Balancing Product Design and Theoretical Insights

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in The Handbook of Design Research in Mathematics, Science and Technology Education.

Erlbaum, Mahwah, NJ. 2007.

Abstract

In this chapter the authors discuss the problem of balancing theory and artifact production in design research projects. Like other authors in this book, we believe that basic educational research benefits by being framed as a problem oriented research process, where design experiments and theoretical investigations go hand in hand. How this can be achieved - and the challenges it creates - is expressed in an 'osmotic model', showing the give and take of focusing simultaneously on product designs and theoretical insights. The authors offer some guiding principles by which researchers can navigate in such a methodological setting. The principles are based on experiences from three research and development projects at Learning Lab Denmark and illustrate the multitude of challenges to be faced, when balancing the processes of product development and the generation theoretical insights.

Introduction

Design research has ideally been described as a process of continuous cycles of design, enactment, analysis and redesign (DBRC, 2003), where the design experiments entail both 'engineering' particular forms of learning as well as systematically studying those forms of learning within the context defined by the means of supporting them (Cobb et. al., 2003). In practice though, this research process can be unbalanced and end up with an emphasis on either the design process or theory development. In a professional production environment there will typically be a strong focus on finishing a product and not necessarily on the generation of theoretical insights. In academic projects the focus will be on what new knowledge the project can provide and not necessarily on whether an actual product is produced and deployed.

The newly established Centre for Learning Games at Learning Lab Denmark has grown out of a wish to find new approaches to educational research in an increasingly complex social context – in Europe this context is sometimes called a "Mode 2 society". Using problem-oriented design experiments has proven valuable here. A Mode 2 society is characterised as having heterogeneous criteria and demands on research, emerging from sources outside of academia (Gibbons et.al., 1994; Nowotny et.al., 2001), and thus is radically different from a classical "Mode 1 society" where research questions are solved within well established disciplines, mainly with internal criteria of quality. Our aim at Learning Lab Denmark is to create methodologies that satisfy these heterogeneous criteria on research by generating new theories about learning, to develop innovative products, and to communicate and support their possible application in practice. We also consider these methodologies relevant for creating organisational changes. But this change is always two-fold: to improve the conditions for learning and to study the changed system. Thus, the purpose of studying the new learning situations goes beyond improving a given product or method. It is equally important to study the social setting that is changing because of the introduction of the new products or learning processes.

Using design experiments as a methodological tool for educational research has several advantages. Designing an artifact can act as a source for finding relevant research topics and help to organize the complexity in educational research. Also, empirical knowledge about learning is always highly contextualized. Extracting more or less generalisable knowledge from such contextualized phenomena requires conscious choices and value judgments. In an effort to give the reader an overview of the process of doing research projects within these methodological concepts, we have generated an 'osmotic model' (see figure 1) showing the give and take between designing artifacts and developing theoretical insights. Finally, we present three cases as examples of projects conducted at Learning Lab Denmark, demonstrating that real life research projects can seem like a far cry from the ideals of how to conduct problem-oriented design research. Case study 1, 'Mathematical writing', is an example of a research process with focus on the theory generating part of the process and with less focus on the designing part. The case exemplifies a typical problem in new scientific fields. There are few examples of technological solutions, where initial theory generation is crucial to be able to do theoretically informed designs of a prototype. Case study 2 is an example of the opposite approach. The case concerns the development of the learning game 'Homicide' and how the process ended up with a strong focus on the design process and less on the generation of theory - partly because of the demand of developing professional technology for the school education. In the last case study 'Redesigning Mathematics In-service Education' we describe a research process that has changed from an ethnographic study of teacher practice to a design research process where new means of in-service education are designed. These three cases illustrate how the constraints of various organizational, financial, technical, political or pedagogical factors make it more or less impossible to implement an ideal or 'perfect' research project that maintains a good balance between processes of product design and theory generation.

Developing Models

In order to discuss and maintain a balance between product and theory generation a researcher can try to visualize an idealized 'work flow' for a research project. In a problem oriented approach the typical starting point is a problem area or the theme that a 'problem owner' wants to study and have solved. It could also be called an area of opportunity. Ideally, this problem is investigated by a transdisciplinary research team, who will collect data in collaboration with the `problem owners´. This group of researchers might be put together for the course of this research project only, as each new study requires a research team possessing a new combination of competencies (Gibbons et al, 1994). A problem or "opportunity oriented" approach is normally not defined by a well established theory within a given paradigm, where a hypothesis can be verified or rejected through empirical investigations and thus be able to refine existing theories. Rather, an opportunity oriented approach can use designs as a way of finding new approaches and solutions. A design experiment is seen as an iterative process by which to create better designs. The knowledge production is related to the iterative cycle of design, interventions and redesign where value creation is related not only to the application of knowledge but also to the production of knowledge, while internal and external communication of knowledge can be qualified by the continuous input of users.

In order to have a model that addresses the push and pull of the work flow in projects, we have developed an `osmotic´ model as shown in figure 1. The model refers to the process of osmosis, because there is an inherent fluctuation between concentrating on designing and theoretical reflections. The osmotic model is not an instruction manual for doing proper research, merely a simplification of navigating between various aspects in the research process. The arrows are meant to show that there is flow, a dynamic osmotic force. The arrows are not indicators of a sequence or a chronology - rather they are phases of a research process, which seem to be necessary for maturity of a design research project. The model takes departure at the center or 'the problem'; and the optimal research process should then be understood as performing iterative and synchronous circle movements in both directions. Note that the word "artifact" should not necessarily be understood as material objects like an abacus or a game, it may just as well be learning strategies, organizational changes or other immaterial process descriptions, which serve as curricular end-in-view or inspiration for prototypes.

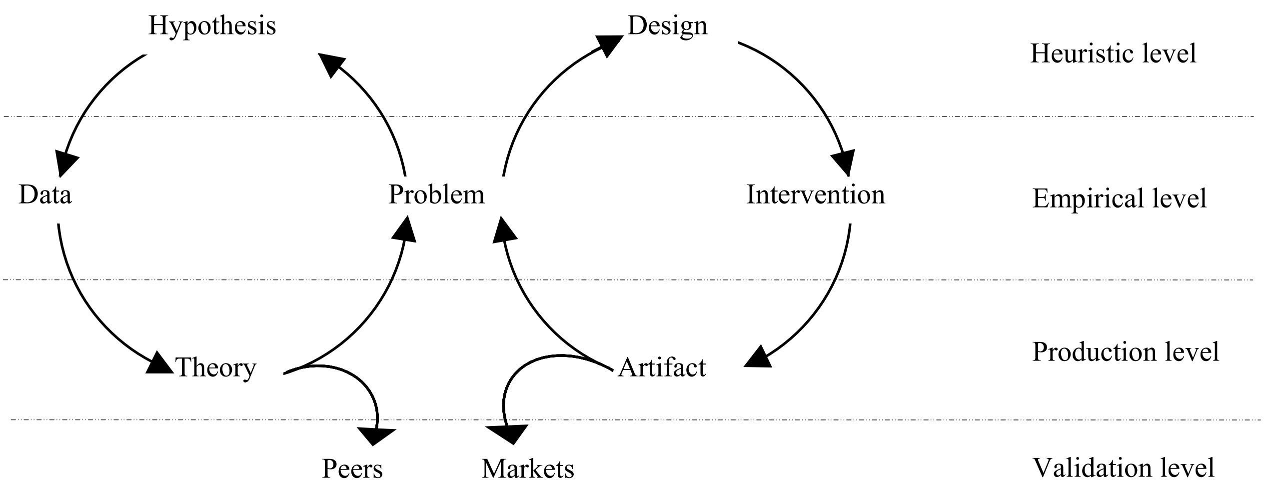

Figure 1'Osmotic Mode': Our current understanding of how to balance artifact and theory generation within a design research paradigm. The left circle mimics the traditional way of doing educational research, where the main "customers" are the peers. The right circle mimics a normal production cycle, but with a much stronger involvement of user feedback. Ideally, a design research project moves in synchronous circular movements, starting from the center and going in both directions. However this synchronicity rarely happens in practice.

In order to explain this very idealized and macroscopic model for conducting research, we break the model down into four steps or phases: a) from problem to design and from problem to hypothesis; b) from design to intervention and from hypothesis to data; c) from intervention to artifact and from data to theories; and d) from artifact to markets and from theories to peers.

a) from problem to design and from problem to hypothesis

Going from a problem at hand to a hypothesis/design entails making a move from the empirical level into the heuristic level - probably the most exciting but also most difficult part of doing research. A pre-requisite is that the researcher has a fairly good knowledge of existing theories about the theme. It also helps to have a sound scientific intuition when making a new hypothesis (a proto-theory) about how the particular problem could be confronted and possibly solved. In order to make this move, a researcher should be able to induce a solution, for example a change of practice. This requires a working knowledge of existing theories, existing artifacts, and design intuition.

b) from design to intervention and from hypothesis to data

It is on this level that design research has a great deal to contribute. Design research implies that the move from design to interventions is never linear; rather it is a circular, iterative process. There can be infinite loops of designing, intervention and redesigning. So, like Ptolemaios, we ought to draw small epi-circles into the figure, between “design” and “intervention” and between “hypothesis” and “data”, in order to acknowledge this fact.

c) from intervention to artifacts and from data to theory

Single classroom interventions and follow up qualitative research are the prime activities for Design researchers at universities. But in order to maintain an ambition of infecting learning communities with new tools and new ideas, we need to create innovative instructional designs which are readily translatable and adaptable to many contexts. An aspect of this need is preparing the artifact for diverse contexts, and not to be satisfied with localized prototypes. It is an important ambition but presents some serious challenges and even obstacles.

d) from artifacts to markets and from theories to peers

In order to ensure successful interventions within educational practice, researchers should consider deployment just as important as theory and artifact development. However, there is cause for skepticism. The history of education reform shows us that very little of lasting effect has been produced by the educational design experiments to date (Williamson, 2003). Some people argue that successful interventions are nothing but a Hawthorne effect (Brown, 1992) or that they are too particular and narrow in scope and impact, and that not much can be done for creating a permanent positive change in classroom teaching and learning. In addition, international studies show that it is unlikely that learning will be remarkably improved by introducing new technologies and media in the classroom without changing the dynamics of teaching and learning (Venezky et al., 2002; OECD, 2004) and without including out of school activities in order to create inspirational formal learning environments (Kozma, 2003).

In addition to the dynamics in figure 4, four conceptual levels are identified. These levels are: the heuristic level; the empirical level, the production level and the validation level. The heuristic level relates to hypothesis and prototype design, where commonsense rules, intuitions and creative processes are mixed and used in order to increase the probability of finding a good candidate for further inquiry. It involves brainstorm processes, mental experiments of pros and cons, trial-and error and lateral thinking. The empirical level in contrast tries to systematize what can be known and what is unknown through well-established scientific operands of experiments and observations, verification, falsification and so on. The production level involves competencies such as organizing, framing, planning, synthesizing and sometimes delegating work. Last but not least: the validation level is less in the hand of a researcher than of people or mechanisms that are used for authentication and dissemination.

Some final comments on the osmotic model – we are proposing that one way to contribute to education reform in the future is to be extremely conscious about creating marketable products which are disseminated to the proper audiences. In this way, we can extend academic validation through peers by external evaluation and selection through users and markets. Thus, evaluation is threefold: peers, markets and user feedback. Beware that ‘markets’ should not be misunderstood as ‘mass markets’. The word markets should be understood as the many different recipients, target groups and stakeholders of the artifacts in question. These stakeholders might be the relevant people who have never heard of you, but who might profit from your design efforts. Thus, in order to ensure successful interventions in educational practice, deployment should be seen as being equal in important to development theory and artifacts.

The ideal research project versus the real-life challenges

As mentioned before, there may be situations where a design solution is too far away from the problem at hand. Some fundamental research problems might simply not be suited for design experiments yet. Such a situation is described in case study 1. Also, the time needed to do iterative research work is often simply lacking. Design research takes time due to the demand for conducting research on learning in context – and developing learning materials in an iterative and collaborative process. There is a persistent problem of time for qualified development time due to the nature of academic funding given for blocks of time or as stipends, such as PhDs or grants. Realistically, even though researchers succeed in creating marketable artifacts, there are other salient issues in the schools, such as lack of teacher training, digital infrastructure and continuous technical support that present challenges. The learning context as the whole – meaning the socio-cultural and political ecology and cultural aspects (including gender) - is often neglected or downplayed when considering deployment and adaptation of new curricular initiatives and artifacts. The later stages of design artifact and teaching practice involving dissemination and diffusion are gaining attention in design research. For example, the Integrative Learning Design Framework (ILD) by Brenda Bannan-Ritland (Bannan-Ritland, 2003) provides an overview of the development and design process, drawing from traditions of instructional design, product design, user-centered design, traditional educational research and web-enabled proto-diffusion. Notably, Bannan-Ritland integrates sociological perspectives on the diffusion of innovations to market (Rogers, 2003, Zaritsky et. al., 2003).

Case studies: Design-based research and mode 2 in practice

In the following three case studies, we describe some of our experiences with the methodological dilemmas that we try to balance, along with the challenges we have faced in practice.

Case study 1: Mathematical writing

The outset of this project was to question how technology can support mathematical writing, 'similar' to the way that prose writing is supported by word processors. The background is that computers are becoming the widest used medium for written communication. It appears as if everything, ranging from personal communications and school reports to research articles, is now developed and presented using a computer. This is a development with many, many advantages. As an example, consider how the global internet supports development of online learning communities, and improves the infrastructure for distributed collaboration. Yet these advantages are dependent mainly on written communication. Word processors allow for other kinds of writing processes than previous technologies, which may be due to the 'printed' appearance of text and the minimal effort involved in restructuring and revising the text.

Several attempts to take advantage of the potentials of digital writing in connection to mathematics, especially in mathematics education, seem to be unsuccessful (see for example Guzdial et al., 2002), and this observation motivated the Mathematical writing project. Understanding how technology might be able to support mathematical writing, can be considered a very challenging design problem. Our review of literature (and our design intuition) indicates that the ideal tool for writing mathematics is not yet made, even though many candidates have been proposed.

So instead of starting this project with developing a theoretically informed design of a prototype, it seemed necessary to understand more fully what people actually do when they 'write mathematics'. In order to study people in context, we turned to the ethnographical approaches used in the areas of workplace studies and computer supported collaboration (CSCW). CSCW is a pragmatic version of ethnography, which has proven an effective approach for understanding the problems with existing designs, and generating new designs. The ethnographic grounding works well in capturing the complexity of, for instance collaborative working situations.

The figure 2 below shows the progression of the research, the rationale behind the ethnographic approach and how it relates to theory and design.

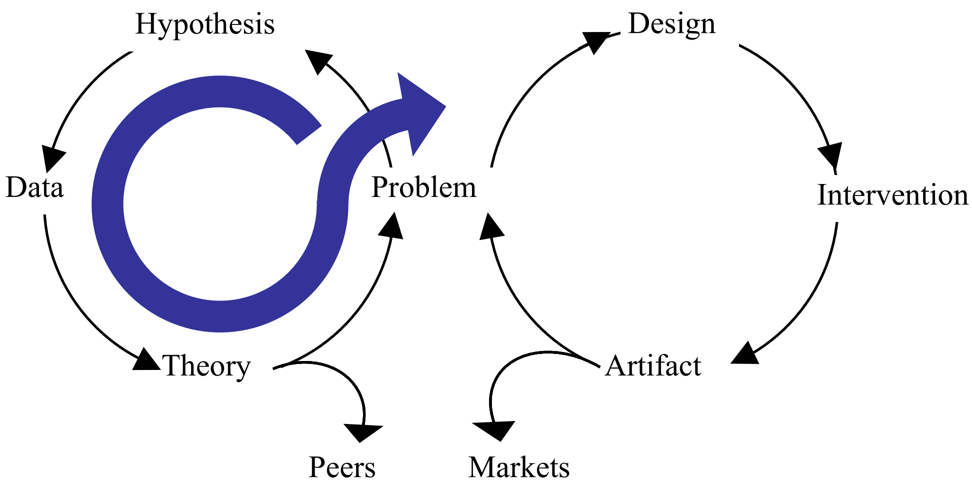

Figure 2: The Ethnographical approach taken in the project mathematical writing.

In this approach, the outset of the research is a problem or interesting practice. This practice is then empirically observed and described, with attention to phenomenon related to the problem in focus but otherwise keeping a very open "hypothesis". These observations should lead to a theoretical description of practice, showing problematic or interesting areas and hopefully provide us with new insights. Design is the expected outcome of the research activity, in the sense that the promise of such research in the long run is a new or improved artifact that eases the practice that the research is about. The figure shows this evolution from research, from theory generation to design artifact.

The research focus was what different types of people do when they work with mathematics - how do they write, what type of media do they use, which kind of representations are central, and how do they collaborate. Two investigations were done: one with professional mathematics researchers about their various writing processes (Misfeldt, 2004a, 2005b) and one with undergraduate students about their collaborative writing (Misfeldt, 2005a).

The first investigation was based on interviews with mathematics researchers where they explained the purposes that writing has for them, both in their individual work process and in their collaborative work processes. The investigation indicated that writing is very important to the mathematics researchers in almost all phases of their work ranging from early idea to finished paper. For many of the researchers, computers become part of the writing process very late in the process, mainly as typing a handwritten manuscript.

The second investigation was a field study of undergraduate students' collaborative work in connection with completing an assignment. The investigation showed that there is a complex interplay between the use of writing as a personal tool, an ostensive tool and a product in collaborative writing activities on mathematics.

The results of the two investigations are discussed using a semiotic framework (Misfeldt, 2004b). This framework allows us to discuss the structure of interaction between people and between people and media on the same level, and lead to design heuristics concerning formula editors taking into account the way formulas are spoken aloud.

In connection to collaboration, it appears that face to face interaction about mathematics draws on several media and that the role of these media shifts between being social and individual. These results are not well suited as a starting point for the design of digital technology, but could point to developing design principles for working environments and for the organization of collaborative projects.

Case study 2: Designing the learning game 'Homicide'

This project was initiated in 2003 at Learning Lab Denmark, and was initially not set up as a design-based research project, but had a mode 2 approach. The project was an experiment in bringing innovative learning materials to 'markets' - i.e. the focus was on deploying new learning material to schools for further research and development. The 'artifact' is an IT-supported role-playing game called 'Homicide', where students play forensic experts solving a murder case (Magnussen & Jessen, 2004). In a week-long investigation process, students analyse clues such as fingerprints and blood found at crime scenes using both theoretical and hands-on practical methods. The investigations are conducted both in the virtual game space and in the physical space in the school laboratories. The game is a mixed-media supported game with the main part of the interaction and problem solving takes place in the social space in the classroom and not as computer-student interaction. The computer serves as a knowledge base which students can go to for such information as criminal investigation handbooks with procedures and scientific background materials, data from crime scenes, video interrogations of suspects, document support, forensic reports, etc. Thus, this game-based learning environment was designed to develop science competencies through a simulation of a real-life learning situation.

The goal was to explore the possibilities for developing a learning game that would support working with the scientific method, using a scientific process of inquiry, and still be an exciting game to play. The aspiration was to make a playful, humorous, yet fairly low budget learning game. We intended the game to be used in schools when integrating different subjects. Aspects of the crime stories and real-life crime lab genres from television series was combined with computer games and traditions of `learning by doing´ through role playing and simulation methods.

The development team consisted of a core of people functioning as designers, writers, developers and researchers. A common feature was that all had some type of academic theoretical approach to game development, as well as a practical media production background. The team included others as needed: actors, consulting teachers and specialized educational researchers.

The development project ran through four different developmental phases. The first phase was the theoretical founding and conceptualization. The team started with a knowledge gathering phase, studying the content of the game (forensic techniques) and researching situated learning theory, activity theory, literary theories and role-play theories in order to conceptualize the learning structure of game. In the second phase the team developed and produced a pen-and-paper-version of ‘Homicide’, which was alpha-tested and generated results on player’s use of roles and their level of science learning content. The researcher was an integrated part of this process, working primarily with science learning content. Phase three was the final phase of the game development phase and lead to the production of a beta version of the game, which went through several iterations (related to two interventions in schools) before finalizing the game design. The game designers, researchers and teachers worked together on integrating science learning elements and game elements in the final product. Phase four included dissemination, teachers' education and proposals for future studies of the game as a learning environment.

In the two studies of Homicide 'in action', we saw that the game's learning environment supported working with the process of inquiry and that was motivating and engaging for the students. In these first interventions with the game in school, the social learning in the game-based learning environment has also proven highly interesting. In the observations of the play-intervention, we not only observed how the students handled large amounts of data to establish theories - they also independently re-designed the game tools in an effort to establish a coherent hypothesis. These tools became increasingly more sophisticated during the week-long play-intervention, which seems to indicate that the students not only used individual skills, but that they operated on a methodological meta-level where tools and methods are evaluated and adjusted to meet the challenges of the game. A theoretical description of this type of simulated situated game-based learning space is relevant, since we have as yet little knowledge about what type of learning processes takes place in this type of learning spaces, what makes a design effective and how to adapt findings to other settings. Future long term observations and design-based research studies of players playing Homicide are needed to gain an understanding of these both theoretical and learning aspects.

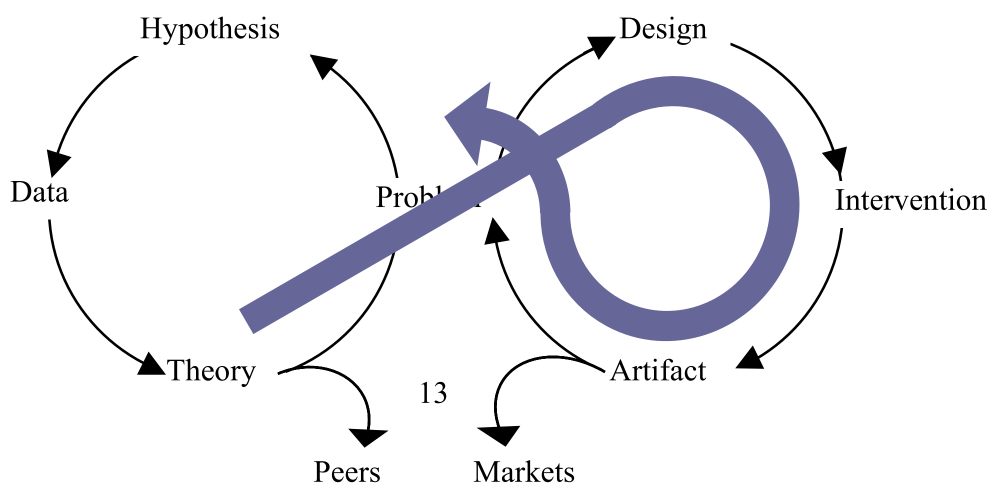

Figure 3: The product design approach taken in the project 'Homicide'

The project focus was on the development of the game. The initial design of concept was theory-driven but the process as a whole lacked deeper analysis in relation to redesign and theory building. This problem may be rooted in the balancing of the roles of developers and researchers. This issue may be endemic to design research project, especially large development projects like Homicide. A team needs to find a common language and cultivate respect for the contributions of each role in the team, yet accept certain limitations on the level of engagement in all aspects. For example, it may not be possible for researchers to fully understand and integrate the theory that is the focus point for the material produced without being herself an integrated part of the development process. The designer will not be able to make theory-driven designs without being an integrated part of the research, but there might be processes that are meaningless to the other part. When the game is 'tuned to work' it might be meaningless to the developer to keep changing elements to get a deeper understanding of the learning processes the game facilitates. The researcher, on the other hand, might find it meaningless to keep adjusting technical details that are non-important to the research focus. One solution could therefore be that researchers and designers should consider having certain separate processes.

In regard to changing existing practice the development and research team has since 2004 been in demand at conferences etc. - showcased for thinking out of the box regarding designing curriculum materials and for introducing a new breed of learning material. Thus, the Homicide game itself does indeed seem to `talk back´ to educational policies and practice in schools – creating demands for teachers training and provoking debates about issues such as curriculum design, transdisciplinarity, and the decreasing interest in learning science among students.

Case study 3: Redesigning Mathematics In-service Education

The goal of this research project was to investigate a narrowly focused curriculum initiative, mediated by an in-service course for mathematics teachers in a traditional mode 1 type of study. In-service education is the most commonly used way to implement new curriculum initiatives, yet little is known in Denmark about how it influences the classroom practice. The initial research questions were: How clear were the intentions in the initiative delivered in the in-service course and in the classrooms? How was the effect of the teacher in-service course on the subject: open problem solving in mathematics?

The background for the project in this case was that a new type of oral mathematics exam after grade nine in the lower secondary schools became compulsory in Denmark in 1997. According to the governmental curriculum requirements, the examination tasks have to be formulated as practical problems of an open character. This new type of exam led to an in-service course "Preparing for Mathematics Exams" offered to mathematics teachers in 1996. These in-service courses were run by pedagogical consultants, but the courses were only offered when enough participants enrolled, i.e. depending on 'the market conditions'.

However, there was no con-committing plan for researching how 'open problem solving' might have positive or negative effects back in the classroom. A Ph.D.- research project at Learning Lab Denmark made it possible in 2002 to start to study the effect of in-service course on open mathematics problem solving – how did the in-service course in fact influences the teachers change their practice?

The Ph.D. researcher started by reviewing curriculum theories and then collected data about the content in the in-service course and the teachers' subsequently teaching practice. The research question was: To what extent can teaching mathematics with open practical problems be learned in an in-service course by the participating mathematics teachers?

The methodological approach was qualitative with investigations of teacher's practice through ethnographically inspired field work and in-depth interviews. The research methods included: semi-structured interviews (Kvale, 2001, Patton, 2002), videotapes (Pirie et al., 2001, Powell et al, 2003, Saljö, 2005), diaries produced by the teachers and materials produced by teachers and students. One of the early research findings was that the in-service course did influence the teachers in using open mathematics problem in the classroom, but at the same time using open problems creates a situation of 'paradigmatic and authoritative flux' where continuous ad hoc decisions have to be made by the teacher. Many of the teacher's decisions are "uncertain" in the sense that they are made on the spot and in response to local conditions. One of the significant elements of working with open problem solving is that students ask questions or suggest solutions which the teacher cannot always be prepared for. Therefore, the teacher has to listen carefully to the student and find quick and suitable responses. The teacher has to concentrate: What does the student mean? What is the context? What is a good response for this particularly student, etc.? But, what typically happens is that the teacher doesn't listen carefully enough and gives automatic responses, as other research confirms (Jarvis, 1999; Skott, 2000).

Listening and responding become crucial skills when using open problem solving in classrooms. The teacher has to listen in another way, because open problem solving can go in so many directions. It seems that teachers stay with their old discourse habits, of knowing the answers to all questions. Indeed, the new context requires new types of leadership, and development of the skills to listen in another way, along with the ability to ask powerful questions and give clear responses.

As the researcher reflected on the early findings, another question appeared: Why does the teacher listen and response so 'poorly' when students solve open practical mathematics problems? With this more narrow focus, the project moved into a design research approach where part of the research focus was on redesigning the in-service course with design experiments, to develop instructional activities and to conduct analyses of the process of the student-teachers' learning and the means by which that learning is supported and organized (Cobb, 2001; diSessa & Cobb, 2004).

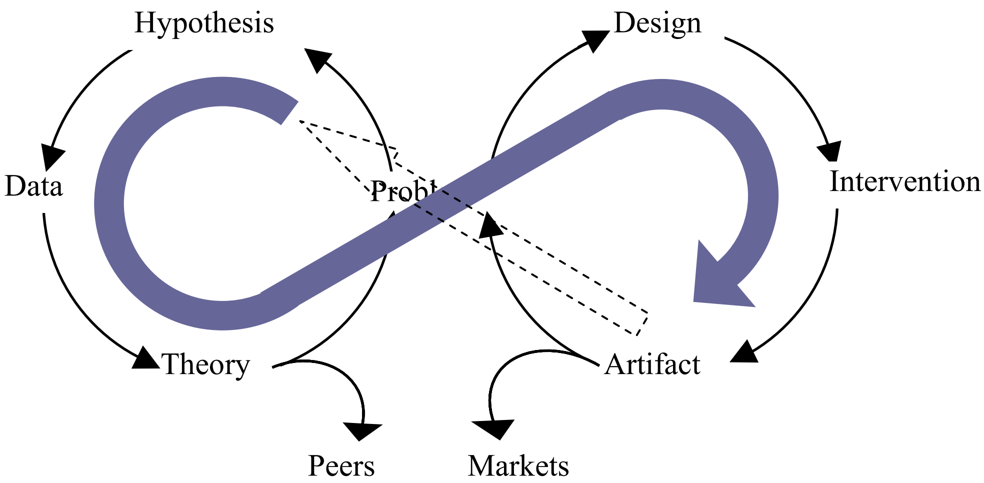

Figure 4: The methodological path taken in the project of teacher in-service education of using open problem solving in mathematics. The project started out with an ad hoc "artifact" – the already formed in-service course – this course is now being redesigned on the basis of the ethnographic data and theoretical refinements.

The shift into the design research framework gave the study a boost because it made clear to the researcher how to ground re-design of the curriculum. Based on the interpretation of the research data and the evaluations made by the teachers, combined with material on the stated goals and the Act visions for the mathematics, the redesign of the course explored how to engage the teachers in 'reflective cooperation'. The theoretical framework under development is about the similarity and differences in the school classroom and the in-service course classroom.

The results of the study show that teachers took with them back in their classroom what they learned at the in-service course. However, the researcher observed that none of the classroom communication came near a kind of 'reflective discourse' organized through communication about the open problem solving - what was the reason for that? - and how could the in-service course be prepared in a different way to meet those needs (needs the teachers maybe weren't aware of)? The new method entailed asking the teachers to keep diaries of communications in the classroom and doing self-observation and reflection about their teaching practice in a more focused ways. The redesign contained reflective cooperation, which was done by arranging a situation where the teachers could experience their own listening and responding activities.

One of the theoretical frameworks used was Leron & Hazzan "The virtual monologue" (1997), a game to imagine a virtual inner monologue in the communicating persons (Ejersbo & Leron, 2005, Ejersbo, 2005). The crucial point of Virtual Monologue is to get the teachers be aware of their own habits and to feel the importance to change together as a group and on the individual level when they are back alone in the classroom. This insight hopefully leads to the possibility that the teacher will be aware of their own way of listening and responding, and in that way develop the necessary skills and competencies.

The research project started as a mode 1 project, influenced of mode 2 requirements, but it changed in the middle into a design research project. That was possible because the in-service courses continued in a cycle with a course each year. One of the difficulties was balancing the different roles between being a consultant and a researcher. The course was redesigned grounded on the theoretical frameworks from the research. On one hand the participating teachers were still satisfied; on the other hand the redesigned courses are only evaluated immediately afterwards the course by the participating teachers, without any classroom studies. The old courses were very popular too and a remaining question is how much the new course influences the subsequent mathematics teaching and why. An iterative process can go on.

Discussion

The evidence from the three case studies shows that there is no straightforward way to plan and carry out a design research project. There are many possibilities and many caveats and there are no stable methodological paradigms or theoretical recipes by which to proceed. Therefore, as a researcher, one has to be pragmatic about the choices at hand and concede to the fact that it may be impossible to do all things at once. Sometimes it will be unimaginable to do intervention trials; sometimes it will be impossible to deploy an artifact. Sometimes it may be best to use some heuristics. Sometimes applying field studies is sensible if the situation is not supported by available designs.

The chosen approach in case study 1 on mathematical writing was to do field work in order to see what does or does not work in a given context. It was necessary to observe how people use digital and other technologies before creating 'humble' hypothesis and concrete design ideas. Creating humble theories is different than attempting to make a grand or high theory, but certainly appropriate and valuable: "Design experiments are conducted to develop theories, not merely to empirically tune 'what works.' These theories are relatively humble in that they target domain-specific learning processes" (Cobb et al., 2003).

In case study three "mathematics in-service education" these two considerations merge nicely. Being a very popular in-service course, some impact is guaranteed. Nevertheless, the research project has managed to iteratively question the nature of this impact and to feed back the knowledge to a revised version of the course, maintaining a large impact. The question is still to explain in a researchable way why the new designs work and suggest which new circumstances it could be adapted to. The crucial point in case study 3 is to keep the balance between developing the course on the market condition and the research condition.

In case study 2 `Homicide´ the focus was on the development part of the process, where intuitions and practical experiences were more dominant in the designing of a new type of learning material than theoretical knowledge. It is difficult to say anything definite about what the right balance is between theoretical findings, heuristics and empirical analysis as it is highly dependent on the context, but it should be something developers and researchers should pay attention to through the whole process. Also, in case study 2 'Homicide' we struggled with the richness of data embedded in the final game design. In the beginning, we were tempted to create a broad, all-encompassing theory on why and how a learning game works. "Beyond just creating designs that are effective and that can sometimes be affected by "tinkering to perfection," a design theory explains why designs work and suggests how they may be adapted to new circumstances." (Cobb et al., 2003) However, the need to restrict the research questions quickly became clear. The grand questions were broken down into an analysis of details, single parameters, certain context aspects or specific hypothesis. Case 2 `Homicide´ illustrates an osmotic pressure, where the concentration of energy was so much on development of a new type of learning material in the start - and now the pull is toward developing the theoretical insights.

There are also lessons to be learned by the design research community. It is not enough to have some nice prototypes that work in some small selected contexts (Barab, et.al., 2004). Production of deployable artifacts is crucial for creating lasting impact on learning communities, although deployment can be seen as a problem for maintaining an iterative design process The question of why cognitively-oriented technological innovations have not become widespread has been addressed by Fishman (Fishman et.al., 2004), who states that a key reason for the limited impact is that most design-based research does not explicitly address systemic issues of usability, scalability and sustainability. We agree. Perhaps, popular notions of "demo or die" should be complemented with "demo and deploy" or "meet the market". We would add criteria of communication and deployment of scientific ideas and artefacts. These criteria can have positive consequences for design related research. First and foremost there is the consequence that the design involved in the research process at some point should be disseminated to some kind of open market, even though this could mean temporarily stopping the iterative design process. The second consequence is to communicate to relevant stakeholders throughout the entire research process. Research communication should be more than research reports that appear only in specialized journals years after the project is finished.

Conclusion

In this chapter we have described some of the central methodological considerations in our attempt to have a practice-oriented approach to educational research.
We have developed an “osmotic model” in order to describe how it is possible to balance the dynamics of a research process. Using this model, we presented three of our research projects and evaluated how they match our own ideal of doing educational research. The picture that emerges from the three cases shows that the ambition is hard to achieve, mainly because it is impossible to address all the aspects involved in the model with full intensity simultaneously. Our advice is that the researcher has to select a suitable methodological approach, guided by a combination of analysis and heuristics regarding the problem as well as pragmatic concerns about resources, partners and so on.

We hope to contribute to the development of methodologies in design research. On our part, there are some enduring problems in the choice of approaches and much work lies ahead on trying to align the actual work done with the ideals. We understand research contexts as a potential collaborative idea and theory generator, which reaches beyond intervention or improving theoretical accounts of teaching and learning. We believe that research results and prototypes should be aimed at different communicative arenas and thinking out of the box is an issue to consider methodologically. Finally, we think that a wider pragmatic diffusion of pedagogical and didactic innovation in scalable, replicable and sustainable form is imperative in order to avoid narrow research projects that never reach maturity.

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Science, Technology and Learning Group at Learning Lab Denmark, Danish University of Education. See www.lld.dk
`Homicide´ project. See http://www.drabssag.dk/. The project is supported by the Danish Ministry of Education's ITMF (Public School IT and Media) fund.

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