of the study and, as Gall, Borg and Gall (1996) argue, delimiting the research problem. Hart (1998) has in general terms highlighted the purpose of identifying key characteristics as the purpose of discovering variables relevant to the study at hand. Literature review A complies with this by using a historical format where the review is organised chronologically. Such an approach is preferable when the emphasis is on the progression of research methods, practices or theories, or on changes in practices over time within a particular field (Randolph 2009). In terms of coverage I apply Cooper's (1988) selection approach of employing a purposive sample and examining only the central articles in the field. In order for this to work, the reader must be convinced that the selected articles are, in fact, pivotal and, just as important, that central articles are not omitted.

The literature review data set is an attempt to uncover a mainstream or popular understanding of design in design-based research. Hence, I chose the most quoted seminal articles published within the last 15 years concerned with design-based research and education.

This approach is inspired by an already published literature review: 'Design-based research: A decade of progress in education research?'. In this review, Anderson and Shattuck (2012) aim at assessing DBR and the trends within this particular field. Using the open-source tool Publish or Perish, the authors performed a Google Scholar search in the relevant academic areas for articles containing the words 'design-based research' and 'education'. From this pool of a little less than two thousand articles, they picked out five articles from each year in the period 2002-2011 with the highest number of citation quotes. The focus was on articles that explicitly use DBR or in some way discuss DBR methodology. Articles that merely cite a DBR research study were not included and only for the year of 2002, the authors were unable to find five articles living up to their criteria, hence only 2 articles were selected.

In order to cover the newest developments within the field, I have updated this search by replicating the approach from the years 2012-2017. The first search was carried out on February 20th, 2018. I chose only journal articles, not conference proceedings, abstracts, book chapters or web articles. In the process of choosing the top five most cited articles, I included articles that cite DBR literature, either because the article itself is a DBR study (i.e. an article using DBR as a methodological approach) or because the article refers to DBR literature. With this new lot of 30 articles, I have a total of 77 articles. While filtering, I extracted those articles that merely refer to using the findings of other articles without themselves being DBR studies or in other ways adding to the theoretical basis of the approach.

Whereas the original review was conducted using only the abstracts, in this study full papers are coded and analysed to generate material for the presented analysis. For each design characteristic, different takes on the initial review method have been applied and are thus presented accordingly in the relevant chapters.

3.2.1. CRITICAL PERSPECTIVES

The Anderson and Shattuck (2012) review is renowned and much cited, but important aspects of the authors' methodological approach have also been criticised. On a general level, reviews relying on the most cited papers for a given year have been criticised for not taking into account the many ways the number of citations can be affected (Fowler & Aksnes, 2007). The large majority of scientific papers are never or seldom cited in the subsequent scientific literature. On the other hand, some papers receive an extremely large number of citations (Aksnes & Sivertsen, 2001; Seglen, 1997). One reason for this is the increasing focus on scientific excellence in science policy (van Raan, 2000). In this context, highly cited papers have been regarded as potential candidates for identifying and monitoring 'excellent' scientific research. However, some papers are cited more often than others for reasons other than the quality of the research (van Noorden, 2017). It may seem ironic, since the present study revisits a literature review, that reviews are, in fact, cited above average compared to other genres within the academic discourse (Glänzel & Czerwon,1992; Aksnes, 2003). With regard to the study sample at hand, my choices do not rest on the idea to review the papers of the highest quality. Rather, my intent is to identify articles that represent 'the mainstream of DBR', i.e. simply the articles that researchers read and reuse the most, and then, within this body of papers, to investigate their understandings of design in relation to intervention, iteration, collaboration and principles. I am aware that this choice of method may omit DBR studies with a low number of citations, even though they provide in-depth studies of design aspects, but a certain portion of these studies are luckily covered through the historical overview in chapter 2.

In a more specific way, McKenney and Reeves (2013) argue in their direct response to Anderson and Shattuck's (2012) original paper, that the insights of the review may have been more useful had the framework been more nuanced, rather than using only the number of citations as their selection criterion and thereby omitting 'grey' research. In this dissertation, grey literature, such as handbooks, book chapters or conference proceedings, is also covered in chapter 2.

McKenney and Reeves (2013) also point out that several researchers may not call 'Design-Based Research' by this name, but are still taking part in design-based activities nevertheless (see chapter 2 for examples of similar research fields and sister research genres). The narrowness of the search term can also be criticised in this study. However, my intention here is to investigate the concept of design specifically with

regards to DBR and only the most relevant perspectives from highly similar approaches are presented in the state of the art.

A third critique has emerged from my own work with the online search tools and the data they provide at different times. When revisiting the review I faced the choice of keeping the original 47 articles or replicating the search to generate a new list of articles. The new list would simply be the articles from 2002-2011 with the highest number of citations at this time. For reasons of comparison, I opted for the former. However, I did compare the number of citations in the original review search from 2012 to a specific search on citations in October 2019. The new numbers reveal the dynamic nature of working with a top 5 most quoted pr. year articles list when comparing citations from all three searches. Thus, no top 5 is the same for any year in any of the searches.

One might argue for choosing the most cited articles of all time using the same search words. The reasoning here is that there might be years where more than 5 articles are present in the all-time top 77 (since 2002) and that the scope of time (one year) is simply an arbitrary span of time with no real relevance in determining what is mainstream or not. While this is true, the spread in time ensures that the review does not exclusively include 'classics', which have potentially accumulated citations throughout the years, but also includes at least some of the newest and most promising articles published within the field.

3.2.2. UPDATING THE SUPPLEMENTAL DATA

The original review presents a series of categories through a supplementary data sheet to create an overview of the articles included in the review. In this section, I introduce data set B through an update of the types of studies and the nationality of authors by adding the data from the additional thirty articles. Other criteria were omitted, as they were not relevant for the scope of this dissertation.

3.2.3. TYPES OF STUDIES INCLUDED

Anderson and Shattuck (2012) identify two distinct types of studies in their review. The first is repository articles about DBR itself (34%) of which the main part was written in the Golden age of DBR (23 out of 31 in the period from 2002-2006). The remaining articles (66%) are actual DBR studies presenting results from various stages of their research cycles. According to the authors, the data suggest that DBR is moving from theoretical discussions about DBR to actual studies in practice within this period.

Adding the 30 newest articles to the pool and reading the papers, I added an additional type of study to the data set, namely literature reviews of which there are seven. The reason behind including these studies in the analysed body is twofold; firstly, reviews

are highly quoted and thus represent some of the most cited in relation to describing DBR. The Anderson and Shattuck (2012) review itself is referred to almost 1,400 times and is placed in the top three of quoted articles among the 77 articles. Secondly, reviews that are not specifically about DBR, but include various insights on the methodology nonetheless, display the popularisation of the approach as other research fields start to compare or at least take notice of the existence of DBR.

The following table provides an overview of the included literature reviews.

Year	Author	Title + DOI	Journal
2016	Maxwell, J.A.	Expanding the history and range of mixed methods research https://doi.org/10.1177/1558689815571132	Journal of Mixed Methods Research
2015	Pedastea, M., Mäeotsa, M., Siimana, L. A., de Jong, T., van Riesen, S. A.N., Kamp, E. T., Manoli, C. C., Zacharia, Z. C. and Tsourlidakid, E.	Phases of inquiry-based learning: Definitions and the inquiry cycle https://doi.org/10.1016/j.edurev.2015.02.003	Educational research review
2014	Gašević, D., Kovanovic, V., Joksimovic, S., and Siemens, G.	Where is research on massive open online courses headed? A data analysis of the MOOC Research Initiative https://doi.org/10.19173/irrodl.v15i5.1954	The International Review of Research in Open and Distributed Learning
2013	Li, M.C. and Tsai, C.C.	Game-based learning in science education: A review of relevant research https://doi.org/10.1007/s10956-013-9436-x	Journal of Science Education and Technology
2013	Chai, C.S., Koh, J.H.L., and Chin-Chung, T.	A review of technological pedagogical content knowledge	Journal of Educational Technology & Society
2012	Anderson, T. and Shattuck, J.	Design-based research: A decade of progress in education research? https://doi.org/10.3102/0013189x11428813	Educational researcher

2009	Dede, C., Ketelhut, D. J., Whitehouse, P., Breit, L. and McCloskey, E. M.	A research agenda for online teacher professional development https://doi.org/10.1177/0022487108327554	Journal of Teacher Education

Table 3-1. Included reviews in targeted reviews

A final note concerns the repository studies, which now not only include studies discussing the nature of DBR, but also studies referring to DBR in one way or another. An example of the latter is Abrahamson and Sanchez-Garcia (2016) where the objective of the article is to contribute to developing a theory of action-based mathematics learning and where the presented arguments are contextualised in findings from a design-based project. As in this example and in others, it should be noted that the repository texts often refer to cases, vignettes or illustrative examples for which reason they might be confused with intervention studies. The pivotal point of distinction in the categorisation is, however, that the purpose of the cases is to illustrate the arguments presented in the theoretical discussion. If on the other hand, the theory was deduced directly from the cases, the studies might have been categorised as intervention studies.

The included 25 repository texts are included in the following table.

Year	**Author**	**Title + DOI**	**Journal**
2017	Ross, J.	Speculative method in digital education research https://doi.org/10.1080/17439884.2016.1160927	Learning, Media and Technology
2016	Gutiérrez, K.D., and Jurow, A.S.	Social design experiments: Toward equity by design https://doi.org/10.1080/10508406.2016.1204548	Journal of the Learning Sciences
2016	Bannan, B., Cook, J., and Pachler, N.	Reconceptualizing design research in the age of mobile learning https://doi.org/10.1080/10494820.2015.1018911	Interactive Learning Environments
2016	Abrahamson, D. and Sánchez-García, R.	Learning is moving in new ways: The ecological dynamics of mathematics education https://doi.org/10.1080/10508406.2016.1143370	Journal of the Learning Sciences

2015	Voogt, J., Laferrière, T., Breuleux, A., Itow, R. C., Hickey, D. T., & McKenney, S	Collaborative design as a form of professional development https://doi.org/10.1007/s11251-014-9340-7	Instructional science
2014	Engeström, Y., Sannino, A., and Virkkunen, J.	On the methodological demands of formative interventions https://doi.org/10.1080/10749039.2014.891868	Mind, Culture, and Activity
2014	Sandoval, W.	Conjecture mapping: An approach to systematic educational design research https://doi.org/10.1080/10508406.2013.778204	Journal of the learning sciences
2013	McKenney, S. and Reeves, T.C.	Systematic review of design-based research progress: Is a little knowledge a dangerous thing? https://doi.org/10.3102/0013189x12463781	Educational Researcher
2013	Fishman, B., Marx, R. W., Blumenfeld, P., Krajcik, J., and Soloway, E.	Design-based implementation research: An emerging model for transforming the relationship of research and practice https://doi.org/10.1207/s15327809jls1301_3	National Society for the Study of Education
2012	Lobato, J.	The Actor-Oriented Transfer Perspective and Its Contributions to Educational Research and Practice https://doi.org/10.1080/00461520.2012.693353	Educational Psychologist
2009	Ruthven, K., Laborde, C., Leach, J., and Tiberghien, A.	Design tools in didactical research: Instrumenting the epistemological and cognitive aspects of the design of teaching sequences https://doi.org/10.3102/0013189x09338513	Educational Researcher
2006	Lewis, C., Perry, R. and Murata, A.	How Should Research Contribute to Instructional Improvement? The Case of Lesson Study https://doi.org/10.3102/0013189X035003003	Educational Researcher
2006	Bielaczyc, K.	Designing Social Infrastructure: Critical Issues in Creating Learning Environments With Technology https://doi.org/10.1207/s15327809jls1503_1	Journal of the Learning Sciences

2006	Chan, T.-W., Roschelle, J., Hsi, S. Kinshuk K., Sharples, M., Brown, T., Patton, C., Cherniavsky, J., Pea, R. D., Norris, C., Soloway, E. , Balacheff, N., Scardamalia, M., Dillenbourg, P., Looi, C.-K., Milrad, M. and Hoppe, U.	One-to-one technology-enhanced learning: an opportunity for global research collaboration https://doi.org/10.1142/S1793206806000032	Research and Practice in Technology Enhanced Learning
2005	Wang, F., & Hannafin, M. J.	Design-based research and technology-enhanced learning environments https://doi.org/10.1007/bf02504682	Educational Technology Research and Development
2005	Reeves, T. C., Herrington, J. and Oliver, R.	Design research: A socially responsible approach to instructional technology research in higher education https://doi.org/10.1007/bf02961476	Journal of Computing in Higher Education
2004	Fishman, B., Marx, R. W., Blumenfeld, P., Krajcik, J. and Soloway, E.	Creating a Framework for Research on Systemic Technology Innovations https://doi.org/10.1207/s15327809jls1301_3	Journal of the Learning Sciences
2004	Kelly, A. E.	Design Research in Education: Yes, but is it Methodological? https://doi.org/10.1207/s15327809jls1301_6	Journal of the Learning Sciences
2004	Collins, A., Joseph, D., & Bielaczyc, K.	Design Research: Theoretical and Methodological Issues https://doi.org/10.1207/s15327809jls1301_2	Journal of the Learning Sciences

2004	diSessa, A. A., & Cobb, P.	Ontological Innovation and the Role of Theory in Design Experiments https://doi.org/10.1207/s15327809jls1301_4	Journal of the Learning Sciences
2003	Bannan-Ritland, B.	The Role of Design in Research: The Integrative Learning Design Framework https://doi.org/10.3102/0013189x032001021	Educational Researcher
2003	McCandliss, B. D., Kalchman, M. and Bryant, P.	Design Experiments and Laboratory Approaches to Learning: Steps Toward Collaborative Exchange https://doi.org/10.3102/0013189X032001014	Educational Researcher
2003	Zaritsky, R., Kelly, A. E., Flowers, W., Rogers, E., and O'Neill, P	Clinical Design Sciences: A View From Sister Design Efforts https://doi.org/10.3102/0013189x032001032	Educational Researcher
2002	Laferrière, T.	Telelearning: Distance and telos	Journal of Distance Education
2002	Gutierrez, R.	Enabling the Practice of Mathematics Teachers in Context: Toward a New Equity Research Agenda	Mathematical Thinking and Learning

Table 3-2. Included repository texts in targeted reviews

Lastly, 45 intervention studies remain which are presented in the table below.

Year	**Author**	**Title + DOI**	**Journal**
2017	Hung, H.T.	Design-Based Research: Redesign of an English Language Course Using a Flipped Classroom Approach https://doi.org/10.1002/tesq.328	Tesol Quarterly
2017	Koivisto, J.M., Niemi, H., Multisilta, J., and Eriksson, E.	Nursing students' experiential learning processes using an online 3D simulation game https://doi.org/10.1007/s10639-015-9453-x	Education and Information Technologies

2017	Kucirkova, N.	iRPD - A framework for guiding design-based research for iPad apps https://doi.org/10.1111/bjet.12389	British Journal of Educational Technology
2017	Novakovich, J. , Miah, S. and Shaw, S.	Designing curriculum to shape professional social media skills and identity in virtual communities of practice https://doi.org/10.1016/j.compedu.2016.11.002	Computers & Education
2016	Rajesh, M	Traditional Courses into Online Moving Strategy	Online Journal of Distance Education and e-Learning
2015	Gašević, D., Adesope, O., Joksimović, S., and Kovanović, V.	Externally-facilitated regulation scaffolding and role assignment to develop cognitive presence in asynchronous online discussions https://doi.org/10.1016/j.iheduc.2014.09.006	The Internet and higher education
2015	Zheng, B., Niiya, M., and Warschauer, M.	Wikis and collaborative learning in higher education https://doi.org/10.1080/1475939x.2014.948041	Pedagogy and Education
2015	Boticki, I., Baksa, J., Seow, P., & Looi, C.-K.	Usage of a mobile social learning platform with virtual badges in a primary school https://doi.org/10.1016/j.compedu.2015.02.015	Computers & Education
2014	Moore, T. J., Glancy, A. W., Tank, K. M., Kersten, J. A., Smith, K. A., and Stohlmann, M. S.	A Framework for Quality K-12 Engineering Education: Research and Development https://doi.org/10.7771/2157-9288.1069	Journal of Pre-College Engineering Education Research (J-PEER)
2014	Bers, M. U., Flannery, L., Kazakoff, E. R., and Sullivan, A.	Computational thinking and tinkering: Exploration of an early childhood robotics curriculum https://doi.org/10.1016/j.compedu.2013.10.020	Computers & Education

2013	Schleppegrell, M.J.	The role of metalanguage in supporting academic language development https://doi.org/10.1111/j.1467-9922.2012.00742.x	Language Learning
2012	Gedik, N., Hanci-Karademirci, A., Kursun, E., & Cagiltay, K.	Key instructional design issues in a cellular phone-based mobile learning project https://doi.org/10.1016/j.compedu.2011.12.002	Computers & Education
2012	Barab, S., Pettyjohn, P., Gresalfi, M., Volk, C. and Andsolomou, M.	Game-based curriculum and transformational play: Designing to meaningfully positioning person, content, and context https://doi.org/10.1016/j.compedu.2011.08.001	Computers & Education
2012	Kinash, S., Brand, J., & Mathew, T.	Challenging mobile learning discourse through research: Student perceptions of Blackboard Mobile Learn and iPads https://doi.org/10.14742/ajet.832	Australasian Journal of Educational of Technology
2011	van Schaik, M., van Oers, B., and Terwel, J.	Towards a knowledge-rich learning environment in preparatory secondary education https://doi.org/10.1080/01411920903420008	British Educational Research Journal
2011	Bodzin, A. M.	The implementation of a geospatial information technology (GIT)-supported land use change curriculum with urban middle school learners to promote spatial thinking https://doi.org/10.1002/tea.20409	Journal of Research in Science Teaching
2011	Schwarz, B. B., & Asterhan, C. S.	E-Moderation of Synchronous Discussions in Educational Settings: A Nascent Practice https://doi.org/10.1080/10508406.2011.553257	Journal of the Learning Sciences
2011	Dierdorp, A., Bakker, A., Eijkelhof, H. and van Maanen, J.	Authentic Practices as Contexts for Learning to Draw Inferences Beyond Correlated Data https://doi.org/10.1080/10986065.2011.538294	Mathematical Thinking and Learning

2011	Duncan, R. G., & Tseng, K. A.	Designing project-based instruction to foster generative and mechanistic understandings in genetics https://doi.org/10.1002/sce.20407	Science Education
2010	Ketelhut, D. J., Dede, C., Clarke, J. and Nelson, B.	A Multi-user Virtual Environment for Building Higher Order Inquiry Skills in Science https://doi.org/10.1111/j.1467-8535.2009.01036.x	British Journal of Educational Technology
2010	Looi, C.-K., Chen, W., & Ng, F. K.	Collaborative activities enabled by GroupScribbles (GS): An exploratory study of learning effectiveness https://doi.org/10.1016/j.compedu.2009.07.003	Computers & Education
2010	Jahnke, I.	Dynamics of social roles in a knowledge management community https://doi.org/10.1016/j.chb.2009.08.010	Computers in Human Behavior
2010	Lee, H.-S., Linn, M. C., Varma, K., & Liu, O. L.	How Do Technology-Enhanced Inquiry Science Units Impact Classroom Learning? https://doi.org/10.1002/tea.20304	Journal of Research in Science Teaching
2009	Stevens, S. Y., Delgado, C., & Krajcik, J. S.	Developing a Hypothetical Multi-Dimensional Learning Progression for the Nature of Matter https://doi.org/10.1002/tea.20324	Journal of Research in Science Teaching
2009	Angeli, C., & Valanides, N.	Epistemological and methodological issues for the conceptualization, development, and assessment of ICT–TPCK: Advances in technological pedagogical content knowledge (TPCK) https://doi.org/10.1016/j.compedu.2008.07.006	Computers & Education
2009	Mohan, L., Chen, J., & Anderson, C. W.	Developing a multi-year learning progression for carbon cycling in socio-ecological systems https://doi.org/10.1002/tea.20314	Journal of Research in Science Teaching
2009	Zhang, J., Scardamalia,	Designs for Collective Cognitive Responsibility in Knowledge-Building Communities https://doi.org/10.1080/10508400802581676	Journal of the Learning Sciences

	M., Reeve, R., and Messina, R.		
2008	Robertson, J., and Howells, C.	Computer game design: Opportunities for successful learning https://doi.org/10.1016/j.compedu.2007.09.020	Computers & Education
2008	Klopfer, E., & Squire, K	Educational Technology Research and Development https://doi.org/10.1007/s11423-007-9037-6	Educational Technology Research and Development
2008	Kurti, A., Spikol, D. and Milrad, M.	Bridging outdoors and indoors educational activities in schools with the support of mobile and positioning technologies https://doi.org/10.1504/ijmlo.2008.019767	International Journal of Mobile Learning and Organisation
2008	Lund, A.	Wikis: a collective approach to language production https://doi.org/10.1017/s0958344008000414	ReCALL
2008	Krajcik, J., McNeill, K. L. and Reiser, B. J.	Learning-goals-driven design model: Developing curriculum materials that align with national standards and incorporate project-based pedagogy https://doi.org/10.1002/sce.20240	Science Education
2007	Koehler, M. J., Mishra, P., and Yahya, K.	Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy and technology https://doi.org/10.1016/j.compedu.2005.11.012	Computers & Education
2007	Barab, S. A., Sadler, T. D., Heiselt, C., Hickey, D. and Zuiker, S.	Relating Narrative, Inquiry, and Inscriptions: Supporting Consequential Play https://doi.org/10.1007/s10956-006-9033-3	Journal of Science Education and Technology
2007	Ketelhut, D.	The Impact of Student Self-efficacy on Scientific Inquiry Skills: An Exploratory Investigation in River City, a Multi-user Virtual Environment https://doi.org/10.1007/s10956-006-9038-y	Journal of Science Education and Technology

2007	Squire, K. D. and Jan, M.	Mad City Mystery: Developing Scientific Argumentation Skills with a Place-based Augmented Reality Game on Handheld Computers https://doi.org/10.1007/s10956-006-9037-z	Journal of Science Education and Technology
2007	Barab, S., Zuiker, S., Warren, S., Hickey, D., Ingram-Goble, A., Kwon, E. J. and Herring, S. C.	Situationally Embodied Curriculum: Relating Formalisms and Contexts https://doi.org/10.1002/sce.20217	Science Education
2006	Mishra, P. and Koehler, M. J.	Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge https://doi.org/10.1111/j.1467-9620.2006.00684.x	Teachers College Record
2006	Echevarria, J., Short, D. and Powers, K.	School Reform and Standards-Based Education: A Model for English-Language Learners https://doi.org/10.3200/joer.99.4.195-211	The Journal of Educational Research
2005	Barab, S., Thomas, M., Dodge, T., Carteaux, R. and Tüzün, H	Making learning fun: Quest Atlantis, a game without guns https://doi.org/10.1007/bf02504859	Educational Technology Research and Development
2005	Puntambekar, S. and Kolodner, J. L.	Toward Implementing Distributed Scaffolding: Helping Students Learn Science from Design https://doi.org/10.1002/tea.20048	Journal of Research in Science Teaching
2005	Hull, G. A., and Nelson, M. E.	Locating the Semiotic Power of Multimodality https://doi.org/10.1177/0741088304274170	Written Communi-cation
2004	Sandoval, W. A., and Reiser, B. J.	Explanation-driven inquiry: Integrating conceptual and epistemic scaffolds for scientific inquiry https://doi.org/10.1002/sce.10130	Science Education
2003	Hickey, D. T., Kindfield, A. C. H., Horwitz, P.	Integrating Curriculum, Instruction, Assessment, and Evaluation in a Technology-Supported Genetics	American Educational

	and Christie, M. A. T.	Learning Environment https://doi.org/10.3102/00028312040002495	Research Journal
2003	Land, S. M. and Zembal-Saul, C.	Scaffolding reflection and articulation of scientific explanations in a data-rich, project-based learning environment: An investigation of progress portfolio https://doi.org/10.1007/bf02504544	Educational Technology Research and Development

Table 3-3. Included intervention studies in targeted reviews

The added distinctions reveal the following landscape of the types of studies included in the review (see table 3-4) with almost 3 out of 5 of the studies being intervention studies, a third containing repository studies and the remaining 10 percent being literature reviews.

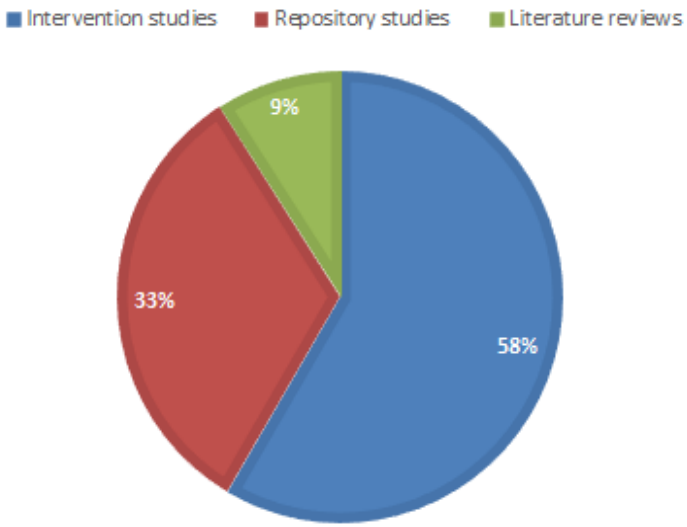


Table 3-4. Distribution of types of studies.

3.2.4. GEOGRAPHICAL DISTRIBUTION OF AUTHORS

The geographical distribution of authors is represented in table 3-5 in the original review. It clearly highlights the predominance of publications using DBR written by authors from the United States. The numbers are explained partly by the origin of the approach and partly by the fact that the journals with special issues on DBR are based in the United States.

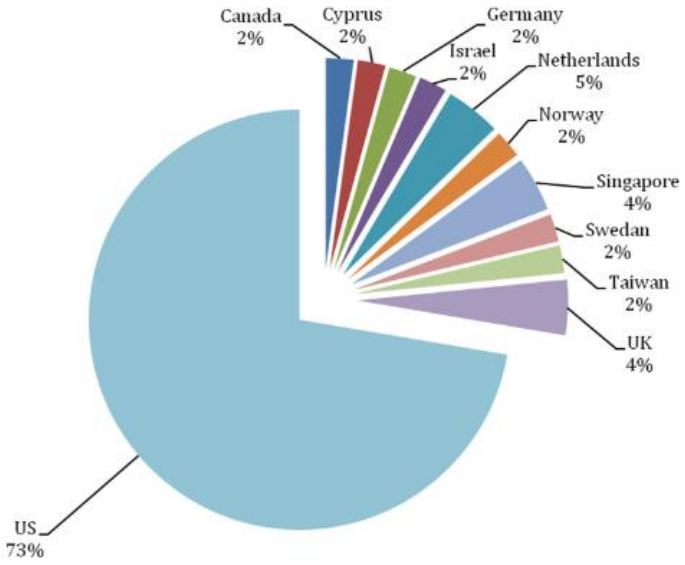


Table 3-5. Geographical distribution of authors (Anderson and Shattuck 2012).

When comparing the distribution in the original review with the numbers from the latest decade (2008-2017), a significant decline in percentage from 73% to 44% in the representation of authors from the US appears. In particular, authors from the UK, Northern Europe and the countries of East Asia are increasingly cited by others.

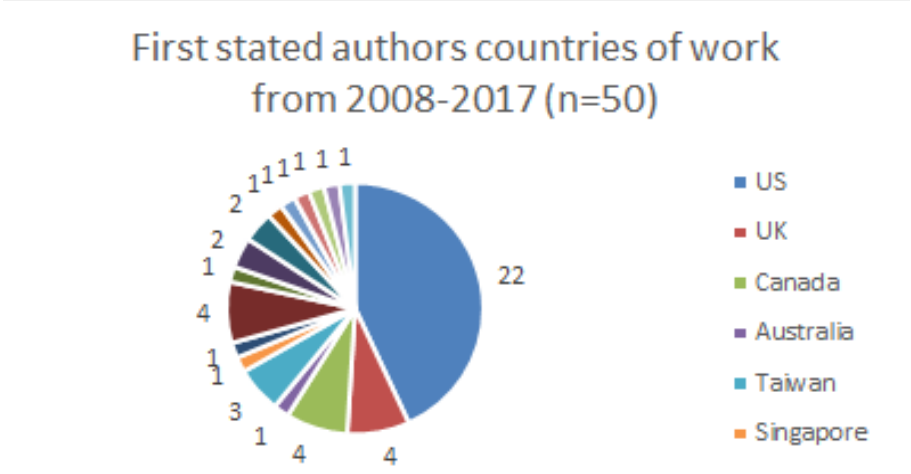


Table 3-6. Geographical distribution of authors 2008-2017.

The numbers indicate that there is a growing trend towards a globalisation of the approach. A number of regions with a strong representation in the DBR community, such as Scandinavia and the major English speaking countries the US, the UK, Canada and Australia, are nevertheless the predominant part of the contributors to DBR. The full picture of the years 2002-2017 is shown below.

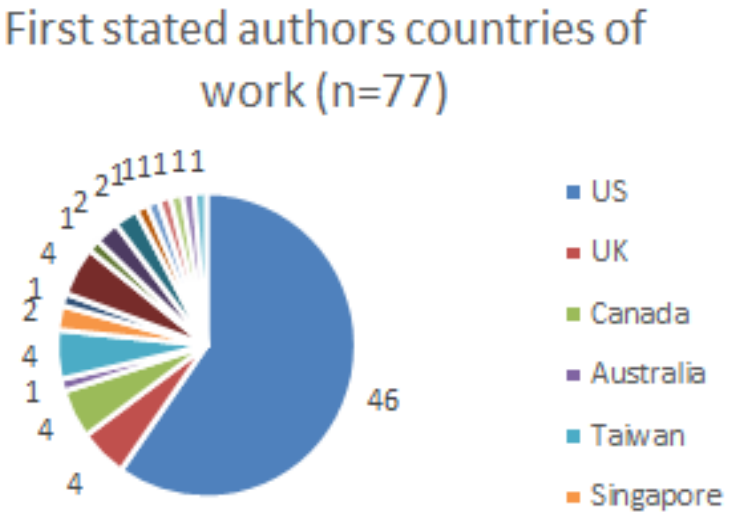


Table 3-7. Geographical distribution of authors all studies from 2002-2017included.

The skewness in representation of nationalities is of particular importance to this study as 'design' might have different connotations in the US and in other prevalent countries such as the UK, Canada and Australia when compared to, for instance, Northern Europe, especially within the field of education. Highlighting this potential bias in the written part of the data might help explain differences when compared to experiences and opinions expressed by Scandinavian design-based researchers and designers in chapters 4-7.

3.2.5. REVISITING THE SAME BODY OF TEXTS FROM FOUR DIFFERENT PERSPECTIVES

The 77 articles are reviewed four times during this dissertation each time with a new focus. Using the historical review to set the direction of the targeted reviews, I pursue in chapter 4 the questions of how DBR studies define the term 'intervention' and how the reciprocal relation between cycles of interventions are explained methodologically. In chapter 5, I revisit the same texts, but this time I look for when and why iterations occur, what the stated purposes for working iteratively in DBR are and what activities support these purposes? Next, in chapter 6, I explore what roles practitioners take on when collaborating with researchers in DBR projects and, lastly,

I investigate how design principles are developed and articulated in the DBR literature?

The 77 articles represent a systematic attempt to point out a canonical body of DBR literature from which a representable perception of a given phenomenon, in this case four activities related to design in DBR, can be analysed. The pool of texts represents popular opinions on how to understand and practice design related activities when conducting studies of DBR. They all, however, abide by the restrictions of the seminal journal format and thus I wanted to supplement the findings from these voices with actual voices from the field. In the following, I lay out how I piloted the interviews with the researchers.

3.3. INTERVIEWS

The second data set consists of a series of interviews with PhD graduates using DBR as an approach in their projects and workshops in different design milieus. Two out of four interviewees have finished their PhDs, while others were in the midst of their studies at the time. The interviews are semi-structured around topics covering the four main characteristics.

The PhD graduates cover vastly different types of interventions. One seeks to develop a MOOC (Massive Open Online Course) for the continuous professional development of midwives globally, another seeks to test and refine a digital teaching material for learning how to read in early primary school, a third study is concerned with designing a learning environment to close the apparent gap between practice and theory in teacher education and, finally, the last project revolves around the idea of creating good practices of e-learning in physiotherapy education.

One of the main reasons for choosing the different interviewees was that of diversity. In a mixed methods perspective this either means aiming at a richer, deeper or fuller picture of the understandings of design activities in DBR or aiming at highlighting discrepancies or tensions between what at first glance seems to be compatible research strategies.

I interviewed the researchers individually once and planned to do a workshop with all of them together. Due to personal reasons, one researcher had to decline and I ended up doing a joint interview with the two remaining researchers located in the western part of Denmark, while the last researcher was interviewed alone. In all sessions, I experimented with the use of recording sketching activities during the interviews.

3.3.1. EXPERIMENTING WITH VIDEO-SKETCHING TECHNIQUES IN INTERVIEW SESSIONS

Through three papers published in 2017 and 2018, I along with a small group of fellow researchers from Aalborg University developed an initial framework for mapping and understanding the potentials of using video in sketching activities (Gundersen, Ørngreen, Henningsen & Hautopp, 2018; Ørngreen, Henningsen, Gundersen & Hautopp 2017; Henningsen, Gundersen, Hautopp & Ørngreen 2017). Using backward snowballing (Jalal & Wohlin 2012) the framework was developed through readings of the literature and minor action research experiments from our own teaching and research (Greenwood & Levin 2007). A considerable part of the theoretical findings from this work can be found in chapter 5 as early iterations and sketching activities are tightly connected within the realm of design.

The empirical material consists of a number of cases. Most notably, we held a four hours workshop on a master studies programme, using video sketching in relation to the students' problem-based learning (PBL) projects. Approximately 75 students from the first semester at the Master of Arts (MA) in Learning and Innovative Change participated in the workshop. The formal objective was to use ICT as a medium for documenting and disseminating students' knowledge and lessons learning about learning and change processes in their problem-based learning (PBL) projects. As lecturers, we also saw the potential to let the students experience how they could learn from and be reflective about their work process as it unfolds, in order to illustrate that the process is just as important as the end product.

The other cases stem from design experiments and data gathering situations in our research, as well as similar teaching and competence development sessions with teachers and educational administrative personnel albeit in smaller scales. A more detailed description of these cases can be found in the three articles on video sketching mentioned above.

The framework consists of four different activities: shape, record, view and edit, and four different purposes: investigate, explore, explain and persuade (inspired by Olofsson & Sjölen 2007). These elements are combinable in different constellations and the media by which sketching activities unfold can vary. From our research, we see that video sketch facilitators and participants can move freely between these modes and maintain a predominantly investigate or persuasive approach depending on the objectives at hand. The framework is illustrated in the following way:

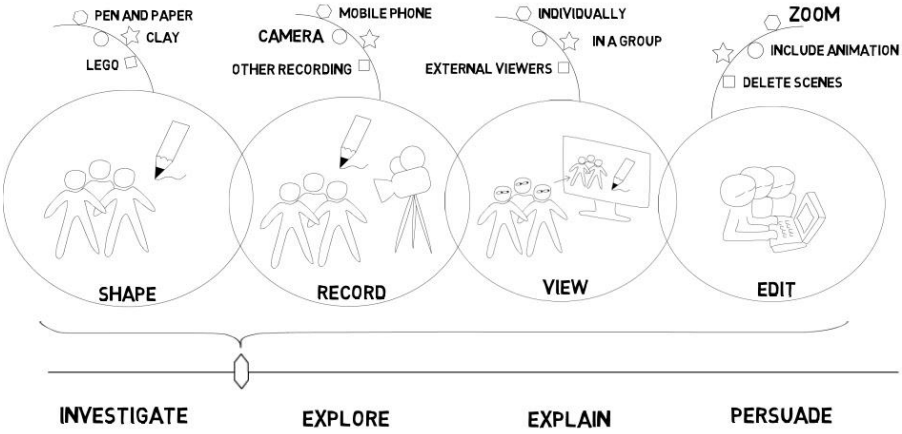


Figure 3-3. Video sketching framework (Gundersen, Ørngreen, Henningsen & Hautopp (2018), p. 521).

When interviewing DBR researchers, I experimented with aspects of the framework to support the reflexion processes of the informants. I made a setup for recording the interviewees' sketches during the interviews using a Stand Scan. A Stand Scan provides means to quickly record shorter sketching sessions by placing a recording device (e.g. a mobile phone) on top of the scanner and turning on the lights. The scanner provides a framing of the shot and the outcomes are short films showing only the sketching actions as illustrated below.

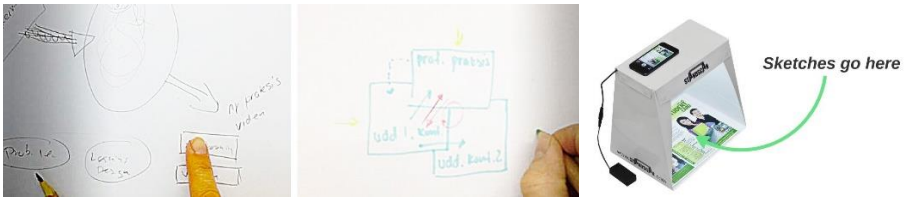


Figure 3-4. Stills from expert interviews using video sketching techniques and illustration of how Stand scan works

Later, I watched the recordings and as a preparation for the follow up interviews, I made small films to show to the participants as a means to start up a dialogue on specific topics of interest, thus applying a range of different combinations of activities and purposes present in the framework. Selected excerpts from the material were also used as exemplary illustrations during the workshop I held with design experts at the Umeå Institute of Design, which I will present later in this chapter. Firstly, however, I wish to highlight the struggles I had getting access to expert designers.

3.3.2. GETTING ACCESS TO DESIGN PERSPECTIVES

My initial plan was to interview an expert designer with a specialty in each of the four identified characteristics of design within DBR. In 2019, I contacted Jon Kolko (founder of Austin Center of Design) as an expert of design processes and interventions, Nick Sousanis (an Eisner-winning comics author and an associate professor of Humanities & Liberal Studies at San Francisco State University) as an expert within iterations and sketching and Richard Buchanan (editor of Design Issues and past president of the Design Research Society) as an expert of design theory and especially problem setting and solving. Although both Sousanis and Buchanan initially showed interest in my project and in setting up an interview, the communication ended when attempting to land a specific date. Kolko declined via email immediately. With these experiences in mind I concluded that I might have aimed too high and subsequently fell short.

Instead, I started looking for opportunities to visit milieus for a period, which house experts on design in order to facilitate workshops, do interviews or initiate informal conversations to help bring design perspectives on my project to life. I ended up landing agreements with The University of Southern Denmark in their department of Design and Communication as well as The Umeå Institute of Design. In both cases, the longer durations of the stays provided me with the opportunity to collect data in various forms as well as engage in activities otherwise only open for the staff present.

Most prominently, I did an online interview with prof. Johan Redström before visiting The Umeå Institute of Design and while I was there sat up a workshop with 10 participating researchers and PhD students. The workshop was organised as a mixture of presentations of challenges derived from the previously analysed data and discussions among the participants in smaller groups. Ørngreen and Levinsen (2017) define workshops as arrangements whereby groups of people learn, acquire new knowledge, problem-solve together or innovate in different ways in relation to a specific issue. They distinguish between perspectives of workshops as a means, as practice or as research methodology each representing levels of knowledge derived from workshop activities. The latter both aims to fulfil the expectations of the participants and their interests, while at the same time produce reliable and valid data concerning a specific research matter. Subsequently, the researcher arranging the workshops takes on the challenging act of balancing the dual role of being a facilitator prioritising participant needs and the role of ensuring the quality of material collected, as the participants become study objects. As I conducted the workshop, I was aware of the multiple roles I had to partake and provided space for the designers to reflect upon their own teaching as a design process as well as supporting the discussions in directions that could potentially accommodate the challenges identified in my data.

3.3.3. ON INTERVIEWING EXPERTS

In my project, I interviewed different researchers with various degrees of experience in working design-based. As mentioned, I interviewed four recently graduated or current PhD students who have based their projects on, or are inspired by, DBR and later, as described above, I interacted with design experts in various forms.

Interviewing experts is a subject of debate and is criticised for being frequently conducted, but only rarely thought through (Meuser & Nagel, 1991). Bogner and Menz (2009) contribute to shaping the debate by differentiating between various forms of expert interviews. Their typology identifies three different types of expert interviews, each intended for a different purpose; the exploratory expert interview is used primarily to provide orientation, the systematising expert interview targets the systematic retrieval of information and the theory-generating expert interview aims - in the spirit of qualitative social research - at reconstructing social interpretative patterns and subjective action orientation criteria (ibid., p.46). In my data collection, I draw on the latter type of expert interview where the goal is the communicative opening up and analytic reconstruction of the subjective dimension of expert knowledge. I seek to formulate a theoretically rich conceptualisation of (implicit) stores of knowledge concerning DBR, conceptions of the understandings of design, which the experts develop through their activities and which are constitutive for the systematic functioning of how design-based educational research is carried out. Through these interviews, I aim at generating theory on what is challenging when conducting DBR studies specifically in relation to design processes and, equally important, theory-based potentials for the future improvement of DBR practice.

In the following part, I describe my general strategy for analysing the material and integrating the different data sets.

3.4. ANALYSING DATA

According to Frederiksen (2013), several studies have in detail discussed reasons for mixing different sets of data, but relatively little has been said about how these types of data, methods and analyses are brought into contact with each other. One direction, however, is provided by Moran-Ellis (2006), who suggests that integration of data sets means creating a coupling or a bridge between parts enabling the researcher to move back and forth between them. An image to illustrate this is integrated systems of transport in which a person is able to change from subways and busses, trains and ferries using tickets that is part of a common structure. The integration does not mean that busses, trains and ferries have grown to become alike, neither do they form a new type of unit; rather they function through a dynamic relation.

In this study, I bring the different datasets together using in vivo coding (Vollstedt and Rezat 2019) and abductive reasoning. Procedures of in vivo coding and its

nomenclature may vary depending on which grounded theory methodology one chooses to follow. I follow Strauss and Corbin (1990) who differentiate between three kinds of coding procedures: open, axial and selective coding. Each procedure embodies different ways of working with data and the researcher can in line with abductive reasoning move back and forth between the three if needed. In each of the targeted reviews, I read and open coded the full articles and supplemented the codes with a search for the key term in question, i.e. intervention, iteration, collaboration or principle, using the qualitative data analysis software tool NVivo to help track, record and quantify my codes. From there I began the axial coding processes linking, clustering and creating new categories, as patterns emerged, in some cases inspired by the historical review. Lastly, I integrated the newly developed codes into cohesive theoretical patterns that could be presented in the dissertation. To give a few examples, in chapter 4, the key term intervention was coded in various different ways to begin with including length, context, in which part of the article it appeared, participants, etc.,each with their own set of subcategories. During the axial coding processes, the term enactment emerged as a frequently used term in relation to intervention. I therefore opted to do an additional search for the term in all of the articles to cover the meanings of the term across the whole review literature body systematically. Similarly, the key term iteration appeared in various forms and in relation to an array of purposes and actions. Linking subcategories of purpose for iterating led to three new overarching categories of what DBR researchers report as reasons for progressing in iterative cycles that would not have been possible without the processes of in vivo coding. The full coding strategies for the four targeted literature reviews are presented separately in each of the relevant chapters.

In order to describe the integration of the data sets, I lean on the two previously described images of the archipelago and the system of transport. Although the approach I have described in this chapter (see fig. 3-1 and 3-2) might present itself to some readers as linear due to the dependency between data sets, the coding processes and reasoning processes leading to the findings presented in the dissertation have been everything but linear. Dependency is thus to be understood in a dynamic sense where later analyses would foster questions to be examined or refined in a previously analysed set, inspiring me to travel back and revisit the material armed with a new perspective. Using the images one could say that I travelled back to an island I had already visited, but this time using a different vehicle to get there (and maybe wearing a different set of sunglasses). This does not mean that the choices I took and the routes I travelled did not have an impact on the knowledge I gained. Had I for instance started by interviewing expert designers, then researchers conducting DBR studies and finally reviewed seminal DBR articles, the results presented in this dissertation would undoubtedly have been different. The journey, however, does reflect my choices in relation to the two challenges I described in the beginning of the chapter. Firstly, that I wanted to start grounded, but informed, from the DBR approach itself and, secondly, that working with a mainstream voice in the form of 77 highly quoted articles would leave perspectives hidden under the murky surface of the water.

CHAPTER 4. DESIGN CHARACTERISTIC ONE – INTERVENTION

In this first of four parts concerning different activities related to working design-based, I look into the interventionist nature of the approach. As it is clear from the historical overview in chapter 2, interventions in DBR can refer to a variety of experiments in everyday educational settings. The practical contribution and the knowledge claim following a DBR study (especially development studies) might surpass the specific classroom or learning situation and encompass a school, a curriculum or an educational format. Interventions vary in time span from weeks to full years. Furthermore, the aim of DBR studies can be different depending on the approach of the research, which may aim to validate a theory or develop a practice and, as a way of avoiding design blur, one can distinguish between intended, implemented and attained designs.

Pivotal as the term *intervention* appear to be in the field not much can be deduced about the theoretical understandings of how interventions are to be understood or connected. It is clear that each intervention is somehow related to the next and that for each intervention, the principles directing the intervention are refined through iterative cycles. However, Zheng's (2015) analysis of interventions across numerous DBR-studies, hints that there is a trending tendency towards not providing the details of the revision processes of the interventions carried out when reporting DBR studies. In other words, the process of how and why one intervention is refined in the next intervention remains a black box.

In this chapter, I wish to explore the theoretical notions of interventions in DBR further and aim to explore the challenge of defining the reciprocal relation between different intervention strategies. I therefore search through the selected body of literature in an attempt to answer the following questions:

- How is the concept of intervention defined?
- On what theoretical basis is it construed?
- How is the reciprocal relation between cycles of interventions methodologically explained in DBR projects?

4.1. CODING STRATEGY

Before searching through the articles and coding them, I did a preliminary search to ensure that the word *intervention* was present in a large enough percentage of the

articles to pursue the questions posed above. Furthermore, I wanted to see if searching for a similar word like *experiment* or a word likely to appear close to *interventions* or related words, as for instance *context*, would offer richer text paragraphs to read and code.

Following this line of thought, I separated the NVivo text searches in the 77 papers using the following three stemmed keywords:

A: intervention
B: context
C: experiment

Option A yielded 65 papers and 597 references. A random and selective sampling by hand resulted in papers all related to DBR-interventions in the study or mentionings of the notion in reviews or repository articles. Option A OR B with stemmed words yielded 75 papers and 2028 references. However, the returned search results seemed to be broad and included a high number of search matches related to different uses and forms of the term 'context'. Option A OR C with stemmed words yielded 75 papers and 1910 references. The returning results were more directly concerned with the types of interventions compared to the previous search. Additionally, some studies use the word 'experiment' exclusively rather than 'intervention' to describe the nature of their inquiry. On a final note concerning the preliminary search, the two articles that were not included in the A OR C search results, turned out to be papers that had non-searchable PDF files. Furthermore, a closer look at all the PDFs revealed a paper which was a book chapter, not a journal article, and it was therefore replaced by the next on the list of the most quoted articles.

I thus initially chose to apply the A AND C results and began analysing the papers. However, the very first paper primarily related to the term 'experience' rather than 'experiment'. Consequently, I made a number of searchers with exact word matches instead of stemmed searches. A OR C with exact matches yielded 68 papers and 541 references, including a large portion with one reference only:

A. intervention, with exact matches yielded 50 papers and 310 references

A. interventi*, with exact matches yielded 66 papers and 545 references

A. intervention OR interventions yielded 66 papers and 526 references

My conclusion based on this information was that there is a high probability that searching for interventi* with exact matches would include the two words *intervention* and *interventions*, and not much more. Moving on to *experiment*, the searches gave the following results:

C. experiment with stemmed words yielded 77 papers and 1374 references

C. experiment with exact matches yielded 44 papers and 231 references

C. experim* with exact matches yielded 67 papers and 787 references.

The last search with the search word experim* avoids reference to experience and thus presents a more concise picture of relevant appearances of *interventions* and *experiments* in relation to how these concepts are theoretically construed.

Searching for interventi* OR experim* thus yielded 75 papers and 1332 references. Two papers, Angeli and Valanides (2009) and Rajesh (2016), did not contain any of the two terms. As for the latter, 'design experiences' and 'formative and developmental research' are terms used to describe the approach of the study, whereas Angeli and Valanides use the terms 'iterations of modifications' and 'cycles of fine-tuning' to describe the different interventions that took place during the five years the project ran.

Based on these initial searches, I applied a coding strategy for the 1332 references where I would read 5-10 lines before and after the match and from there determine the theoretical basis of the use, i.e. look for references. The initial code tree was revised after each of the categories were coded once. An early issue concerning the coding strategy was the fact that one of the most used references Brown (1992) includes both interventi* and experim* in the title. This made the code 'part of literature list' a significant code in terms of occurrences. Another code, 'participants experimenting' which entailed participants experimenting with various subject-related materials during the observed intervention periods, showed that even though I made initial efforts to narrow down the scope of the search terms I still received hits that did not directly relate to my object of study.

The next part follows the logic of first presenting the findings from the intervention studies in order to provide as grounded an analysis as possible. The findings from the repository texts are then presented as either suggestions for fitting categorisation ideas or discrepancies between the theory explained and the interventions carried out. Finally, the reviews offer either further solidification of findings in the earlier categories or new perspectives from other fields of research.

4.2. FINDINGS FROM INTERVENTION STUDIES

The interventions in the 45 studies vary to a large degree in terms of contexts, duration and object of study. The complete overview can be found in the "supplemental data intervention studies" spreadsheet. Interventions mainly take place in primary or secondary school settings. The most prevalent school subjects are science and math

but non-subject areas such as computer games are also present. A smaller group of studies analyse higher education such as nurse and teacher training.

In addition, the length and the number of iterations differ. Interestingly, when comparing the updated data to the original Anderson and Shattuck supplement data, the authors seem to conflate duration of a project, the amount of interventions and the phases treated as part of the study. All these different aspects are put into the data sheet in the same category labelled *iteration*.

4.2.1. MINIMAL AND TRANSFORMATIVE INTERVENTIONS

The scope of the interventions in the different studies also vary to a large degree. This includes not only the size of the intervention context, as discussed previously in relation to how DBR evolved from classroom settings to - in some instances - reforming school curricula, but also to the degree of disruption the researchers seek to cause in the existing context. Consider the reasoning behind choosing a DBR approach as intervention strategy in this case:

> 'The primary reason DBR was selected as research methodology was that there is no manipulation of experimental conditions. The students, as volunteer research participants, spent no more time than normally spent engaged in class activities, and the conditions of the study were naturalistic, or what one would ordinarily expect in a university classroom facilitated by this particular educator. The only difference was that a loan scheme ensured that all students had use of iPads loaded with Blackboard Mobile Learn and an electronic version of the assigned textbook.' (Kinash et al., 2012, p. 643)

Then compare it to the ambition of socially responsive design work as put forward by Barab et al. (2007):

> '...socially responsive design work involves engaging participants in activities that expose inequities, stirring interest in complicated issues and stimulating local ownership over the entire process. Socially responsive design work brings together critical ethnography, instructional design, and social activism with a focus on producing a designed artifact and process that has at its core the goal of facilitating individual and societal transformation.' (Barab et al., 2007, p. 92)

In the first instance, emphasis is put on a *minimal* degree of disruption; as students spent no more time than they normally would, there is no manipulation of experimental conditions and the conditions of the study are described as naturalistic. The authors stress that the only difference was that a loan scheme ensured access to iPads for the students. In contrast to this, the latter excerpt shows how the authors aim at individual and societal transformation. The authors link the process of the

intervention to critical ethnography and social activism. Not only does the intervention strategy seek to engage local ownership, it directly aims at exposing existing inequities.

The figure below is an attempt to illustrate this dichotomy in intervention strategy as the circle in the middle represents a context yet to be exposed to an intervention. The circle to the left is exposed to a minimal degree of intervention and the shape to the right is undergoing transformative changes due to the degree of the intervention.

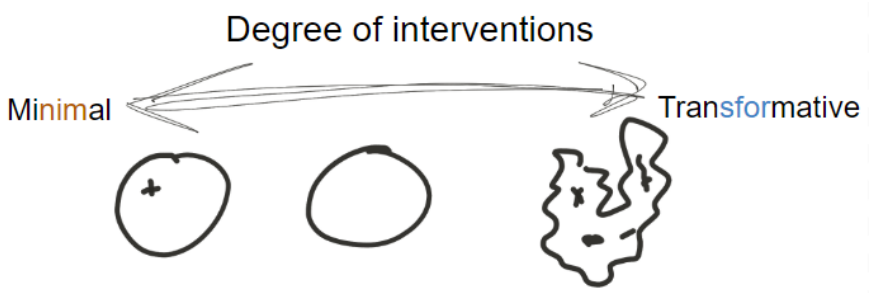


Figure 4-1. Degree of intervention between minimal and transformative

While the two examples represent extremes at the opposite sides of the spectrum, the differences help highlight the diversity of what DBR studies label as intervention. Between the two positions, a key term for discussing interventions in the reviewed studies is the concept of *enactment*.

4.2.2. ENACTMENTS

A prevalent term in the studies related to the realisation of principles, hypotheses or theory is enactment (Hickey, Kindfield, Horwitz & Christie, 2003; Krajcik, McNeill & Reiser, 2008; Schwarz & Asterhan, 2011; Lee, Linn, Varma & Liu, 2010; Bodzin, 2011; Duncan & Tseng, 2011; Schleppegrell, 2013). At first glance, enactment seems to be synonymous with the previously introduced idea of the implemented design. Duncan & Tseng (2011) writes:

> 'The enactment lasted 5 weeks during the late fall and early winter of 2003–2004 and closely followed our intended design.' (Duncan & Tseng, 2011)

In other words, the intended design of the authors was quite similar to the implementation of it, which was realised through a 5 weeks enactment period. This is also the case in Bodzin's (2011) article where 'the enacted classroom curriculum was consistent with the intended designed curriculum' (p. 288). We saw earlier that the notion of implemented design stems from curriculum research and a majority of the references trace back to the enactments of curricula (Hickey, Kindfield, Horwitz &

Christie, 2003; Barab, Sadler, Heiselt, Hickey & Zuiker, 2007; Bodzin, 2011; Duncan & Tseng, 2011). Lee, Linn, Varma & Liu (2010) speak of classroom enactments where evidence is drawn to refine design experiments and Barab, Sadler, Heiselt, Hickey & Zuiker (2007) explore the potential of a multi-user virtual environment where participants are able 'to enact collaborative learning activities of various types' (p. 60). Hickey, Kindfield, Horwitz & Christie (2003) explain how an assessment team and a development team in collaboration look for opportunities to build understandings of various curricular enactments in a range of implementation contexts. These references indicate that enactments cover a range from smaller contexts, e.g. learning activities and classroom environments, to plentiful contexts affected by curriculum change. The understanding also seems to be that a particular enactment is something that unfolds in a context and includes more than one agent.

There are, however, also examples of enactment or enacting tied specifically to teachers (Looi, Chen & Ng, 2010; Lee, Linn, Varma & Liu, 2010; Schwarz & Asterhan, 2011) or teaching materials (Squire & Jan, 2007; Krajcik, McNeill & Reiser, 2008). Schwarz & Asterhan (2011) speak of a teacher enacting different strategies when moderating discussions and Lee, Linn, Varma & Liu (2010) mention how teachers are scaffolded as they learn to enact inquiry teaching. Uniquely, Looi, Chen & Ng (2010) employ the term related to an activity and add 'with good teacher facilitation' (p. 18). It is unclear whether this use of the term implies that the teaching is part of the enacted activity or should be seen as a supplement to the enactment. With regards to teaching materials, examples from the studies cover how researchers investigate materials as enacted by teachers and students (Krajcik, McNeill & Reiser, 2008), classes where a software tool referred to as an innovation is enacted (Hickey, Kindfield, Horwitz & Christie, 2003) and lastly how an augmented reality game was designed and enacted (Squire & Jan, 2007). For all of these cases, it can be argued that the participants play a part in the enactment and that the usage of the term does not differ much from the classroom examples presented above.

Enactment thus seems to be tied to the understanding that an intended design solution is implemented through agents (often teachers but not exclusively) acting according to the intention of the innovation in various contexts. This summary is in line with how the Design-Based Research Collective (2003) defines interventions:

> 'We see interventions as enacted through the interactions between materials, teachers, and learners. Because the intervention as enacted is a product of the context in which it is implemented, the intervention is the outcome (or at least an outcome) in an important sense.' (Design-Based Research Collective, 2003, p. 5)

McKenney and Reeves (2012) further elaborate on this as they stress how planned and unplanned processes take place when interventions are played out during enactment. Enactments are shaped by the intended intervention, the context in which they are situated and the manner in which they are introduced. A way to distinguish

enactments from each other is by the level of fidelity. An enacted intervention have a high degree of fidelity in cases where the intended intentions, methods and strategies remain intact.

Side effects caused by the enactments can include both benefits and negative consequences. Adaptions can be counter-productive and lead to lethal mutations. Similarly, mutual adaption can occur when practitioners meet the goals of interventions in different ways than those conceived by the designers. An example of a lethal mutation from the reviewed body of literature is Zhang, Scardamalia, Reeve and Messina (2009) where the teacher decides to abandon a fixed small-group structure altogether in favour of all students starting with the same top-level goal.

A popular understanding of interventions in DBR studies is thus tied to the enactment of intended interventions in various contexts, where the agents playing it out can influence, change and even put design ideas in the grave. Following this line of understanding, one can deduce that an intended design of an intervention must provide at least some kind actionable instructions for educators and teachers in order to be enactable. At the same time, the nature of the guidelines must have enough wriggle room for the practitioners to adapt in situ. I will return to this point in Chapter 7 where I discuss the nature and structure of design principles. Furthermore, the fidelity and adaption aspects of enactment imply that there is a mutually dependant knowledge flow between design ideas and the bodily realization of them, which is a topic I will elaborate further on when discussing the potential of early iterations in Chapter 5.

4.2.3. LACK OF TERMONOLOGY CONCERNING REVISION PROCESSES

The main part of the intervention studies provide some level of information on research design and the revisions that set apart one intervention from the next. However, there seems to be no terminology that provides insights into the strategy of the researchers in terms of how one intervention affects another. In other words, in what way developed solutions are designed to synergise with one another from a knowledge gain perspective when tested through enactments.

When authors in DBR describe their research design, they use terminology from classic research design (longitudinal studies, case studies, etc.). I start by giving examples illustrating longitudinal and cross-sectional studies followed by case studies.

Mohan, Chen & Anderson (2009) present a research study where three different locations in Michigan, California and Korea form a cross-sectional design involving students at different grade levels. In contrast, Lund (2008) applies a longitudinal approach using the same group of 31 students over 2 semesters in his attempt to develop a collective approach to language production using Wikis. In the case of

Barab et al. (2007), the reported findings are based on a longitudinal study following the same group of 28 gifted 4th graders, but the authors express a wish for comparing results from a lesser gifted group of pupils to see whether ordinary students would benefit in similar ways from the intervention.

Land and Zembal Saul (2003), van Schaik, van Oers and Terwel (2011), Klopfer and Squire (2008), Koehler, Mishra and Yahya (2007), Squire and Jan (2007), Robertson and Howells (2008) and Sandoval and Reiser (2004) all present some form of case study framework for their work. The cases cover a span from individual pupils (Robertson & Howells, 2008), teacher pairs (Land & Zembal Saul, 2003), teams of students, in some instances including teachers (van Schaik, van Oers & Terwel, 2011; Squire & Jan, 2007; Klopfer & Squire, 2008; Koehler, Mishra & Yahya, 2007) to whole classroom interventions (Sandoval & Reiser, 2004).

Across these general descriptions of the overall research design, more weight seems to be put on which clusters of participants take part in different interventions as opposed to in what way the interventions are connected. In other words, neither cross-sectional, longitudinal nor case studies by nature indicate how researchers plan to revise interventions or how one intervention ties into the next from a design perspective.

Two studies (Zheng, Niiya & Warschauer, 2015; Moore et al., 2014) provide thick descriptions of each iteration of their designs. Both articles describe the iterations carried out chronologically, but differ quite substantially in terms of how iterations link to interventions. One study seems to understand intervention synonymously with iteration:

> 'The third iteration was conducted in fall 2008. Participants in this activity were 48 female and 21 male undergraduate students. The wiki platform chosen in this activity was Mediawiki. Based on the feedback from the previous two iterations, this design consisted of three phases: group forming, composing and editing, and discussion. The topic of this activity was Google products. Similar to Iteration 2, students were asked to sign up for a sub-topic; individuals who signed up for the same sub-topic formed a group.' (Zheng, Niiya & Warschauer, 2015, p. 364)

Iterations are conducted over a period with participants, and the authors refer to them as events in which the students enact different activities much like how interventions are enacted as accounted for above. However, the method section reveals that an iteration entails (re)design, implementation, data collection and evaluation in a cycle repeated four times. The authors provide no reasoning behind the amount of iterative cycles or how they were meant to interlink from the beginning of the project.

Moore et al. (2014) provide a more detailed view into the framework of their revision processes. They plan iterative cycles of revision using the phases of *problematic*

situation, conceptual foundation, product design, and *system of use* to develop an engineering education at K-12 level. Especially the third phase, *product design*, is of interest as this is where the study aims to develop the framework for the education through interventions. The authors take the reader through five iterations from the initial conception of the framework (as none existed previously) and testing in a controlled setting, to the application of the framework to all 50 states' science standards documents in its current form. Immediately, a strategy of spread is apparent when comparing the development of the curriculum from iteration to iteration. A single state took part in the first test, 15 in the second and as mentioned 50 in the last test. Another purpose across the five interventions is evaluation according to subject knowledge and legislation. The framework was tested through engineering expert review, stakeholder feedback and state academic standards. The study represents a strategy of combining expert knowledge feedback (also beyond the members of the research team), multiple contexts and feasibility in practice. The authors state that the testing of the framework is also a test of the underlying theories that went into its development and that these tests required different research methods. The combined strategy for testing these strategies within their production design phase is not described.

The two studies show how detailed descriptions of revisions processes are indeed possible within the seminal article format but, at the same time, that a fitting vocabulary for describing the overall design intervention strategy might be missing. What DBR studies instead seems to grab for are traditional ways of describing research design that mostly cover which clusters of participants take part in different interventions.

4.2.4. SUMMARY OF REVIEW FINDINGS

The review pictures a diverse landscape of what interventions in DBR can be in terms of contexts, duration and object of study. Also, the degree of disruption vary from minimal intervention strategies with little manipulation of experimental conditions to radical intervention strategies where researchers aim at individual and societal transformation as well as exposing existing inequities.

A prevalent theoretical term for understanding interventions in DBR is enactment where an intended design solution is implemented via agents acting according to the intention of the proposed innovation. The way agents adapt an intended design can result in both beneficial and counterproductive mutations. The level of fidelity is a way of describing and evaluating to what degree an enactment is carried out in alignment with the intentions of the designers.

In relation to revision processes, there seems to be no terminology that provides insights into the strategy of the researchers in terms of how one intervention affects another. More weight is put on which clusters of participants take part in different

interventions as opposed to in what way the interventions are connected. The interventions in DBR studies are described by using traditional research design terms such as case studies, longitudinal studies, cross-sectional studies, etc. A fitting vocabulary for describing the overall design intervention strategy remains absent.

The findings from this review function as a basis for discussing challenges and potentials in the next part where experts within DBR and design research have room to express their perspectives on interventions.

4.3. VOICES ON INTERVENTIONS

In the following, I present how different experts within the field of DBR and design research understand the concept of intervention. I start by presenting the voices of four researchers who in their respective PhD dissertations either worked directly with a design-based intervention strategy or were heavily inspired by DBR. I did two rounds of interviews where the first gave room for the experts to express their ideas of how they see the role of interventions in DBR. In the second round, the interview questions were either specifically targeted at confirming or adjusting my understanding of their statements from the first interview or took the form of invitations to explore potentials of accommodating challenges I had identified between the two rounds of interviews. I incorporate the different design research experts from the milieus in Kolding and Umeå when discussing the potentials related to interventions.

4.3.1. DEVELOPING A PRODUCT AND THE SIGNIFICANCE OF CONTEXT

When I interviewed the four DBR researchers the first time, I asked them very openly how they understand the notion of intervention. Their answers showed great diversity and in some cases revealed that interventions in isolation are complicated to account for.

Researcher A maintains that even though she developed a MOOC, the course run on the platform was not itself the intervention. The intervention was the complete learning design and the guiding principles behind the MOOC. She explains:

> Researcher A: ‘The intervention is the learning design. That is at least how I think of it.’
>
> Interviewer: ‘So it is the MOOC?’
>
> Researcher A: ‘It is the course, yes.’
>
> Interviewer: ‘So the course is an intervention?’

> Researchers A: 'Yes, but then it is not by itself, because it is everything…it is the way it was developed. It is the way the pedagogy is linked to everything that is supposed to happen.'

Later, the researcher seems to lean more towards the idea that the course is the intervention.

> Researcher A: 'I would say that the intervention… it is… it is the fact that if I had not done this, it would never have happened. This course would not have been realized if I had not had the idea and then sat down and developed it.'

And later to further ratify the point:

> Researcher A: 'It is the fact that it happens! What actually occurs. It is the fact that this international MOOC for midwives was developed and that the professionals have the opportunity to learn from each other and meet, to interact and to become competent in evidence-based midwife practice.'

In the end, the idea of developing a low-tech MOOC accessible for as many professionals as possible around the globe is what defines the intervention, more than it is the theme of evidence-based practice and the specific target group of midwifes.

> Researcher A: 'In principle, the course could have been made for another profession. If you change some of the articles on midwifery to texts on nursing, occupational therapy, physiotherapy, it could have been targeted for another group. And in principle it could have been about something other than evidence-based practice.'

When framed this way, the intervention, for her, is more akin to an event rather than a course focusing on the subject-related needs of a specific target group. The intervention is driven by the guiding principles of *easy to use, low requirement of bandwidth* and *general accessibility*, which aims at gathering professionals from all over the world to learn from each other. The intervention takes the form of a designed event where social interaction can occur cross time and space with the aid of technology.

Very different in scope is the teaching material developed by researcher C. When asked about the nature of his intervention, he explains:

> Interviewer: Would you say that you have developed an intervention?
>
> Researcher C: 'No, I would say that all these considerations about… all the consideration that would normally be part of an intervention, right? Those actions you are trying to implement… those interventions… they are in reality embedded in the teaching material and the teacher's guide.'

In an attempt to understand the relation between material and context, I ask about the term 'embedded'.

> Researcher C: 'I have developed a digital teaching material, which has a clear intention and which facilitates that the processes, which I presume strengthen the learning objectives the material aims to fulfill, can actually happen. So partly, there is a user design for the teacher and the pupil, which leads them towards a situation, which is embedded in the teaching material or is produced by the material. For instance, when teaching literature where pupils get to read meaningful texts, discuss meaningful texts even though they might not technically be at a level reading wise where that would be possible or make sense.'
>
> Interviewer: 'This makes me very, very curious. So if for instance, the context in one case was the school, or maybe even a classroom, and in another, it was home? Then it makes no difference because it is embedded in the product?'
>
> Researcher C: 'Yes, it does because the teacher plays a crucial role in scaffolding and there is a complete teacher's manual or a video guide for what the teacher must do in relation to the pupils to support them. Nevertheless, if they had someone else in their home, a mother or a father, who was acquainted with what it takes to support the pupil through the processes and what the pupil need to focus on, then it would not make that big of a difference apart from the classroom dialogue, which is also a part of it.'

The intended lack of interest in the context and the possible social interaction between the pupils is both the weakness and the strength of the intervention. For researcher C every pupil is an isolated case, and what he studies is the interaction between the learner and the material.

A possible way to explain the different approaches taken by the two researchers is through the scope of validation studies and development studies. Through his study, researcher C explores the hypothesis that a certain theory of change, if embedded in a teaching material, would outperform the existing teaching materials for developing reading skills currently available on the market. Similar to validation studies, his starting point is theoretical. In opposition to this, researcher A is inspired to develop her MOOC based on opinions raised by practitioners at the International Day of the Midwife. It is the urgent need for the professionals to educate themselves continually and the scarce opportunities to exchange experiences with other midwives, which prompt the idea to develop an open, online course. Where researcher C seeks to validate a theory, researcher A aims at solving a problem identified by practitioners.

4.3.2. DEVELOPING A PROCESS AND UNDERSTANDING A CULTURE

Common for researcher B and D is that their interventions do not entail a materiality. What they design are processes of educational relevance. Through the interviews, I pursued how designing those processes might differ from designing products.

> Interviewer: 'What would you say you design?'
>
> Researcher D: 'How to teach.'
>
> Interviewer: 'Is that different from designing a cup?'
>
> Researcher D: 'Yes, because it is a process you design. The process you try to design, or lay out a plan for, it is never finished. It will always be something that can be changed. Some students may do something different from what you expect, so it never becomes a finished product, even though it may appear to be one when you have developed a course plan.'

For researcher D the intervention is what comes before the enactment. The product she designs takes the form of a plan that can take multiple forms when realised.

> Researcher D: 'Designers might say what they design is a drinking process, but if I were to compare the cup [with her own learning design], then it is the artifact you have designed and in a learning design it is a draft for a process, which may or may not unfold on the basis of the plan, but you might also just build on the plan… or eventually everything might happen.'

Enactments are simply variations of the initial plan that unfolds based on the original draft, a draft that exists only for practitioners to build on. In a sense, what researcher D designs is always in a sketching phase as she is more interested in the process and the context than the final design.

> Researcher D: 'In reality, this is what I am interested in the most through this process. The fact that you gain knowledge on everyday practice. In reality, I am less interested in the design itself, well that interests me as well, but I am really interested in the context in which the design can emerge.'

According to researcher D, collaborating on interventions with practitioners works as a catalyst for shaking up existing understandings and thereby as a researcher you gain insights on how people think and feel.

Initially, however, researcher D had a different intervention strategy in mind. She explains:

> Researcher D: 'In any case, the idea was that I would begin with the physiotherapists, then the nurses, then maybe the teachers, with the aim of saying something general on how e-learning influences the development of professional identity.'

This strategy resembles a comparative strategy somewhat similar to a number of the research designs, including case studies, among the review texts presented earlier. At some point during her study, she decides to abandon this strategy and chooses to focus only on the physiotherapists. In other words, she abandons one intervention strategy for another. I will return later on in this chapter to what this new approach entailed.

When asked about interventions, Researcher B self-critically doubts whether DBR, to the standards he upholds, is actually how he would label his own work.

> Interviewer: 'Would you say that you have designed an intervention?'

> Researcher B: 'Yes, in fact to a degree that I nearly decided not to label my study a Design-Based Research project and instead use the term a sociocultural intervention project.'

The reasoning behind this is researcher B's respect for designerly ways of working and how he finds that the design term is often misused. Suddenly, a hairdresser is a hair designer and so on.

> Researcher B: 'If you want to maintain the term design, and this is a part of what I said to begin with, then in the minds of people within the field of design, there is something called sketching, something called co-creation, something called co-designing, which is different from co-creation, and there is a lot in prototyping, and that is also why I deliberately said, that the prototype part is something I have not taken into account because it is simply a… it is something I lack in my own approach to DBR. Because I simply did not have sufficient knowledge on design as a term.'

In contrast to the claim in the historical overview put forward by Rowland (2007) that researchers of DBR consider design skills as an inherent capability, researcher B lists a series of pivotal design actions that are not incorporated in his own practice. Therefore, he is reluctant to claim that he has designed an intervention, but would instead use a lesser design-heavy term such a 'pedagogical intervention research'.

In the second round of interviews, he returns to his position in relation to DBR and the purpose of his intervention strategy.

> Researcher B: 'I establish a design to create premises to study something different and, Peter, I remember the first time we spoke the two of us, that you can have different paths within DBR, and I postulated that you can distinguish between three, right? The one that is all in on studying a

> teaching material, a design, how a design works and through that doing formative evaluations. In the other end of the spectrum, someone who tries to change a practice and finally there is the path of building a design to study, how to put it, maybe in reality something that lies between the socio-material and the sociocultural and that is the approach I have had. We have developed a learning design to be able to study how students transform knowledge and the design is important because without it, we could not have studied it, right?'

Through these three paths researchers B defines his purpose of doing interventions as either something in the middle or perhaps in a different spectrum between the radical intervention strategies as touched upon earlier and a broader category of either minimal or material-driven design intervention strategies. What researchers B implies is that much like researcher D, he intervenes not to design the best solution to a problem but to understand a context or a culture.

At this point during my project, I struggled to grasp the underlying intervention strategies of these diverse accounts of interventions. Along with the rest of the DBR field, I did not have a language to frame and thereby ask my informants directly about their strategy.

4.3.3. DRIFTING AS A POTENTIAL FRAME FOR REVISION STRATEGIES

During my stay at the Southern University of Denmark, I had numerous formal and informal discussions on design and the implications of working design-based in educational research. A breakthrough in relation to understanding revision processes in a design-based project was through an informal discussion with an associate professor at the Institute of Design and Communication. He pointed to a paper, he along with a group of fellow colleagues had published back in 2015 while reviewing the dissertations of PhDs in design in an attempt to grasp the progression of the studies theoretically. The term they used was *drifting* and in the initial discussion, he sketched out three different kinds of drifting on a piece of paper (see fig 4.2 below). The published typology, however, entails five different ways of drifting when researching through design (Krogh, Markussen & Bang, 2015). The five typologies are accumulative, comparative, serial, expansive and probing.

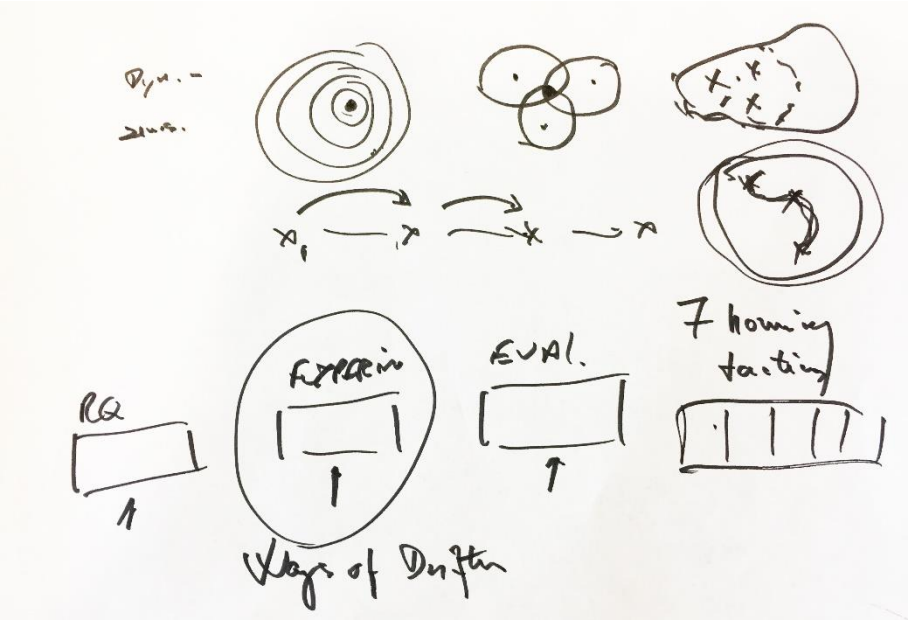


Figure 4-2. Original drawing of ways of drifting on a scrap of paper in the hallways of Southern University Denmark, 2018.

The first category, *accumulative*, is the least forgiving in terms of allowing the researcher to drift, while *probing*, on the other hand, allows for the largest degree of drifting.

The accumulative approach is characterised by closed settings, where experiments are evaluated for their cognitive qualities rather than their contextual appropriateness. Similar to the types of lab experiments that DBR initially opposed to, accumulation loses in relevance what it gains in depth of knowledge on the particular, clarity and rigor. The iterative experimentation is stacked into the next generation of the design product or intervention.

The second approach, called *comparative*, attempts to explore the subject by means of several design cases with a shared platform of comparison. A comparative approach might comprise one central design case tried out in a range of contexts or a set of different design cases tried on both identical and different contexts. Additionally, iterative versions of the same concept that change according to the context also fall into the comparative category. The approach is characterised by acknowledging complexity and each design experiment should reveal as yet undocumented additional qualities of a concept and confirm some previously found qualities.

The third approach, *serial*, denotes how design experiments are carried out in a certain order determined by how neighbouring experiments in a sequence influence one

another. Each stage generates insights or raises questions that lead the work onward and insights are thus gained through design experiments that proceed chronologically.

The *expansive* approach resembles the work of geographers or biologists mapping new areas. In contrast to serial experimentation, there are no successive or linear directions to follow as researchers reveal the qualities of an area as yet uncovered. The keywords for this approach is broadening and extending, as researchers rather than deepening their knowledge of a domain, widen and extend the concerns we should include in our scope.

The last approach, *probing*, is characterised by being illogical, artistic and impact-oriented. The examples show researchers who select their next intervention strategy in an eclectic, wicked, ir-reductive, and self-contradictory manner. Choices are made by pursuing opportunities in the immediate environment. Often this approach is driven by a high personal motivation and engagement in the research pursuit, where the research activities are points of impact in a research field larger than what a single research project can be expected to cover.

The typology provides a starting point for a concise description of different knowledge outcomes such as depth of knowledge, acknowledging complexity, extending knowledge of a certain area, etc., that may result from research experimentation. At the same time, it holds potential to articulate an intervention strategy and vocabulary for making the revision processes between interventions transparent.

The authors provide a neat overview of their typology via the following graphics, where the column to the far right refers to the studies from which the typology was made:

Table 1 Table of typology

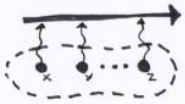
Method	Graphic model	Keywords	Exponent(s)
Accumulative		Depth, stacking	Frens
Comparative		Acknowledging complexity	Ross, Fogtmann
Serial		Systematising local knowledge	Lynggaard, Bang
Expansive		Broadening, extending	Dindler, Trotto
Probing		Illogical, artistic, impact oriented	Busch, Worbin

Figure 4-3. Ways of drifting (Krogh, Markussen & Bang, 2015).

In the second round of interviews with DBR researchers, I presented the typology to get their perspectives on drifting as a potential way of describing intervention strategies on the field of DBR.

4.3.4. PURSUING THE POTENTIAL OF DRIFTING IN DBR

The introduction of drifting to the researchers revealed quite diverse opinions and reactions.

Researcher C immediately identified his approach as accumulative. This might seem odd as the accumulative approach is presented in contrast to the ambitions of DBR. However, if understood slightly modified, the idea of depth and stacking knowledge seem to align well with his choice of rigorously testing and refining his teaching material with the same group of pupils. In his study, he purposely avoids giving attention to the surrounding context. What he studies is a teaching material and the particular pupil interacting with it. What the study might lack in contextual awareness, it gains in depth.

Researcher D found similarities between her approach and the explorative approach:

> Researcher D: 'My intention was not just that I would solve a problem, but that I would learn more about the context. The expansive model illustrates it well; there is a problem in a context, which looks a bit odd, and I gradually learn more about the amorphous context through working with a problem, and the problem changes from context to context.'

The strategy here echoes the original typology as the researcher aims at revealing new qualities about an unfamiliar context acknowledging the complexity at hand.

Researcher B was reluctant to place himself in relation to a specific way of drifting. He argues that:

> Researcher B: 'A diagrammatic approach might say less than words.'

Nonetheless, he formulated what in my view is a novel way of drifting sequentially and explorative simultaneously.

> Researcher B: 'I establish a design to create premises to investigate something else. We have developed a research design to be able to investigate how students transform knowledge.'

In this case, the interventions aim at uncovering knowledge about certain participants within a context or culture. This knowledge may result in others being able to design new interventions that scaffold leaners' knowledge transformation processes.

I did not get the chance to discuss drifting with researcher A, as she declined my invitation to a follow-up interview due to personal reasons. Furthermore, as she only did one intervention, her strategy of interlinking one intervention with another would at best case be hypothetical.

4.4. DRIFTING – A THEORETICAL POTENTIAL TO LINKING INTERVENTIONS IN DBR

At this point, I would like to take a step back to clarify the nature of the potential I strive to point at and how this links to my object of study, which are the design-based activities researchers perform in DBR. We know from Edelson (2002) that the theoretical output of a DBR study can be either descriptive in the form of domain theories or design methodologies or prescriptive design frameworks. Design methodologies provide guidelines for the process rather than the product. Frameworks, on the other hand, are prescriptive design solutions. When I study the design-based activities performed by researchers within the field of education, the potentials I point at can relate both to the design methodology of DBR and to activities related to developing design frameworks.

In the case of drifting, I wish to point at a potential to improve the design methodology of DBR. Based on this emergent language for describing how interventions connect to each other, researchers within the field can explain their intentions of why and how they seek to benefit from doing interventions, or in other cases, why they choose to divert from the intervention strategy they initially described. Subsequently, the activities the researchers perform when realising interventions are transformed by the intervention strategy whether it be accumulative, comparative, sequential, explorative or probing. The relation between strategy and activity makes drifting as a framework for describing intervention strategies relevant in a discussion on design-based activities in DBR.

In order to pursue the potential of drifting further, I revisited the 45 intervention studies and coded them based on the five ways of drifting. The initial codes revealed the following distribution:

Ways of drifting	# coding references	# items
Accumulative	12	9
Comparative	29	23
Serial	9	7
Expansive	18	15
Probing	2	2
Unclassified	10	10

Table 4.1. Coding references in relation to ways of drifting

The coding shows that a majority of studies apply a comparative or expansive intervention strategy. The least prevalent way of drifting is probing which comes as no surprise due to its artistic nature. Accumulative and serial intervention strategies are also noticeably present, so the palette of drifting strategies is complete. In ten studies, I was not able to classify the strategy at first attempt. Most often, I struggled to decide between to possible ways of drifting. Furthermore, the graph reveals 66 items and not 45, which is the number of intervention studies included in the review. The reason for this is simply that the unclassified studied were coded in more than one category. I therefore decided to go through each text with more than one reference in order to determine which way of drifting was the most probable. At the same time, I removed multiple codes of the same strategy in the same item.

The new coding revealed the following pattern:

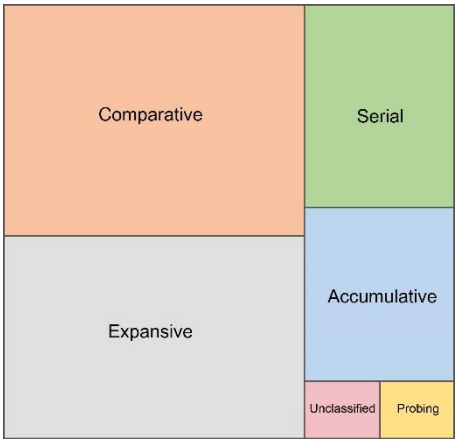


Figure 4-4. Distribution of ways of drifting in intervention studies

The figure shows an almost equal distribution of comparative (16) and expansive (14) strategies as the two most prevalent ways of drifting. Combined, the two strategies cover two thirds of the intervention studies. Equally comparable are the sizes of serial (7) and accumulative (6) strategies, which are the third and fourth most popular ways of drifting. Lastly, only one study was categories as having a probing strategy and one study remained unclassified.

In the following, I provide some exemplary insights into each of the categories to highlight how descriptions in the studies relate to the theoretically abstract strategies. The examples are not meant to be exhaustive and function as such only to provide support for the argument of the potential of thinking design intervention strategies within a framework for different ways of drifting.

4.4.1. COMPARATIVE AND EXPANSIVE STRATEGIES

The study by Klopfer and Squire (2008) provides a good example of how fellow researchers of DBR can benefit from applying a comparative drifting strategy. The authors start by setting the scene of the different contexts in which the interventions are enacted:

> 'This paper explores the design experiment of Environmental Detectives, presenting a rapid prototyping approach to designing software platforms, and serving as a narrative case study of a design experiment in action (Barab & Squire, 2004b; Brown, 1992; Hoadley, 2002). We narrate our development process across four case studies involving four instructional contexts with two different populations of users.' (Klopfer & Squire 2008, p. 222)

Later, they highlight what they learn when comparing one context to another:

> 'Local classroom cultures and contexts played a profound role in shaping how the software was used, suggesting the importance of varying implementation contexts when designing new platforms for broad audiences. Unlike any previous case, the high school students we studied took the game and turned it into a scavenger hunt activity where the goal was to collect as much information as possible in the allotted time. These

> observations caused us to make several design changes, including more implementations of cascading events, more timed events, and generally speaking, more efforts to represent the game as a dynamic system.' (Klopfer & Squire 2008, p 224)

In this case, by the means of comparison and acknowledging the complexity of how software platforms might work in different local cultures, the authors reveal additional qualities to explore from the unique usage of a specific group. A comparative framing could have helped clarify their overall strategy in direct relation to the interventionist nature of DBR, had the authors chosen drifting as a way of describing the reciprocal relations between their interventions.

In relation to expansive strategies, Kucirkova (2017) describes how at the start of the project on using the Our Story app the three participating teachers were encouraged to use the app as they deemed best. As all teachers took the use of the app in different directions, they provided a number of insights for the design team to work on in developing the software further. The article serves as an example of a novel technology that has yet to be mapped out and where varied deployments in history lesson settings, when working on children's diary writing skills and personalising children's stories help uncover new grounds and reveal qualities the researchers did not know existed before the interventions. Linking the interventions via the expansive drifting strategy could have helped to explain theoretically the open-ended approach that characterised the study and the interventions that were part of it. Similarly, Robertson and Howels (2008) describe how they 'needed a flexible approach which would enable us to revise plans for the field study based on the reflections of the researchers and teachers who were taking' (p. 566). They wanted this approach in order to better understand game making and the pedagogical implications related to it when trying to develop a theoretical framework game based learning. Again, what the researchers are implicitly asking for is a vocabulary for a strategy where interventions are interlinked that allow for broadening and extension as teachers and researchers revise one intervention and move on to the next. An expansive drifting strategy might fill that role.

4.4.2. ACCUMULATIVE AND SERIAL STRATEGIES

As mentioned, accumulative and serial intervention strategies are less prevalent among the 45 reviewed interventions studies. The research design description provided by Zheng, Niiya and Warschauer (2015) is an example of an accumulative approach, in which the purpose of the intervention strategy could have benefitted from being framed within the drifting metaphor. They write:

> 'In this study, design-based research is used in the following iterative cycle: a wiki-based learning activity was designed, the design was implemented and formal data were collected with a variety of methods with which the design was then evaluated and analysed for problems.

> Following this, an attempt to address these problems was implemented in the redesign. The redesign then undergoes iteration following the same cycle. A total of four iterations were conducted using this design.' (Zheng, Niiva & Warschauer 2015, p. 361)

The strength of this design, to stack knowledge through four iterations in similar contexts as opposed to exploring different solutions or trying out the wiki-based solution in vastly different contexts, is not justified through this description. Without the drifting framing, the design is left open for critique such as the arbitrary number of redesign cycles. Similarly, Kinash et al. (2012) could opt for arguing for the benefits of an accumulative way of drifting as a way of accommodating the weaknesses they point to in their study when they write:

> 'The primary limitation of this research was that it was conducted with one group of students at one university. Ethical responsibility to students meant that there could not be a control and an experimental group, thereby preventing experimental design.' (Kinash et al 2012, p. 650)

An example of a serial approach where each stage is carried out in a certain order that leads the experiments onward is put forward by Schleppegrell (2013):

> 'Initially a team of researchers worked closely with a small group of teachers, introducing them to SFL metalanguage in talk about the texts of their literacy curriculum. The teachers subsequently used the metalanguage in interaction with students, and learning from this observation of enactment, the researchers created units of study that were implemented by other teachers after professional development sessions that introduced the units and gave teachers opportunities to learn and practice using the approach.' (Schleppegrell 2013, p. 158)

In the first step, teachers were introduced to a metalanguage, which they subsequently used in interaction with students in the second step. Based on the enactment new professional development sessions were conducted completing a serial design in which each step depends on the previous step. Highlighting the sequential aspect of the research design would have made the study stand out more and given the authors the opportunity to elaborate on the specific chronology they chose to implement.

4.4.3. OUTLIERS AND FLUID CATEGORIES

Hull and Nelson (2005) and Dierdorp, Bakker, Eijkelhof and van Maanen (2011) represent a few outliers in the analysis. In the first study, the authors describe how they had no clear preexistent model to follow and intuitively felt their way through much of their analysis. This makes the study the only study that applies a probing strategy. In the second study, they authors state that due to the main question of the

paper, they do not report on the design process covering three full design cycles and thus omit any insights as to the reciprocal relation between interventions.

With all studies categorised and with the examples laid out, the potential of drifting as a methodological strengthening of DBR is evident. Further research is admittedly needed and the exactness of the categorisation (though not the primary intention) might in some cases be debatable. Interviews with the authoring researchers or further detailed coding might very well reveal different results. Examples of studies that could have been coded otherwise include as an example Koehler, Mishra and Yahya (2007), which is listed as an explorative study as they state the purpose of their study in this manner:

> 'In particular, we are interested in better understanding the manner and process by which TPCK develops through participation in a design-based activity (neither of which was the focus of attention in our previous research studies).' (Koehler, Mishra & Yahya (2007), p. 745)

At the same time, they do have two groups, which they to some degree compare. Also Krajcik, McNeill and Reiser's (2008) research design initially included both comparative elements (2 different units) and accumulative elements. I opted to categories the study as expansive because their iterations revealed new knowledge, which they did not plan to pursue to begin with. The examples show what is already mentioned in the introduction to drifting (Krogh, Markussen & Bang, 2015), namely that the five forms are not meant to be mutually exclusive, but their use demands careful consideration of what kind of knowledge interest researchers have.

4.5. CRITICAL PERSPECTIVES

A concern regarding drifting as a framework for intervention strategies in DBR was raised during the expert designer workshop in Umeå.

> Expert designer workshop participant A2: 'You can never set up your design interventions to do this. You can't say beforehand my interventions are going to be of the comparative kind or serial or whatever. It is something you do in hindsight looking at the interventions presented in these particular PhDs. You can then say, generally, look they have been doing this, but how these people decided to move, and that is exactly your question, is contingent of the topic, of the person that did it, of the foundations they were using.'

In this perspective, drifting can solely be identified in hindsight and never planned in advance. Whether this claim only has merit in design or design research, or maybe also in DBR, remains speculative. It is, however, a point to be mindful of when exploring drifting as a potential in DBR. A counter argument would be that even if the claim is true, drifting as a frame for explaining intervention strategies in published

papers that include at least three interventions should still be possible as a design-based way of explaining the progression in a DBR study. Another possible route would be to tackle this objection head on by planning on an intervention strategy, but at the same time keeping the door open for changing it based on the results of the actual interventions. In other words, I would argue that researchers of DBR put forward their initial strategy and the reasons for changing it during the project. This could potentially lead to interesting and transparent papers on the dynamics of DBR interventions.

4.6. SUMMARY

Summing up on the diverse landscape of interventions in DBR, the purpose of this summary is to highlight the challenges of researching through interventions in DBR and the potential of utilising drifting as a starting point for developing a vocabulary of describing overall intervention strategies.

DBR studies tend to be described using traditional research design terms such as case studies, longitudinal studies, cross-sectional studies, etc. A fitting vocabulary for describing the overall design intervention strategy remains absent throughout the selected studies. The consequences are - in the mildest cases - a lack of transparency regarding the intentions of researching through interventions as well as a black box of potential divergent routes taken during a project period to accommodate adversities, and - in the strongest cases - arbitrary intervention setups leading to poor design processes.

Based on input from expert designers, I suggest drifting as a potential starting point for DBR to develop such a vocabulary. The purpose of this emergent framework is for researchers within DBR to be able to explain their intentions of why and how they seek to benefit from doing interventions or in other cases, why they chose to divert from the intervention strategy they initially chose.

My analysis of the selected intervention studies suggests that comparative and expansive strategies are already prevalent in DBR studies, whereas serial and accumulative are less represented, albeit still to a degree that makes them relevant.

Dialogues with experts of both DBR and in the field of design suggest that the drifting framework is still in its infancy and thus requires further research before becoming a solid methodological reference point.

CHAPTER 5. DESIGN CHARACTERISTIC TWO – ITERATIONS

In this chapter, I focus on exploring understandings of how researchers work iteratively in DBR. Previously, in the historical overview in chapter 2, we saw how design experiments are ideally developed and tested in an iterative manner. The revision process includes that conjectures are refuted, new conjectures are developed and selected conjectures are subjected to tests. Akker (2003) frames an overall perspective on how designs iterate through intended, implemented and attained designs. This perspective is often echoed in explanatory phase models of how to conduct DBR. Where Reeves' (2006) model mainly puts emphasis on iterative cycles in relation to testing and refining solutions in practice, Easterday, Lewis and Gerber (2017) plead that researchers should focus on low-fidelity prototyping and collecting the minimal amount of data needed to quickly reject failure and identify potential successes before testing in practice. Thus, there seems to be disagreement, or at least differing understandings, as to the purposes of working iteratively. Zheng (2015), however, concluded in her review on DBR studies that half of the studies comprised only one cycle lasting from a month to more than three years. Furthermore, details on how the revision processes move from one intervention to the next are not always reported on, as also discussed in the previous chapter.

On the topic of revision, Dede (2005) finds that DBR studies are victims of design blur when the involved researchers apply a strategy of expanding the design to include conditions for success that might be problematic. This leads to processes in which unpromising designs are never abandoned or studies evolve into full-scale systemic reform initiatives. Similarly, Easterday, Lewis and Gerber (2017) warn against two opposing scenarios where researchers either focus too much on controlled testing and thereby waste resources verifying potentially bad design, or never advance beyond theory building and radically novel designs and, therefore, are unlikely to provide strong evidence for the efficacy of an intervention or principle.

In the following, I explore these practices and concerns further. I do this by searching for iterations in the selected studies, challenging or solidifying initial understandings through interview data and finally exploring possible potentials to answer identified challenges and thus strengthen the methodological basis of DBR.

The questions guiding this exploration are:

- When and why do iterations occur?
- What are the stated purposes for working iteratively in DBR?
- What activities support these purposes?

5.1. CODING STRATEGY

I started by searching for "iteration" using the stemmed words search function. The search yielded hits in 55 of the 77 studies, with the highest number being 68 hits. 55 articles had two or less hits, and 16 articles had more than 5 occurrences. 32 of the 45 intervention studies, 6 of the 7 literature reviews and 17 of the 25 repository texts mention the word 'iteration' in one form or the other.

Building on the previously presented models of DBR (Reeves, 2006; Easterday, Lewis and Gerber, 2017), I coded words and sentences in the immediate context of the search hits, which indicated the purpose and actions related to iterations. The words included, but were not limited to, 'focusing', 'understanding', 'conceiving', 'exploring', 'developing', 'refining', 'enhancing', 'prototyping', 'building', 'testing' and 'presenting'. I started by coding the repository texts and literature reviews before moving on to the intervention studies. Later, my analysis of the repository texts led me to group actions related to iteration into broader categories of purposes of either design/development, editing/revision, testing/evaluation or analysis/theory generation.

As a part of my axial coding approach at this stage, I revised the initial categories to concentrate the analysis on the understanding and use of the term 'iteration'. For instance, the code 'part of research design OR method section' included a great range in terms of detail and occurrences. Some studies include only one brief mentioning, while others included several and returned to the term later on in the article. Similarly, studies are often defined as DBR studies in general terms, which among other things means they are characterised by an iterative working manner. Other authors directly describe iteration in relation to the study at hand. Categories such as 'Descriptive - as a general way of describing a project', 'Descriptive - in relation to DBR in general', etc. appeared as the in vivo coding process unfolded.

The scarce use of the term 'iteration' among the intervention studies led me to carry out an additional search on the term 'cycle' as my analysis of the repository texts revealed a close link between the two terms.

5.2. FINDINGS FROM THE LITERATURE REVIEW

The first category includes findings from repository texts that further elaborate on the understandings of iterations in DBR. Following this, I present a common way of using the term 'iteration' in seminal work on intervention studies, which is characterised as being brief and descriptive. Moreover, I introduce the plenitude of ways in which the term 'cycles' are used in popular DBR literature and conclude with three types of iterative cycles with different purposes.

5.2.1. META PERSPECTIVES

On a general theoretical design level, Zaritsky, Kelly, Flowers, Rogers and O'Neill (2003) describe core activities of design as iterative and somewhat unpredictable. The purpose of the design process is to expose which conceptual issues are important and which are peripheral as well as the workability, cost and adoption of the innovation. The authors stress that three dangers exist in this stage, either when designers rush too quickly to embrace a design, when they attempt to fix a very similar design or when speculation goes too far and wishful thinking face disconfirming data at later stages. Kelly (2004) uses 'iteration' and 'intervention' to distinguish Design-Based Research from ethnographic studies by stressing the engineered and acted upon environment that design-based researchers study. He draws on terms from the radical interventions strategies (presented in chapter 4) of Barab, Thomas, Dodge, Carteaux and Tüzün (2005), where working design-based is equal to iteratively critiquing and changing a local culture through interventions in the role of a critical ethnographer.

A large portion of the repository texts ratifies the earlier stated notion that iterative progression is a basic component of working design-based (Gutierrez & Jurow, 2016; Voogt et al., 2015; Fishman, Penuel, Allen, Cheng & Sabelli, 2013; diSessa & Cobb, 2004; Gašević et al., 2014; Reeves, Herrington & Oliver, 2005; McKenney & Reeves, 2013; Wang & Hannafin, 2005; Bannan-Ritland, 2003; Bannan, Cook & Pachler, 2016). Notably, Bannan-Ritland (2003) speaks of processes of iteration, and Reeves, Herrington and Oliver (2005) highlight the iterative nature of proposed solutions. Similarly, Bannan, Cook and Pachler (2016) see iteration in multiple contexts over time and, finally, Wang and Hannafin (2005) draw upon the DBR Collective (2003) when stating that DBR is characterised by iterative cycles of design, enactment or implementation, analysis and redesign.

Even though Anderson and Shattuck (2012) point out that a variety of terms are used in DBR studies to discuss iterations (e.g. year, site, phase, iteration, cycle, phase, case study), especially 'cycles' are put in conjunction with the term 'iteration' across the repository and review texts (Fishman, Penuel, Allen, Cheng & Sabelli, 2013; diSessa & Cobb, 2004; Wang & Hannafin, 2005, Voogt et al., 2015; Bannan, Cook & Pachler, 2016; Dede, Ketelhut, Whitehouse, Breit & McCloskey, 2009); Reeves, Herrington & Oliver, 2005; Laferrière, 2002).

As indicated by the excerpt below, the purpose of iterative cycles may vary be it cycles of design (Voogt et al., 2015; Fishman, Penuel, Allen, Cheng & Sabelli, 2013; diSessa & Cobb, 2004; Bannan, Cook & Pachler, 2016), revision cycles (Dede, Ketelhut, Whitehouse, Breit & McCloskey, 2009), cycles of testing (Fishman, Penuel, Allen, Cheng & Sabelli, 2013) or cycles of analysis (diSessa & Cobb, 2004; Dede, Jass Ketelhut, Whitehouse, Breit & McCloskey, 2009).

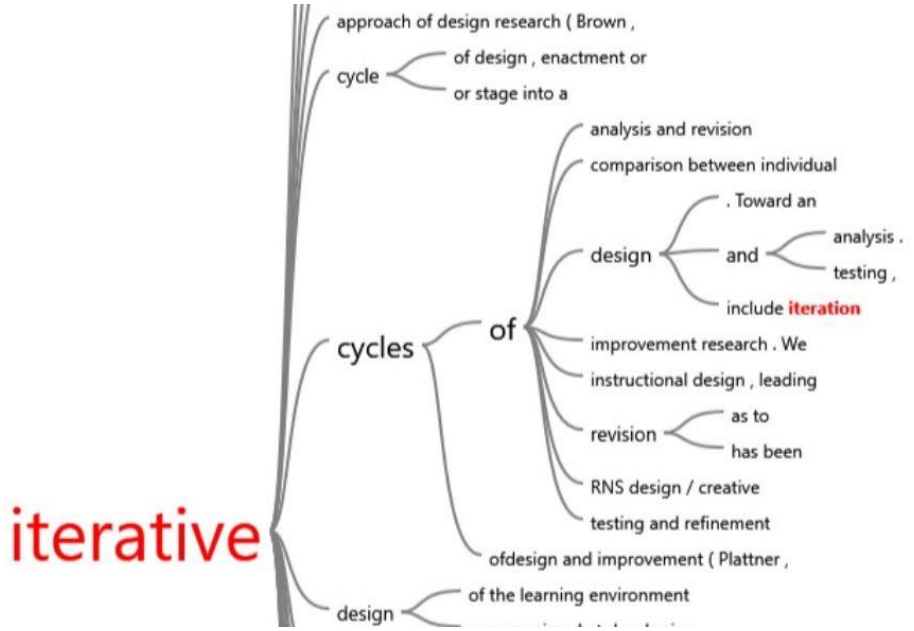


Figure 5-1. Excerpt of an NVivo generated word tree for a search for the word 'iteration' using stemmed words in the repository and review sets of the selected literature.

There is a tendency across the articles to link iteration closely to refinement. Wang and Hannafin (2005) speak of refining a design continuously and iteratively, and in the case of Voogt et al. (2015), teachers contribute to the refinements of the following iterations. When summarising key components of design practice, Anderson and Shattuck (2012) mention iterative refinement and the continuous evolution of a design as it is tested in authentic practices. Reeves, Herrington and Oliver (2005) speak of rigorous and reflective inquiry to test and refine innovative learning environments, as well as long-term engagement involving continual refinement of protocols and questions.

This tendency is somewhat implicitly echoed in the studies where 'an iteration' seems to equal 'an intervention'. DiSessa and Cobb (2004) mention how every iteration showed substantial student involvement and Voogt et al. (2015) translate 'iteration's to 'cycles of research-interventions'. diSessa and Cobb (2004), however, also acknowledge the value of exploring variations when redoing an activity in various contexts. Gašević et al. (2014) find that the applicability of DBR in MOOC contexts is limited due to how MOOCs do not always offer possibilities to perform multiple iterations as they may only run a single time or on an irregular basis.

The focus on 'iteration' as 'revision' through implementation is discussed by Ruthven, Laborde, Leach and Tiberghien (2009). They write:

> 'Our argument is that the availability of design tools capable of identifying and addressing specific aspects of the situation under design can support both the initial formulation of a design and its subsequent refinement in the light of implementation. In short, producing robust designs and securing well-functioning implementations calls for development of a more systematic apparatus to guide the constructive process through which a design is generated and adapted.' (Ruthven, Laborde, Leach & Tiberghien, 2009, p. 329)

The rather unassailable argument the authors make is that the quality of an intervention and its subsequent refinement is dependent on the quality of the original idea. Thus, iterative working methods should entail ways of supporting both the identification and formulation of initial proposals as well as ways to revise them systematically.

A few studies also coin the iterative aspects of DBR to testing and analysis (Bannan-Ritland, 2003; Bannan, Cook & Pachler, 2016). Local theory development during implementation interacts with formative evaluation of data collection and analyses through an iterative process in the case of Bannan-Ritland (2003), whereas testing through iterative cycles of design and improvement is how Bannan, Cook and Pachler (2016) phrase it.

To sum up, iterations are mainly described as interventions that are refined through implementations over time in various contexts. However, the iterative manner of working design-based can also refer to earlier stages where ideas for solutions are conceived or in later stages where data is analysed. There is a call for systematic ways of guiding the process of the former as interventions and their further refinement rest upon the qualities of the initial ideas. Finally, the term 'iteration' is closely linked to different variations of cycles of design wherein all of the above purposes might be present.

5.2.2. BRIEF AND DESCRIPTIVE USE OF ITERATION

A series of intervention studies position themselves as DBR studies by briefly introducing the main characteristics of the approach in the method section. In a number of the intervention studies, this is the only mentioning of iteration throughout the text (Jahnke, 2010; Koivisto, Niemi, Multisilta & Eriksson, 2017; Hung, 2017). Other studies tie the brief descriptive use of iteration in their method section directly to the actual project at hand. The uses of iterations include either a way of introducing to the project (Mishra & Koehler, 2006; Gedik, Hanci-Karademirci, Kursun & Cagiltay, 2012; Laferrière, 2002), summarising the project or pointing towards future research at the end (Hickey, Kindfield, Horwitz & Christie, 2003; Barab et al., 2007a). In one case, the authors both summarise and point to future research (Boticki, Baksa, Seow & Looi, 2015). The latter study provides illustrative examples of the brief and descriptive use. In the method section, they state:

> ‘The study employs Design-Based Research (DBR) to develop a deeper understanding of the processes involved in implementing seamless mobile learning. With iterative cycles of studying the processes and outcomes of interventions in building teacher capacity, lesson and technology design, we can refine the processes to develop a program for designing technology enhanced learning environments and develop strategies in and out of the classroom’ (Boticki, Baksa, Seow & Looi, 2015, p.124)

Later in their concluding statements, they write:

> ‘At the same time, in our next iteration of work, we need to improve our learning design to motivate students to continue using the devices as their learning hub on a more sustained basis.’ (Ibid 2015, p. 135)

While all studies in this category underline the value of the iterative manner in which DBR projects progress, they do not integrate the term when reporting on them other than as a nod to the design-based position as such or as a comment on future work as exemplified in the quotation above.

The scarce use of the term ‘iteration’ in this group of texts suggests that other terms related to iteration are more common within DBR when referring to such processes. As revealed through the analysis of the repository codes, ‘cycles’ are a very common way of describing the iterative manner in which DBR projects progress. Analyses of the uses, however, reveal that the contexts in which ‘cycles’ appear, and the purposes of working cyclically, vary from study to study.

5.2.3. CYCLES

Approximately two thirds of the intervention studies mention ‘cycles’ in some form of capacity (31 of 45), although far from all in relation to DBR methodology. The most frequent use of ‘cycles’ is either in a variation of ‘design cycle’ or ‘cycle of design’, as the illustration of two excerpts of a word tree generated from a stemmed search on ‘cycle’ in all the intervention study texts reveal.

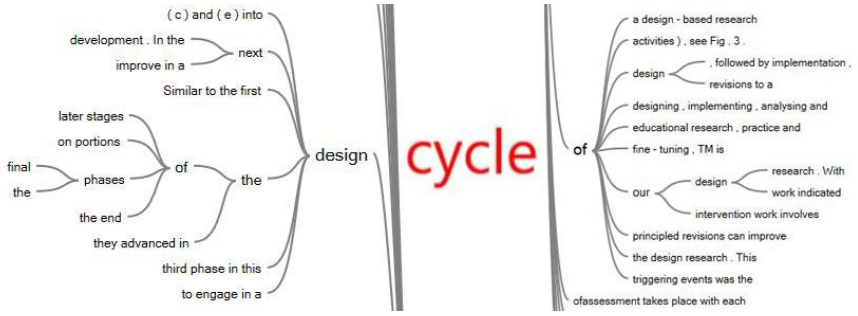


Figure 5-2. Two excerpts of a large word tree showing the term 'cycle' in the intervention studies joined to illustrate different purposes and relations.

Twelve studies use the phrase 'design cycle', 'cycle of design' or 'cycles of design' (Hickey, Kindfield, Horwitz & Christie, 2003; Puntambekar & Kolodner, 2005; Barab et al., 2007b: Squire & Jan, 2007; Krajcik, McNeill & Reiser, 2008; Robertson & Howells, 2008; Looi, Chen & Ng, 2010; Dierdorp, Bakker, Eijkelhof & van Maanen, 2011; Schleppegrell, 2013; Koivisto, Niemi, Multisilta & Eriksson, 2017; Kucirkova, 2017; Novakovich et al., 2017).

A cycle of design is often supplemented by other cycles with seemingly different purposes in the intervention studies. Schleppegrell (2013) speak of iterative cycles of design and implementation and Kucirkova (2017) mention that the iterative nature of DBR typically evolves through cycles of design/development, editing/revision and testing/evaluation. Similarly, Koivisto, Niemi, Multisilta & Eriksson (2017) uses iterative cycles to design, test and evaluate their simulation game in healthcare education. The iterative design efforts of Krajcik, McNeill and Reiser (2008) demonstrate that an ongoing cycle of principled revision can improve the learning outcome of instructional designs. Lastly, Squire and Jan (2007) explain how their logic of inquiry involves iterative cycles of design, theory generation, redesign, and theory refinement.

From this list, it is clear that design in conjunction with cycles can refer both to initial design efforts before any implementation has occurred and in other instances, it can include implementation or testing but not theory generation.

A common practice is to report only on one cycle of design, which implies that cycles of design can also refer to all activities mentioned above (development, implementation, revision, redesign, testing, etc.) as well as theory generation. Looi, Chen and Ng (2010) state that their article only reports their findings from the first cycle of design research while Barab et al. (2007b) report on their second cycle of design work. Two examples speak of the participants' design processes and not the researchers (Robertson & Howells, 2008; Puntambekar & Kolodner, 2005). Here, a cycle of design is followed by implementation and later testing (Robertson & Howells, 2008) or it is evaluated and redesigned (Puntembekar & Kolodner, 2005).

Despite the uncertainties regarding what cycles of design entail, the reasons for applying iterations in DBR seem relatively consistent as they are either related to iterations between problem and idea (development), implementation and refinement (prototyping) or measuring effects and evaluation (knowledge generation).

To sum up, working iteratively is a basic component of DBR most often used in conjunction with cycles of design. The notion of iteration is not very prevalent in DBR studies despite the fact that it is consistently put forward as a defining characteristic of how researchers within the field operate. When included, it is in many cases only

as a demarcation of the DBR position or as an indication of future research. As revealed through the analysis of the repository texts, cycles are a very common way of describing the iterative manner in which DBR projects progress. The initial analyses of the uses in the intervention studies, however, reveal that the purpose and extent of such cycles vary from study to study. Three broad purposes appear relatively consistent through the majority of the studies and include iterations between problem and idea, implementation and refinement and measuring and evaluation.

In the following, I present how the intervention studies describe these three purposes. Activities related to understanding a problem, exploring a solution space and developing intervention proposals are all put in the category of development. Researchers carrying out activities of either implementing, trying out, building or revising, enhancing and refining are captured through the next category of prototyping. Lastly, iterations related to measuring effects or attempts to generalise are grouped in the category of knowledge generating.

5.2.4. DEVELOPING

Generally, the early stages of DBR projects are not particularly well described in the selected literature. This may come as no surprise as seminal work often prompt researchers to present their results rather than their process. On the other hand, it could be argued that claiming to use a design-based approach while leaving out key activities, such as how you developed your solution to a given problem, is problematic from both a design and a research perspective. A few articles even openly discuss the dilemma of how to answer a research question and, at the same, time explain the process that led you to the answer. Dierdorp, Bakker, Eijkelhof and van Maanen (2011) as an example simply state that they omit reporting on the cyclical design process due to the nature of the main question of the paper.

Kucirkova (2017) offers a collaborative approach to developing educational apps as she structures regular workshops with teachers that feed into an iterative process of continuous improvement. Similarly, Duncan & Tseng (2011) formed a collaborative design team including teachers to ensure relevant expertise in the use of teaching materials in classrooms. The decision to include teachers was motivated by a need for a high fidelity implementation of the materials designed. Schwarz and Asterhan (2011) include pedagogical and technological experts along with teachers from five different countries in their collaborative and iterative design process. Additionally, the first draft of the curriculum project of van Schaik, van Oers and Terwel (2011) was designed in cooperation with experienced teachers, although no direct link to working iteratively is specified.

Klopfer and Squire (2008) provide a thorough description of prototyping iterations. It might seem counter-intuitive to place a prototyping approach in the category of development rather than in prototyping. The reason for doing so rest on the fact that

the authors argue for a rapid prototyping approach where many possible solutions are proposed and developed, rather than a prototyping approach aimed at revision and fine-tuning. The goal of this process is to build a small-scale prototype in order to test key system features. I will touch upon the differences between sketching and prototyping later in this chapter.

Moving away from traditional behaviourist and system-oriented approaches to instructional design, Angeli and Valanides (2009) depict an iterative design and development process where affordances of technology, content, pedagogical strategies, setting and learners are considered in increasing detail throughout.

The majority of articles that mention the early phases thus describe a collaboration between researchers and educators. Whether this tendency can be generalised to how DBR studies are typically carried out, or whether the fact that it is mentioned in these particular articles highlight a rarity among DBR strategies, is at this point uncertain. I will return to the different roles of the researcher, the educator and the designer in DBR in chapter 6 on collaboration with practitioners.

5.2.5. PROTOTYPING

The defining factors of the intervention studies category specify that some kind of intervention must take place. It is therefore not surprising that examples of implementation and refining processes are plentiful throughout the selected studies. Not all studies, however, link these activities to iterative processes.

Lobato (2012) describes multiple iterations where the underlying understanding is tied to incremental improvement. Barab et al. (2007b) and Voogt et al. (2015) both speak of iteratively refining curricular activities. (Kurti, Spikol & Milrad, 2008) describe two iterative stages of implementation where indoor and outdoor activities are experimented with either sequentially and simultaneously.

Jahnke (2010) describes a hermeneutic approach, which is integrated within a DBR design including data collection, analysis as well as interventions. The iterative refinement through nine phases cover four intervention periods and five rounds of data analysis. Stevens, Delgado and Krajcik (2010) aim at forming an empirically tested hypothetical and multidimensional learning progression for the study of matter through iterative refinement and testing. The TangibleK Robotics Program, developed by Bers, Flannery, Kazakoff and Sullivan (2014) is iteratively implemented and assessed in collaboration with both children and teachers over the course of five years.

Bodzin (2011) and Echevarria, Short & Powers, 2006 both focus on fidelity of implementation during longer periods where daily observations or videotaping serve as tools for data collection. Also, Looi, Chen and Ng (2010) describe enacted

classroom implementation. Here, the focus is on the co-design aspect of GroupScribbles activities.

In line with the repository descriptions of DBR, a significant group of studies describe a cyclical, incremental refinement process through implementation and analysis in different rounds and varying duration. A couple of studies specifically focus on fidelity of interventions, and others on specific aspects when interventions are enacted.

5.2.6. KNOWLEDGE GENERATING

The third and last category highlight the studies in which knowledge generating or measuring the effects of an intervention are mentioned in relation to iteration.

A couple of studies tie an iterative working manner directly to analysis or theory-generation. Mishra and Koehler (2006) describe a process of analysing the development of their course as iterative with continual revisits based on feedback from members in the group. Mohan, Chen & Anderson (2009) highlight the benefits of having three assessment cycles when looking for patterns across their interventions in their cross-sectional research design. Finally, Hull and Nelson (2005) admit to cleaning up the description of their process of analysis in order to make it more comprehensible for the reader. The procedure they actually applied, they state, was more iterative and recursive.

Other studies describe how the effectiveness of a given intervention will be measured as part of future research. Van Schaik, van Oers and Terwel (2011) describe how their intervention is studied in action in the first phase and in future phases will be redesigned and used in an experiment with a control group. Barab, Thomas, Dodge, Carteaux and Tüzün (2005) describe a process where the continual production of naturalistic interpretations based on both qualitative and quantitative data over extended time frames and at multiple sites involves continuously working on data collection, coding and analysis in a cyclic manner. The lessons learned at each step help direct the subsequent processes.

5.2.7. SUMMARY OF REVIEW FINDINGS

The main findings from the review indicate that even though the notion of iteration is consistently put forward as a defining characteristics of how researchers within the field operate, it is not very prevalent across the selected studies. When dealt with, it is in many cases only used as a demarcation of the DBR position or as an indication of future research. Most often iterations are used in conjunction with cycles of design, which in itself is also a broad term where the purpose and extent vary from study to study.

The purposes of working iteratively can be clustered in three categories where the aim is either to help develop ideas, refine implemented intentions or generate theory over time. The majority of studies that do describe an iterative working manner link it to continuous implementation and incremental improvement. Generally, activities taking place in the early stages of DBR projects are not particularly well described, which may come as no surprise as seminal work often prompt researchers to present their results rather than their process. A couple of studies also tie iterative cycles of work directly to analysis or theory-generation.

5.3. VOICES FROM THE FIELD

In the following, I present four voices on iteration represented by researchers of DBR. I start by highlighting the difficulties of speaking in abstract terms about iterations in DBR. I then move on to analysing the different purposes each researcher pursued in their projects in relation to working iteratively.

5.3.1. WHAT ITERATIONS ARE WE TALKING ABOUT?

Researcher A explains how she did not have the opportunity to carry out more than one iteration of her intervention. For this reason, she methodologically labelled her study as inspired by DBR and thereby not fully committing to the approach as she felt a more iterative manner of working would be needed to do so. Implicitly, in this statement the conflation between interventions and iterations, as previously highlighted in the reviewed intervention studies, reoccurs.

Researcher B directly confronts this issue when he speaks of the difficulties of articulating the iterative process in which DBR projects progress:

> ‘The term iteration is difficult. Because what kinds of iterations are you referring to? You could say that there are two major iterations in my project, because I label them iteration one and two. … But iterations occur all the time within the bigger iterations, tiny iterations.’ Researcher B

In his view, although he labels his interventions as iteration one and two, the two terms are not to be conflated. Iterations happen continuously throughout the design research process, and describing iterations retrospectively in abstract terms through an interview can be difficult.

Nonetheless, Researcher B, C, and D all provided valuable insights into the primary purposes of why and when iterations occurred during their respective projects. In the following, I present three different chains of reasoning for doing iterations in a DBR project. Researcher D speaks of early iterations when she facilitates new grounds for designing teaching in e-learning settings. Researcher C describes the thorough process of going back and forth between trying out a teaching material in practice and refining

it based on the evidence extracted from these enactments. Finally, researcher B presents a narrative where the purpose of why he intervenes (as explained in more detail in the previous chapter) is to understand a theoretical problem in a specific culture. The iterative manner in which he works is therefore closely tied to how his understanding of these two elements progress. What progresses is neither an intended nor an implemented design but rather a theoretical basis for future interventions related to this problem set. What researcher B is aiming to achieve is to pave the way for others to design. Although not fully similar, each of these different purposes presented through the voices of the researchers can be seen as related in a chronological order to the three purposes of designing, prototyping and knowledge generating as described above. In this manner, the following three sections function as richer examples of what is previously described.

5.3.2. FACILITATING NEW GROUNDS

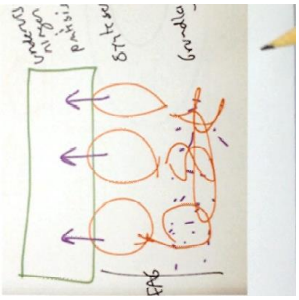


Figure 5-3. Early sketch work by researcher D

Researchers D describes her role in the early phases of her project as that of the facilitator. The challenge that she, and the practitioners she worked with, are trying to tackle is how to set up an e-learning format in a physiotherapy program.

Researcher D showed me a sketch that she drew in collaboration with the practitioners at a design workshop she arranged in the early stages of her project. She refers to it as an object that scaffolds the thoughts of the design team.

> 'We refer to this and point at it [the sketch]. Instead of saying "the theoretical classroom" or something like that, we just say "well, here we could…", I mean we simply point at it. Up here, the students could do blogging…. So we draw the space that the designs can unfold within. It is what we refer to and what we point at. The design itself and who does what, or what does the teacher do or whichever way you would draw it - we do not draw that.' Researcher D

In this case, the function of the sketch is that of a shared point of reference. The sketch provide a common frame for understanding the full educational programme the project aims to improve. The sketch seemingly represents the current situation and the ideal future simultaneously. The researcher explains:

> 'It was used in several ways. Both to show how things are and how they ought to be. The lecturers could say... "as of now, we do not have any links between theoretical and clinical teaching. Those up there (pointing at the sketch) do not even exist today even though we have drawn them. That is

> what we need to do." ...So it is a drawing of how we wanted the design to function.' Researcher D

The sketch researcher D refers to is the third version of how the group represents the function of the design. At a different point during the first interview, she refers to the sketch as what the design aims to achieve. Interestingly, as also referred to in the initial quote, the sketch does not depict the intended design, which is meant to be enacted. Rather, the sketch is a medium for opinions to be shared and ideas for change to bounce back and forth between the members of the group. When I asked her in the second interview to elaborate on the purpose of the sketch she makes the following distinction:

> 'What we used it for was to draw the scene. The actors who would move around on the scene we did not know how to draw. Should we draw them when he is here or here? When he left or before or after or what? It was a staging of the design where we could discuss what happens. The temporal progression we only talked about, and the spatial part of the design we were able to maintain through a sketch.' Researcher D

The distinction between the spatial and the temporal part of the design highlights a problem in early developments of educational solutions. The temporal aspect of how a teaching and learning situation unfolds is difficult to materialise and thus maintain.

The study of researcher D is an example of a process where early iterations occur to help scaffold the problem setting activities as well as the idea generation activities of a team of researcher and practitioners. Sketches play a part of shared reference points continuously throughout the process, albeit challenges of materialising and maintaining the temporal aspects of educational processes exist.

5.3.3. REFINING MATERIALS

Whereas, researcher D works iteratively to scaffold the problem setting and idea development activities in collaboration with the practitioners, researchers C focuses on iterating a specific solution.

During a period of five months, he spends his time refining a teaching material based on prototype testing in a classroom and redesigning at his desk.

> 'I was not interested, primarily, in theory generating. I was primarily interested in workability. To get this thing out there and see if it worked.' Researcher C

Through this iterative process, the teaching material evolves technically and in accordance with the theory that led to the development of the solution. Researcher C

describes this period as associated with a lot of working hours and at times his skills were tested beyond his competencies.

> ‘This was more or less what I tried out in the school right? There were continuous iterations because I realised all kinds of things that did not work or that were too difficult or unmanageable. Some of the things I was able to redesign relatively easy with a bit of elbow grease right? And some issues I realised I was not able to solve on my own.’ Researcher C

What researcher C is trying to accomplish by focusing primarily on workability is to incorporate as much of the existing theory that the material is based on into the product itself. He is, in other words, trying to concretise the abstract theory through the development of a teaching material. In his own words:

> ‘I have come further and further towards actually getting as many of… to facilitating so many of the elements or components of my basic reading theory… sort of molding them in… in order for the teaching material to be able to do something in relation to them. And you can say that in parallel with the theory remaining unchanged down here, that is, the reading theory, I could not, I did not want to change it, and it was not my aim to do so, and so it materialised right? In a concrete way, which it did not have before in a practical… in a materiality in the form of a teaching material that those who invented the theory did not at all care for or even thought of.’ Researcher C

At a certain time researcher C reaches the limit of how much he alone can optimise the teaching material and decides to contact a publisher in order for them to finish the product. The period leading up to this, described above, which involves a first prototype presented for a group of teachers and numerous refinements tried out in the classroom, researcher C labels a period of formative evaluation. Prior to this, he redesigned an existent teaching material and in the end of the iterative development, he arranged an RCT of the material as produced by the publisher. The iterative manner in which the teaching material progress is captured in the following figure based on the original drawings made during the interview, which can be detected in the background.

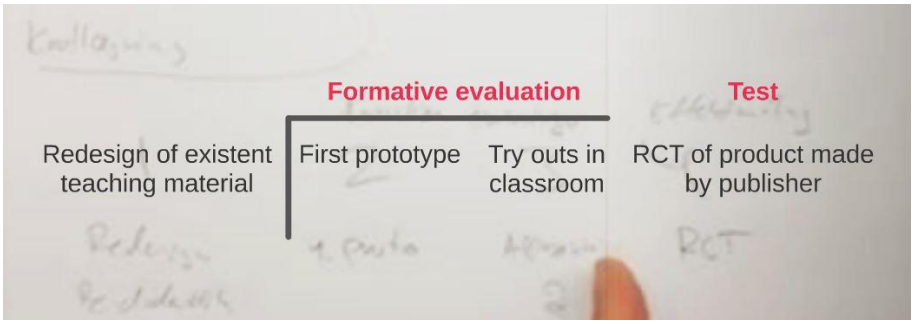


Figure 5-4. Iterations as described by Researcher C

Throughout this process, the main idea remains the same.

> Researcher C: 'In a way, it is the same teaching material. The main idea and many of the elements are the same.'
>
> Interviewer: 'All the way through?'
>
> Researcher C: 'Yes, all the way through, yes. It is fair to say that the main idea becomes more and more technically optimised according to the theory I build on.'

The main reasoning behind working iteratively in the study by researcher C is thus to refine a solution within a confined space. In contrast to exploring a possible solution space or branching out into different directions, he pursues the main idea that prompted the development of the teaching material. The cyclical way in which he incrementally refines his solution is very akin to how repository texts describe an idealised process of DBR. At the same time, what he is mostly preoccupied with is how to make his solution work as opposed to generating theory.

5.3.4. PAVING A WAY FOR OTHERS TO DESIGN

In this last example, researcher B shows humility towards his own ability to work iteratively with ideas and simultaneously a great deal of respect towards the skills set of professional designers.

> 'Often you stick to some of the first ideas you get. That is to say, okay, I might have two or three ideas that are possible. I mean there were a lot of factors that came into play, and I had to say, okay, I can have lots of ideas. And I did! But it was more in the form of a list. And then they got crossed out because they could be realised.' Researcher B

And later on:

> ‘Brainstorming is always a good thing to do, but I have in no way worked in the same way as a designer would have.’ Researcher B

I will return to this point later in this chapter as I frame the challenge related to the potential I seek to formulate as a contribution to the DBR approach. It is obvious, however, that researcher B finds that he has not worked design-based when initially forming ideas for the project. Instead, he explains how his project progressed analytically through concepts and models. His errand is not to measure whether his specific design solution, concerning the transformation of subject-specific knowledge for teacher training students, is more effective in comparison to others. Instead, the study addresses how to identify theoretical and pragmatic implications for how to design for transformation of knowledge.

Comparing his process to that of researcher C, he concludes that his iterations have the characteristics of being more analytical, holistic and to a lesser degree applicable in practice. In the second interview, which was carried out with researcher B and researcher C simultaneously, he further clarifies this point:

> ‘Where you [researcher C] sort of have a fixed theory as the basis of your design, and which continuously inform what you do and where you try to make your design facilitate that specific theory, I am in reality looking to explore what we theoretically can say before we decide to design for it.’ Researcher B

The information researcher B gets from observing how students and lecturers act during the experimental conditions continuously refine his understanding of the key terms that he works with and how they interlink. In his view, this way of iterating is in line with a fundamental dialectic interaction that takes place in a majority of DBR projects to change by understanding and to understand by changing. This process is for researcher B characterised by countless curls of thought that according to him have not been captivated by any model of DBR. Unlike, researcher C, there is no designed product or even an end to working with a problem.

> ‘What characterises my project is that there is no end product. It is always a process towards constantly trying to understand and improve, understand and improve, understand… it does not end in a fixed materiality, if you can call it that, because that would mean ending up in something like “this is the exact way you should teach” and you would not do that.’ Researcher B

It is, however, the same idea that runs through the entire process. What happened during the first intervention happened on a general level also in the second. The students received teaching, they went to practice it in a classroom setting, and they returned for more teaching and reflection through compulsory assignments. What did change was how the involved actors understood the elements connected to

transformation of knowledge and how those incremental changes had implications for how to setup future teaching and learning situations.

The example aims to show that iterations are not exclusively tied to setting up interventions or refining them through prototype testing. Iterations within DBR can be analytical and can serve the purpose of understanding the context that you aim to design for and the theory that you wish to design with. Where researcher C covers the type of knowledge generation that comes in the form of measuring effect, researcher B falls in the category of analytically refining his understanding in order to design more efficiently.

Of the three examples, only researcher D works with setting the problem to begin with. An area that, at least through the reported articles, is only scarcely covered in the intervention studies. This contrasts with the reasons for which professional designers purposefully iterate early when faced with the task of designing a specific solution.

5.4. IDENTIFIED CHALLENGES: THERE IS ONLY ONE PROBLEM…

The initial analysis points to at least a couple of challenges related to how researchers within the field of DBR understand and practice an iterative manner of working while conducting their research.

Firstly, the term ‘iteration’ is not as prevalent in intervention studies as descriptions from the repository texts of the approach might suggest. A majority of articles do not mention the term and often only as a demarcation of DBR as a methodological position, without the purpose or the extent of working iteratively are easily recognisable in the studies. This tendency is partly be explained by the more frequent use of ‘cycles’ as a key term, which covers the iterative manner in which DBR projects progress. Cycles, however, differ quite substantially in both meaning and purpose from early idea development, over refinements based on feedback from interventions, and finally to analytic changes via an evolved understanding of key terms and how they connect.

Secondly, among these three purposes early iterations of setting and solving a challenge are rarely or only briefly described. Among the interviewed researchers, at least three out of the four unanimously said that their idea of the solution to a design challenge was quite clear from the beginning of their projects. When asked directly whether they explored other possible solutions or if they went astray from their original idea they responded across all projects that they did not. The problem to be solved and the solution to it was, in other words, set to begin with.

As we shall see in the following, having a set problem to begin with clashes with the basic purpose of doing early iterations in much design work. Across multiple disciplines, sketching activities are the primary way for designers to set and solve challenges before any prototypes are built or any interventions have taken place. In the next part, I explore these activities and look for potentials to be implemented in the works of design-based researchers.

5.5. EXPLORING SKETCHING ACTIVITIES IN DBR

I explore the potentials of sketching activities in DBR by first pointing to a certain mindset introduced by Professor Redström in the interview I did with him before visiting the Umeå Institute of Design. Next, I discuss the challenges and potentials of sketching with the design-based research experts and set the challenge anew. Based on the input from the experts of the field, I look for alternative ways of sketching and introduce what I see as a promising contribution to early iterative design-based work within the field of DBR, which I label 'enacted sketching'.

5.5.1. A MINDSET OF CELEBRATING ALTERNATIVES

The primary reason for working iteratively in design became clear through an interview I did with Professor Johan Redström of Umeå Institute of design. I presented the four-phase model by Reeves (2006) as part of an introduction to how design-based researchers operate, and his response to the two first phases of identifying a challenge and developing solutions was:

> 'The first two phases are completely intertwined, so for instance the problem and the solution seems to co-evolve.' Prof. Redström

He went on to say that the way you fame a problem has such an enormous impact on which solutions appear interesting, possible or feasible. The important part is that you want to know as much as you can before you design. His opinion echoes what was earlier presented by Ruthven, Laborde, Leach and Tiberghien (2009), namely that the quality of an intervention and its subsequent refinement are dependent on the information that is available to you before you plan for an intervention and the quality of the original idea.

Redström expresses high hopes for the potential of working this way in education, but warns that it demands a different kind of mindset.

> 'I actually think it is very, very possible to do this within educational research, but I think it calls for a different mindset, calls for different values in which you do not necessarily seek to as early as possible establish what is the problem and then have a procedure that allows you to measure progress on that problem in terms of an implemented solution that gets a

> good test result, but rather the fact that you partly engage in making these situations because you want to find out what the alternatives are, so it is like opening up the space of possible formats of education as much as it is about finding out whether a particular format responds to a set of criteria, or assessment criteria in a good way or not.' Prof. Redström

If we unpack this quote, the two key points Redström makes are first and foremost that engaging in design activities requires a particular way of thinking, which is characterised by opening up solution spaces and staying open for alternatives. Secondly, as a consequence of this you do not want to rush forward in the hope of finding a problem to solve and start measuring the effect of your immediate solution to it.

Admittedly, the field of education presents itself as a tricky case when it comes to playing around with lots of alternatives in the initial phases of design. Redström explains:

> 'And this is the tricky part, I guess, when it comes to education, I am just finishing, and that is that .. You can't fool around with people's education to… I mean, you can only do it to a certain extent. You can't sort of say okay we will keep you here for four years and we have no idea whether you will actually learn anything in the end, but it is a risk you have to take. I mean that's not okay. You can't do it like that so you have to do it… you have to make sure that their learning objectives, that their learning outcomes and all of that will be satisfied.' Prof. Redström

What Redström is alluding to here is that to truly see the effect of different educational formats, we have to look at the full span of a programme, and of course students and other stakeholders will not be satisfied with an experimental education programme when aiming at becoming competent within a specific discipline.

Nonetheless, Redström emphasise the potential of working this way in the field of educational research as he concludes:

> 'But I think still within that there is a chance for experimentation around formats and trying things out, not as the complete package, but as a part of the package, but it requires this mindset of celebrating alternatives not just because you want to find which is best, but because you enjoy alternatives.' Prof. Redström

I pursued this potential, which led me to the archetypical activity across all design disciplines: sketching.

5.5.2. THE CHARACTERISTICS OF SKETCHING

In an often cited Q&A session, Eames (1969) answered the question ‘what are the boundaries of design?’ with the counter question ‘what are the boundaries of problems?’. Although elegantly simplistic, the quote underpins the ability of skilled designers to be able to explore, set and solve challenges.

One of the most common activities across all design disciplines related to this capacity is sketching (Black, 1990; Fallman, 2003; Buxton, 2007; Belardi, 2014; Krogh, Markussen & Bang, 2015).

Although sketching can be utilised with numerous purposes in mind, including investigating the problem field, exploring the solution space, explaining the functionalities of a design or persuading a potential client into investing in manufacturing a refined idea (Olofsson & Sjölén, 2007), the dominant perception of what sketching activities provide is centred around setting and solving design challenges in a dialogue between designer and sketch output (Suwa & Tversky, 1997; Goldschmidt, 2003; Schön, 1992; Vistisen, 2015). Masterfully illustrated by Sousanis (2015) (fig. 5-5), the activity is often compared to that of a conversation or dialogue between designer and the material she is sketching with. The designer is not merely transcribing ideas from head to paper, but simultaneously generating new ideas in search of a greater understanding, equally distributing her mental capacities between conception and perception. In line with this, Fish & Scrivener (1990) have argued that study sketches bridges the ‘abstract and categorical’ descriptions (language) and the ‘concrete and spatially specific’ depictions (imagery). Sketches are thus positioned as ‘the percept half of a hybrid percept - mental-image that amplifies the mind’s capacity to make descriptive-to-depictive translations’ (Fish & Scrivener, 1990; McGlynn, 2013).

Figure 5-5. Designer and sketch (Sousanis 2015).

In a review of sketching in design processes covering literature from the mid1960s until the beginning of the 2010s, Vistisen (2015) identified two perspectives on sketching: one as visual thinking and one as visual communication. The dominant perspective, sketching as visual thinking, focuses on the ability to mediate the sensemaking process between the designer and the design problem as described above. On the other hand, Buxton (2007) places sketches as shared points of reference against which we can compare other ideas or re-interpretations of the existing

sketches. In support of this view, Hutchins (1995) regards sketches as artefacts, which may act as a form of distributed cognition - a way of putting ideas 'out there' for debate, critique, and most importantly new interpretations. This second perspective emphasises the inclusive value of sketching in the design process. From this viewpoint, the main value of sketching is its inclusive way of using visual spatial expressions in the design process (Schütze, Sachse & Römer, 2003; van der Lugt, 2005; Buxton 2007). Relatively few studies have focused on sketching as communication and the result is that sketching studies have developed a processual focus on sketching and pays less attention to the sketch as the outcome of the process.

Across these two positions on the purposes of sketching notably Belardi (2014), Buxton (2007) and Herbert (1993) have tried to sum up the characteristics of a sketch. In Belardi's (2014) imaginary lectures on why architects still draw, he offers a definition on sketching based on a series of examples from the history of creative activity:

> '...sketching is a quick, readily available, dense, self-generative, and, above all, extraordinarily communicative notational system.' (Belardi, 2014, p. 34)

On the topic of self-generative attributes, he underpins the destabilising role sketches are ready to perform, in which they immediately after their definition can renew themselves in what he labels an act of parthenogenesis. Because of the indeterminate nature of a sketch, it is able to continuously regenerate itself, offer new suggestions, sometimes even to the surprise of the authoring designer (ibid, p. 28-30).

Buxton (2007) offers a similar list of relevant attributes in an attempt to capture what sketches are:

> 'Quick, timely, inexpensive, plentiful, clear vocabulary, distinct gesture, minimal detail, appropriate degree of refinement, suggest and explore rather than define and have an element of ambiguity to them.' (Buxton 2007, p. 113)

Also, somewhat overlapping Herbert mentions lack of detail, rough and unfinished character, and manageable size as characteristics of what he labels study sketches and points to three unique qualities of this type of sketches that facilitate design thinking - immediacy, ambiguity, and mutability (Herbert, 1993, pp. 103-104).

Based on these lists, we can conclude that sketches are characterised by being realisable in a short period of time without much preparation, ambiguous in nature due to a certain lack of detail, communicative, open for interpretation and with the ability to continuously mutate.

5.5.3. WE ARE NOT DESIGNERS – REVISITING THE CHALLENGE

With the purpose and basic characteristics of sketching established it would seem obvious to simply encourage researchers of DBR to start sketching when investigating a problem field or exploring a solution space. The data from the interviews with the researchers, however, suggest that a couple of new challenges occur when attempting to implement sketching activities as part of a DBR project.

The first one has to do with the ability to draw. When asked about early iterations or sketching processes, researcher A states:

> 'At no point during my project have I drawn the MOOC.' Researcher A

Neither did she feel comfortable sketching during the interview. Researcher C did his early presentations of his teaching material in PowerPoint as he admitted to not being skilled at drawing either. Researcher B, as I have previously mentioned, had numerous reservations about his own ability to generate ideas the way professional designers do. Researcher D is the only one who actively applied sketching activities as part of her early iterations. In her case, sketches play the part of shared reference points or visual communication tools, where participants can materialise ideas and make them open for debate. Although, the inclusive value of sketching is highlighted through this example, researcher D still struggles with materialising the temporal aspects of educational processes as well as the enactments taking place inside the sketched out space.

The researchers thus express both a lack of skill and that they struggle with the form. The last challenge has to do with the second challenge educational design researchers face when attempting to apply sketching activities as part of their early iterative work: How to represent teaching and learning situations? The challenge has been framed by neighbouring the field of design-inspired educational research, *Learning Design*, as the representational problem, i.e. the way in which we maintain and share ideas of how to design structures around human learning (Conole, 2013; Dalziel, 2015: Mor, Craft & Maina, 2015).

The challenge of doing early investigative and explorative iterations thus resets to the question: how can researchers conducting DBR benefit from early sketchwork taking the temporal aspects of teaching and learning situations into account and without the researchers having to master the art of drawing?

5.6. ENACTED SKETCHING

In the concluding part of this chapter, I will point to the potential of a less traditional form of sketching, which I label *enacted sketching*, inspired by and akin to various existing techniques within design, such as experience prototyping (Buchenau & Suri,

2000), embodied sketching (Ylirisky & Buur, 2007) and bodystorming (Scleicher, Jones & Kachur, 2010).

During the workshop with the design experts at the Umeå Institute of Design, different ideas of sketching in less traditional ways were put forward. In a group, they discussed the challenge of time and timing.

> 'I think what helps in the timing more is trying it out. But still, I think often, and we dealt with this in the language project, so many people have just thought out the activities without actually ever trying them.' Expert designer workshop participant C1

The designer draws on his previous experience from a project on language learning in the wild. After some initial brainstorming sessions, he states:

> '…and then we go and do it. So we create groups, and go out and do it, and use those experiences as a basis of understanding whether that sort of perspective or idea was interesting.' Expert designer workshop participant C1

In a different group, a discussion went as follows:

> Design expert workshop participant A1: 'What I am talking about is a kind of situation where you want to do an intervention in a situation, it is not about knowledge, that can be another idea, but this is more I picture myself seeing how people do things together, and then that is the context of the idea, and then of course you iterate with different ideas, different parameters maybe that you bring in, and then you have kind of a basic scenario and then you play a scenario.'
>
> Design expert workshop participant A2: 'Right.'
>
> Design expert workshop participant A1: 'And together with others, and you have input on that, and then you change things, and then you play the scenario again and probably find new things that "oh no! We can do this instead". That would push even more because it is very uncertain and unpredictable, but at least you have a frame, an outline of what you want to do as a start.'

What the designers are pointing at is the potential to do sketching in a more physical way using your own body to get experiences from. These activities can be repeated with variation or using different parameters, but at the chore is the idea of enacting ideas early.

Prof. Redström expresses similar ideas on enacting ideas in the field of education at early stages of the design process:

> ‘It wouldn’t be hard to imagine scenarios where you actually try out different formats early on to see what works. I mean what works if you have set things up in a lecture style, or group work style, seminar style, discussion style. I mean how much do you prepare before, how much do you just act. I mean these are all sorts of things that you already do in a teaching situation so stepping a bit back from that and realising so that is what’s already happening what will be the next level of that.’ Prof. Redström

He continues to present the case of enacted scenarios as both a question and an encouragement to exploring this path:

> ‘How do we stage even more experimental formats for the pedagogical situation? And how do we work with that? And I think there is so much to build from…’ Prof. Redström

In an attempt to pursue this potential, I begin by separating the activity of sketching from pen and paper and discuss various alternatives within the field of temporal sketching such as sketching with video and animated sketching. Having expressed my reservations towards these possible media I argue for a quicker and less artistically demanding form of sketching, which is based upon the insights of what researchers of DBR already do when planning for interventions to be enacted (see chapter 4 for further details on enactment).

5.6.1. DIFFERENT MEDIA FOR SKETCHING

Oxman (1995) contributes to the definition of sketching with an important distinction between the medium of sketching and the series of actions made by the designer that result in transformations of the representations. With this differentiation, it is possible to look at vastly different sketching media. Traditional media counts pencil, markers, pastel, airbrush, etc., but new research within the field has proposed to expand this category to include temporal media as well (Gundersen, Ørngreen, Henningsen & Hautopp, 2018). An example is Vistisen’s (2016) approach to sketching with animation and his model of expressive capacity, which sums up different media use (figure 5-6).

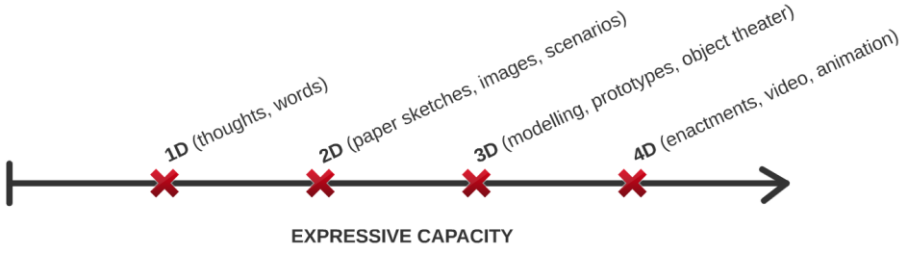


Figure 5-6. Expressive capacity (Vistisen 2016).

According to Vistisen (2016), the advantages of enactments, videos and animations compared to, for instance, scenarios is that the latter only provides information on individual states, while the first also informs the designer about transitions. Much like in the example of Researcher D, the temporality of interactions is only implied by crude annotation or, in the case of storyboards, through the space between states.

Ylirisky and Buur (2007) argue that video can play a role as either the designers' clay, enabling expression of concepts, or as social glue where video supports the social process of collaboration and the development of an operative image of the design problem. Using video as a sketching tool is, however, costly, time consuming and does not as easily as traditional sketches present future scenarios (Buxton 2007, Vistisen 2016).

As an alternative Vistisen (2016) propose animated sketching as way to explore different alternative proposals as long as the designers adapt rough animation techniques such as Terry Gilliam's cut-out techniques in Monty Python or the stop motion style of animated sitcom South Park in order to keep the disposable nature of quick, ambiguous and disposable characteristics of sketches intact. Keeping the reservations expressed by the interviewed researchers towards any artistically demanding activity in mind, I, instead, present the case of building on the tradition of enacting prototypes in DBR through interventions and transform it into early iterative sketching activities for investigating problem fields and exploring solution spaces.

5.6.2. A MODEL FOR ENACTED SKETCHING IN DBR

As we saw earlier, a popular understanding of interventions in DBR studies is tied to the enactment of intended interventions in various contexts. Whereas the common way of applying enactments are through the perspective of prototyping and refinement, it seems justifiable to assume that less detailed actionable instructions can be played out in the same manner. However, instead of seeking a high level of fidelity or recruiting highly skilled professional aiming at a high degree of adaption, enacted sketching activities should purposefully aim for immediacy, ambiguity, interpretability and dynamic mutability.

The characteristic of immediacy covers that enacted sketching should require a minimal effort to set up. I suggest intended design ideas should be played out only by the smallest design teams, with minimal use of props and without any roleplaying. This makes enacted sketching different from bodystorming where team members often play the roles of the involved actors involved in a scenario (Scleicher, Jones & Kachur, 2010). What design researchers should aim at, however, is not to represent adequate futures, but scenarios that generate dialogue and questions. This of course ties into the ambiguous nature of enacted sketching and the purpose of sketching activities in general as what you ideally strive at is to investigate possible futures and,

in the words of Redström, to celebrate the alternatives. A good sketch thus generates more than one interpretation and branches into numerous alternatives ways to either set or solve a problem. Finally, enacted sketches should be able to mutate dynamically as they unfold. Participants sensing a potential must be able to either re-direct the enactment on the fly or a make a note to re-enact an intended design from any given point in time.

Enacted sketching adds a layer to the well-known activities in DBR of developing an intended design, adapting it through enactments as an implemented design and evaluating the fidelity of the attained design. A way to depict the interaction between these processes in a simple way is illustrated below:

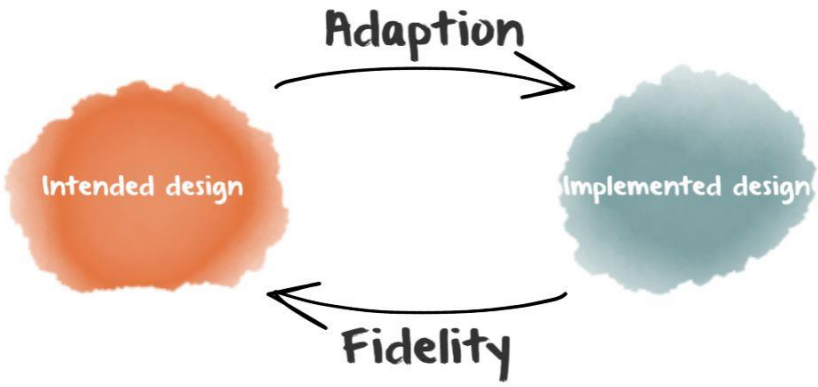


Figure 5-7. Interaction between intended and implemented design in enacted sketching

However, where you would normally strive for as high a level of adaption as possible and rate the fidelity in terms of accuracy towards the intended design, the goal in enacted sketching is different. What you strive for here is a quick and inexpensive way of exploring ideas and, contrary to the refinement strategy of prototyping, what you read from the enactment in sketching are alternatives, promising mutations and questions that raise dialogue within the design team. Thus, a model for enacted sketching may look like this:

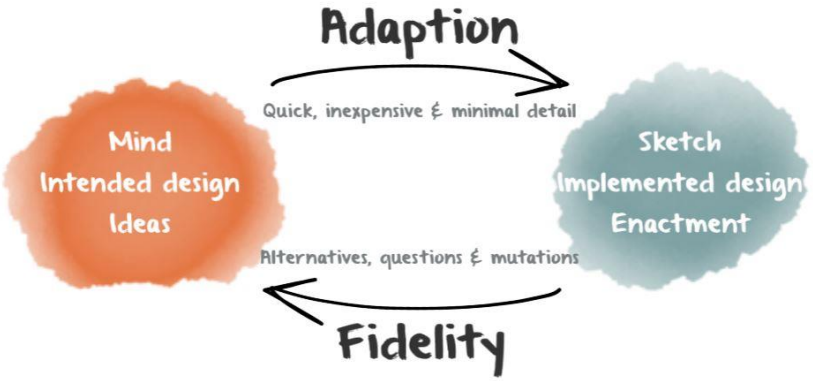


Figure 5-8. Elaborated interaction between intended and implemented design in enacted sketching

Similar to experience prototyping (Buchenau & Suri, 2000), enacted sketching has the added benefit of developing a common vision of what the team is trying to bring into being. The shared experience of immediately enacting various ideas can help foster a foundation for a common point of view.

5.6.3. REACTIONS TO ENACTED SKETCHING

Discussing enacted sketching during the second round of interviews with the design-based researchers, the potential received both praise and concerns. All three researchers expressed enthusiasm towards the idea of being able to do early iterations and welcomed the potential as an interesting alternative.

The researchers raised concerns regarding two different aspects when presented with the potential. The first aspect had to do with the collaborative aspect of DBR and the second related to funding and project management issues.

Researcher D found that in her process, she had already pushed the boundaries of how many new aspects the practitioners she worked with could cope with.

> 'I think, they felt there was plenty of new stuff and it was strange to think in terms of e-learning, blogs and video and reflection in relation to practice periods, and even to get those doing practice periods involved. That was plenty! "Do not come here and act stranger than that! That was not something for them. I simply do not think so… I simply do not think they found it so exciting that they would care to experiment in an even more playful manner.' Researcher D

The point researcher D makes here seems very valid in light of the shift in mindset needed not only for the researchers who very possibly have a share in the way a project is set up, but also for practitioners who might not even think any change is needed to begin with. I discuss the roles of researchers and practitioners in relation to design-based research activities in more detail in the following chapter. For now is seems fair to simply conclude that enacted sketching might not be for all, be it researchers or practitioners.

The second concerned raised was put forward by researcher B, who not only had concerns regarding the duration of the early phases of the design process, but also in relation to receive funding for research projects.

> 'I think it is also about something as simple as when you need to get your application through, you have to choose something you go for. That is what you bet on.' Researcher B

The argument researcher B alludes to is that in many application processes, you have to present both a problem and a solution to a problem. Finding room to and having the confidence of keeping the setting and solving of a problem open in a project description is not an easy task. Who would want to fund a research project with no well-defined problem to begin with? In relation to this, how much time can you feasibly allocate to the investigation of a problem space? These questions are beyond the scope of this dissertation, but I wish to make two remarks to keep the discussion balanced; Firstly, design projects from a range of different disciplines are funded on a daily basis, so the challenge is not unique to design-based research. Secondly, if design-based researchers were able to convince funds that systematic and time-consuming sketching activities would result in better solutions, they might be persuaded to listen.

5.6.4. SUMMARY

In this last section I sum up what the challenges related to early iterations In DBR are and what potential activities hold promise with regards to accommodating to these. We saw from the literature review that using early iterations to set the problem or explore the multiple solutions is less reported on than iterative refining and measuring activities. From the interviews, we learned that researchers working with DBR from a very early point in a project are set on the solution they want to test in a specific context. We also gained the insight that some DBR researchers are not comfortable with traditional sketching methods such as using pen and paper to help these processes unfold. Furthermore, sketching situations that unfold over time are additionally challenging. It is, however, possible to sketch using an array of different media and in ways that capture the temporality of educational situations, while still maintaining the quick and disposable nature of sketches.

For this set of challenges, I have suggested what I label *enacted sketching*, which draws upon existing terms of activities in DBR, such as intended and implemented designs, adaption and fidelity. The purpose of enacted sketching is to quickly and inexpensively create scenarios as a way of exploring ideas for interventions, which during the enactment can foster new alternative, possible mutations and a shared communication reference. Enacted sketching is at this point a speculative potential and further research is needed in order to determine the efficiency and feasibility of the activity.

CHAPTER 6. DESIGN CHARACTERISTIC THREE – COLLABORATION WITH PRACTITIONERS

A part of the initial ambition of DBR was to make theory of education more relevant for the people working in the field every day. One of the ways to achieve this was to collaborate in varied degrees with the practitioners themselves. As we saw in the introduction to DBR in chapter 2, the emphasis on collaboration has changed over time from practitioners helping enacting an envisioned design to practitioners also taking part in problem identification, development of solution and, in rare cases, theory generation. As practitioners became involved in more DBR activities, especially problem identification, the scope of DBR studies also expanded from a primary focus on validating learning theory to broader problem sets.

Questions arise, however, as to whether repository descriptions of ideal collaborative processes depict the actual nature of the collaboration between researchers and practitioners. Rowland (2007) in particular alludes to the fact that DBR studies seem to imply that the competency of the developer or designer is a natural possession of researchers but in his view educators might be better equipped to take on that role. Further insights into what roles are assigned to whom and who possesses which competencies may shed light on the nature of collaboration in DBR and make the descriptions of how practitioners are involved in DBR more transparent.

Thus, the questions I pursue in the review part of this chapter are:

- What roles do practitioners take on when collaborating in DBR projects?
- In which processes of DBR do researchers and practitioners collaborate?

6.1. CODING STRATEGY

Similar to my coding strategy on iteration I opted to start by searching through the repository and review texts to either further solidify the understandings of collaboration with practitioners highlighted in chapter 2 or challenge these understandings. I did this by searching for ‘collaborate’ with stemmed words and read the surrounding passages. The query yielded 445 references distributed between 26 articles.

In order to capture the roles of practitioners and the elements on which they collaborate, I carried out open coding in the intervention study texts. Among the coding categories were *purpose of activity* (subcategories: mapping problems, idea generation, refining, testing and generating theory) and *with whom* (teacher, educator, fellow researcher, etc.). However, through in vivo coding and informed by my work on coding the texts in relation to intervention and iteration presented in the previous chapters (4 and 5), I narrowed my focus to three different roles that practitioners can partake when engaged in DBR. The three roles cover a movement from less to more engaged in DBR activities. The first role is that of the *implementer* or *cooperative partner*. Here, practitioners are solely involved in the DBR processes when an intervention is developed and/or ready to be implemented. Thus, practitioners help implement the intervention, as it was intended or act as cooperative partners in relation to the feasibility of the enactment of the intervention in the local context. The second role refer to practitioners as *co-designers*. In this case, practitioners take active part in the identification of the problem and the development of the solution. The third and last role grew out of the in vivo coding as I realised that a significant part of the researchers are also in charge of implementing the intended design as practitioners. I labelled this *integrated practice* where the practitioner takes part in all of the research activities as the practitioner as the co-researcher. Through this scope, I was able to categorise all but two of the 45 intervention studies.

In the following, I start by presenting the results from the repository and review texts and then move on to describe how the intervention studies present the practitioners as either implementers, co-designers or co-researchers.

6.2. METAPERSPECTIVES ON COLLABORATION

The claim based on the overview in chapter 2 that collaboration with practitioners is a central activity in working design-based is further solidified in the review of the repository texts. Bannan, Cook and Pachler (2016) make the case that DBR differs from other research strands as researchers engage in long-term collaboration with practitioners when integrating research into design processes. Wang and Hannafin (2005) underline how researchers collaborate intimately with participants to achieve theoretical and pragmatic goals of changing educational practices. In addition, Li and Tsai (2013) bring forward the benefits of having research and design activities guiding each other as researchers and participants strive to make improvements to both practice and theory. Finally, Reeves et al. (2005) simply state that DBR requires intensive collaboration among researchers and practitioners.

The initial criticism put forward by Rowland (2007), i.e. that the competencies of the designers are somehow assumed to be inherently possessed by researchers of DBR, seems valid in more recent work also. Consider this passage on collaboration from Anderson and Shattuck (2012):

> ‘The partnership in a design-based study recognizes that teachers are usually too busy and often ill trained to conduct rigorous research. Likewise, the researcher often is not knowledgeable of the complexities of the culture, technology, objectives, and politics of an operating educational system to effectively create and measure the impact of an intervention. Thus, a partnership is developed that negotiates the study from initial problem identification, through literature review, to intervention design and construction, implementation, assessment, and to the creation and publication of theoretical and design principles.’ (Anderson and Shattuck 2012, p. 17)

What the authors imply here is that knowledge of the context combined with a rigorous research approach are needed to form a partnership to carry out a study from problem identification to the creation of design principles. No significant weight is put on the competencies needed to identify a problem, to design and construct an intervention or to be able to formulate useful principles.

Not all repository texts neglect the complexities of design processes. Bannan, Cook and Pachler (2016) point out that little emphasis has been placed on the systematic design process subsumed in DBR and stress that integrating design with research is neither easy nor simple. Kelly (2004) calls for a broader cross-disciplinary approach if DBR is ultimately to survive.

Fishman is the main author of two texts (Fishman, Marx, Blumenfeld, Krajcik & Soloway, 2004; Fishman, Penuel, Allen, Cheng & Sabelli, 2013), which focus on the collaboration between teachers and researchers. He and his co-writers call for teacher collaboration as an area in need of more attention and questions the degree of co-ownership when teachers implement innovations primarily designed by researchers. They call for a strong collaboration between school systems and external developers in order to address gaps of culture, capability and policy/management. A collaboration that goes further than the endorsement by the central office, but includes creating a shared vision and plans for enactment that account for differences between the capacity of the school system and the demands of the innovation. Additionally, the authors point to the potential issue of teachers lacking specialised knowledge generated from a collaborative research approach. Voogt et al. (2015) suggest that it is crucial for teachers to partake an active role in the design process over an extensive period in order to develop professionally when engaging in DBR. Through different cases, the study shows how agency was realised because teachers were actively involved in problem definition and solution.

6.3. ROLES OF PRACTITIONERS

The distribution of the roles of the practitioners in the 45 interventions studies when applying the coding categories of implementer, co-designer or co-researcher unfolds as shown in the graph below:

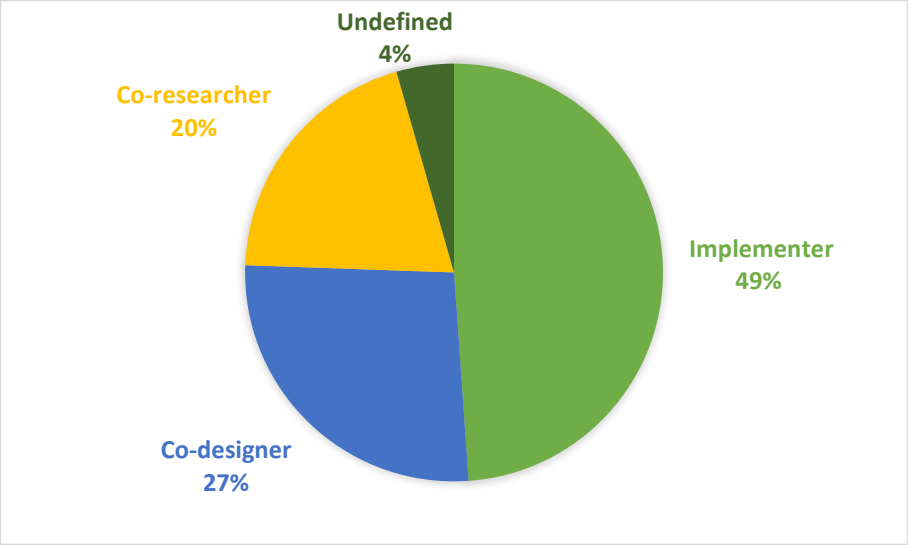


Table 6-1. Distribution of roles of practitioners in the 45 intervention studies.

In the following, I describe through examples the types of activities that are most often tied to the identified roles. I start with the role of the implementer, proceed with the role as co-designer and end with the fully integrated design-based research partner in role of a co-researchers.

6.3.1. PRACTITIONERS AS COOPERATIVE PARTNERS AND IMPLEMENTERS

In this category practitioners perform several activities related to the preparation and enactment of an intervention. The category covers half of the studies (22 of 45) and thus represents the predominant way of collaborating with practitioners in the selected studies.

A group of studies describe how practitioners (often teachers) implement intended designs developed by researchers through either one or several iterations (Krajcik, McNeill & Reiser, 2008; Hickey, Kindfield, Horwitz & Christie, 2003; Klopfer & Squire, 2008; Bers, Flannery, Kazakoff & Sullivan, 2014). Moore et al. (2014) specifically choose the State of Massachusetts - because engineering standards are

core requirements for all students - to test the first prototype of their developed framework, while Ketelhut (2007) describes how teachers of a whole district volunteered to implement the River City project in their science classes. Puntambekar and Kolodner (2005) receive suggestions about how to provide individual students with guidance from the participating teacher and later the teacher learn how to facilitate activities that encourage student-teacher interactions.

Kucirkova (2017) developed an app and in this case, teachers were encouraged to use the app in their respective classrooms as they deemed best. The feedback provided by the teachers through implementation included the children's preference for small-format books and consequently the possibility to print not only A4 but also A6 format books was introduced. In a study reported by Boticki, Baksa, Seow and Looi (2015), the teachers are engaged in designing how to implement the use of a mobile learning system developed by the researchers. Next, the teachers and researchers jointly identify learning opportunities and activities based on a field trip in relation to the implementation of the system. Similarly, Looi et al. (2010) provide a scribble software tool to teachers who then have 6 weeks for enculturating a new practice of rapid collaborative brainstorming and critique along with their students.

A common strategy across a group of studies is to choose a practitioner of either high level of skill and/or experience in teaching (Barab et al., 2007a; Barab et al., 2007b; Robertson & Howells, 2008; Squire & Jan, 2007) or show particular interest in the research carried out by the researchers (Sandoval & Reiser, 2004). In the two studies authored by Barab et al. (2007a, 2007b), the teacher is described as being an exceptional educator and very comfortable with having research conducted in her classroom. Robertson and Howells (2008) collaborate with a specialist ICT teacher and Squire and Jan (2007) work with a teacher who has more than 25 years of experience in teaching inquiry-based. In all these cases, the researches opt for a strong cooperative partner to implement their ideas, but do not invite the practitioner to be part of the development team. Sandoval and Reiser (2004) describe how a teacher showed interest in their work and shared the same goals for engaging students in inquiry. The researchers chose to collaborate with this teacher since he is willing to integrate the design ideas of the researchers into his existing curriculum. In this case, the design solution initially belonged to the researchers before the teacher was assigned to help integrate it.

In a rare case, one of the authors teach the first three offerings of a course (Gašević, Adesope, Joksimović & Kovanović, 2015), which makes him an example of a researcher who is also a practitioner, whereas the last three offerings were taught by an instructor who was not involved in the study. According to the authors, the last instructor followed the course design outlined in the article, which makes this a case in which a team of researchers develop a course to be implemented by a practitioner.

Generally, this category comprise of examples of practitioners who either implement solutions developed by researchers in advance or practitioners who provide feedback on implemented solutions. The role of the practitioners entails that they can provide expert level feedback based on their experiences, while an intervention is enacted. This information is then passed on to the researchers who redesign their solutions accordingly.

6.3.2. PRACTITIONERS AS CO-DESIGNERS

The studies in this category cover instances where practitioners are involved in the early stages of design, including problem setting and idea generation. Roughly one-fourth (12 of 45) of the intervention studies belong to this category and it thus represents a common strategy in terms of collaboration. The studies include cases where researchers and practitioners either collaboratively develop (Land & Zembal-Saul, 2003; Bodzin, 2011; Schleppegrell, 2013; Zheng, Niiya & Warschauer, 2015), design (Echevarria, Short & Powers, 2006; Kurti, Spikol & Milrad, 2008; van Schaik, van Oers & Terwel, 2011) or form a design team with additional experts to develop (Barab et al., 2005; Schwarz & Asterhan, 2011; Koivisto et al., 2017) interventions to be enacted in practice.

Zheng, Niiya and Warschauer (2015) address a series of identified learning problems through a collaborative development process with a participant teacher. Schleppegrell (2013) describes an iterative process of development with teachers and Land and Zembal-Saul (2003) transform a learning environment in close collaboration with the course instructor.

(Kurti, Spikol & Milrad, 2008) conduct two trials using educational scenarios that are designed together with teachers. van Schaik, van Oers and Terwel (2011) design the first draft for a curriculum project in cooperation with experienced teachers. Bodzin (2011) collaborate with an experienced science teacher over a couple of years as members of a design partnership where the teacher ensures that the materials developed meet the diverse needs of the 8th grade students in a school and are aligned with the state standards. Furthermore, the teacher also provides valuable information to the development team about learning activity ideas and implement the initial prototype in a role comparable to the cooperative partner described in the previous category. Finally, Echevarria, Short and Powers, 2006 develop a model of instruction through a cyclical process, wherein researchers and project teachers design, use, analyse and redesign features of the model.

In the studies by Schwarz and Asterhan (2011), Koivisto et al (2017) and Barab et al (2005) practitioners and researchers are joined by other experts to form the design team involved in the project. Schwarz and Asterhan (2011) describe a collaborative, iterative process involving pedagogical experts, technological experts and teachers from five different countries, and Koivisto et al. (2017) design a game in collaboration

with researchers, nurse educators, students and programmers. Finally, Barab et al. (2005) work with children, staff, and parents as co-designers, who together determine the purpose, value and worth of the emergent collaboration and design work throughout the design and implementation process.

In comparison to the previous category, the design and development work is more equally shared between researchers and practitioners in the above examples. The role of the practitioners is to actively engage in the development phase and work intimately with the researchers and potentially other experts to design the intervention to be carried out in practice. Detailed information as to what these work processes entail and the degree to which practitioners provide either contextual knowledge or present novel design solutions remain more or less black boxed.

6.3.3. PRACTITIONERS AS CO-RESEARCHERS

In nine cases, the practitioner is also part of the research team (Hull & Nelson, 2005; Koehler, Mishra & Yahya, 2007; Zhang, Scardamalia, Reeve & Messina (2009); Dierdorp, Bakker, Eijkelhof & van Maanen, 2011; Duncan & Tseng, 2011; Gedik, Hanci-Karademirci, Kursun & Cagiltay, 2012); Novakovich, Miah & Shaw, 2017) or even the sole researcher involved in the project (Hung, 2017). The last study in this category is a unique case where a teacher seems to be involved in the research processes, but does not appear to have been involved in writing the article (Lund, 2008).

In eight of the forty-five intervention studies, researchers implement their design propositions themselves. Koehler, Mishra and Yahya (2007) conduct their research within the context of a faculty development course taught by the first author. This is also the case in the teaching experiment and the enacted learning strategies presented in the article by Dierdorp, Bakker, Eijkelhof and van Maanen (2011). In Zhang, Scardamalia, Reeve and Messina (2009), one of the authors teaches all three classes of 4th graders and Hull and Nelson (2005) have funded and operated the technology center in which their research take place. Novakovich, Miah and Shaw (2017) remove bias by letting an outside researcher collect consent forms and questionnaires in a project where the lead researcher is also the instructor. The second author in the study by Duncan and Tseng (2011) pilot a new curriculum in her biology classroom and Hung (2017) play the dual role of teacher and researcher in a study on skills-based English. All three authors play the role of participants providing reflections and insights gained from the implementation process in the project carried out by Gedik, Hanci-Karademirci, Kursun and Cagiltay (2012).

A unique case is described by Lund (2008) where the teacher in collaboration with the researcher decides to investigate specific learner experiences related to the development of a WIKI through open-ended response forms. As the teacher is described as being actively involved in the direction of the research focus, the teacher

plays at least a partial role as a co-researcher although it appears as though the teacher was not directly involved in publishing the findings.

6.3.4. TECHNOLOGY DRIVEN VERSUS INSTRUCTIONALLY DRIVEN INTERVENTIONS

The three different types of collaboration point to differences in what type of knowledge practitioners are expected to bring to a given project and where the competencies of design are placed.

In the studies where practitioners implement, there seems to be an overweight of cases in which developed technologies are brought into a context. In cases where practitioners co-design interventions have a more instructional character. Apps (Kucirkova, 2017), learning systems and software (Boticki, Baksa, Seow & Looi, 2015; Looi et al., 2010) and digital games (Ketelhut, 2007) are all examples of technologies developed by researchers where the practitioners' main input is put into use once the product meet the actual learning environment. On the other hand, when practitioners co-design, the purposes of the interventions are e.g. to transform a learning environment (Land & Zembal-Saul, 2003), design educational scenarios (Kurti, Spikol & Milrad, 2008), develop a curriculum (van Schaik, van Oers & Terwel, 2011), develop a model for instruction (Echevarria, Short & Powers, 2006) or a reaction to a series of learning problems (Zheng, Niiya & Warschauer, 2015).

This division is not, however, set in stone as exemplified in e.g. Putambekar and Kolodner's (2005) instructional study where practitioners are cooperative partners and in Koivisto et al. (2017) who co-design a game along with nurse educators, students and programmers. Thus, a careful conclusion is that in technology driven intervention studies practitioners predominantly play the part of implementers, whereas in instructionally driven intervention studies practitioners are often co-designers.

6.3.5. SUMMARY

Collaboration with practitioners is a central activity in DBR according to the repository texts, but it can play out in different ways. Generally, in half of the intervention studies the practitioners play the role of implementers, while in one-fourth of the studies the practitioners are co-designers. In one-fifth of the studies, the researchers also assume the role of the practitioner. Some repository texts calls for collaboration as an area of DBR in need of more attention, while others plead a broader cross-disciplinary approach if the DBR approach is to survive. The importance of feeling a sense of co-ownership in relation to interventions is another point raised in several repository texts.

The data from the intervention studies suggest that in studies where practitioners are implementers, the interventions are predominantly technology driven. In studies

where practitioners are co-designers, interventions tend to be of an instructionally driven character.

The difference in the type of knowledge that researchers, teachers and other collaborators bring to the development, implementation and evaluation of educational innovations is seldom discussed explicitly. Rowland's (2007) claim that in DBR, it is assumed that researchers naturally possess design competencies thus remains warranted and is in some cases amplified by the descriptions of collaboration processes in the repository texts.

6.4. VOICES ON COLLABORATION

In this section, I further explore the nature of collaboration with practitioners through interviews with researchers of DBR. The researchers portray significantly different paths when describing how they collaborated with practitioners. While they all present unique paths of collaborating with practitioners, some are more in line with the majority of the intervention studies, while others describe processes unprecedented in the selected literature.

I start by presenting a strong opinion shared by the informants related to being respectful of teachers and not wanting to criticise their practice. From there, I illustrate three different paths of collaboration before describing the kind of knowledge that practitioners have brought to the projects of the informants. Lastly, I describe the lack of proficient design skills in the selected studies and point to the challenges related to this.

6.4.1. WE ARE NOT HERE TO CRITISISE

In relation to collaboration with practitioners, there is a general consensus among the researchers that they do not want to criticise the work of the practitioners.

Researcher D gives the following response as to why she became engaged in DBR in the first place:

> Researcher D: 'I think it makes my role more legit if I also bring something to the table and I am not just standing there, observing and possibly criticising what they do.'
>
> Interviewer: 'Yes, so a part of it is not to be a criticising researcher?'
>
> Researcher D: 'Yes, at least not exclusively. Yes, if something needs to be criticised, you have to do it very gently in my opinion so that they do not start to defend the poor practice they may have, but instead in a calm and collected way point to areas, which can be improved. Instead of saying

> that this is really poor, I do a lot of, and I think this way I can achieve the most, collaboration with the practitioners and tone down that role of the researcher really.'

Researcher C echoes this opinion in a more direct way, as he states that descriptive research has a tendency to put teachers down.

> Researcher C: 'I think a lot of research in schools end up bashing teachers. Yeah! Where you observe a lot of teaching and then conclude that they do not know how to teach literature. This is not proper literature teaching and then they mention ten theoretical positions which they want the teaching to reflect, right?'

Despite his position, researcher C finds it necessary to move away from the ideal of collaborating with practitioners in the very early stages in order to identify his design challenge.

> Researcher C: 'Ideally, I should generate the problem with the teachers, and here I question the theory because the teachers do not view how to teach reading as a major issue… the most popular teaching material among teachers is the one I find to be the worst. At all!'

Researcher C therefore ends up using the participating practitioner more as a cooperative partner and implementer rather than as a co-designer.

6.4.2. DIFFERENT PATHS OF COLLABORATION

The four researchers have quite diverse accounts of their collaboration with practitioners. Through my questions to the nature of their collaboration, I try to map out the different paths in relation to four overall categories of activities as depicted below. Since Researcher A did not finish her study, I have omitted her from this figure.

Figure 6-1. Different paths of collaboration between researchers and practitioners

As mentioned, researcher C struggled with the ideal way of collaborating with practitioners and his own problem identification. Since the teachers did not share his concern with the existing teaching materials, he applied a strategy of developing a prototype to get the teachers feedback on something more tangible.

> 'What I did was to identify this problem set and then work out a very rudimentary prototype to show the teachers or a focus group of teachers. I think I had seven teachers or something like that the first time my design met the gaze of a teacher, my own design so to speak, right? This gave the opportunity for them to give feedback on something concrete instead of having them discuss how teaching reading skills could improve in general.' Researcher C

The level that the teachers gave feedback on was primarily of a practical nature, such as the text size, suitability for the intended target group, issues for colour-blind pupils, etc. These were all aspects that researcher C felt challenged the concretisation of his design, but not the fundamental idea. From this initial feedback, researcher C further developed the prototype for a teacher to implement in her class. Even though teachers were involved in the pre-implementation processes, the purpose of their roles was more in line with refining than developing. The path of how researcher C has collaborated with practitioners thus resembles other technology driven DBR interventions, where researchers are exclusively working on problem identification and development of solutions. Practitioners are brought in to provide expert context knowledge on the feasibility of implementation. Neither do practitioners contribute in the theorisation processes following the interventions.

Researchers B and D involve their collaborative partners in activities related to development to a higher degree. When asked about the contribution of the practitioners, researcher D answers:

> 'They have contributed to everything. It was a collaboration between them and I where we produced sketches for learning designs that we subsequently translated into a concrete practice, which they could use and work with themselves.' Researcher D

Challenges arose for her in the process of moving from intention to implementation. Much to her regret, the educators did not want her to participate in the interventions in the classrooms.

> 'The problem was at the time when they had to implement it, I was no longer a part of it. The problem was that they were so engaged in the process that they thought: "what is that researcher supposed to do? Is it not sufficient that we simply move on ourselves?" "Yes", they replied to each other, "that is actually fine". At this point, I had delivered a contribution they found really valuable and then they took it from there. Redesign and so on is not something I have been a part of. Researcher D

The story represents a rather unique path of collaboration where the practitioners and the researcher are intimately involved in problem setting and developing solutions, but then the researcher is excluded from the data collection processes during the interventions and thus also from refinement. She explains how the roles shifted from helping each other in the initial activities to her becoming an evaluative outsider judging their performing practices. A positioning of roles that the practitioners felt was so uncomfortable that they chose to exclude her from these activities.

Researcher B collaborates with two sets of practitioners during his project. The first are the educators at the teaching training faculty with whom he designs the interventions. The second is the teacher in whose class the interventions occur. In terms of designing the solution, the educators are co-designers, whereas the teacher has a role resembling the implementer. In terms of problem identification, researcher B explains that he was the one who introduced the problem to be solved.

> 'I am the one who brings the idea to the table because I see a challenge. Then you might say "wait, is the design then an attempt to try to solve that challenge?" And I guess it is. The idea for my project stems from both personal teaching experience and from the fact that in the literature there is a sort of dichotomist division between theory and practice.' Researcher B

The path of collaboration for researcher B then becomes centred on the development of solutions and the testing in practice. Problem identification and theory generation is left for him as a researcher to do.

Thus, Researcher B and D also follow the pattern of relying more on practitioner involvement in the early stages when designing for instructional change. To a slightly higher degree than researcher B, rResearcher D involves her collaborative practitioners in activities related to problem identification. In contrast to her colleagues, and much DBR literature, she does not participate in the testing and redesign activities following the development phase.

6.4.3. THE TYPES OF KNOWLEDGE PRACTITIONERS BRING

During the interviews, I tried to pursue the types of knowledge that practitioners complement the researchers with through their collaboration according to the informants. In different ways, the answers formed a pattern related to knowledge of context, of the specific practice and subject specific knowledge. Researcher D explains:

> 'The practitioners bring their knowledge on practice and their knowledge of their field of expertise. The researcher brings some design knowledge, and I had a practical knowledge on how to do teacher education. I had a more theoretical design knowledge.' Researcher D

In her opinion, what the educators she collaborated contributed with was not how to teach, but their knowledge of expertise:

> 'Their subject-specific knowledge is quite strong, but their educational knowledge was limited.' Researcher D

Continuing our discussion on the knowledge of the teachers in researcher C's project and the knowledge contribution they bring, we discussed the following:

> Interviewer: 'If you were to say more about in what way or on which level they provided feedback? I mean if you were to elaborate on their contribution? How would you label it?'
>
> Researcher C: 'I would label it at a practical level. They could see it in their local context with their pupils and in relation to them evaluate that some part would be able or not be able to…or… create situations….how to put it… imagine some situations where the teaching material would hit or miss in relation to certain pupils.'

In terms of expertise on research as well as teaching and design, it is clear that the practitioners only cover a certain part of the teaching expertise. In the case of

researcher C, he has already stated that the practitioners did not see what he labelled a highly problematic way of teaching reading skills, and what researcher D values in her collaborators is their knowledge on subject-specific matters, not the way they teach. This leaves the researchers with the responsibility of research, design and to some degree educational matters as well.

Researcher B touch upon how the role of designer comes into play:

> 'They have a subject specific knowledge that they contribute with and what I do in reality… I do not dictate a certain design. I stimulate them to think in design… how to say it…I must be careful not to say solutions, right? In frames of design and solutions to challenges in relation to something the students have to acquire in terms of knowledge or skills, proficiencies, etc.' Researcher B

Comparing these statements to the initial critique put forward by Rowland (2007) that it is assumed that DBR researchers possess design competencies, it seems as though the informants support this view. However, as we shall see in the following section, the researchers are quite critical of their own abilities to work in designerly ways (a finding that is also picked up upon in the previous chapter on iterations).

6.4.4. WE DO NOT WORK AS DESIGNERS

When asked either explicitly about their design competencies or implicitly through questions related to traditional design activities, the informants show a remarkable insight as to their own abilities and limitations. Such traditional design activities include explorative sketching as discussed in chapter 5, rapid prototyping and aspects of facilitation and co-creation.

Previously, we saw how researcher B felt that the design term is often misused in such a way that suddenly everybody designs (see chapter 4). He described as an example how prototyping was not something he took into account when developing his proposal for how to work with theory and practice in teacher education. He concurs to giving form to something, but not in a way comparable to how designers work:

> Researcher B: 'I have given form to something. What I doubt is whether I have been part of a design process in the ears of designers.'
>
> Interviewer: 'And why do you not think they would think that you have been part of that?
>
> Researcher B: 'Maybe it is just what I see when I see designers work further down the hallway; they do not jump to a design in the three weeks it takes to write a PhD application. I mean, they have so many sub-

> processes, and they have a completely different take on what having an idea entails.

He describes how a team of designers has developed a plentitude of prototypes while designing a game and compares it to how he would sit and quickly jut down ideas in an attempt to be innovative and then erase them again almost immediately.

Researcher B expresses a wish to work design-based but feels he falls short compared to proficient designers. Likewise, in relation to facilitating workshops or co-creating with practitioners, researcher D explains how she feels her way through facilitating a series of design workshops without knowing exactly what to do:

> Interviewer: 'What do you think about…you say you actually did not have that much experience working design-based, so what was it like facilitating a large design process? What kind of tools did you have to be able to do that?'
>
> Researcher D: 'Well, I did not know what to do so I just went out on a limb and did it together with them [the educators] and then it turned out quite fun. The process I had with them was not very controlled, it was more explorative all the way through. They did not know either what I was supposed to have done or could have done, that I could have scripted some workshops or something like that in order to have something specific emerge faster, so we discussed, talked and drew a little and then we came up with something and they tried it out.'

Researcher D describes a process of collaboration where she takes on the role of the facilitating designer, but does so in an explorative and uncontrolled way. She does not have specific tools to work with but, at the other hand, the practitioners seem contend with the way she sets up the collaboration and how she facilitates the process of innovating their practice.

Researcher A comes the closest to the idea of the naturally competent designer. She compares being a midwife, which is her first profession, to being a designer:

> 'The things a midwife does, and I have been a midwife for 30 years, is to support, how to say it, processes that happen by themselves. And if I were to look at my life in its entirety and also in this, maybe especially in this, then that is what I do. It is to support processes that happen by themselves. It is to facilitate. How can I facilitate that those present here get a better opportunity to learn from each other and share with each other? That is what I am curious about at all times and that is the designer within me who is curious about how to support that. I do not know if I design all the time, but I cannot help being curious about how I do it.' Researcher A

The curious mindset researcher A describes could be compared to the mindset of celebrating alternatives as put forward by Prof. Redström during my interview with him (see chapter 5). It does seem, however, to be limited to a mindset only and not supplemented with a systematic or professional skill set of working design-based.

Through their collaboration with practitioners, the informants take on the role of the designer. They work with the skill sets they have and the degree as to which they reflect upon themselves as designers vary. None of them present a proficient way of working design-based, rather they describe an intuitive and pragmatic 'what works' attitude.

6.5. CHALLENGE – LACK OF DESIGN COMPETENCY

The roles of practitioners in DBR studies are divided between a majority of implementers, one-fourth of co-designers and a group where the researcher is also the practitioner. In studies where the innovation is driven by technology there tends to be a larger percentage of implementers compared to instruction driven interventions. The role of the designer is seldom described in detail and thus does not seem to play a major part in DBR studies.

The difference in the type of knowledge researchers, teachers and other potential collaborators bring to the development, implementation and evaluation of educational innovations is seldom discussed explicitly. The claim by Rowland (2007) that design competency is assumed in DBR studies to be a natural possession of researchers thus remains warranted and is in some cases amplified by the descriptions of collaboration processes in repository texts.

According to the informants, the knowledge that practitioners bring is either subject-specific or bound to the specific context of the intervention. Knowledge on teaching and learning, research and to some degree design processes are domains of the researcher carrying out the DBR study. Some informants view their own limitations in relation to design skills as problematic, while others seem more satisfied with either their own inherent abilities or alternatively choose an explorative approach.

In light of this, it seems fair to conclude that systematic ways of investigating a problem field, exploring numerous different solution proposals and facilitating how to process the input from practitioners when innovating an existing practice are underdeveloped in the field of DBR.

A challenge in DBR is thus how competencies in design can become part of the design-based research process or, alternatively, how those involved can work with the skill set they have to accommodate this challenge.

6.6. POTENTIAL – DISTRIBUTING DESIGN COMPETENCY

The data from the design experts mainly concern the claims of design expertise of the people involved in design processes. For the sake of simplicity, their input can be placed on a continuum with what has been labeled as 'the genius designer' in one end and 'collaborative organisations' in the other end. To explain this further, suggestions for potentials related to collaborating with practitioners the data point in directions of involving practitioners even further in DBR studies and distributing the competencies needed to develop, implement and evaluate an educational innovation to a larger degree.

When pointing at potentials to accommodate the challenge above, I therefore start by using the data to highlight some of the challenges associated with the idea of a lone designer carrying an innovative process and supplement it with theoretical perspectives. From there, I move on to describing the potentials in distributing design competency by making collaboration processes more tangible.

6.6.1. GETTING PRACTITIONERS MORE INVOLVED

When discussing collaboration with practitioners in the workshop at Umeå Institute of Design, the notion of the *genius designer* was brought up in one of the group dialogues as a position in opposition participatory design.

> Design expert workshop participant A2: **'**What we touch on is the type of design being applied in design-based.'
>
> Design expert workshop participant A1: 'Yes, I think so.'
>
> Design expert workshop participant A2: 'Is it user centred.'
>
> Design expert workshop participant A1: 'Yeah.'
>
> Design expert workshop participant A2: 'Or is it participatory?'
>
> Design expert workshop participant A1: 'I think it is participatory or…'
>
> Design expert workshop participant A2: 'It sounds a bit like the type of design-based research being done has more to do with this genius designer.'
>
> Design expert workshop participant A1: 'Yeah, yes.'
>
> Design expert workshop participant A2: 'Maybe with some users involved…'
>
> Design expert workshop participant A1: 'Yeah.'

> Design expert workshop participant A2: 'User-centred design, but it has not adopted this iteration of…'
>
> Design expert workshop participant A1: 'No.'
>
> Design expert workshop participant A2: 'Or is it just more visible in the way that he [the workshop facilitator, i.e. the author of this dissertation] presented it.'

The underlying criticism that DBR is still based on the idea of the lone designer and has not adopted a participatory approach to design is further discussed at other times during their conversation, mainly in relation to problem identification:

> Design expert workshop participant A2: 'This situation of the researcher seeing a problem that the practitioners do not have is highly problematic from a participatory design perspective.'

And a little bit later regarding the roles of the practitioners:

> Design expert workshop participant A2: 'We are talking about the second question: What role do practitioners have with regards to identifying and formulating the design challenge, so…'
>
> Design expert workshop participant A1: 'Important!'
>
> Design expert workshop participant A2: 'They should be fully the expert.'
>
> Design expert workshop participant A1: 'Yeah.'

The power shift from the designer to the user is mirrored in group C where the discussion evolves around the type of feedback practitioners can provide when positioned in a role as implementer:

> Design expert workshop participant C1: 'If you have a strong idea, then it becomes, like, how we deal with the users in design or here where you are just asking the users to respond to your design.'
>
> Design expert workshop participant C2: 'Yeah.'
>
> Design expert workshop participant C1: 'You are trying to get input on a very narrow thing you are not going to try and find out.'
>
> Design expert workshop participant C2: 'Yeah, exactly.'

The discussion covers the difference between practitioners as co-designers or implementers presented through the review material. In the eyes of the discussants,

the scope of feedback from practitioners, when placed in the role of implementers, becomes very narrow.

On the other hand, the same group sees reasons for omitting practitioners at certain stages depending on what you are looking to accomplish. In the same vein of looking for reasons to keep practitioners in the role of implementers, the participants put forward an argument for helping practitioners suspend their disbelief, which seems to resonate well with the descriptions of collaboration put forward by both researcher C and D.

> Design expert workshop participant C1: 'In all our projects, and the project with the municipality with everything else, the whole trick of working with practitioners and when you hold workshops, and when you hold activities is how to get them suspend their disbelief. You know that this is prac.. valuable, how to get them engaged, but also how to get them to suspend the practicality, the practical problems of everyday, to be able to suspend those constraints of it. And I think when hearing this, as well all about this idea that, you know, you want the practitioners in but you do not want them to define the problem, it might have something else to do with as well how you are sort of helping them lift themselves out of that. the practicalities of their current practice. To give them a more future orientation.'
>
> Design expert workshop participant C2: 'True.'

On the one hand the design experts of Umeå point to the potential of involving practitioners more and in every stage of the design process and, on the other hand, they flag the potential danger of having to struggle with practitioners about issues of practical matters illy fitted to activities of problem identification and brainstorming solution proposals. Exploring this potential further thus requires a way to accommodate the new issues such actions would generate, but the issue in itself also leads to the question of how to get practitioners involved to begin with. To widen this question further it is also necessary to identify which people have an interest in innovating existing educational practices.

I discussed these aspects with Prof. Redström during my interview with him. A discussion that circled around involving a broader range of people into the collaborate activities of DBR.

6.6.2. INVOLVING A BROADER RANGE OF PEOPLE

The overall message from Prof. Redström regarding collaboration was the dangers of claiming expertise and the benefits of involving a range of people in the design processes when innovating educational settings. He stated:

> ‘One of the things that designers quickly learned, and sometimes in the hard way, is that it is dangerous to claim expertise and authority in all cases, and it is often very humbling and effective to actually bring in other perspectives, not necessarily because they are experts, but simply because they allow you to see the issues at stake in a different light and that allows you to simply come up with more interesting, relevant or even better solutions to the problem. The expertise is also grounded in a given perspective and depending on that perspective some things will emerge and some other things will not. And that is why you need sort of a mobility there and sometimes questioning things that are sometimes taken for granted.’ Prof. Redström

In his view, bringing in more people is important not only to get additional expert knowledge perspectives, but simply to have different perspectives in order to shake up solidified perceptions. This, according to Redström, will lead to more interesting, relevant or even better solutions to a problem.

People who are interested in improving teaching and learning in general thus include people who practice teaching and those who receive it, those paying for it, those ultimately responsible for the quality of it and those who depend on people acquiring specific skills:

> ‘There are all sorts of people that actually have at stake.. or an interest in what is going on or what is coming out of a learning situation. The students obviously have an interest in what comes out of it being the carrier of it, the teachers have their interest because they are sort of supporting and leading that process of learning, and then of course there are other people that will benefit from people knowing these things in the end who also have a stake in this… I mean what do they know? How does that relate to what we would hope they would know?’ Prof Redström

The argument he makes is intertwined with the challenge discussed in chapter 5 on the iterative working manner of DBR. If your interest as a design researcher is to test the efficacy of a solution, then having a mindset of alternatives and celebrating the branching out of ideas through enacted sketching might not be the most suitable route for you. On the other hand, if you aim to investigate a problem space or explore a plentitude of possible solutions, there is a potential in setting your expert knowledge aside to stay open for other perspectives provided by non-experts who have an interest in the matter you are researching.

Participatory design (Binder et al., 2011) is considered as an approach that tries to involve users in design. The aim is to let people, practitioners or users encounter what Redström (2008) has characterised as ‘use before use’. This approach to design has its roots in the Scandinavian countries and started from the standpoint that those affected by design should have a say in the design process. An additional motive for

applying participatory design is the potential to ensure that existing skills can be made a resource in the design process. In the following part, I pursue the potential of accommodating the challenges associated with collaborating with practitioners in DBR through the means of participatory design. As participatory design constitutes a field of its own and an adequate introduction to the approach thus exceeds the scope of this study, I focus mainly on the aspects of enabling a range of perspectives and skills to come into play and the importance of tangibility in relation to this ambition.

6.6.3. MAKING COLLABORATION PROCESSES TANGIBLE

Two types of values guide participatory design strategically (Ehn, 1988). Firstly, a social and rational idea of democracy as a value that leads to considerations of conditions for proper and legitimate user participation. Secondly, a value that underlines the importance of allowing participants' tacit knowledge to come into play in the design process. This covers not only their formal and explicit competences, but also skills fundamental to the making of design artefacts in the broadest meaning of the word. These values also shape the role of designers engaged in this type of design processes.

According to Manzini (2015) in his book with the incisive title *Design, When Everybody Designs*, a role of professionally trained designers presently emerge due to a rising demand for design-orientation, not only within industries, but also in everyday life.

> 'Design is a culture and a practice concerning how things ought to be in order to attain desired functions and meanings. It takes place within open-ended co-design processes in which all the involved actors participate in different ways. It is based on a human capability that everyone can cultivate and which for some - the design experts - becomes a profession. The role of design experts is to trigger and support these open-ended co-design processes, using their design knowledge to conceive and enhance clear-cut, focused design initiatives.' (Manzini, 2015, p. 53-54)

In order to fill this role, designers must take part in collaborative organisations akin to social networks where active involvement and the relational intensity play important parts in the type of design work a group of people can realise.

Open-ended co-design processes are supported by making proposals visible and tangible. Manzini (2015, p. 133) points at three main categories in this regard: *conversation subjects*, *conversation prompts* and *experience enablers*.

Conversation subjects aim at showing 'what the world could be like if', to encourage reactions and interactions between different potentially interested actors. Conversation prompts are communication artefacts aimed at facilitating social conversations, i.e. to illustrate the state of things, viable alternatives, or to consolidate

output and offer the possibility of replicating it through solution replication toolkits. Finally, experience enablers can be prototypes, small-scale experiments, or even full-scale pilots with a twofold aim. They anticipate possible pinpoint solutions, and they are design devices that offer the agents a direct tangible experience of what a solution could be like so that they can offer constructive criticism (ibid. p.133).

With the help of these tools, stakeholders with little experience in design processes can become involved in all stages and not only those familiar to them, as we have seen with teachers in the role of implementers. Conversation subjects seem a promising starting point to overcome the challenge of working with practitioners who are caught up in the practicalities of their current practice because they provide the practitioners with an orientation of the future. Similarly, conversation prompts and experience enablers are proven design tools to make abstract design thinking processes more tangible and thereby easier to engage with for participants at all levels. Activities around the development and facilitation of conversation prompts, and experience enablers might also help researchers of DBR in reporting on the early stages of collaboration.

Thus, a challenge in DBR is how competencies in design can become a part of the design-based research process or, alternatively, how those involved can work with the skill set they have to accommodate this challenge.

6.6.4. SUMMARY

The most prevalent way of collaborating in DBR is to bring in practitioners in the role of implementers and benefit from their expert knowledge on the specific context and target group. Some repository texts call for collaboration as an area of DBR in need of more attention, especially in terms of giving practitioners a greater sense of co-ownership of the innovations developed through the research. The role and skill set of the designer is seldom described in detail in the intervention studies and thus does not seem to play a major role in DBR studies. The claim by Rowland (2007) that design competency is in most cases assumed to be a natural possession of researchers in DBR thus remains uncontested.

The informants also take on the role of the designer in their descriptions of how they have collaborated with practitioners. They describe an intuitive and pragmatic ‘what works’ attitude rather, than a proficient skill set. Much like how the knowledge of practitioners is described in the intervention studies, the knowledge that practitioners bring, according to the informants, is either subject-specific or bound to the specific context of the intervention. The roles and expertise of practitioners and researchers are relatively well-defined, whereas the role of the designer in DBR is left as a responsibility picked up by the researchers and fulfilled with varying degrees of awareness. Some informants view their own limitations in relation to design skills as problematic, while others seem more satisfied with their own inherent abilities.

Thus, a challenge in DBR is how design proficiency can become part of the design-based research process or, alternatively, how those involved can work with the skill set they have to accommodate the absence of it.

Potentials alluded to by design experts is to bring in more perspectives early in the design processes as has been the practice in participatory design since the 1970s. Two main obstacles here are to lift practitioners out of the everyday practicalities and to scaffold the participation of non-proficient designers in the process. These challenges can be accommodated via provoking dialogue and making ideas tangible. Specific tools to do so are conversation subjects, conversations prompts and experience enablers as described by Manzini (2015). These tools may function as a starting point for researchers of DBR to mitigate the absence of educated designers.

CHAPTER 7. DESIGN CHARACTERISTIC FOUR – DESIGN PRINCIPLES

In this chapter, I will discuss the fourth and final characteristic of working design-based in DBR. As is evident from the overview in chapter 2, design principles are repeatedly put forward in key literature on Design-Based Research as the way in which knowledge from design interventions is generalised and thus may be of use and bear relevance to similar interventions in the future (Herrington & Reeves, 2011; Kali, 2008; Plomb & Nieveen, 2013; Reeves, 2006; van den Akker, 1999; van den Akker, Gravemeijer, McKenney & Nieveen, 2006). Simultaneously, recurring critique both internally and externally has been raised against Design-Based Research for not producing useful scientific insights for practitioners, policymakers and fellow researchers. Dede (2005) concludes that the field of DBR tends to be characterised either by global but trivial conclusions or by sizable but local findings. Dede (2005) also finds that many DBR projects change either the format or the setting of the intervention, which makes analysis across cycles of intervention difficult. Concerns have also been voiced about whether design research can live up to the premise of simultaneously evaluating proposed interventions and testing the underlying theory behind them (Phillips & Dolle, 2006). Similarly, Sandoval (2014) suggests that there are researchers 'who are conducting systematic design research, but we are not talking much about how we do it or how not to do it' (p. 19).

Van den Akker (van den Akker, 1999; van den Akker, Gravemeijer, McKenney & Nieveen, 2006) suggests that design principles could support design researchers in their task through heuristic statements. The intention is not to guarantee successful interventions, but to generate principles that allow depiction and discussion of the currently most appropriate knowledge for specific design and development tasks. The development of knowledge through Design-Based Research can thus be seen as a continuous refinement of *conjectures* (Sandoval, 2004) to be tested in local settings and generalised principles that have proven effective across various contexts. In the process of a DBR study, principles progress from guiding principles of the interventions (also called conjectures) to conclusive principles when generalised post-interventions (also sometimes referred to as refined principles).

Edelson (2002) introduces three types of theoretical output from DBR studies in the form of *domain theories*, *design methodologies* or *prescriptive design frameworks*. The latter are generalised design solutions, which describe the characteristics a designed artefact or intervention must possess in order to achieve a particular set of goals in a particular context. Due to the objective of Design-Based Research and the

nature of the theoretical output, Edelson (2002) stresses that the lessons learned from design experimentation should not be judged by the same standards as traditional empirical research (Ibid.). Two unique and important evaluation metrics for design research are, in his view, novelty and usefulness. A set of refined and coherent design principles can thus form a design framework and the quality of the research should be valued in terms of the radicality of innovation and the recognisability and usefulness for practitioners.

Despite the vivid debates on design principles within the DBR community, the apparently many and varied forms in which design principles are used in the literature, collectively intrigued me along with my senior colleagues Professor Rikke Ørngreen and Professor Thorkild Hanghøj. According to our initial discussions, there seems to be a lack of consistency, standards or common ground when testing, describing, applying, refining or generating new design principles. This made us curious about what constitutes a design principle in DBR literature.

Consequently, the aim of this chapter is to take a closer look at how design principles are defined and used within DBR and provide suggestions for improving the development of design principles. The overall objective is to gain insight into the following question:

- How are design principles developed and articulated in the DBR literature?

7.1. CODING STRATEGY

The coding in the review on design principles was carried out in collaboration with two colleagues at Aalborg University, Prof. Thorkild Hanghøj and Prof. Rikke Ørngreen.

The analysis was conducted using three categories (referred to a 0, 1 and 2) that were separated by the level of depth in which the selected body of literature dealt with design principles. The first category (0) covers articles that do not mention design principles or only mention them in the reference section (i.e. if the words ‘design principles’ are included in the title of an article). The second category (1) applies to studies that discuss design principles more or less elaborately in relation to either methodological approaches or findings. Finally, the third category (2) of articles focuses primarily or in great detail on the very concept and methodology of design principles in DBR.

Additionally, the early stages of our research revealed a couple of interesting numbers regarding the frequency of appearances of design principles in the literature of DBR in comparison to how salient design principles are argued to be in the much cited DBR reviews and DBR method articles (e.g. Anderson & Shattuck, 2012; Herrington & Reeves, 2011; Kali, 2008; Plomb & Nieveen, 2013; Reeves, 2006; van den Akker,

1999; van den Akker, Gravemeijer, McKenney & Nieveen, 2006). As Table 7.1 shows, 23% of the total number of articles identified through Google Scholar mention design principles, a percentage that has remained relatively steady throughout the increased popularity of DBR during the last 15 years and has never exceeded 25%.

	With no period selected	From 2012 and forward	2004	2008	2010	2012	2014	2017
"design based research"	18.500	11.500	198	642	1060	1380	1930	2390
"design based research" and "design principles"	4.230	2.870	34	145	241	325	459	498
Percentage of articles that use design principles in the DBR literature	23%	25%	17%	23%	23%	24%	24%	21%

Table 7-1. Articles mentioning design principles identified through Google Scholar

Of course, this can be explained by the use of other similar ways of presenting findings in DBR, such as 'domain knowledge' or 'guidelines,' simply just using the term 'findings' or the body of articles mentioning DBR but not themselves being design-based studies.

7.2. FINDINGS

In the next step of our analysis, we analysed all the DBR studies mentioning design principles, using the strategy laid out above. This revealed a landscape of the three categories (0, 1 and 2), as seen in Table 7-2.

Category	Number of Papers
0	55
1	17
2	5
Total	77

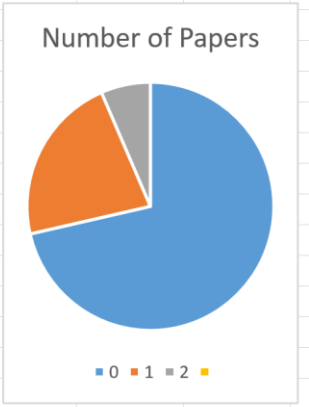


Table 7-2. Distribution of categories among the selected studies concerning design principles

Category 0: The articles in this category do not mention design principles or only do so in the reference list. This includes approximately 70% of the articles, which means that approximately 30% do mention and use design principles. In this specific (and somewhat narrow) respect, the sample is therefore comparable to the distribution in the total number of articles (Table 7-2).

Category 1: The articles in category 1 concern studies that discuss design principles in relation to either methodological approaches or findings. There are 17 articles in this category, which we analysed in more detail. Seven of the studies were conducted within the context of science education (Barab et al., 2007b; Bodzin, 2011; Duncan & Tseng, 2011; Lee, Linn, Varma, & Liu, 2010; Li & Tsai, 2013; Looi, Chen, & Ng, 2010; Sandoval & Reiser, 2004), which indicates a stronger tradition within research on science education than in other areas of educational research for discussing and clarifying design principles when conducting DBR, as well as the fact that DBR seems to be applied relatively often in a science education context.

The degree of detail in which design principles are presented in the articles ranges from brief mentions in relation to explaining the methodology of DBR (McCandliss, Kalchman & Bryant, 2003) to rather extensive uses of principles throughout the study (Barab et al., 2007b). A number of articles primarily apply design principles during the initiation of the design process iterations (Jahnke, 2010; Koivisto, Niemi, Multisilta & Eriksson, 2017; Laferrière, 2002). Gutiérrez and Jurow (2016) also return to their initial principles in their discussion and conclusion, but do not summarise how the study leads to new or qualified principles after the design intervention. Others are vaguer in their use of design principles by referring to them in DBR literature but without using their own principles, instead referring to learning objectives (e.g. Duncan & Tseng, 2011).

Category 2: The articles in this category involve studies that focus in detail on the very concept and methodology of design principles in DBR. There are five articles in this category. Sandoval (2014) proposes conjecture mapping as an approach to clarifying links between theoretical assumptions, specific designs and the use of these designs. Ruthven, Laborde, Leach and Tiberghien (2009) point to a public apparatus of design tools, while the Reeves, Herrington and Oliver (2005) article states that principles must do real work by being transformed into educational practice. Wang and Hannafin (2005) offer a valuable overview of what they describe as a paradigm to encompass similar approaches, including design experiments, design research, development research and formative research as well as DBR itself. Each variant emphasises its own distinct features of design principles. Wang and Hannafin (2005) also divide DBR into categories based on certain characteristics in which two out of five - pragmatic and contextual characteristics - explicitly aim at producing design principles. When dealing with the approaches in greater detail, however, the interactive approach also relates to the generation of design principles.

Two themes emerged through our analysis of the selected studies: the articulation of heuristics for design principles and the temporal aspects of using design principles as conjectures versus using them as conclusive principles.

7.2.1. HEURISTICS FOR DESIGN PRINCIPLES

Across the selected studies, we found no clear consensus on how to formulate and report specific design principles. To give an example from Laferrière (2002), several design principles are lumped together, which makes it difficult to identify specific the constituents of each principle:

‘At each iteration of the design process, the project gained in clarity and complexity. Connectivity, ease of access, support, and co-constitutionality (the existence of a sociotechnical infrastructure) were the first design principles applied. Other principles were participatory design, authentic multimodal social interactions, interrelatedness, active collaborative learning, progressive distributed expertise, collaborative reflective teaching, and knowledge building.’ (Laferrière, 2002, p. 33)

Some of these quoted design principles relate to particular technological aspects of the study, whereas other principles are formulated in very broad terms and are not described in any further detail in the article. In this way, the reporting of DBR research may risk bundling so many design principles together that it becomes too complex either to understand or to show the relationships between the different assumptions underlying each principle. On the other hand, there is also a danger of trying to formulate design principles that are too specific, that is, by trying to identify specific design principles for the development of technological tools that will ensure certain types of learning outcomes.

In our analysis of the studies, most of the design principles are described with a relatively low level of context-specific detail on how the principles are used. However, there are exceptions to this, for example, Sandoval and Reiser (2004). Their four principles mirror many of the focal points stressed by the core literature on design principles. Through the principle of 'represent theories as explanatory frameworks', for instance, the authors present a convincing rationale to support the principle and they include cues as to how and when to apply it, and lastly, the context in which the principle occurs. Less easy to track are the principles generated by Koivisto, Niemi, Multisilta & Eriksson (2017) when designing 3D simulation games in healthcare education. The initial principles rest on a literature review and are summarised with a title and the corresponding theoretical foundation next to it. New insights concerning the use of these principles are presented in the discussion, but the principles are not separated and individually refined. For instance, it is not clear which of the principles, 'among nursing processes', 'immersive 3D environment' and 'realistic and authentic patient scenarios', are referred to when the authors conclude that 'the better the game enables interaction, the more realistic and engaging the learning experience will be' (p. 396).

Another aspect of the design principles in the reviewed literature that is less prevalent is the procedural aspect. Even in cases where the procedural aspect is present in the way the principles are formulated, there is still a lack of information on how to implement them in practice. Consider the following principle presented by Hung (2017) on flipped learning for language educators: 'Maintain up-to-date professional knowledge and skills to build a transformative learning community in the flipped classroom that empowers L2 learners to be active and responsible for their own learning' (p. 188). Despite providing the context of when to apply this particular principle, the article offers little insight as to how to maintain up-to-date professional knowledge and skill or how to build a transformative learning community.

Despite van den Akker (1999) being a much-cited researcher within the methodological discussions of DBR, we did not find a single empirical example in any of the reviewed articles using his formula for design principles. Heuristics for working with design principles thus exist for the design-based researcher. However, these templates are seldom applied in the research literature and cannot be seen as 'standards' within the field.

7.2.2. CONJECTURES AND CONCLUSIVE DESIGN PRINCIPLES

Throughout the categorised literature, design principles are described both as guiding and as conclusive of the design process. Summarising this point in their review, Shattuck and Anderson (2012) state that designs evolve from and lead to the development of practical design principles.

The reviewed studies that describe interventions are especially focused on the early introduction of design principles as a guiding mechanism (Bodzin, 2011; Koivisto, Niemi, Multisilta & Eriksson (2017); Sandoval & Reiser, 2004; Voogt et al., 2015). Yet despite the common understanding that design principles are developed through each iteration of the design process (Jahnke, 2010; Laferrière, 2002; Schleppegrell, 2013), it is rarely possible to compare theoretically generated design principles with refined and conclusive principles. This may be due to the limited journal format in which the studies are presented, the main reason being that the articles do not necessarily return to their guiding principles when concluding their studies but rather (and understandably so) return to their research questions or, in other cases, to reflections regarding the research design itself.

There are exceptions to this. For instance, Barab et al. (2007b) develop four design principles aiming at establishing a situative embodiment in science education through the use of digital games; these are presented as a concluding paragraph at the end of the extensive article. The article is an example of what van den Akker, Gravemeijer, McKenney & Nieveen (2006) label 'development studies'. These involve preliminary research in the form of problem analysis and the development of a conceptual framework; iterative design cycles in the prototyping phase; and most importantly for the scope of this article, a retrospective analysis followed by a specification of design principles and how they link to the initial framework. In contrast to validation studies, it is this derivation of design principles for use in practice that is the fundamental aim of development studies. It is worth noting that the article spans more than 30 pages and that the authors therefore to a lesser degree face the problem of having too much story to tell, which is identified as a key challenge when reporting on design research studies (McKenney & Reeves, 2012, p. 201). The tendency to omit refined or newly generated design principles when reporting design research findings through seminal articles might relate to the nature of the studies and to the guidelines and limitations provided by many scientific journals.

From a theoretical perspective, Sandoval (2014) offers a promising contribution to the development of an argumentative grammar for design-based research through the introduction of conjecture maps. Similar to guiding design principles, a conjecture map contains the embodiment of how to support learning in some context through design conjectures, whereas theoretical conjectures articulate the ideas, a research team has about how mediating processes produce desired outcomes. In this way, a conjecture map helps distinguish conjectures about how designed features of a learning environment will function in their intended setting from conjectures about how these features mediate learning and produce intended outcomes. Given the focus on guiding design principles in DBR literature, conjecture mapping holds promise in clarifying and specifying the use of design principles when moving through each iteration of the design process. I shall return to conjecture mapping later in this chapter when discussing the potentials of design principles.

7.2.3. SUMMARY OF REVIEW FINDINGS

Our analysis of the reviewed literature reveals a discrepancy between methodological texts on DBR and empirical studies applying the approach. The common narrative presented in much DBR literature is that the pool of knowledge in the form of practical and useful design principles is constantly growing and evolving. However, the majority of the reviewed studies only briefly mention design principles and thus do not contribute to this constant evolution. Furthermore, those who apply design principles primarily do this through an initial clarification, which aims to 'guide the DBR research practice' without systematically returning to their outsets. In fact, we were only able to locate one study (Barab et al., 2007b) in our review that systematically documents the iteration and refinement of the applied design principles. In terms of how design principles are presented in the studies, we found no clear consensus on how they are defined or formulated.

7.3. VOICES FROM THE FIELD

The four interviewed researchers express vastly different views on how to present the knowledge obtained through their projects. Researchers A and C talk effortlessly about the principles that guided their artefacts, both technically and in educational terms. The processes described in chapter 5 on refining materials bear consequences for the roles that principles have for researchers A and C when compared to the more facilitative approaches of researchers B and D.

Researchers B and C show a greater deal of reluctance in terms of identifying, applying and generating design principles. A key element is that they are not directly aiming at solving a problem, rather they attempt to understand a context, a practice or a theoretical term through their interventions.

In the following, I start by introducing the reflections of researcher A and C concerning the roles principles played in their projects before describing the hesitant voices of researcher B and C. In the last part, I highlight some of the alternatives to design principles that the researchers point to in order to identify potential new ways of generalising knowledge in DBR.

7.3.1. TECHNICAL AND EMBEDDED PRINCIPLES

Based on her initial mapping, researcher A was able to formulate a series of guiding principles for constructing her online course. Some of these were technical in nature such as the interface being self-explanatory for even a novice online course participant, the course should not require too much bandwidth to attract as many midwives around the globe as possible. In conjunction with the subject-specific content provided by experts of the field, the principles formed the intervention. As

researcher A did not finish her work on the online course, we can only speculate what her refined principles might have looked like.

Researcher C transforms the underlying reading theory into principles, which he embeds in the teaching material he is developing.

> 'My theoretical contribution lies in operationalising the very abstract computer simulation generated reading theory into instructional principles with the use of text to speech technology, right?' Researcher C:

Based on his research through interventions, he is able to formulate four principles, which are procedural in nature and loosely follow the heuristic prescriptions presented earlier by van den Akker (1999), i.e. if a teaching material should support pupils' reading skills, then it is advisable to integrate X, Y and Z characteristics in the reading material.

It is noteworthy, though, that both researchers find that their principles are of a nature that make them applicable beyond the situation in which they were developed. Had researcher A paired the principles with other subject-specific knowledge contents, the course could have targeted a different group of professionals. Researcher C also imagines that his principles can be realised in different ways, for instance, as a series of principles for how to read aloud with a child.

In both cases, working with design principles seem unproblematic and they are used for guiding and generalising the findings from the interventions. The principles are procedural in nature and generally follow the heuristic guidelines presented earlier in this chapter.

7.3.2. UNDERSTANDING RATHER THAN IMPROVING

Researchers B and D voice a more hesitant stance in relation to the development and application of design principles. Both researchers stress the fact that they are not directly solving a problem and thus do not refine guiding principles through their interventions. Researcher D even goes as far as doubting the functionality of design principles:

> 'I have never really understood what the point of those design principles actually is. I mean, I do not think I have developed a design so thoroughly and tested it in so many different contexts that I would be able to say that these principles are eternally valid in all of the experiments I have done.' Researcher D

Rather, they both seek in unique ways to understand a context through the means of intervening. Researcher D explains:

> Researcher D: 'Through these design proposals, we get to know what people think the future could look like in this context and what it could definitely not look like. That is, what experiments would they never accept to participate in. Therefore, you gain broader knowledge about a context and not just, if we compare it to the somewhat caricatured descriptive research, then you gain knowledge about the present but also about a potential future.'
>
> Interviewer: 'But a lot about the context?'
>
> Researcher D: 'Very, very much about the context. Mostly, it is that kind of knowledge you gain.'

Similarly, researcher B explains how the designs for him are a means to obtain knowledge about something else than the design solution itself.

> 'I investigate something by designing something, but what I investigate is not the design. What I do is I design to investigate something else.' Researcher B

Later in the same interview session, he further specifies:

> 'The knowledge I produce is not knowledge about the design itself. It is not knowledge on DBR either. It is mainly knowledge about students' capability to transform knowledge between professional education and professional practice that we have tried to push in different directions by designing for it.' Researcher B

The shared interest in understanding by means of intervening make both researchers reluctant to generalise their knowledge in the form of principles. They both underline the situatedness of their research, which makes abstract principles a less preferable way for them to communicate their findings.

> 'I think of it as something eternally valid that you develop from the tiny experiment you do in a specific context from which you then should be able to deduce some principles that would be applicable to all kinds of different contexts you have not been a part of.' Researcher D

In addition, the procedural aspect of design principles further seem to clash with how the two researchers view the knowledge they produce. Researcher B simply states:

> 'I would at any cost avoid telling someone: 'this is how you should do this or that'. Researcher B

Researcher D supports this position in a few more words:

> ‘I would be afraid of making a statement on something I did not know anything about by recommending that you should simply do this and that, and then it would all work out. I would feel I would have to take all kinds of reservations to a degree where it would become counterproductive to what I wanted to communicate.’ Researcher D

The quote is reminiscent of the critique put forward by Dede (2005) as touched upon earlier in relation to making knowledge produced by educational researchers relevant. What is in question here is whether design-based researchers are able to strike a balance between recognisable and novel as well as useful and abstract.

7.3.3. VARIATIONS AND ALTERNATIVES TO PRINCIPLES

Despite their reluctance towards design principles, both researchers B and D show a willingness to think in alternatives and to present the knowledge they gain from their projects in a form that can guide future design experiments. The ideas presented by the two center around descriptive variations and pattern recognition:

> ‘Instead of generating design principles, I think I do design variations.’ Researcher D

For researcher D, the dependency on the context is what matters the most. The more detailed and well described the context is, the more willing she is to articulate principles or variations thereof:

> ‘Yes, and then that you in a way embedded in the term link it to a specific context. That is was not something like… this is just how you should design and then it will always be perfect. I mean, that it was context dependent principles.’ Researcher D

She imagines that it if she were to generate principles, she would collect a heap of comparable experiments from different contexts in order to feel she had enough knowledge to back up a principal claim. This conception is very akin to the initial mapping of existing knowledge that DBR projects often apply in order to generate guiding principles, while at the same time it bears resemblance to the ability to recognise patterns across multiple descriptions. The latter represents an alternative, which researcher B and I discussed during his interview.

> Researcher B: ‘My perspective is situated. And the situated perspective limits me from saying that someone else would most probably benefit from in the same way as I did, but you can recognise patterns and from there ask: how do I apply this to my local practice?’

> Interviewer: So what you are aiming at, if I understand correctly, is to describe something and then it is up to others to recognise this in their own practice and evaluate whether this is something that would work for them?
>
> Researcher B: Yes.
>
> Interviewer: In this way, they said it themselves and you did not.
>
> Researcher B: Or, 'he did it this way, let us do some more research to investigate this. Let us test it in other ways or let us challenge it by saying we have some research here that contradict it.'

The perspective raised by researcher B is in line with how he perceives Design-Based Research in general and the way he contributes with new knowledge. What he strives for is new knowledge on a theoretical level from situated design interventions. He does not aim at solving a specific challenge, nor does he claim to find the most efficient way of teaching Instead, he becomes part of a continuous knowledge flow where each similar intervention tells a situated story, which is open for interpretation and contributes to a shared pool of knowledge.

7.3.4. IDENTIFIED CHALLENGES

The reviewed studies and the interviews point to a challenge in DBR of constantly evolving the existing knowledge pool in the form of useful design principles. A major part of the studies does not or only briefly mention design principles. The minority that does identify guiding principles through an initial clarification, fails to present refined and conclusive principles in almost every case. The findings point to a potential staleness in the knowledge pool that design-based researchers build on or use as an outset for new interventions.

Based on the interviews, those intervention studies that seek to understand a practice or context through interventions rather than improve it through solving a specific challenge seem less suited to generate knowledge in the form of principles. The hesitation towards principles from this perspective rests partly on a reluctance to generate abstract best practices based on highly situated experiments and partly on the fact that the knowledge researcher B and D produce, is not prescriptive in nature.

An equally serious challenge is that there seems to be no clear consensus on how design principles are defined or phrased. This in part leads to confusion as to what the functions of principles are to begin with. The challenges I pursue through the remaining parts of the chapter are thus:

- How can studies that aim to understand through interventions contribute to a shared pool of knowledge in a form that can inform future design studies?

- What changes can be made to the existing guidelines for generating design principles to make this way of passing on knowledge more useful for researchers within DBR?

7.4. TWO DIFFERENT PATHS FOR COMMUNICATING RELEVANT DESIGN KNOWLEDGE

In the following section, I investigate the two challenges raised above by keeping both the potential for alternative ways of communicating design knowledge and revising the existing guidelines for generating design principles open. I start by highlighting a few points raised by Prof. Redström on both issues. Next, I discuss how design principles can become more useful for researchers of DBR by analysing the limitations and concerns raised by the practitioners in relation to the existing knowledge already present in popular and lesser-known DBR papers. I do this by exploring the potential of *conjecture mapping* as proposed by Sandoval (2014) in conjunction with the knowledge discussed in the section on the characteristics of design principles. Lastly, I explore the potential of design patterns as an alternative to design principles in studies with less focus on the prescriptive aspects.

7.4.1. PRINCIPLES CAN BE PROPOSITIONAL IN NATURE

According to Prof. Redström, generic guidelines in the form of principles have played a part in the field of design since the 1960s. Well aware of the dilemma of generalisation described earlier, he stresses the difficulty in identifying at what point a designer or researcher feel qualified to come up with a principle. In many design disciplines, however, principles are to a lesser degree seen as a means to isolate cause and effect in all cases.

> ‘You want these principles to be almost like gravity. That they are always the case. And if they are not, they are not really principles. But many design principles had more the character of “consider this…” or “make sure you pay attention to these things” or “if you are entering into something like this, don’t forget that you also need to”, so it is very seldom that they are very direct.’ Prof. Redström

Therefore, he suggests a more pragmatic attitude towards how to measure the validity of design principles:

> ‘The only way to find out what is a good principle is to try them out. You write loads of them and see what works.’ Prof. Redström

In addition to this, he suggests making principles a part of the whole design process. Much like early iterations of design proposals (as discussed in chapter 5), generating a plentitude of principles in the beginning of a project to see where they lead you

according to the criteria you set up can support the iteration process from conjecture to refined principle. In this sense, principles are propositional in nature as opposed to deductive.

The key element when formulating principles is, according to Redström, that they are actionable. That when explained to a practitioner he or she would get the sense of how to execute it themselves. The balance between instructional and abstract remains tricky. On the question on how to formulate principles, he explains:

> 'It is not so vague that your reaction is "okay, I get it, but what does that actually mean if I am going to do something?" Then it is too vague. Then it is more like an observation or something. And if it is so specific that there is no room for improvisation, if there is no room for adopting for context, like if you are going to make a slide show it has to be red and this is the colour code for it. That is like "sure, but that is just one way of doing it." So then, it gets too specific. So you need to somehow find a balance where the suggestion is evocative enough to inspire you and specific enough so you can get a sense of "okay, I will try this then", but not determined to the point where it doesn't seem to apply outside a very particular context and therefore it doesn't become so relevant.' Prof Redström

In search for an alternative to principles, Redström also points to patterns as he mentions the huge influence that the ideas of Alexander (Alexander, Ishikawa & Silverstein, 1977) on pattern languages has had on computer science.

> 'In that case, it was not so much as a set of guidelines for designers. If you just do this, it will be good. But it was more like… it was also very much a way of involving people that didn't know so much about design to take part in the design decisions, because there were things to start from, there were building blocks that you could relate to, and there were relationships between the building blocks that were sort of there before you had to figure them out. So, there was something to start with for a novice.' Prof. Redström

Redström introduces design patterns as a way of generalising design knowledge that is still useful as a starting point for others to build upon their design ideas. Patterns, in his view, have the added benefit of making it easier for people without design experience to get involved, which at least at first glance seems potentially beneficial for design-based researchers who aim at collaborating closely with practitioners.

Armed with these new insights, I now turn to discuss two different paths, each with the potential to accommodate the challenges posed above. Firstly, I revisit the knowledge on design principles and attempt to formulate a series of characteristics that might help mitigate the difficulties and reluctance many researcher of DBR seem

to have in generating this particular form of knowledge. Secondly, I investigate the potential of design patterns based on the original ideas of Alexander (Alexander, Ishikawa & Silverstein, 1977) in conjunction with the newly found interest in patterns in the neighboring field *Learning Design*.

7.1. CLARIFICATIONS FROM WITHIN THE FIELD OF DBR

The lack of consensus on how design principles should be understood, generated and applied is also debated within the DBR community itself. In order to inform the thematic analysis and the statements of the informants, I did an additional review on design principles in DBR, applying snowballing techniques (Greenhalgh & Peacock, 2005) to the repository texts placed in category 2 primarily.

Design principles are prescriptive in nature and relate to many different types and aspects of educational interventions and contexts, for example, curriculum design principles (Bodzin, 2011), the development of educational technologies (Sandoval & Reiser, 2004), professional development (Voogt et al., 2015), pedagogical approaches (Lewis, Perry & Murata, 2006) and different combinations of these. In terms of defining what a design principle is, one of the most prominent voices in educational design research is van den Akker (1999; van den Akker, Gravemeijer, McKenney & Nieveen, 2006), who suggests that design principles can support design researchers in their tasks through heuristic statements in a format such as the following:

> 'If you want to design intervention X [for the purpose/function Y in context Z], then you are best advised to give that intervention the characteristics A, B, and C [substantive emphasis], and to do that via procedures K, L, and M [procedural emphasis], because of arguments P, Q, and R.' (van den Akker, 1999, p. 9)

The intention of the statement is not to guarantee successful interventions, but to generate principles that allow depiction and discussion of the currently most appropriate knowledge for specific design and development tasks.

Less often cited is Baumgartner and Bell's (2002) paper, 'What will we do with design principles?' Here, the authors suggest that design principles within DBR should be phrased through the lens of three key questions: Who is the audience for design principles? What is the model of the use of design principles? What characteristics must design principles have to be useful to this audience?

In their answer to the first question, Baumgartner and Bell (2002) focus on those who design, that is, educational researchers, content experts, curriculum and technology developers, and teachers, and they conclude that the principles should inform their design decisions and that the result of relying on them should lead to more effective learning designs (p. 5).

From the perspective of Baumgartner and Bell (2002), the practice of using design principles related to the second question differs from the practice of discovering and refining them. While some design principles can be generated after a design process is complete, the argument that these authors put forward is that in order to be useful, design principles should be accessible from the beginning of the research process. As opposed to being explanatory in terms of giving reasons why an intervention was successful, useful design principles are generative in nature, leading designers to come up with new designs on the back of the guidance provided by the existing principles. The contrast between generative and explanatory design principles is discussed in further detail in the thematic findings, where I introduce Sandoval's (2014) term *conjectures*, as it was part of the findings in our review data material.

The final question Baumgartner and Bell (2002) tackle is the characteristics of the principles. The authors list two key issues when producing generative design principles. First, principles must provide a means for the designer to know how and when to apply the principles and must also provide the rationale behind them. Secondly, they should provide means for the designers to know whether the application of the principles was successful or not.

More recently, Bakker (2019) has analysed the use of design principles in five specific DBR projects, through the different categories of domain (topic), design principle, aim, design and focus of principle. He further discusses how researchers can benefit from being explicit about the nature of their design principles as either values, criteria, predictions or pieces of advice. Since Bakker perceives design principles as amalgams of value and knowledge, he suggests that researchers be explicit about their values and analytically distinguish these values from the empirical knowledge about how to achieve desirable outcomes. Finally, he provides the following approach to formulating design principles: Use an easy to remember name, summarise the principle in a couple of sentences, explain the surrounding values to be adopted and make it clear whether the principle is supposed to be a prediction, a heuristic or an informal piece of advice.

Even though all three of these approaches (by van den Akker, 1999; Bakker, 2019; Baumgartner & Bell, 2002) handle the question of how to phrase design principles quite differently, we also see clear similarities in their lines of thought. Design principles should inform the design process and guide educational designers towards informed decision-making. The rationale behind, or the arguments for a specific principle, should be transparent, and the procedural aspect of a principle is of pivotal importance, as it provides means for the designer to know when, how and why to apply a principle. This does not mean that doing so will automatically lead to effective educational design solutions, because, as stressed by Baumgartner and Bell (2002), tacit knowledge is often required to successfully apply design principles, and the principles are inherently context-bound and may not be transferable to new contexts.

Some researchers argue for collecting and making design principles visible through open repositories, for example Barab, Dodge and Gee (2009) and Kali and Linn, who are the main editors of the Design Principles Database (http://www.edu-design-principles.org) described in Kali (2006). However, the timeliness and generalisability of such initiatives may prove to be difficult, and the databases we assessed seemed abandoned and outdated.

7.1.1. CONJECTURE MAPPING

The challenge of design principles seems to be at one hand that the perception within the field is that principles represent too bold assumptions on the relationship between cause and effect in educational situations and, on the other hand, that if DBR fails to produce new knowledge in the form of actionable recommendations, the shared knowledge pool will grow stale. This perception can at least partly explain the lack of generated principles in the DBR literature.

A way to change this potential is to steer away from the dogmatic side of principles and focus more on the propositional side of them. This in effect might also help scaffold the designer's mind-set of praising the alternatives as presented in chapter 5. Following the suggestions of Redström, principles should be integrated into the design process at the earliest stages, not in order to find the ones that will guide a specific intervention, but to generate so many that they can help design researchers do explorative work on the basis of tentative principles. We have already seen that researchers of DBR are more willing to put forward conjectures. What we need in addition are researchers refining them in the end.

Sandoval's (2004, 2014) conjecture mapping technique represents a promising coherent starting point for keeping track of conjectures, while maintaining their provisional and suggestive nature:

> 'A conjecture map reflects a research team's commitment to what it sees as the most important design problem to be solved and its initial ideas of the important questions to ask and the "varying degrees of uncertainty" (Walker, 2006, p. 11) about those questions.' (Sandoval 2014, p. 21)

A conjecture map consists of three elements: *embodiments*, *mediating processes* and *outcomes*, which provide the structure for mapping specific, testable conjectures and relations between them. Sandoval (2014, p. 24) differs between two types of conjectures; design conjectures take the general form akin to design principles of 'if learners engage in the embodiment of a specific activity structure, involving various tools, through a certain discursive practice, then this mediating process will emerge.' Theoretical conjectures, on the other hand, in a conjecture map take the general form of 'if this mediating process occurs, it will lead to this outcome' (Sandoval 2014, p. 24).

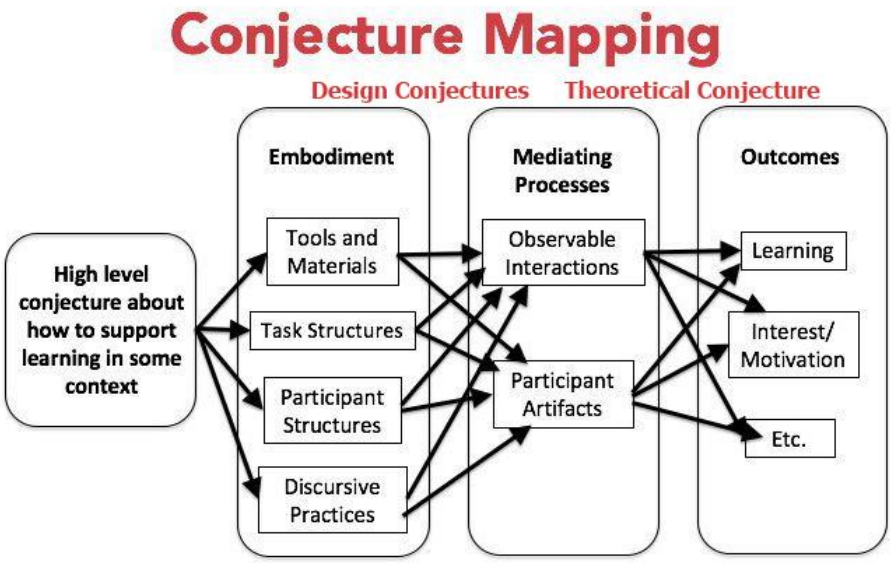


Figure 7-1. Generalized conjecture map for educational design research. Sandoval (2014, p. 21)

Testing design conjectures thus requires methods that can determine whether the expected mediating process does in fact emerge, and that can provide evidence to trace that process back to the designed elements. Continuously testing design conjectures to see whether the desired mediating processes actually occur in the intended way can be investigated through the unpolished enacted sketching activities in the beginning of a project, described in chapter 5, to scaled-up versions of functional prototype designs in the final stages of a project.

Such design conjectures might help maintain the provisional nature of guidelines for designing and, at the same time, make the development of refined design proposals more transparent.

A few words remain in terms of how to formulate conjectures in a manner that makes it possible for researchers of DBR to generate them and, at the same time, relevant for practitioners.

7.1.2. ARTICULATING DESIGN CONJECTURES

A key characteristic of design principles is that they are actionable or, with reference to the discussion on interventions and iterations in chapters 4 and 5, which agents involved in a design process can enact it. This particular trait is, as we have seen, what causes researchers of DBR to be careful in putting principles out there in the first place

because they feel a principle should always apply the way it was formulated, which is seldom the case in educational situations. However, as we just saw principles can be viewed in a more suggestive manner in the form of provisional conjectures where the aim is to try to formulate an actionable and testable hypothesis. The tricky part is to strike a balance between a conjecture being specific enough to inspire a person to try it out and, at the same time, not determined to a point where it does not apply outside a particular context or does not leave any wriggle room for personal interpretation.

We know from Baumgartner and Bell (2002) that the important questions to be aware of when generating or evaluating a conjecture are when, how and why to apply it. Not only should a conjecture have a procedural aspect, it should also always make the rationale behind it transparent. Returning to our initial review, Barab et al. (2007b) provide four such conjecture-like formulations of which we can now use one as an example.

The challenge in the design conjecture of 'Illuminating content – context relations' was to establish an analytical stance without undermining the students' sense of situative embodiment. The context is curriculum research in science education in schools using technology and gaming methods. The procedural aspect cover several aspects: Firstly, it is central to establish a rich perceptual and/or narrative grounding. Secondly, the curriculum should invite students to assume the role of field investigator. Thirdly, the curriculum should support students in developing a certain attunement, which includes an appreciation of the way contextual particulars and the underlying formalisms relate to each other, while also recognising aspects of the formalism that has potential value to other contexts. The reason for this is supported theoretically by Gibson's (1986) ecological psychology. The mediating process to look for when evaluating whether the embodied curriculum worked in the intended way is productive and critical interaction among students and potentially in the artefacts they create.

The studied enactment of the above design conjecture included that the researchers developed a 3D virtual, multiuser environment building on strategies from online roleplaying games. The game allowed participants to use an avatar to travel to virtual places to perform educational activities, chat with other users and mentors and build virtual personae. However, leaving room for personal or professional interpretation, the design conjecture could be enacted in numerous other ways while still honoring the suggestions put forward through the procedural aspect. In other words, the conjecture leaves enough wriggle room for design researchers and practitioners to explore several enacted scenarios before settling on a few design proposals to prototype and refine.

Conjecture mapping still demands for researchers of DBR to be willing to formulate prescriptive knowledge. In cases where researchers are at a stage where what they are trying to achieve is solely to understand a context through the means of interventions,

conjectures might still prove to be either too daring a task or deemed premature. Therefore, in the concluding section of this chapter, I will look into design patterns as a way of contributing to the shared pool of educational design knowledge without the use of prescriptive guidelines.

7.1.3. DESIGN PATTERNS

The concept of design patterns was originally developed by Alexander (Alexander, Ishikawa & Silverstein, 1977) within the field of architecture. The aim was to accumulate and generalise solutions in the form of externalised knowledge and to allow all members of a community or design group to partake in discussions relating to design.

Design patterns are abstractions of expert knowledge that seek to generalise from successful practice without detaching from its context. Alexander explains that a pattern:

> 'Describes a problem which occurs over and over again in our environment, and then describes the core of the solution to that problem, in such a way that you can use this solution a million times over, without ever doing it the same way twice' (Alexander, Ishikawa & Silverstein, 1977, p. x).

Design patterns thus distil the reusable elements of design from distinct cases, so that they can be applied in new similar situations. A design pattern captures a recurring problem, the context in which it occurs, and a possible method of solution. The basic idea is that every design problem begins with an effort to achieve fitness between the form in question and its context. The form is the solution to the problem; the contexts defines the problem.

Describing the context of the problem and its solution helps mitigate the risks of over-generalisation. Still, patterns should be written in such a way that they help the reader understand enough about a problem and solution so that they can adapt the problem description and solution to meet their own needs of a particular context.

Patterns are regarded as hypotheses that represent the current best guess as to what arrangement of the environment will help to solve the problem at hand. According to Alexander and his fellow authors (Alexander, Ishikawa & Silverstein, 1977), grouping the patterns form a kind of language rather than a prescriptive way to design or solve a problem. They are tentative and can evolve under the impact of new experience and observation.

In recent times, the field of *Learning Design* has revitalised the ideas of design patterns. In addition to patterns, design narratives are put forward as a means to illustrate a problem and the manifestation and resolution to it in a concrete context.

Narratives are first person accounts of practitioners that provide descriptions of design experiences where a challenge they have faced and successfully overcome are described in detail. In contrast to patterns, narratives are not organised into modular structures for the immediate application in new situations. Narratives are as such one step closer to the concrete practice compared to patterns. Design patterns are similarly organised in design languages, which again move one step away from the concrete and towards the abstract.

In relation to the challenges raised by the practitioners, design narratives, patterns and languages thus provide a series of potential ways to describe a problem, a context and a solution in forms that range from the concrete, i.e. the specific context, to the thematically abstract based on the preferences of the designer.

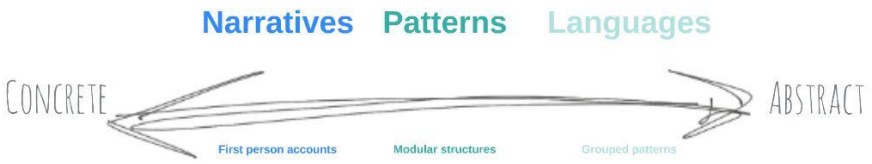


Figure 7-2. Generalised design knowledge between the concrete and the abstract

Narratives, patterns and languages thus form a trio of potential ways of describing useful knowledge for future designs in ways that both accommodate the fear of overstating the cause and effect relationship that some researchers of DBR tend to stray away from and in a less direct way tell practitioners what to do.

An added benefit of design patterns is that they attempt to democratise the design process by distilling the reusable elements of design from distinct cases into modular structures that can be applied in similar situations. This helps novice designers engage in conversations about design solutions in structuring the different parts beforehand.

7.1.4. ADDITIONAL PERSPECTIVES – MOVING AWAY FROM PROBLEMS

Before summing up the findings from this chapter, I would like to point to an additional perspective, which is not directly apparent in the data I collected during the project. However, my informants, in particular researcher B, hinted that working design-based does not necessarily imply working to solve a problem or a challenge. In the vein of this, I highlight a few supplementary views on design in the form of even more tentative potentials than the ones presented above.

David Pye, a professor of furniture design at The Royal College of Art, write in his book on the nature and aesthetics of design that things have no inherent use or

function. What is the activity proper to a straight cylindrical bar of steel, he asks? What function is the form following or, in other words, what problem is this tool fit to solve? Following this logic no solution is ever fit to a problem (shaped by a context) and consequently as he state:

> 'Nothing we design or make ever really works.' (Pye 1978, p. 13)

An additional reason for this is that economy has wide implications for design processes.

> 'It seems to be invariably true that those characteristics which lead people to call a design functional are derived from the requirements of economy and not of use.' (Pye, 1978, p. 34)

Economy in this context refers to an unpleasant catalogue made of effort, trouble, time, risks and enduring discomfort. Few devices, he points out, get results which would otherwise be unattainable. Instead of driving, one could walk, but the economy involved is what makes people value the use of a car. The example of the car also relates to another salient point put forward by Pye when it comes to designing, namely that whenever we design something, we do so to get an intended result, but along with that we get unwanted results as well. Touching upon this, Kolko (2014) introduces the term *forgivable attributes*.

The success of a solution does not depend on its ability to match any conceivable purpose, but on its ability to deliver the promised value proposition. Users tend to be forgiving of imperfect products and services as long as the promised value proposition is obtained. This is why limited space in vehicles, the security control in airports or the inconveniently small buttons on mobile devices, are accepted in trade of instantly delivering messages to friends and family and being able to travel great distances in short time. According to Kolko, users are even more likely to forgive suboptimal solutions when entering new territory, which the early stages of text messaging serve to show as mobile users were sometimes required to hit the same button four times to enter a single letter. Such design attributes, which are clearly less than optimal but yet acceptable, are called forgivable attributes (Petersen & Gundersen 2016, p. 180).

It seems doubtful looking through the history of educational inventions that such economic considerations have not played a part within this field. Presumably, also within the framework of specific design-based projects. Similarly, the argument of looking exclusively at the results of a design, rather than its intended functions to solve a problem, as suggested by Pye, sounds compelling.

The implications, however, as to what such an abandonment of intended functions, along with the recognition that every design is a least to some degree a failure, is beyond the scope of the present dissertation to uncover and instead warrant further investigation into the field of design processes in DBR.

7.1.5. SUMMARY

This chapter has shown that despite the frequent mentioning of design principles in repository texts, refined principles are seldom published in the highly quoted articles of DBR. This places DBR in an awkward spot where temporary studies have no new knowledge to rely to when mapping existing guiding principles for their interventions. On top of this, confusion seems to exist on the phrasing and functions of design principles. Finally, design principles do not fit well with branches of DBR studies that seek to understand contexts rather than improving them and generating prescriptive theory.

These challenges can be accommodated in various ways. I have pointed to the potential of conjecture mapping as a technique that maintain the provisional nature of guidelines for designing and, at the same time, make the development of refined design proposals more transparent. Conjecture mapping, however, still demands for researchers of DBR to be willing to formulate prescriptive knowledge. Another potential route to take would be that of generating design patterns. In a continuum containing design narratives and design languages in either end, design patterns are placed in the middle for researchers who seek to produce knowledge useful for practitioners and future research with less prescriptive elements when compared to design principles. Design narratives, patterns and languages thus provide a series of potential ways to describe a problem, a context and a solution in forms that range from the specific context to the thematically abstract based on the preferences of the designer. Working with design patterns might also help mitigate some of the collaboration issues pointed out in chapter 6, as patterns can help practitioners, and other novice designers, engage in conversations about design solutions.

CHAPTER 8. CONCLUSION

In this concluding part, I sum up the key design-based activities in DBR, the challenges researchers within the field face when practising these activities and the potentials to accommodate these challenges. I do this across the four different activities identified in the historical overview of DBR: researching through interventions, working iteratively, collaborating with practitioners and generating design principles. Thus, the first part of this chapter puts the activities in the historic context of DBR. The second part describes the challenges related to working in this way, and the third part presents the potentials as a cohesive package for researchers in the field to enjoy, explore, critique, etc.

In the closing remarks I also point to a number of additional reasons that can help explain some of the challenges in ways I have not explored. These include publication biases and the current landscape of research funding, i.e. issues that are highly relevant for researchers,although not exclusively limited to researchers of DBR. The opinions raised in this part are mainly generated from the interviews with the four researcher informants in conglomeration with grey literature pointing at the difficulties of reporting on design-based activities.

The initially hardest challenge for this study was to single out the design elements in DBR. I opted to identify activities for working design-based from DBR itself through a historic review, which provided an overview of the development, differences and similarities of design activities in DBR since its infancy. The overview provided me with four activities consistently put forward, although in varied ways, which shape the body of the dissertation.

Another issue was how to cover the broad spectrum of research associated with the DBR label, when diving deeper into the four activities through targeted reviews. Here, I simply chose to focus on the understandings that are most popular. Hence, I reviewed the most cited papers on education and DBR. Naturally, this choice omitted a large pool of relevant perspectives from lesser-cited articles, but again my reasoning was that salient points read only by a selected few do not represent the most popular ways of understanding activities tied to design-based ways of working in DBR. Additionally, the findings from the reviews are informed by the historical overview as well as nuanced by in-depth interviews with researchers of the field.

The last methodological challenge I faced was how to pinpoint potentials in relation to the identified challenges I identified from the literature and interview data. From the beginning, I decided that I would not only provide a critical view on design-related activities in DBR, a decision which rested mainly on the fact that I am a practitioner of DBR myself and therefore will return to conducting DBR after my studies. Giving something back to the community in terms of ideas for methodological improvement

seemed in place and would arguably have a motivational effect on my own work. My hypothesis was that experts of design are able to provide directions for me to explore that would otherwise be difficult to identify from the abundant literature on design and design theory. The data from these informants worked as a basis for my own further investigation of the potentials in relation to DBR.

8.1. DESIGN-RELATED ACTIVITIES OF DESIGN-BASED RESEARCHERS

DBR can be described as a series of approaches that aim at creating relevant and useful knowledge for practitioners and which are at the same time empirically grounded in real life settings. It grew from smaller design experiments in classroom settings often concerned with the further development of a learning theory and/or the implementation of technology. Since its infancy in the early 90s, DBR has branched out into several similar approaches and has risen steadily in popularity.

The growing popularity of the design-based approaches has led to large scale interventions with different foci as well as a growing problem-based perspective on interventions, rather than the initially more theory-based approach described in the original studies.

Four activities remain constant in the repository texts on DBR in relation to conducting design-based research. The first is to act out interventions and conduct research through them. This activity refers to a variety of experiments in everyday educational settings and interventions vary in time span from weeks to full years. As a means to differentiate between interventions at different stages of maturity, the concepts of intended, implemented and attained designs have been put forward to designate the difference between a speculative and a tested intervention.

The second activity is the iterative working manner employed by researchers in the field. Although the purpose of iterations in DBR historically is tied primarily to both the ideation and the implementation stages, the revision process is generally described as the development and refutation of conjectures as well as the testing of a few selected conjectures. As with interventions, iterations differ in length and the amount of iterations comprised in DBR studies varies as well, although the majority contains only a few.

A third activity in conducting DBR is collaboration with practitioners. Historically, the emphasis on collaboration has changed over time from a perspective where practitioners would help enact an envisioned design to practitioners taking a more active part in problem identification, development of solutions and, in rare cases, theory generation. As practitioners became involved in more activities of DBR, especially problem identification, the scope of DBR studies also expanded from a primary focus on validating learning theory to broader problem sets. The steadily

growing interest to involve practitioners aligns with the initial ambition of DBR to make educational theory relevant for practitioners.

The fourth and final activity associated with conducting DBR in this study is to generate design principles. Guiding principles or conjectures steer the development of intended designs, whereas conclusive design principles are formed based on implemented design solutions. Conclusive design principles are thus an attempt to generalise knowledge gathered from interventions in ways that bear relevance to similar interventions in the future. Historically finding an appropriate balance between global, but in some cases trivial conclusions, on the one hand, and sizable, but local findings, on the other, has been a matter of debate within the DBR community. Ideally, the development of knowledge through DBR is a continuous refinement of conjectures, tested in local settings and generalised via principles that have proven effective in various contexts or influenced by different factors. A set of refined and coherent design principles form a design framework, which according to some theorists should not be evaluated by the same standards as traditional research, but rather in terms of the degree of innovation and recognisability and usefulness for practitioners.

Conclusively, design-based activities in DBR are thus developed interventions implemented in local practices to test existing theories or solve practical problems. The progress of refining interventions can be described as iterative in which conjectures are refined or refuted, as implemented solutions either mutate or are abandoned. Tested conjectures are generalised via conclusive design principles that should be measured in terms of novelty and the usefulness for practitioners beyond the practice in which the interventions took place. Practitioners are involved in these activities to ensure the relevance of the intended intervention, the proper implementation of the solution and the recognisability of the generalised principles.

8.2. CHALLENGES OF WORKING DESIGN-BASED

Initial challenges associated with conducting DBR are hinted at in the historical overview, challenges I pursue in this study through reviewing the most cited journal articles in the period from 2002-2017 and by interviewing researchers with experience in working with DBR.

Across the four activities, I present three sets of challenges. The first set relates to developing solutions to practical problems, the second set is concerned with the implementation of intended interventions and the third set deals with challenges of generalising knowledge on the basis of completed interventions.

8.2.1. INVESTIGATING PROBLEMS AND DEVELOPING SOLUTIONS

The early stages of DBR studies are in most cases only scarcely described. Examples of iterations before interventions are implemented in practice are thus seldom reported in any significant detail. Initial investigation of the problem and the subsequent exploration of the solution space remain undisclosed for scrutiny or simply do not take place. Only in 1 out of 4 reported cases, practitioners are involved in activities of problem investigation and ideation for solutions. In some cases, the iteration term seems to be confused with the intervention term or deliberately understood as having similar meanings.

Bearing in mind that early iterations are highly valued across all design disciplines, mostly in the form of various sketching activities, the lack of reported tangible materials to spark branching idea processes presents a serious challenge to the quality of solutions pursued in DBR studies. Additionally, the lack of early representations of ideas complicates the inclusion of other collaborative partners such as practitioners of teaching and learning, in activities related to problem setting and solving.

The interview data suggest a lack of skill among DBR researchers in terms of generating such materials and setting up situations where tangible objects can play a mediating part among collaborative actors. On a concrete level, researchers express no proficiency regarding sketching activities in general and point to the additional challenge specifically concerning teaching and learning in which conveying the temporal aspect and complexity of educational situations in a meaningful manner have proven a challenging matter.

A challenge for researchers of DBR is thus how to generate early iterations that can help raise the quality of proposed solutions in ways where practitioners are also involved in a collaborative manner.

8.2.2. IMPLEMENTING SOLUTIONS

The implementation and testing of solutions are where most of the reviewed articles channel their focus when describing the research conducted. Activities tied to the implementation of solutions are also where practitioners are most commonly involved. Some challenges related to implementation are inherited by the previous problem set. The quality of interventions is thus expectedly lower if only one problem and one solution have been explored before the actual implementation. Furthermore, the sense of ownership from practitioners might also diminish in cases where practitioners only play the part of implementers and have no agency of the setting and solving of the problem that the interventions seek to mitigate.

The data, however, also point to a challenge regarding interventions in terms of the methodological nomenclature of DBR. DBR studies tend to be described using

traditional research design terms such as case studies, longitudinal studies, cross-sectional studies, etc., whereas a fitting vocabulary for describing the overall design intervention strategy remains absent throughout the selected studies. The consequences are a lack of transparency regarding the intentions of researching through interventions, a blackboxing of potential divergent routes taken during a project period to accommodate adversities and arbitrary intervention setups leading to poor design processes.

8.2.3. GENERALISING KNOWLEDGE

Lastly, when researchers of DBR seek to generalise knowledge on the back of their interventions, a third set of challenges appear. First, few studies generate refined design principles when reporting on their studies. The continuum of identified existing knowledge, over conjectures to conclusive principles, thus appear to be broken. This in time leads to a situation where no new principles are generated and the existing pool of knowledge from which researchers draw upon as a result become outdated.

Additionally, no consensus seems to exist in terms of how to formulate design principles, both guiding and conclusive, although attempts to generate heuristic formulas have been proposed.

The interviewed researchers, especially those who primarily intervene through a change in teaching setup and not via a technology, express a reluctance towards formulating principles for two reasons. One rests on the uneasiness of generating abstract best practices based on highly situated experiments. The second reason is that the knowledge they produce is not prescriptive in nature. According to the researchers, principles are either too bold or not cut for the kind of knowledge they produce.

As only practitioners who are themselves researchers in the given project, according to data, are involved in the generation of theory, a danger emerges as for the ambitions of DBR to ensure that the knowledge is usable and applicable by practitioners. In other words, if the practitioners are not involved in the evaluation of the generated principles how do researchers know if principles are recognisable and applicable for them?

Challenges thus remain as to how researchers of DBR formulate principles that are useful for practitioners and at the same time not too presumptuous in terms of claims between cause and effect. Furthermore, the revision processes of principles throughout a DBR study should ideally be transparent in order for practitioners to apply them both in early development activities and when implementing them in practice once refined.

8.3. TWO AREAS THAT HOLD POTENTIAL TO IMPROVE DESIGN-BASED ACTIVITIES IN DBR

In order to accommodate the three problem sets laid out above, I conclude by presenting two areas of potentials where researchers might find useful starting points for moving the continued progression of the DBR approach forward methodologically. The first relates to the nomenclature of DBR and the second to practices, both of which hold potential for leading to more novel and efficient design solutions.

I start by describing a set of potentials that can help mitigate the challenges of DBR studies that lack suitable ways of conveying their intervention strategy as well as a means to track the progression of knowledge from initial problem setting to refined principles based on data from enacted interventions. Then, I present a set of potentials related to activities that can lead to more thorough processes of setting challenges, exploring solution spaces, involving more non-researcher actors and finally making collaboration processes tangible. Together they form a path to explore in order to accommodate the three challenges stated above. In their current forms, the sets are purely theoretical and need testing in practice as well as further research.

8.3.1. BUILDING ON THE EXISTING METHODOLOGICAL VOCABULARY OF DBR

The form and flow of knowledge in DBR studies have been discussed in this dissertation in chapter 4 on interventions and chapter 7 on principles. Together, the discussions form a potential to improve DBR on the level of design methodology, which due to the relatively short life span of the approach, has yet to be matured. The data suggest that especially the areas of how knowledge is refined through DBR projects as well as how to make intervention strategies transparent in the methodological setup are in need of further development.

There seems to be no clear consensus on how design principles, the form in which knowledge is presented in the field, are defined or phrased, which leads to confusion as to what the functions of principles are to begin with as well as their applicability. Additionally, the informants point to a type of intervention studies that seek to understand a practice rather than improve it. The confusion and the difference in purpose of intervening might be part of the reason for the majority of studies opting to omit design principles all together from their articles. Similarly, stating clearly how interventions throughout a DBR-project are intended to connect holds potential to further clarify what type of knowledge the study seeks to generate as well as the form that knowledge might take at different stages throughout the project.

At present, few studies describe the way planned interventions are linked throughout a study, what characterises the researchers' pursuit of knowledge and explicitly make

transparent to what degree the knowledge output is descriptive or prescriptive in nature. The five intervention strategies presented in chapter 4 offer a starting point for making these methodological considerations transparent. Is a study an in-depth study seeking specific knowledge on the same problem in the same or very similar context for the purpose of generating stacked knowledge through an accumulative strategy? Or is it an explorative study aiming at broadening what little knowledge we might have in relation to, for instance, a novel technology in education using an expansive strategy? Additionally, as discussed in chapter 7, are the researchers seeking to refine a known set of existing principles via conjecture mapping or do they seek to describe untrodden turf via design narratives to form the beginning of a design pattern?

Drifting strategies, conjecture mapping and design patterns together form a set of potentials to describe DBR projects of vastly different foci and approaches. Using the informants as examples, researcher C might have benefitted from describing his intervention strategy as accumulative and with the aim of refining prescriptive design conjectures for learning how to learn to read in your mother tongue. In contrast to this, researcher D could have leaned on the vocabulary of the expansive strategy and with the use of design narratives kept the richness of the particular context intact and avoided the prescriptive nature of design principles.

The set of potentials alluded to here could in time be part of a larger and more proven vocabulary for researchers within DBR to be able to explain their intentions of why and how they seek to benefit from doing interventions or in other cases, why they chose to divert from the intervention strategy they initially described. My data suggest that such a vocabulary is still in its infancy and therefore further research is required to establish a solid methodological reference point.

8.3.2. MITIGATING THE LACK OF DESIGN COMPETENCIES AMONG DBR RESEARCHERS

Researchers conducting DBR might find the need for an almost insurmountable set of competencies within fields of education, research, design and sometimes technology. My data suggest that DBR researchers are struggling to meet their own standards in relation to being able to iterate when setting and solving problems in the beginning of a project and to collaborate with practitioners at all stages of a study. These areas can be traced back to the key activity of sketching in design and to more recent approaches of participatory design.

In chapters 5 and 6, I elaborated on these challenges and presented a set of potentials for moving forward. Firstly, in relation to early iterations, and specifically the challenges of overcoming the lack of drawing skills among DBR researchers and the difficulties of representing teaching and learning situations, I put forward the activity of enacted sketching. The purpose of enacted sketching is in a quick and inexpensive manner to create scenarios as a way of exploring ideas for interventions, which during

the enactment can foster alternative routes, mutations and a shared communication reference. The activity is characterised by immediacy and minimal effort. The design research team creates and plays with scenarios with minimal use of props and without any roleplaying. The aim is to generate dialogue, questions and the possibility for the participating parties to sense potentials and redirect the enactment on the fly.

The shared communication reference that enacted sketching provides is also a key ingredient in inviting collaborative partners on board the design processes. Half of the intervention studies in the targeted review in chapter 6 used practitioners in a role of implementing solutions developed by researchers in advance and then providing feedback based on their experiences. Historically, a key ambition in DBR was to invite practitioners to partake in problem identification and solving which again would lead to solutions being more relevant and more easily applicable in the messy settings for which the solutions were designed. Open-ended co-design processes, such as enacted sketching or similar activities within the categories of conversation subjects, conversation prompts or experience enablers, represent a set of potential ways to engage with practitioners while making proposals visible and tangible.

The degree to which such activities, should they be implemented as integrated parts of DBR projects, can mitigate the absence of trained design skills remain to be investigated empirically. However, my data suggest that the potential of setting aside expert knowledge and emulating use before use to a great extent remains to be explored within the field of DBR.

8.4. CLOSING REMARKS

The two ambitions of increasing the relevance of educational research for practitioners and policy makers and the wish to empirically ground theories in naturally occurring test beds that pioneered DBR back in the early 90s are still relevant today and stand as peaks for design researchers in education to climb towards when conducting their research. In general, many aspects of the DBR methodology have been refined, also within areas that are regarded as the design-based grounds of the approach. In other areas, there is still a long way to go. This dissertation points to specifically early iteration processes, systematic ways of linking interventions, involving practitioners to a fuller degree than that of the implementer and appropriate language for conveying knowledge for future designs, as areas in need of further development.

Reasons beyond lack of skill or unwillingness to work in designerly ways undoubtedly exist. Most prominently, I wish to point at funding and publication biases. As I stated in the introduction, my errand is not to criticise the work of my fellow colleagues or to smear the DBR approach as a whole. My ambition is quite the opposite, to move the approach forward. It is understandable that time consuming processes of problem setting and solving do not align well with funding research projects, which more often than not need a ready and fixed challenge as well as a possible solution. Likewise,

trying to fit in detailed descriptions of design processes puts researchers in a dilemma of scientifically sound transparency versus 'getting to the point' when facing the constraints of journal templates of the modern era. However, in my view such obstacles should not lead us to abandon the climb.

Enacted sketching, ways of drifting, participatory design prompts, conjecture mapping and design patterns are notions that hold promises for future DBR projects to explore. They may not all work as alluded to in the present dissertation and are certainly not for all researchers dedicated to conducting DBR. They are, nonetheless, a starting point for the continuous advancement of ways of conducting research that strives to be relevant and grounded at the same time.

LITERATURE LIST

Abrahamson, D., & Sánchez-García, R. (2016). Learning is moving in new ways: The ecological dynamics of mathematics education. *Journal of the Learning Sciences*, 25(2), 203-239. https://doi.org/10.1080/10508406.2016.1143370

Aksnes, D. W. (2003). Characteristics of highly cited papers. *Research Evaluation*, 12(3), 159-170. https://doi.org/10.3152/147154403781776645

Aksnes, D. W., & Sivertsen, G. (2001). The effect of highly cited papers on national citation indicators. *Proceedings of the 8th International Conference on Scientometrics & Informetrics*, Sydney, Australia, 23-30.

Alexander, C., Ishikawa, S., & Silverstein, M. (1977). *A pattern language: Towns, buildings, construction*. New York: Oxford University Press

Anderson, T., & Shattuck, J. (2012). Design-based research: A decade of progress in education research? *Educational Researcher*, 41(1), 16-25. https://doi.org/10.3102/0013189x11428813

Angeli, C., & Valanides, N. (2009). Epistemological and methodological issues for the conceptualization, development, and assessment of ICT-TPCK: Advances in technological pedagogical content knowledge (TPCK). *Computers & Education*, 52(1), 154-168. https://doi.org/10.1016/j.compedu.2008.07.006

Bakker, A. (2019). Design principles in design research: A commentary. *Unterrichtsentwicklung Macht Schule*, 177-192. https://doi.org/10.1007/978-3-658-20487-7_10

Bannan-Ritland, B. (2003). The Role of Design in Research: The Integrative Learning Design Framework. Educational Researcher, 32(1), 21-24. https://doi.org/10.3102/0013189x032001021

Bannan, B., Cook, J., & Pachler, N. (2016). Reconceptualizing design research in the age of mobile learning. *Interactive Learning Environments*, 24(5), 938-953. https://doi.org/10.1080/10494820.2015.1018911

Barab, S. A., Dodge, T., & Gee, J. P. (2009). The worked example: Invitational scholarship in service of an emerging field. Paper presented at the *Annual Meeting of the American Educational Research Association*, San Diego, CA.

Barab, S. A. & Squire, K. (Eds.) (2004a). Design-based Research. Clarifying the Terms. A Special Issue of the Journal of the Learning Sciences. *Journal of the Learning Sciences*, 13(1). New York: Psychology Press. https://doi.org/10.4324/9780203764565

Barab, S., & Squire, K. (2004b). Design-Based Research: Putting a Stake in the Ground. Journal of the Learning Sciences, 13(1), 1–14. https://doi.org/10.1207/s15327809jls1301_1

Barab, S., Thomas, M., Dodge, T., Carteaux, R., & Tüzün, H. (2005). Making learning fun: Quest Atlantis, a game without guns. *Educational Technology Research and Development*, 53(1), 86-107. https://doi.org/10.1007/bf02504859

Barab, S. A., Sadler, T. D., Heiselt, C., Hickey, D., & Zuiker, S. (2007a). Relating Narrative, Inquiry, and Inscriptions: Supporting Consequential Play. *Journal of Science Education and Technology*, 16(1), 59-82. https://doi.org/10.1007/s10956-006-9033-3

Barab, S., Zuiker, S., Warren, S., Hickey, D., Ingram-Goble, A., Kwon, E. J., & Herring, S. C. (2007b). Situationally embodied curriculum: Relating formalisms and contexts. *Science Education*, 91(5), 750-782. https://doi.org/10.1002/sce.20217

Baumgartner, E., & Bell, P. (2002). What will we do with design principles? Design principles and principled design practice. Paper presented at the *Annual Meeting of the American Educational Research Association*, New Orleans, LA

Belardi, P. (2014). *Why Architects Still Draw*. Cambridge, Massachusetts: MIT Press

Bell, P. (2004). On the Theoretical Breadth of Design-Based Research in Education. *Educational Psychologist*, 39(4), 243-253. https://doi.org/10.1207/s15326985ep3904_6

Bers, M. U., Flannery, L., Kazakoff, E. R., & Sullivan, A. (2014). Computational thinking and tinkering: Exploration of an early childhood robotics curriculum. Computers & Education, 72, 145-157. https://doi.org/10.1016/j.compedu.2013.10.020

Binder, T., De Michelis, G., Ehn, P., Jacucci, G., Linde, P., & Wagner, I. (2011). *Design Things*. Cambridge, Massachusetts: MIT press. https://doi.org/10.2752/175470813X13705953612480

Black, A. (1990). Visible planning on paper and on screen: The impact of working medium on decision-making by novice graphic designers. Behaviour & Information Technology, 9(4), 283-296. https://doi.org/doi:10.1080/01449299008924244

Blaikie, N. W. H. (1991). A critique of the use of triangulation in social research. *Quality and Quantity*, 25(2). https://doi.org/10.1007/bf00145701

Bodzin, A. M. (2011). The implementation of a geospatial information technology (GIT)-supported land use change curriculum with urban middle school learners to promote spatial thinking. *Journal of Research in Science Teaching*, 48(3), 281-300. https://doi.org/10.1002/tea.20409

Bogner A. & Menz, W. (2009). The Theory-Generating Expert Interview: Epistemological Interest, Forms of Knowledge, Interaction. In A. Bogner, B. Littig, & W. Menz (Eds.) (2009), *Interviewing experts* (pp. 43-80). Basingstoke, UK: Palgrave Macmillan. https://doi.org/10.1057/9780230244276_3

Boticki, I., Baksa, J., Seow, P., & Looi, C.-K. (2015). Usage of a mobile social learning platform with virtual badges in a primary school. *Computers & Education*, 86, 120-136. https://doi.org/10.1016/j.compedu.2015.02.015

Brewer, J., Hunter, A. (2006). *Foundations of Multimethod Research: Synthesizing Styles* (2nd ed.). Thousand Oaks, CA: SAGE Publications. https://dx.doi.org/10.4135/9781412984294

Brown, A. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *The Journal of the Learning Sciences*, 2(2), 141-178. http://dx.doi.org/10.1207/s15327809jls0202_2

Bruce, C. (2007). Questions arising about emergence, data collection, and its interaction with analysis in a grounded theory study. International Journal of Qualitative Methods, 6, 51–68.

Buchenau, M., & Suri, J. F. (2000). Experience prototyping. *Proceedings of the Conference on Designing Interactive Systems Processes, Practices, Methods, and Techniques*, 424-433. https://doi.org/10.1145/347642.347802

Burdick, A. (2009) Design without designers. Keynote speak at Conference on the Future of Art and Design Education in the 21st century, February 9th, 2009, University of Brighton

Buxton, B. (2007). Sketching User Experiences - Getting the Design Right and the Right Design. San Francisco: Focal Press Morgan Kaufman

Cicourel, A. V. , Jennings, K. H., Jennings, S. H., Leiter, K. C. W., MacKay, R., Mehan, H., & Roth, D. H. (1974). Language Use and School Performance, New York, Academic Press.

Cobb, P., Confrey, J., diSessa, A., Lehrer, R., & Schauble, L. (2003). Design Experiments in Educational Research. *Educational Researcher*, 32(1), 9-13. https://doi.org/10.3102/0013189x032001009

Collins, A. (2010). Design Experiments. *International Encyclopedia of Education*, 367-372. https://doi.org/10.1016/b978-0-08-044894-7.01296-3

Collins, A. (1992). Toward a Design Science of Education. *New Directions in Educational Technology*, 15-22. https://doi.org/10.1007/978-3-642-77750-9_2

Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design Research: Theoretical and Methodological Issues. *Journal of the Learning Sciences*, 13(1), 15-42. https://doi.org/10.1207/s15327809jls1301_2

Conole, G. (2013). *Designing for Learning in an Open World*. New York, NY: Springer.

Cooper, H. M. (1988). Organizing knowledge synthesis: A taxonomy of literature reviews. Knowledge in Society, 1, 104-126.

Creswell, J. W. (2015). *A concise introduction to mixed methods research*. Thousand Oaks, CA: SAGE Publications.

Dalziel, J. (2015). Reflections on the Art and Science of Learning Design and the Larnaca Declaration. *The Art & Science of Learning Design*, 3-14. https://doi.org/10.1007/978-94-6300-103-8_1

Dede, C. (2004). If Design-Based Research is the Answer, What is the Question? A Commentary on Collins, Joseph, and Bielaczyc; diSessa and Cobb; and Fishman, Marx, Blumenthal, Krajcik, and Soloway in the JLS Special Issue on Design-Based Research. *Journal of the Learning Sciences*, 13(1), 105-114. https://doi.org/10.4324/9780203764565-4

Dede, C. (2005). Why design-based research is both important and difficult. *Educational Technology*, 45(1), 5-8

Dede, C., Ketelhut, D. J., Whitehouse, P., Breit, L., & McCloskey, E. M. (2009). A Research Agenda for Online Teacher Professional Development. *Journal of Teacher Education*, 60(1), 8-19. https://doi.org/10.1177/0022487108327554

Design Based Research Collective. (2003). Design-based research: An emerging paradigm foreducational inquiry. Educational Researcher, 32 (1), 5-8. https://doi.org/10.3102/0013189x032001005

Dierdorp, A., Bakker, A., Eijkelhof, H., & van Maanen, J. (2011). Authentic Practices as Contexts for Learning to Draw Inferences Beyond Correlated Data. *Mathematical Thinking and Learning*, 13(1-2), 132-151. https://doi.org/10.1080/10986065.2011.538294

diSessa, A. A., & Cobb, P. (2004). Ontological Innovation and the Role of Theory in Design Experiments. *Journal of the Learning Sciences*, 13(1), 77-103. https://doi.org/10.1207/s15327809jls1301_4

Dohn, N. B., & Hansen, J. J. (2018). Design in educational research - clarifying conceptions and presuppositions. In N. B. Dohn (Ed.), *Designing for learning in a networked world* (pp. 25-47). Abingdon: Routledge. https://doi.org/10.4324/9781351232357

Duncan, R. G., & Tseng, K. A. (2011). Designing project-based instruction to foster generative and mechanistic understandings in genetics. *Science Education*, 95(1), 21-56. https://doi.org/10.1002/sce.20407

Eames, C. (1969). Interview with Charles Eames by Madame L'Amic of the Musée des Arts Décoratifs, Palais de Louvre, France

Easterday, M. W., Lewis, D. G. R., & Gerber, E. M. (2017). The logic of design research. *Learning: Research and Practice*, 4(2),131-160. https://doi.org/10.1080/23735082.2017.1286367

Echevarria, J., Short, D., & Powers, K. (2006). School Reform and Standards-Based Education: A Model for English-Language Learners. *The Journal of Educational Research*, 99(4), 195-211. https://doi.org/10.3200/joer.99.4.195-211

Edelson, D. C. (2002). Design research: what we learn when we engage in design. *Journal of the Learning Sciences*, 11 (1), 105-121. https://doi.org/10.1207/s15327809jls1101_4

Ehn, P. (1988). *Work-oriented Design of Computer Artifacts*. Falköping, Sweden: Arbetslivscentrum/Almqvist & Wiksell International.

Ejersbo, L. R., Engelhardt, R., Frølunde, L., Hanghøj, T., Magnussen, R., & Misfeldt, M. (2008). Balancing Product Design and Theoretical Insight. In A. E. Kelly, R. A. Lesh, & J. Y. Baek (Eds.), *The Handbook of Design Research Methods in Education: Innovations in Science, Technology, Engineering and Mathematics Learning and Teaching* (1 ed., pp. 149-163). Mahwah, NJ: Lawrence Erlbaum Associates

Engeström,Y. (2011). From design experiments to formative interventions. *Theory & Psychology*, 21(5), 598-628. https://doi.org/10.1177/0959354311419252

Erzberger, C., & Kelle, U. (2003). Making inferences in mixed methods: the rules of integration. In A. Tashakkori & C. Teddlie (Eds.), *Handbook of Mixed Methods in Social and Behavioral Research* (pp. 457-488). Thousand Oaks, CA: SAGE Publcations

Fallman D., (2003). Design-oriented human-computer interaction. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '03)*. ACM, New York, NY, USA, 225-232

Fish, J., & Scrivener, S. (1990). Amplifying the Mind's Eye: Sketching and Visual Cognition. *Leonardo*, 23(1), 117-126. https://doi.org/10.2307/1578475

Fishman, B. J., Penuel, W. R., Allen, A. R., Cheng, B. H., & Sabelli, N. O. R. A. (2013). Designbased implementation research: An emerging model for transforming the relationship of research and practice. *National Society for the Study of Education*, 112(2), 136-156.

Fishman, B., Marx, R. W., Blumenfeld, P., Krajcik, J., & Soloway, E. (2004). Creating a Framework for Research on Systemic Technology Innovations. *Journal of the Learning Sciences*, 13(1), 43-76. https://doi.org/10.1207/s15327809jls1301_3

Flick, U. (1992). Triangulation Revisited: Strategy of Validation or Alternative? *Journal for the Theory of Social Behaviour*, 22(2), 175-197. https://doi.org/10.1111/j.1468-5914.1992.tb00215.x

Fowler, J. H., & Aksnes, D. W. (2007). Does self-citation pay? *Scientometrics*, 72(3), 427-437. https://doi.org/10.1007/s11192-007-1777-2

Freudenthal, H., Janssen, G. M., & Sweers, W. J. (1976). Five years IOWO on H. Freudenthal's Retirement from the directorship of IOWO: IOWO Snapshots. Dordrecht: Reidel

Gašević, D., Kovanovic, V., Joksimovic, S., & Siemens, G. (2014). Where is research on massive open online courses headed? A data analysis of the MOOC Research Initiative. *The International Review of Research in Open and Distributed Learning*, 15(5). https://doi.org/10.19173/irrodl.v15i5.1954

Gašević, D., Adesope, O., Joksimović, S., & Kovanović, V. (2015). Externally-facilitated regulation scaffolding and role assignment to develop cognitive presence in asynchronous online discussions. *The Internet and Higher Education*, 24, 53-65. https://doi.org/10.1016/j.iheduc.2014.09.006

Gedenryd, H. (1998). *How Designers Work: Making Sense of Authentic Cognitive Activity.* PhD Thesis, Lund University.

Gedik, N., Hanci-Karademirci, A., Kursun, E., & Cagiltay, K. (2012). Key instructional design issues in a cellular phone-based mobile learning project. Computers & Education, 58(4), 1149-1159. https://doi.org/10.1016/j.compedu.2011.12.002

Gibson, J. J. (1986). *The Ecological Approach to Visual Perception*. Boston: Houghton Mifflin

Glaser, B. G. (1978). Theoretical sensitivity. Mill Valley, CA: Sociology Press.

Glaser, B. G. (1998). Doing grounded theory: Issues and discussions. Mill Valley, CA: Sociology Press.

Glaser, B. G. (2001). The grounded theory perspective I: Conceptualization contrasted with description. Mill Valley, CA: Sociology Press.

Glaser, B. G. (2005). The grounded theory perspective III: Theoretical coding. Mill Valley, CA: Sociology Press.

Glaser, B. G., & Strauss, A. L. (1967). The discovery of grounded theory. New York: Aldine.

Glänzel, W., & Czerwon, H.-J. (1992). What are highly cited publications? A method applied to German scientific papers, 1980-1989. *Research Evaluation*, 2(3), 135-141. https://doi.org/10.1093/rev/2.3.135

Goldschmidt, G. (2003). The Backtalk of Self-Generated Sketches. *Design Issues, 19*(1), 72-88. https://doi.org/10.1162/074793603762667728

Gravemeijer, K., & Cobb, P. (2006). Design research from a learning design perspective. In J. van den Akker, K. Gravemeijer, S. McKenney & N. Nieveen (Eds.), *Educational Design Research* (pp. 17-51). London: Routledge

Greene, J. C. (2007). *Mixed methods in social inquiry*. San Francisco: Jossey-Bass

Greenhalgh, T., & Peacock, R. (2005). Effectiveness and efficiency of search methods in systematic reviews of complex evidence: Audit of primary sources. *BioMed Central Journal Clinical Research*, 331(7524), 1064-1065. https://doi.org/10.1136/bmj.38636.593461.68

Greenwood, D. J., & Levin, M. (2007). *Introduction to action research: Social research for social change.* SAGE publications, 2nd edition.

Guest, G. (2013). Describing Mixed Methods Research, *Journal of Mixed Methods Research*, 7(2), 141-151. https://doi.org/10.1177/1558689812461179

Gundersen, P., Ørngreen, R., Henningsen, B., & Hautopp, H. (2018). A Collaborative Video Sketching Model in the Making. *Interactivity, Game Creation, Design, Learning, and Innovation*, 520-529. https://doi.org/10.1007/978-3-319-76908-0_50

Gutiérrez, K. D. & Jurow, A. S. (2016). Social Design Experiments: Toward Equity by Design. *Journal of the Learning Sciences*, 25(4), 565-598. https://doi.org/10.1080/10508406.2016.1204548

Haertel, G. D., & Means, B. (2003). *Evaluating educational technology: Effective research designs for improving learning*. New York: Teachers College Press.

Hammersley, M. (2008). 2 troubles with triangulation. In Bergman, M. M. (Ed), *Advances in mixed methods research* (22-37). London: SAGE Publications. https://doi.org/10.4135/9780857024329

Hart, C. (1998). Doing a literature review: Releasing the social science research imagination. London: Sage.

Heath, H. (2006). Exploring the influences and use of the literature during a grounded theory study. Journal of Research in Nursing, 11, 519–528.

Henningsen, B., Gundersen, P. B., Hautopp, H. & Ørngreen, R., (2017). Collaborative Video Sketching. Proceedings of the 2nd Association for Visual Pedagogy Conference. Otrel-Cass, K. (ed.). 1 ed. Aalborg: Dafolo Forlag A/S, p. 43-51 9 p. (Undervisning og læring; No. 1).

Herbert, D. M. (1993). *Architectural Study Drawings*. New York, NY: Van Nostrand Reinhold.

Herrington, J., & Reeves, T. C. (2011). Using design principles to improve pedagogical practice and promote student engagement. In P. S. G. Williams, N. Brown, & B. Cleland (Eds.), *ASCILITE 2011 - changing demands, changing directions*, (pp. 594-601). Hobart, Tasmania: ASCILITE

Heskett, J. (2002). Design - a very short introduction. Oxford, UK: Oxford University Press. https://doi.org/10.1093/actrade/9780192854469.003.0001

Hickey, D. T., Kindfield, A. C. H., Horwitz, P., & Christie, M. A. T. (2003). Integrating Curriculum, Instruction, Assessment, and Evaluation in a Technology-Supported Genetics Learning Environment. *American Educational Research Journal*, 40(2), 495-538. https://doi.org/10.3102/00028312040002495

Hoadley, C. (2002). Creating context: Design-based research in creating and understanding CSCL. In G. Stahl (Ed.), *Computer support for collaborative learning*, 2002 (pp. 453-462). Mahwah, NJ: Lawrence Erlbaum Associates

Hull, G. A., & Nelson, M. E. (2005). Locating the Semiotic Power of Multimodality. *Written Communication*, 22(2), 224-261. https://doi.org/10.1177/0741088304274170

Hung, H.-T. (2017). Design-Based Research: Redesign of an English Language Course Using a Flipped Classroom Approach. *TESOL Quarterly*, 51(1), 180-192. https://doi.org/10.1002/tesq.328

Hung, D., Lim, K. & Huang (2010). Extending and scaling technology-based innovations through research. In OECD, *Inspired by technology, driven by pedagogy - a systematic approach to technology based schools innovations* (pp. 89-102). https://dx.doi.org/10.1787/9789264094437-7-en

Hutchins, E. (1995). *Cognition in the Wild*. Cambridge, Massachusetts: MIT Press.

Jahnke, I. (2010). Dynamics of social roles in a knowledge management community. *Computers in Human Behavior*, 26(4), 533-546. https://doi.org/10.1016/j.chb.2009.08.010

Jalali, S., & Wohlin, C. (2012). Systematic literature studies: database searches vs. backward snowballing. In *Proceedings of the ACM-IEEE international symposium on Empirical software engineering and measurement* (pp. 29-38).

Johnson, R. B., Onwuegbuzie, A. J., & Turner, L. A. (2007). Toward a Definition of Mixed Methods Research. *Journal of Mixed Methods Research*, 1(2), 112–133. https://doi.org/10.1177/1558689806298224

Kali, Y. (2006). Collaborative knowledge building using the Design Principles Database. International Journal of Computer-Supported Collaborative Learning, 1(2), 187-201. https://doi.org/10.1007/s11412-006-8993-x

Kali, Y. (2008). The design principles database as means for promoting design-based research. In A. E., Kelly, R. A., Lesh, & J. Y., Baek (Eds.). *Handbook of Design Research Methods in Education: Innovations in Science, Technology, Engineering, and Mathematics Learning and Teaching* (pp. 423-438). Mahwah, NJ: Lawrence Erlbaum

Kelly, A. E. (2003). Theme Issue: The Role of Design in Educational Research. *Educational Researcher*, 32(1), 3-4. https://doi.org/10.3102/0013189x032001003

Kelly, A. E. (2004). Design Research in Education: Yes, but is it Methodological? *Journal of the Learning Sciences*, 13(1), 115-128. https://doi.org/10.1207/s15327809jls1301_6

Kelly, A., Lesh, R., & Baek, J. (Eds.) (2008). *Handbook of Design Research Methods in Education*. New York: Routledge.

Ketelhut, D. (2007). The impact of student self-efficacy on scientific inquiry skills: An exploratory investigation in River City, a multi-user virtual environment. *Journal of Science Education and Technology*, 16(1), 99-111. https://doi.org/10.1007/s10956-006-9038-y

Klopfer, E., & Squire, K. (2008). Environmental detectives—the development of an augmented reality platform for environmental simulations. *Educational Technology Research and Development*, 56(2), 203-228. https://doi.org/10.1007/s11423-007-9037-6

Kinash, S., Brand, J., & Mathew, T. (2012). Challenging mobile learning discourse through research: Student perceptions of Blackboard Mobile Learn and iPads.

Australasian Journal of Educational Technology, 28(4). https://doi.org/10.14742/ajet.832

Koehler, M. J., Mishra, P., & Yahya, K. (2007). Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy and technology. *Computers & Education*, 49(3), 740-762. https://doi.org/10.1016/j.compedu.2005.11.012

Koivisto, J-M, Niemi, H., Multisilta, J., & Eriksson, E. (2017). Nursing students' experiential learning processes using an online 3D simulation game. *Education and Information Technologies*, 22(1), 383-398. https://doi.org/10.1007/s10639-015-9453-x

Kolko, J. (2014). Why Investment in Design is the Only Way to 'Win' in Education, *UX Magazine*, September, 2014.

Krajcik, J., McNeill, K. L., & Reiser, B. J. (2008). Learning-goals-driven design model: Developing curriculum materials that align with national standards and incorporate project-based pedagogy. *Science Education, 92*(1), 1-32. https://doi.org/10.1002/sce.20240

Krogh, P. G., Markussen, T., & Bang, A. L. (2015). Ways of Drifting - Five Methods of Experimentation in Research Through Design. *Smart Innovation, Systems and Technologies*, 39-50. https://doi.org/10.1007/978-81-322-2232-3_4

Kucirkova, N. (2017). iRPD - A framework for guiding design-based research for iPad apps. *British Journal of Educational Technology*, 48(2), 598–610. https://doi.org/10.1111/bjet.12389

Kurti, A., Spikol, D., & Milrad, M. (2008). Bridging outdoors and indoors educational activities in schools with the support of mobile and positioning technologies. *International Journal of Mobile Learning and Organisation*, 2(2), 166. https://doi.org/10.1504/ijmlo.2008.019767

Laferrière, T. (2002). Telelearning: Distance and telos. *Journal of Distance Education*, 17(3), 29-45.

Laferrière, T., Montane, M., Gros, B., Alvarez, I., Bernaus, M., Breuleux, A., Allaire, S., Hamel, C. & Lamon, M. (2010). Partnerships for Knowledge Building: An Emerging Model. *Canadian Journal of Learning Technologies*, 36(1), 1-20.

Lagemann, E. C. (2002). *Usable knowledge in education: A memorandum for the Spencer Foundation Board of Directors*. Chicago: Spencer Foundation

Land, S. M., & Zembal-Saul, C. (2003). Scaffolding reflection and articulation of scientific explanations in a data-rich, project-based learning environment: An

investigation of progress portfolio. *Educational Technology Research and Development*, 51(4), 65.84. https://doi.org/10.1007/bf02504544

Lawrenz, F., & Huffman, D. (2002). The archipelago approach to mixed method evaluation. *American Journal of Evaluation*, 23(3), 331-338. https://doi.org/10.1016/S1098-2140(02)00203-5

Lee, H.-S., Linn, M. C., Varma, K., & Liu, O. L. (2010). How do technology-enhanced inquiry science units impact classroom learning? *Journal of Research in Science Teaching*, 47(1), 71-90. https://onlinelibrary.wiley.com/doi/abs/10.1002/tea.20304

Lewis, C., Perry, R., & Murata, A. (2006). *How Should Research Contribute to Instructional Improvement? The Case of Lesson Study*. *Educational Researcher*, 35(3), 3-14. https://doi.org/10.3102/0013189X035003003

Li, M.-C., & Tsai, C.-C. (2013). Game-Based Learning in Science Education: A Review of Relevant Research. *Journal of Science Education and Technology*, 22(6), 877-898. https://doi.org/10.1007/s10956-013-9436-x

Lobato, J. (2012). The Actor-Oriented Transfer Perspective and Its Contributions to Educational Research and Practice. *Educational Psychologist*, 47(3), 232-247. https://doi.org/10.1080/00461520.2012.693353

Looi, C.-K., Chen, W., & Ng, F. K. (2010). Collaborative activities enabled by GroupScribbles (GS): An exploratory study of learning effectiveness. *Computers and Education*, 54(1), 14-26. https://doi.org/10.1016/j.compedu.2009.07.003

Lund, A. (2008). Wikis: a collective approach to language production. *ReCALL*, 20(1), 35-54. https://doi.org/10.1017/s0958344008000414

Manzini, E. (2015). Design when everybody design - An introduction to design for social innovation. Cambridge, Massachusetts: MIT press

Mark, M. M. (2015). Mixed and multimethods in predominantly quantitative studies, especially experiments and quasi-experiments. In S. N., Hesse-Biber, R. B, Johnson (Eds.), *The Oxford Handbook of Multimethodand Mixed Methods Research Inquiry*, pp. 21-41. Oxford University Press: Oxford

McGlynn, M. J. (2013). Thinking it through: the importance of study sketches and the implications for design education. EAEA-11 conference 2013, 465-472

McKenney, S., & Reeves, T. C. (2013). Systematic Review of Design-Based Research Progress. Educational Researcher, 42(2), 97-100. https://doi.org/10.3102/0013189x12463781

McKenney, S., & Reeves, T. C. (2012). *Conducting Educational Design Research*. New York: Routledge.

Meuser, M., & Nagel, U. (1991). ExpertInneninterviews - vielfach erprobt, wenig bedacht: ein Beitrag zur qualitativen Methodendiskussion. In D. Garz, & K. Kraimer (Hrsg.), Qualitativ-empirische Sozialforschung : Konzepte, Methoden, Analysen (S. 441-471). Opladen: Westdt. Verl. https://nbn-resolving.org/urn:nbn:de:0168-ssoar-24025

Meuser, M., & Nagel, U. (1991). Expertlnneninterviews — vielfach erprobt, wenig bedacht. *Qualitativ-Empirische Sozialforschung*, 441-471. https://doi.org/10.1007/978-3-322-97024-4_14

Mishra, P. & Koehler, M. J. (2006). Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. *Teachers College Record, 108*(6), 1017-1054.

Mohan, L., Chen, J., & Anderson, C. W. (2009). Developing a multi-year learning progression for carbon cycling in socio-ecological systems. *Journal of Research in Science Teaching*, 46(6), 675-698. https://doi.org/10.1002/tea.20314

Moore, T. J., Glancy, A. W., Tank, K. M., Kersten, J. A., Smith, K. A., & Stohlmann, M. S. (2014). A Framework for Quality K-12 Engineering Education: Research and Development. *Journal of Pre-College Engineering Education Research (J-PEER)*, 4(1), Article 2. https://doi.org/10.7771/2157-9288.1069

Mor, Y., Craft, B. & Maina, M. (Eds.) (2015). *The Art & Science of Learning Design*. Rotterdam: Sense Publishers, Springer. https://doi.org/10.1007/978-94-6300-103-8

Morse, J. M. (1991). Approaches to qualitative-quantitative methodological triangulation. *Nursing Research*, 40(2), 120-123. https://doi.org/10.1097/00006199-199103000-00014

Nieveen, N. M., McKenney, S., & van den Akker, J. (2006). Educational design research: The value of variety. In J. van den Akker, K. Gravemeijer, S. McKenney, & N. Nieveen (Eds.), *Educational design research: The value of variety* (pp. 151-158). London: Routledge.

Novakovich, J., Miah, S., & Shaw, S. (2017). Designing curriculum to shape professional social media skills and identity in virtual communities of practice. *Computers & Education*, 104, 65-90. https://doi.org/10.1016/j.compedu.2016.11.002

Olofsson, E. & Sjölén, K. (2007). *Design Sketching*. Sundsvall, Sweden: KEEOS Design Books AB

O'Neill, D. K. (2012). Designs that fly: what the history of aeronautics tells us about the future of design-based research in education. *International Journal of Research*

& Method in Education, 35(2), 119-140. https://doi.org/10.1080/1743727x.2012.683573

Oxman, R. M. (1995). The reflective eye: visual reasoning in design, In A. B. Koutmanls, H. Timmerman, & I. Vermeulen (Eds.). *Visual data bases in architecture* (pp.89-112). Aldershot, UK: Averbury

Petersen, A. K. & Gundersen, P. B. (2016) Designing innovative education formats and how to fail well when doing so. In Nortvig, A-M., Sørensen, B. H., Misfeldt, M., Ørngreen, R., Allsopp, B., Henningsen, B. & Hautopp, H. (ed.). *Proceedings of the 5th International Conference on Designs for Learning*. Aalborg Universitetsforlag, p. 175-186.

Phillips, D., & Dolle, J. (2006). From Plato to Brown and beyond: Theory, practice and the promise of design experiments. In Verschaffel, L., Dochy, F., Boekaerts, M., Vosniadou, S. (Eds.), *Instructional psychology: Past, present and future trends. Sixteen essays in honor of Erik de Corte* (pp. 277-292). Oxford, UK: Elsevier Science Ltd.

Plomb, T., & Nieveen, N. (2013). Educational Design Research: Introduction and Illustrative Cases. Enschede: SLO

Puntambekar, S., & Kolodner, J. L. (2005). Toward Implementing Distributed Scaffolding: Helping Students Learn Science from Design. *Journal of Research in Science Teaching*, *42(*2), 185-217. https://doi.org/10.1002/tea.20048

Pye, D. (1978). *The nature and aesthetics of design*. London, UK: Herbert Press

Rajesh, M. (2016). Traditional Courses into Online Moving Strategy. *The Online Journal of Distance Education and e-Learning* 4(4), 19-63.

Randolph, J. J. (2009). A guide to writing the dissertation literature review. *Practical Assessment, Research & Evaluation*, 14(13), 1–13)

Redström, J. (2008). *Making design theory*. Cambridge, Massachusetts: MIT press
Reeves, T. C. (2006). Design research from a technology perspective. In J. Van den Akker, K. Gravemeijer, S. McKenney, & N. Nieveen (Eds.), *Educational Design Research* (pp. 52-66). London: Routledge.

Reeves, T. C., Herrington, J., & Oliver, R. (2005). Design research: A socially responsible approach to instructional technology research in higher education. *Journal of Computing in Higher Education*, 16(2), 96-115. https://doi.org/10.1007/bf02961476

Richey, R. C., Klein, J. D., & Nelson, W. A. (2004). Development research: Studies of instructional design and development. In D. H. Jonassen (Ed.), *Handbook of*

research for educational communications and technology (2nd ed., pp. 1099-1130). Mahwah, NJ: Lawrence Erlbaum Associates

Robertson, J., & Howells, C. (2008). Computer game design: Opportunities for successful learning. *Computers & Education*, 50(2), 559-578. https://doi.org/10.1016/j.compedu.2007.09.020

Rowland, G. (2007). Educational inquiry in transition: Research and design. *Educational Technology: The Magazine for Managers of Change in Education*, 47(2), 14-23.

Ruthven, K., Laborde, C., Leach, J., & Tiberghien, A. (2009). Design tools in didactical research: Instrumenting the epistemological and cognitive aspects of the design of teaching sequences. *Educational Researcher*, 38(5), 329-342. https://doi.org/10.3102/0013189x09338513

Sandoval, W. (2014). Conjecture Mapping: An Approach to Systematic Educational Design Research. Journal of the Learning Sciences, 23(1), 18-36. https://doi.org/10.1080/10508406.2013.778204

Sandoval, W. A. (2004). Developing Learning Theory by Refining Conjectures Embodied in Educational Designs. Educational Psychologist, 39(4), 213–223. https://doi.org/10.1207/s15326985ep3904_3

Sandoval, W. A., & Bell, P. (2004). Design-Based Research Methods for Studying Learning in Context: Introduction. *Educational Psychologist*, 39(4), 199-201. https://doi.org/10.1207/s15326985ep3904_1

Sandoval, W. A., & Reiser, B. J. (2004). Explanation-driven inquiry: Integrating conceptual and epistemic scaffolds for scientific inquiry. *Science Education*, 88(3), 345-372. https://doi.org/10.1002/sce.10130

Schleicher, D., Jones, P., & Kachur, O. (2010). Bodystorming as embodied designing. *Interactions*, 17(6), 47-51. https://doi.org/10.1145/1865245.1865256

Schleppegrell, M. J. (2013). The role of metalanguage in supporting academic language development. *Language Learning*, 63(s1), 153-170. https://doi.org/10.1111/j.1467-9922.2012.00742.x

Schoonenboom, J., & Johnson, R. B. (2017). How to Construct a Mixed Methods Research Design. *KZfSS Kölner Zeitschrift für Soziologie und Sozialpsychologie*, 69(S2), 107-131. https://doi.org/10.1007/s11577-017-0454-1

Schön, D. A. (1992). Designing as reflective conversation with the materials of a design situation. *Knowledge-Based Systems*, 5(1), 3-14. https://doi.org/10.1016/0950-7051(92)90020-g

Schütze, M., Sachse, P., & Römer, A. (2003). Support value of sketching in the design process. *Research in Engineering Design*, 14(2), 89-97. https://doi.org/10.1007/s00163-002-0028-7

Schwarz, B. B., & Asterhan, C. S. (2011). E-Moderation of Synchronous Discussions in Educational Settings: A Nascent Practice. *Journal of the Learning Sciences*, 20(3), 395-442. https://doi.org/10.1080/10508406.2011.553257

Schwen, T. M. (1977). Professional scholarship in educational technology: Criteria for judging inquiry. *AV Communication Review*, 25(1), 5-24

Seglen, P. O. (1997). Citations and journal impact factors: questionable indicators of research quality. *Allergy*, 52(11), 1050-1056. https://doi.org/10.1111/j.1398-9995.1997.tb00175.x

Sousanis, N. (2015). Unflattening. Cambridge, Massachusetts: Harvard University Press

Squire, K. D., & Jan, M. (2007). Mad City Mystery: Developing Scientific Argumentation Skills with a Place-based Augmented Reality Game on Handheld Computers. *Journal of Science Education and Technology*, 16(1), 5-29. https://doi.org/10.1007/s10956-006-9037-z

Stevens, S. Y., Delgado, C., & Krajcik, J. S. (2009). Developing a hypothetical multi-dimensional learning progression for the nature of matter. *Journal of Research in Science Teaching*, 47(6), 687-715. https://doi.org/10.1002/tea.20324

Strauss, A., & Corbin, J. (1998). Basics of qualitative research (2nd ed.). Thousand Oaks: Sage.

Strauss, A. L., & Corbin, J. M. (1990). *Basics of qualitative research: Grounded theory procedures and techniques*. Thousand Oaks: Sage Publications.

Streefland, L. (1991). *Fractions in Realistic Mathematics Education: A Paradigm of Developmental Research*. Dordrecht: Kluwer Academic Publishers. https://doi.org/10.1007/978-94-011-3168-1

Suwa, M., & Tversky, B. (1997). What do architects and students perceive in their design sketches? A protocol analysis. *Design Studies*, 18(4), 385-403. https://doi.org/10.1016/s0142-694x(97)00008-2

Thornberg, R. (2012). Informed grounded theory. Scandinavian Journal of Educational Research, 56(3), 243–59.Clarke, A.E. (2005). Situational analysis: Grounded theory after the postmodern turn. Thousand Oaks: Sage.

Ylirisku, S., & Buur, J. (2007). *Designing with video: focusing the user-centred design process*. London: Springer

van den Akker, J. (2003). Curriculum Perspectives: An Introduction. In J. van den Akker, W. Kuiper, & U. Hameyer (Eds.), *Curriculum Landscapes and Trends* (pp. 1-10). Dordrecht: Kluwer Academic Publishers.

van Den Akker, J. (1999). Principles and methods of development research. In: van Den Akker, J., Nieveen, N., Branch, R.M., Gustafson, K. L., & Plomp, T., (Eds.), *Design Methodology and Developmental Research in Education and Training (1-14)*. Kluwer Academic Publishers: The Netherlands, 1-14.

van den Akker, J., Gravemeijer, K., McKenney, S., & Nieveen, N. (Eds.) (2006). *Educational Design Research*. London: Routledge

van der Lugt, R. (2005). How sketching can affect the idea generation process in design group meetings. *Design Studies*, 26(2), 101-122. https://doi.org/10.1016/j.destud.2004.08.003

van Noorden, R. (2017). The science that's never been cited. *Nature*, 552(7684), 162-164. https://doi.org/10.1038/d41586-017-08404-0

van Raan, A. F. J. (2000). The Pandora's box of citation analysis: Measuring scientific excellence - The last evil? In Cronin, B., & Atkins, H. B. (Eds.), The web of knowledge: A Festschrift in honor of Eugene Garfield (pp. 301-319). Medford, NJ: American Society for Information Science

van Schaik, M., van Oers, B., & Terwel, J. (2011). Towards a knowledge-rich learning environment in preparatory secondary education. *British Educational Research Journal*, 37(1), 61-81. https://doi.org/10.1080/01411920903420008

Vistisen, P. (2015). The Roles of Sketching in Design: Mapping the tension between functions in design. *Proceedings of the Nordic Design Conference (NORDES) 2015*, 6

Vistisen, P. (2016). Sketching with animation - using animation to portray fictional realities aimed at becoming factual. Aalborg: Aalborg University Press.

Vogt, W. P. (2008). Quantitative versus Qualitative is a Distraction: Variations on a Theme by Brewer and Hunter (2006). *Methodological Innovations Online*, 3(1), 18-24. https://doi.org/10.4256/mio.2008.0007

Vollstedt M., Rezat S. (2019) An Introduction to Grounded Theory with a Special Focus on Axial Coding and the Coding Paradigm. In: Kaiser G., Presmeg N. (eds) *Compendium for Early Career Researchers in Mathematics Education*. ICME-13 Monographs. Springer, Cham. https://doi.org/10.1007/978-3-030-15636-7_4

Voogt, J., Laferrière, T., Breuleux, A., Itow, R. C., Hickey, D. T., & McKenney, S. (2015). Collaborative design as a form of professional development. *Instructional Science*, 43(2), 259-282. https://doi.org/10.1007/s11251-014-9340-7

Walker, D. (2006). Toward productive design studies. In J. Van den Akker, K. Gravemeijer, S. McKenney, & N. Nieveen (Eds.). Educational Design Research (pp. 8–13). London, England: Routledge.

Wang, F., & Hannafin, M. J. (2005). Design-based research and technology-enhanced learning environments. *Educational Technology Research and Development*, 53(4), 5-23. https://doi.org/10.1007/bf02504682

Zaritsky, R., Kelly, A. E., Flowers, W., Rogers, E., & O'Neill, P. (2003). Clinical Design Sciences: A View From Sister Design Efforts. *Educational Researcher*, 32(1), 32-34. https://doi.org/10.3102/0013189x032001032

Zhang, J., Scardamalia, M., Reeve, R., & Messina, R. (2009). Designs for Collective Cognitive Responsibility in Knowledge-Building Communities. *Journal of the Learning Sciences*, 18(1), 7-44. https://doi.org/10.1080/10508400802581676

Zheng, L. (2015). A systematic literature review of design-based research from 2004 to 2013. *Journal of Computers in Education* 2(4), 399-420. https://doi.org/10.1007/s40692-015-0036-z

Zheng, B., Niiya, M., & Warschauer, M. (2015). Wikis and collaborative learning in higher education. *Technology, Pedagogy and Education*, 24(3), 357-374. https://doi.org/10.1080/1475939x.2014.948041

Ørngreen, R., Henningsen, B., Gundersen, P. B. & Hautopp, H. (2017). The Learning Potential of Video Sketching. I D. A. Mesquita , & D. P. Peres (red.), *Proceedings of the 16th European Conference on e-learning ECEL 2017*: Porto, Portugal, 26-27 October 2017 (Vol. 1, pp 422–430).

Ørngreen, R., & Levinsen, K. T. (2017). Workshops as a Research Methodology. Electronic Journal of E-Learning, 15(1), 70-81. [569].

SUMMARY

The purpose of the study is to explore the potentials and challenges of performing design-based activities when researching through interventions in educational arenas. In four parts, the dissertation dives into first the understanding of different activities tied to working design-based, then the challenges such understandings hold and, finally, one or more areas that have the potential to meet the challenges. Across the four activities, three sets of challenges are presented. The first set relates to developing solutions to practical problems, the second set is concerned with the implementation of intended interventions and the third set deals with challenges of generalising knowledge on the basis of completed interventions. Additionally, two areas of potentials are presented. The first relates to the nomenclature of DBR and the second to practices, both of which hold potential to lead to more novel and efficient design solutions. The findings are generated using a multimethod approach in which literature reviews are combined with data from interviews. The findings from the reviews are nuanced, challenged or solidified through interviews with four researchers who during their PhD studies have worked with or are inspired by design-based research.

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