The Dream About the Magic Silver Bullet – the Complexity of Designing for Tablet-Mediated Learning

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The Dream About the Magic Silver Bullet – the Complexity of Designing for Tablet-Mediated Learning

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ABSTRACT
In this paper, we report three cases of the integration of technology, such as web-enabled media tablets in Scandinavian schools. Both qualitative and quantitative data have been applied. A daily challenge for teachers is to coordinate their group of students in a way that enables collaborative learning. We report the gaps and interrelations between the dreams and the practice of the teachers. They dream about an interconnected praxis – the magic silver bullet – and establish their visions of inter-connectivity because of their breakdown experiences of media tablets aiding complexity instead of reducing it. The teachers must learn how to navigate during the breakdowns before media tablets reduce complexity and reach a state in which the tablets take part in the classroom ecology as functional organs. The teachers have to deal with complex situations during class *in situ*. In order to be able to continue with the class, the teachers become *jongleurs* of different design elements, including the handling of didactical designs and the breakdowns caused by the integration of media tablets; the teaching practice moves away from a common routine activity and turns into a *design project*.

Categories and Subject Descriptors
K.3.1 Computer Uses in Education

General Terms
Design, Human Factors, Theory.

Keywords
Media tablets, Educational technology, Cooperation, Design

1. INTRODUCTION
The omnipresence of mobile technology has lead to new situations in educational institutions in the western countries. In early times, Information and Communication Technology (ICT) has been segregated from the classrooms and placed in computer labs [17]. This has changed with the invention of smaller devices like tablet computers and smart phones. Now, instead of segregation, a shift is happening to co-located settings in which ICT becomes part of the classroom. The teachers' acceptance on mobile technologies in the classrooms is changing from a negative attitude towards traditional ICT into a more positive attitude towards media tablets [20].

As any new technology, media tablets do not lead to a better or worse practice, but the adoption of new technology matters and can lead to different metamorphoses and situated actions ([43], [56]). "Technology will probably not change what it takes to learn (…) but it may change how the process of learning is facilitated" [31]. The adoption of new technology in education affects existing teaching practices. It could be that media tablets serve as substitutes for textbooks and laptops or the teachers create new designs for cooperative learning [21].

In three studies of Danish classrooms, this paper aims to explore teaching practices enhanced by media tablets. Mobile technologies, e.g. media tablets, might be adjusted to the existing teaching practice or a re-design is required. When using technology, different elements, for example teaching objectives, learning activities and assessments, require a reflection a new balance, and a new adjustment in what could be called a new form of "constructive alignment" [3] in which the elements fit to each other to support student learning. A constructive alignment is like a house with building blocks or pieces of a bigger puzzle that fits with the other pieces. The model of digital didactical designs [22] is one possible approach to study the complexity of teaching as social practice. To plan teaching and to do it in practice is a matter of coordination. We demonstrate the ecological complexity from a close ethnographical study supported by in-depth interviews and an online survey.

The paper reveals a gap between the digital didactical design *thinking* (what the teachers wish for) and the application of the

designs in social *practices* – especially the increasing complexity and breakdowns that teachers have to deal with.

2. THEORETICAL PERSPECTIVE

Prior research on ICT, mobile technology and media tablets in education reports that the use of mobile devices improved student engagement and the achievement of learning [41], [54], [55], [50]. In 2010, Melhuish & Falloon's study [40] show that media tablets are useful for a) utilizing and creating content in a collaborative, interactive way [19], b) it is useful for student-centered activities [37], [44] and c) the devices improve teaching practices [9].

International research on mobile technology in education reveals that such devices create a new quality of online presence and open access to information [53] while sitting in the classroom [21], useful for user-generated contexts [45], and can change the ownership and power relations [58] towards learner-centered concepts [37]. Mobile technology potentially fosters student creativity [4] and student collaboration [5].

Highly relevant is whether the devices are integrated into the pedagogical design or not [39]. Educational technologies can have implications ranging from being mere substitutes with only limited effects, up to completely redefining the pedagogy [47]. A focus on tools alone cannot explain the emergence of new teaching designs and "is hard to convert into a pedagogy for teaching and learning since tools are always specific to tasks" [60], p. 155.

Studies on integrating technology, pedagogical and content/subject knowledge by teachers, known as TPCK models, show how these dimensions affect each other [28]. This points toward a lack of the aforementioned existing studies on mobile learning focus. They focus on micro levels of learning from a learner's perspective; they neglect that teaching is also a *design project* developed and carried by teachers. However, the discourse surrounding TPCK is in our view largely blackboxing how teachers appropriate, coordinate and collaborate through educational technology at the level of *practice* [29]. Still under-explored and under-researched is how the new situation of co-located spaces, created through the use of media tablets, affects the teacher's practice for enabling learning.

In our research, we study the integration of mobile technology in teaching practices in co-located settings; where media tablets and teaching spaces merged together to new expanded communication spaces. We define teaching practices as the creation and doing of sociotechnical-pedagogical designs in classrooms.

2.1 What is a "design" in teaching practices?

The word 'design' focuses on specific actions and parts of activities by the teachers in schools. Design is the act of giving a form: it shapes a focus and key points. A design focuses on certain elements but does not take all of the reality into consideration. A design has both a planned component and an operative doing – it is process and product at once. The teachers design teaching activities for enabling students' learning. We call these didactical designs. The word Didaktik (didactics) comes from a Greek term that means the theory of teaching. The European approach of Didaktik does not only include the methods of 'how to' teach, but also embraces the question of 'what to' learn (curriculum and content), 'why', 'when/where', and in what kinds of situations.

A digital didactical design is a design that focuses on fostering students' learning, in particular technology- and tablet-enhanced learning. It involves a formulation of teaching objectives by the teachers and the plan for achieving those objectives by creating learning activities for students. It also includes forms of process-based assessment (especially guided reflections) in order to enable student development. The enablement of learning is the central concept. Teachers can enable learning by applying different instructions that help to increase the likelihood that learning really takes place [61]. Following the concept of "informed choices" [42], the approach of digital didactical designs is an attempt to make the relation between design, education and technology visible [8].

2.2 Digital Didactical Design approach

The term 'digital didactical design', draws inspiration from the European concept of "Didaktik" [27] – the "content-student-teacher" relation. It is enhanced by a digital didactical design grounded on different concepts ([12], [18], [12]) that stress the differences of teaching activities and learning activities. This view on didactics, activities *and* design puts teaching and learning into a new light. Learning is not only a cognitive effort and teaching is not only a tool to reach the cognitive dimension. Instead, teaching is rather an activity-driven design, and learning is an on-going activity of knowledge production instead of consumption. An elaborated example of "activity designs for learning" is published in [16], which shows that designing teaching and learning needs a "multimodal perspective" [52]. A digital didactical design includes different design elements and their relations. In an ideal world, a teacher does design and shape these elements below:

1. Teaching objectives (and expected learning outcomes).
2. Forms of learning activities in order to foster the intended learning outcomes.
3. Process-based feedback and assessment (peer-reflections, teacher's feedback, self-assessment) [2] [24].
4. Social relations and roles [23].
5. Integration of technology (e.g. media tablets).

The teacher constructively aligns these elements to support learning ([3], [49]); see the middle layer in Figure 1 (on next page). The assumption is that the better these five elements aligns to each other, the higher the likelihood that the students will learn. In our research, we study how the teachers *design* such digital didactical designs for media-tablet learning. Are the teachers "´bowling alone" or do they create digital didactical designs in cooperation with each other? How do they coordinate and juggle the different design elements? What do the teachers design (what not), how and why? We studied the choices and the design rationales the teachers made, and it became clear how complex the situation is for the teachers.

2.3 Complexity and Improvisation

The integration of mobile technologies and media tablets in teaching practice is more complex than it seems. Koehler et al. [28] show that the interrelation of content, technical and pedagogical knowledge creates different types of knowledge that are important when teaching with ICT (TPCK model). Loveless [33] illustrates by the example of primary schools how the co-evolutionary development of subject knowledge and didactics needs the support of "improvisation". Media tablets enable student collaboration in classrooms and monitor class activities in hitherto unseen ways. However, such new modes of activity can produce counterintuitive developments on the classroom level in what Grudin [13] called "the breakdown of intuitive decision-making". The complexity of utilizing ICT for education is also studied by Kirschner and Davis [26], which reveals rubrics of how

technology should be used and integrated in training programs for teachers.

The requirement for teachers today is not only to use technologies, it is also to design competence development, learning activities, social relations and assessment, together with the integration of new technologies. The complexity increases substantially. It is not enough to design teaching as content delivery (see Figure 1, the inner layer). Teachers have an increasing toolbox of didactical means to choose between, but these tools are not alternatives to each other. They may be used in concert and orchestration, which is, on the other hand, a driver of complexity. In addition, the teachers' performances are increasingly compared to the outside world, see Figure 1, the outer layer (e.g. the Danish schools have recently been under tremendous pressure in popular media because they are perceived as loosing out against Chinese schools). Thirdly, schools are increasingly competing, and the pressure on both management and pedagogues to be innovative, is increasing. The innovator has to consider how his innovation is perceived from the viewpoint of different stakeholders like school management, parents, students, and colleagues ([51], [48]), see Figure 1.

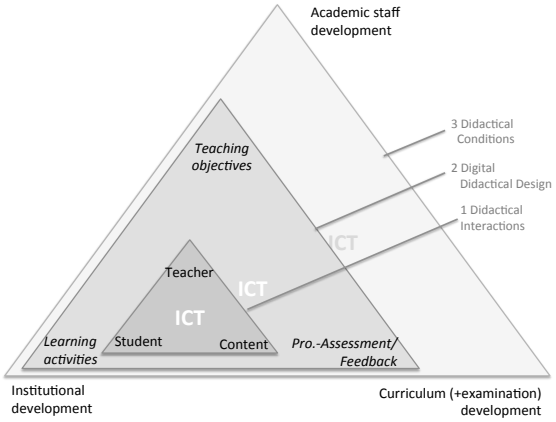

Figure 1. The three layers of education affect each other (influenced by innovation such as technology).

This adds to a setting that has arguably always been complex. Learning and development arises from a number of actions and operations on the micro level [32], and is the reason for why there is such a large research field on the learning sciences that the relationship between these micro levels are complex and difficult to disentangle.

In sum, when we refer to complexity, we refer to it on the middle layer (Figure 1) of teacher and student activities as well as to the fact that innovation of learning activities often takes place in an open system outside the classroom.

We formulate it like this:

Complexity in the classroom is constituted by a multitude of choices for the individual change agent, where some of the choices are not known, and it is a complexity that is mediated by the observation and feedback of a community outside of the learning activity.

3. RESEARCH METHODS

The research study took place in Danish K-9 schools from fall 2012 to winter 2013. The cases did not use the same methods. We provide an overview below.

The different methods were related to the timeline of the schools' adoption of the devices and this paper aimed to combine the varied approaches in a fruitful manner. The different methods followed the approach of triangulation to establish the validity of the qualitative study [14]; data triangulation (different sources and stakeholders), methodological triangulation (different methods), investigator triangulation (different researchers in the same field), environmental triangulation (different locations, different times).

Case I was design-driven, employing a future workshop (see 3.1 for details). In case II, the researchers applied a qualitative, ethnographical approach for exploring the use of mobile technology in classrooms, in particular to understand the choices by the teachers, and how they design teaching activities for fostering students' learning in co-located settings. The respondent selection was based on voluntary sampling [10] and included those classrooms where teachers agreed voluntarily to be part of the research and to be observed and interviewed. We further analysed teaching situations in which the media tablets were adjusted to several different learning objectives and activities. For further methodological details, read 3.1 for case I, read 3.2 for case II, and 3.3 for Case III. Case III took a mixed methods approach and was part of a bigger study with classroom observations.

3.1 Description of Case I

This case took place at a small primary and lower secondary school of Mou in Northern Jutland, Denmark in October 2012. The case was a student-led semester-project, which aimed to envision design principles that could help to facilitate collaborative learning. To achieve this, a future workshop was conducted with 7 teachers in October 2012 [35]. The workshop included three phases: critique, fantasy, and implementation [25]. The purpose of the future workshop was to support the teachers to externalize the experiences that they made with the use of media tablets in their teachings. In the *critique phase* the teachers discussed the media tablet as a functional learning tool. In the *fantasy phase,* it helped them to visioning and discussing solutions to the critiques they created during the first phase (e.g. how software incompatibility issues could be resolved by hiring a tablet supervisor on the school). The teachers retained their knowledge by drawing the situations they discussed in the two first phases. Then, the teachers used their externalized knowledge in order to form strategies for implementing them into their classroom teachings [36]. To ensure a steady retention of the teachers' externalization, the future workshop progressed through the utilization of inspiration cards [15]. The inspiration cards were divided into three categories: Technology, Domain and Action. The technology cards represented all types of technologies – not just the digital kind. The domain cards represented information on the domains in which the given technologies were physically present, e.g. "The Classroom" or "Common Areas". The action cards were familiar to the domain cards but focused more specifically on the actions and the utterances that were directly connected to the use of technologies in the domains. The use of inspiration cards ensured both facilitation of discussion amongst the teachers, and documentation of their externalisations (Figure 2). The inspiration cards also allowed a range of flexibility and creativity during the discussions, since the different combinations of the cards could take the discussion in different directions and possibly uncover valuable tacit knowledge [35]. The result of the future workshop was roughly three hours of teacher-teacher discussion about the praxis with media tablets in teaching.

Figure 2. Inspirations cards and drawings ensured retention of externalizations on the future workshop.

In order to process this data we used a general inductive approach to label and categorize through open coding and abstraction [11]. Open coding involved reading through the transcripts several times whilst applying headings that would describe the content of sections of text. The headings were then put into separate coding sheets in which they were placed under higher order categories. This effectively resulted in a level of abstraction that made it possible to describe what each category represented. The result of this process was 37 labels across three generic categories (Table 1). The labels refer to topics and situations of designing teaching in each of their respective generic categories. By describing these generic categories, we describe our findings.

Table 1. Generic categories and their labels.

Praxis with tablets	Problems	Dreams / visions
- Compatibility. - Hardware limitations. - Learning by doing. - Long learning curve. - The younger the more teacher control. - Apps with rewards. - Administrator rights. - Fragile hardware. - Writing on a tablet. - Game narration. - Overhead backup. - Creation. - Software quality. - Tablet as reward. - Extra-curricular activity.	- Expensive. - Pupils guess and remember. - Reward can become an issue. - Ability to skip tasks can be problematic. - Outdated software. - Internet issues.	- Internet based. - Using the tablet as a remote. - Tablets for all. - Knowledge sharing. - Shared-area for learning. - Immersion. - Parental involvement. - Teacher training. - A tablet supervisor. - Total access. - The tablet lesson. - Replace all the books. - Replace paper. - Inclusion. - Teacher supervision in app. - An app that provides all the needed shortcuts.

3.2 Description of Case II

This case took place in March 2013 at the primary and lower secondary school of of Gug in Northern Jutland, Denmark. In 2012, the school decided to buy iPads for teachers and students. All 62 teachers were given the opportunity to receive a media tablet on behalf of the school if they attended eight teaching courses about the iPad, which they all accepted. The case was a student-led semester-project, which studied how the media tablet was used in the complex ecology that constitute classroom teaching, and more specifically, situations in which the media tablet became a teaching tool and/or learning device [36] (Fig. 3).

Figure 3. Young students working with media tablets.

A close scope ethnographic study was performed in a class of 20 students at the age of 6-7 with two teachers involved. The form was participant observation with the roles of the observers being openly recognised to all involved as researchers [46]. The observers followed the class in the subjects of native language and math lessons. The study lasted 18 hours in total. The observers used field notes along with pictures and videos during observations. Small semi-structured post interviews were conducted with the teachers after each lesson [30].

First, the data was processed by identifying patterns as singularities, regularities, and variations [46]. These patterns, that were identified across different phases of the observed lessons, were organized in "settings" relating to the observed activity with the media tablets, undertaken by the class, e.g. students solving math puzzles with the media tablet [36].

Each setting was then subjected to a second analysis with the Human-Artefact Model (HAM), an activity theory based thinking tool, drawing upon Leontiev's hierarchies of activity to divide user activity into layers according to the users perceptual orientation within the use situation [7]. The creation of each individual HAM model was done by arranging the data in different categories, according to the layer of the activity addressed within the data. The data analysis involved five steps:

1. Identifying the user(s) activity and the goal(s) of the user(s) in the specific use situation.
2. Forming a hypothesis regarding the motivation governing the user activity.
3. Identifying handling and learned aspects within the data.
4. Identifying elements of adaption in the data.
5. Identifying tensions within the different layers of the user activities and the relation to the contextual setting [7].

This analysis provided a different perspective in relation to the tensions in the handling of the media tablets on a user-device level, especially how this tension evolves into breakdowns, as well as reasons for implementing recovery strategies and learning situations, as the result of interactions between human(s) and artefact that become too complex to handle [7].

3.3 Description of Case III

The case III took place at the municipality of Odder in Denmark; the main survey was conducted in September 2013. The community implemented iPads for all their 7 schools; ca. 170 teachers and 2,000 students from preschool class to year 9 (K-9) got media tablets. The students got the tablets in January 2012. Instead of using new laptops, the politicians in Odder decided to use iPads. The headteachers and the local department of the teachers union were consulted to make sure that the parties agreed. We applied an explorative qualitative approach with mixed methods, particularly a) classroom observations, b) teacher interviews and school visits (usually 1 school per day), and c) online questionnaires and meetings with head teachers as part of a larger study about media tablets and Nordic countries didactics (Denmark, Sweden, Finnland).

a) 24 classroom observations (45-90 mins. each) and interviews with the teachers (approx. 60 mins. each) were conducted in six schools in April 2012, August 2012 and August 2013, all based on a voluntary and purposeful sampling [10]; 7 male teachers and 17 female teachers. The teaching subjects comprised Native Language (Danish), Math, English, Art, Music, Chemistry and Physics. The classes ranged from preschool class to 9th grade with different class sizes of 10 to 27 students (a mix of male and female students). Two to five researchers conducted the classroom observations. With the teachers' permission, they took notes, photos and made video recordings. The classroom observations were guided by the theoretical model of the Digital Didactical Design, including teaching aims, learning activities, forms of process-based feedback and assessment, and the degree of technology integration, the linking of teaching and learning in the practice.

b) The interviews were conducted by a total of three researchers and audio recorded. The interview guide was divided into five parts and contained 12 questions. Data from the observations and interviews were first analyzed according to each classroom and then open coded ([1], [6]). For the data analysis we created a scheme adopted from the theoretical framework. The aim was to make the digital didactical design for each classroom visible. The data were coming from the observations and the interviewed teachers of the classroom. We analyzed the teachers' didactical design practice including the integration of the tablet-use according to the extent of usage: a low (tablet as pen and paper substitute), a medium (tablet as laptop substitute) and a high extent (a new multimodal device). The analyzed data were checked by content validation and peer-review validation, where at least 3 researchers checked the analysis of the data. Such a *communicative* validation was done by using intersubjective methods, which is important to proof the quality of the research outcomes [1].

c) The online survey, which regarded all teachers, comprised 22 items; closed questions on the teaching practice using media tablets. It was conducted in September 2013 and pre-tested in the summer of 2013. From a total of 170 teachers in Danish schools, the online survey was answered by n=148 teachers from all seven schools in the municipality, who started to use media tablets in January 2012. Some of the teachers skipped some questions. 85 were completed; response rate was 50.2 percent, 30 male and 70 female teachers. The teaching practice ranged from less than 1 year to 35 years (mean = 17-18 years; median: 16-17 years, standard-dev. 11). The results from the observations, the interviews, and the online survey, were presented and discussed with all of the teachers, see Fig. 4.

Figure 4. Discussing the results with the teachers.

4. FINDINGS

First, we present the results of the teachers' visions, and then we present our findings from the studying of the teachers' design practice.

4.1 Case I: Visions of the Teachers

Table 1 (section 3.1) gives an overview about the clustered teachers' expression under "dreams/visions". The ideas, that the teachers expressed mostly, referred to the media tablet as a complexity-reducing medium with greater interconnectivity. One cognitive conception of the teachers is that the media tablet could potentially replace all books and whatever paperwork the teachers usually have to deal with:

"FWT1 – 1:29:10: No, but it would be fine if it could replace all the books, because a bag like this gets quite heavy."

"FWT1 – 1:44:54: And then we must replace the books."

"FWT2 – 48:54: And that is also the explanation as to why we do not just discard all those damn books and only use apps."

The teachers seem to know the technical possibilities, but they are also quite aware that there are obstacles in the way of ever achieving such paperless practice. They all agree that it would be most beneficial if everyone had a media tablet each, because otherwise the paperless idea would fall short. In connection to the idea about paperless practice, the teachers dream about a practice that draws on the benefits of interconnectivity:

"FWT1 – 1:09:46: Well, regarding that app, it would be nice if you could sit and work in it, and then the next time it was able to find a network out here on the countryside, then it would automatically connect. Everything that you would have worked on would still be saved and it would not have been in vain. And the kids would not feel frustrated because their work suddenly did not look like it did when they were working on it here at the school."

"FWT2 – 1:00:00: […] there you can create them and you can create their email addresses, which means that their results will automatically be sent to you. And then I can sit at home and watch that 'Patrick' has made these and those math-equations and he has progressed like this and so on."

The teachers understand that, in a perfect world, it would be possible to have everyone connected to the Internet. They explain their dream as a dream of total access, in which interconnectivity allows them to ensure greater inclusion, not only of students, but also of parents. They are not dreaming about a particular app to

include all functions, but rather a diverse eco-system of apps that all interconnect to allow for greater monitoring and retention, as well as a faster way to plan curriculum and spend more time teaching than planning. A very low-practical wish is for example the ability to use the media tablet as a remote control, allowing the teacher to be physically positioned anywhere in the domain. The dream of interconnectivity derives from bitter experiences with software and hardware incompatibility issues, administrator rights and out-dated software, all of which causes common activity breakdowns that result in media aiding complexity instead of reducing it. The teachers realize that these are issues that need to be efficiently addressed in order for their praxis to become less complex. The teachers see the Internet and the promise of a web-based ecosystem of apps that allows for greater interconnectivity as a dream solution that could remove most of these issues.

4.2 Case II: Breakdowns

Table 1 (section 3.1) gives an overview of the clustered teachers' expression labelled as "problems". The teachers had concerns regarding the technology such as "expensive" and "internet issues". On the other hand they expressed concerns with regard how the pupils would use the tablet, "pupils guess and remember" and "the ability to skip tasks can be problematic" when using the tablet in the classroom. In detail, case II aims to demonstrate the *complexity* of the artefact ecology of a classroom, from a close ethnographical study. During the observational period, several incidents of unforeseen interaction issues were documented, that developed from simple obstacles for the shared activity of the class, to causing breakdowns in the workflow within the classroom, hereby resulting in either the teacher revising her teaching strategy and students losing focus, braking away and engaging in wild fire activity [36].

In two specific settings, we observed how the teacher introduced what could be considered as secondary artifacts to support her activity of directing the class members towards a specific outcome. In both cases, the motive of the teacher was to manage the class activity by breaking it into a chain of separate actions that could be seen and copied by the students.

A) This setting is based on observations from two occasions, where the teacher extended the functionality of the media tablet by connecting it to a projector. In the first instance, this was done in order to guide the pupils through the task of installing an application on the tablet, and later to move an icon to the front page of the media tablet. In both cases, the teacher introduces her tablet into the teaching situation as an illustrative tool, allowing her to direct the activity of the class as a whole, by breaking a complex activity into smaller manageable sub goals through visualizations of her activity. When functional, the addition of the projector enabled her to successfully maintain the individual student's attention focused on the different interactive aspects of the downloading process, by allowing the students to monitor and mirror her actions when in doubt. During the second instance, we experienced how the failure of the secondary artifact (projector) ended up causing a significant breakdown in the teacher's activity, while complicating her possibilities of recovering. The teacher made several attempts to master the breakdown in one device (projector), only to experience another breakdown (Internet connection failed), and she eventually had to abandon her initial goal, and move on to a different activity in the classroom.

B) During the second setting, the students were instructed to login to "*infuse learning*" – an online teaching application that allows the teacher to create interactive quizzes and monitor the progress of the individual pupils in real time on her own media tablet via a special teacher dashboard application. Instructions consisted of a URL, written on the blackboard for the pupils to copy into the media tablets Internet browser. We observed how the login-procedure caused a sudden rise in the complexity of the situation, resulting in several students experiencing tensions and breakdowns in their activity. Judging from the insights gathered in the previous project (on the future workshop), few teachers assumed that the simple task of login would cause significant problems for teachers and affect the whole class. The teacher had to troubleshoot several pupils, who were unable to recover from their breakdowns during this activity. The breakdowns were usually simple spelling errors that might have occurred because the students had to shift their attention between the blackboard and their media tablets. Furthermore, students that were able to overcome the obstacle on their own had to wait for everyone to log in before they were allowed to complete the curriculum. Some of those who were already logged in and who were just waiting for everyone else to get help from the teacher, ended up wasting the time by talking, fooling around and wrestling, which actually did not seem to be a disturbance to anyone, including the teacher, because she was busy helping the other students recover from their breakdowns.

By analyzing both settings through the HAM analysis model, it became clear that a sudden rise in the complexity caused the students to shift their operational orientation towards the breakdowns, hereby losing their focus on the current task at hand. In both cases, the underlying cause of the breakdowns could be identified as a rise in tension between the users adapted strategy for creating desired outcomes (goals), their chosen path of action (handling), and their ability to adapt these to the conditions offered by the tablet, e.g. students have to switch the focus to and from the blackboard during the login procedure in setting B. The tension caused when encountering obstacles, would eventually bring students to a point where they had to reevaluate their activity on a procedural level in order to keep up, creating grounds for disturbances in the classroom. We equally observed that, once all the students were logged in to infuse learning, the teacher regained control of the classroom. The complexity had been reduced, and the students had no trouble navigating the system once they were past the login-screen. The added functionalities in the system did not add noticeably to the complexity of the teaching situation.

Especially in setting A it becomes visible how the extensions such as a projector, adds to the potential of a sudden rise in complexity, due to a break in the chain of connected devices. From the HAM analysis, it becomes apparent how an unanticipated rise in complexity, due to a breakdown, impacts the margin of maneuver of the teacher by significantly reducing her possibilities of facilitating the shared activity of the class.

One significant post analysis finding was how the inclusion of the media tablets, when interpreted through the complexity lens, becomes a double-edged sword, with one side relating to the complexity found within the artifact, and the other relating to the addition of further complexity of the classroom ecology itself. From a student perspective, the media tablet adds a form of inner complexity, by offering the students multiple paths to follow in the student-tablet situation. This inner complexity causes tensions for the students, when tasks become too complex, like for instance, navigating through a serious breakdown. From a teacher's perspective, the inclusion of the tablet opens new possibilities in regards to facilitating an ongoing exchanging and

transformation of material between the teacher and the students. We see how an unforeseen rise in complexity means the teacher's attention is diverted from the goal fulfillment towards the operational aspects of engaging with the technology, with the consequence, that the teacher-student-exchange of material comes to a halt. From a teacher perspective, the challenge to successfully integrating the tablet into her teaching practice rests on her ability to manipulate the device into states, in which the tablet takes on the role as a functional organ. The criteria for a successful use therefore becomes a question of the tablet supporting the teacher in framing the activities of the class community on a meta level, while equally facilitating learning on a one-to-one basis through e.g. visualizations.

The cases show how the implementation of media tablets into the classroom means that the teacher's role takes a leap in the direction of a didactical designer. The teacher creates a sociotechnical-pedagogical scenario and prototype for tablet-enhanced teaching and learning, put these into practice, improvise during practice, manipulate the technology for their needs, and change the scenario for the next time. The teaching practice moved away from a common routine and turned into a *design project*.

4.3 Case III: Teachers are Jongleurs

The findings of case III support the qualitative data from cases I and II. It shows the complexity of designing teaching practices where the tablet integration is aligned to the teaching and learning activities. In addition, case III shows in what domains the teachers struggle while carrying out such an digital didactical design in practice.

The survey findings of case III show that the teachers have a strong belief that media tablets are useful to support learning. The majority of the teachers (around 80%; Q18) believe that media tablets are able to improve teaching practice and student learning. This confirms a recent study on technology belief [20], which showed that the acceptance on media tablets is increasing. Usually the majority of the teachers show a weak acceptance of computing in education but with the invention of the media tablet, the acceptance rates have increased significantly. The amount of teachers who do belief in the tablets is high, but how many really do re-align their teaching practices?

Around half of the teachers actively integrate the media tablets in learning activities (they can give specific examples about innovative usage, Q2). This is also supported by our classroom observations where 16 of 24 cases are constructively aligned designs to support tablet-enhanced learning; 8 cases are not, which means that they did not re-design their teaching practices. Around 40% of the teachers want to integrate media tablets better than they do but do not know exactly how to do it and around 10% do not believe in tablets, and therefore do not use them in their classrooms (Q1, Q2, Q4, Q6). The SAMR model [47] is useful to understand the level of technology use from low to high extent of ICT-integration merging into a digital didactical design:

- **S**ubstitution: "Technology is used as a direct substitute for what you might do already, with no functional change" – low extent of tablet use
- **A**ugmentation: "Technology is a direct substitute, but there is functional improvement over what you did without the technology" – low-medium extent of media tablet use
- **M**odification: "Technology allows you to significantly redesign the task" – high-medium extent of tablet use
- **R**edefinition: "Technology allows you to do what was previously not possible" – high extent of tablet use

Whereas 11 of 24 in-depth observed classrooms illustrate that the teachers integrated the tablet into the didactical design of teaching and learning in high extent (R=11; M=5), the other 8 classrooms did integrate the media tablets in a medium or low level (A=5; S=3).

The potential of integrating media tablets into classrooms can be seen in the teachers' responses towards collaboration, didactical integration, and different functionalities for student learning activities:

- Around 35% of the teachers say that they include the media tablets into teaching and learning truthfully, "*I can give you some examples of how I design teaching and learning in a way that the tablets support collaboration among my students*" (Q1). Whereas, around 55% think media tablets are useful but do not use them for student collaboration. The other teachers say that such devices have no effects (4%) or "*they are not good for collaboration*" (6%).
- The teachers use the tablets in a wide range of different activities for meaningful learning (Q3); "*my students use the iPads for...*" creating presentations, writing texts, reading, recording and editing videos, note-taking (around 80% each), creating and editing images, controlling the interactive whiteboard (tablet as remote control), recording/editing audio files (around 60% each), listening to audio books, creating digital stories, and sharing/demonstrating their knowledge (50% each). The teachers say that they do not use the media tablet as a student response system and do not use it for online conferences.
- 80% of the teachers say the students use the media tablets for presenting their learning outcomes in a new form (Q5); to some extent (52%) and to a large extent (29%).

The teachers mention that they experience some social changes over the last two years from since they started using media tablets. Almost 90% said that the teachers role was changing – especially the planning of activities; "*The way I plan the activities on the classroom has changed*" and "*the way I act in the classroom*" (41%) (Q7). The teachers also perceive a change of human interaction since they use media tablets "*in a useful way*"; the student-teacher-interaction (76%, Q8) and student-student-interaction (75%, Q9) have been assigned as more positive since the media tablet has been launched. The use of different multimodal resources increased (80%, Q13). The teachers say that this is the main difference to the traditional classroom, and the majority say that there is a huge need on training for both technical issues, but more importantly, training for digital didactical design thinking (80% Q12).

We followed some of the innovative teachers (33%) and aimed to understand how they handle the increase of complexity. From our in-depth-interviews, the data informs a kind of passion towards teaching and learning. Their teaching philosophy is based on activating the students' potential. The following quotes support this:

"*I want to set the knowledge of my students free.*"

"*I'm supporting learning by foster my pupils doing mistakes.*"

"*I tell my students: make mistakes, that's good.*"

"*I tell my students: be creative.*"

"*I want to challenge my students.*"

The innovative teachers use the media tablet like a "*booster*" to foster student learning. We wanted to know if the teachers thought the media tablet made a difference. This was interesting, because the schools had laptops before they purchased media tablets. All interviewee's said that they liked the tablets more than laptops. The problem with the laptops was that they were often out of energy, the software was not updated, or software bugs prevented them from working. One teacher said; "*You don't waste time like with the laptops where the batteries where out of energy or the software wasn't installed*".

The teachers argued that the laptops wasted a lot of teaching time in classrooms whereas tablets reduced those problems. One innovative teacher said; "*Now, with the iPads, I have more time for my students*". The interview data shows that for the teachers the media tablets differ from laptops in many aspects, but the most important difference is that different teachers made the following statements:

"*The iPad works - you open it and it works.*"

"*It's easy… my old father use it too.*"

"*It's mobile… pupils can bring it home.*"

"*It isn't time consuming like the laptops.*"

"*I have more time for my students for individual guiding.*"

"*The students are equal now. All of them now have access to knowledge.*"

The quote; "*…my old father use it too"* is very interesting. Some years ago, quotes like "*my young daughter/son uses the new technology*" was used. Since the young generations grow up with the new mobile technology, it seems to be normal that they are able to use it (it does not mean that they really can). Nowadays, it is a sign for 'easy-to-use' when the old generations, who never tried to use computers before, uses them too. Making something easy to use is not only an individual usability issue; it also enables the limited resource of teacher attention to be focused on issues of collaboration rather on making up for bad usability.

The teachers also mentioned challenges. They observed that the students perceived tablets as a tool for playing and that they did not accept it as a "*working machine*". Some teachers mentioned that this view changed after some weeks of using the tablets in the lessons. Others were afraid that the students did other things and that they did not focus on the assignments in the classroom. The media tablet is easy to use for chatting and using other forms of social media during class. For the teachers, it is not clear what the students do when they use the media tablet. The teachers asked themselves; "*Is the iPad for note-taking or are they using Facebook?"*. The majority of the interviewees argued that this problem of distraction had always been present, even before they started using tablets. Years ago, the students wrote letters on a piece of paper or just had oral chats. Contrary to common complaints, we did not find any support to the fear that media tablets increased complexity by bringing non-school social life into the classroom through social media.

One teacher mentioned another challenge:

"*The biggest challenge for us teachers is to know when to shut off the iPads; when do we use iPads? When do we use other things?"*

This quote makes clear that the implementation of new technology does not mean to banish other technologies, tools or materials. Instead of focusing on tablets only, a mix of different tools for different classes might be useful to enhance learning. It also reveals that the situation becomes complex for the teachers. The design of teaching gets more and more complex nowadays; from textbook learning (one design element) to many different possibilities of enabling learning using different kinds of technologies, choosing between different online open resources, creating learning activities where the student becomes a pro-sumer, and creating guided reflections for collaborative learning. The teacher becomes a juggler (jongleur) of many different design elements.

Despite of cases I and II, which show the increase of complexity for teachers, the early-adopters in case III have a different viewpoint. They say that the media tablet has one advantage in comparison to other technologies like laptops and stationary computers: "There is no technology in there!" (the teacher who gave this statement pointed her finger to the media tablet). Of course, a media tablet is made of electronics and it is a purely technological device. However, with this quote, we understood the innovative teachers' point of view. They perceive the media tablet as a device that is easier to use than the complicated older PC programs. Years ago, technology in teaching was seen as being very complicated, but there has been a change with media tablets. The tablets "*just work*". Therefore, to the innovative teachers, the media tablet is not perceived as being challenging in itself, but the complex interplay of different technologies, didactical designs, educational resources and the breakdowns that derives from these contextual elements becomes the challenges they are learning to navigate.

5. DISCUSSION AND CONCLUSION

In an empirical study about media tablets at Scandinavian schools, the research aim was to explore the teachers' strategies and their (re-)designs in the teaching practice of integrating new technology in the classrooms moving to a new practice of Digital Didactical Designing.

In this paper, we provided a multifaceted view into the use and consideration of tablet devices in the context of primary school settings. In many ways, the study redefines and reveals the nature of the classroom from the teacher being a simple tablet-enhanced instructor to one of handling both instruction and technical support. The paper highlighted the various ways in which teachers dealt with this complexity. Such co-located tablet-mediated communication spaces "require teachers to undertake more complex pedagogical reasoning than before in their planning and teaching" [59]. While this is a manner that runs incongruent to teacher perceptions of classroom possibilities with tablets, our study provides evidence that these perceptions are markedly different with tablets as the technological intervention than with other tools (e.g., laptops).

Moreover, the model of the classroom and interactions between teachers and students is *in constant motion*, swayed by the expectations and perceived potential of digital technologies and grounded by the realities of the digital technologies in use. The teacher in co-located spaces becomes a juggler and a digital didactical designer; the teaching practice moves away from a common routine activity and turns into a *design project*.

The teacher creates sociotechnical-pedagogical scenarios and prototype for tablet-enhanced teaching and learning, put these into practice, improvise during practice, manipulate the technology for

their needs, and change the scenario for the next time. The issue is not merely to look at some teacher strategy and see if pedagogy, technology and content (as in TPCK) is connected, but to be attentive towards how the teachers combine these *in situ*.

When social complexity through technology integration rises, one coping strategy is to search for a reduction of complexity. For the teachers, the media tablets and their apps are targets for a projection of that wish for reducing complexity, which is clearly visible in our workshops, classroom observations, and interviews. Teachers tend to assign *interconnectivity* as their wish of a solution.

The magic silver bullet is the teachers' wish and belief that interconnectivity can help solve many of their problems on the floor. First, the teachers are able to envision the benefits of an interconnected praxis in which media tablets are justified through their mobile traits. Secondly, they establish this vision because of their breakdown experiences of media tablets aiding complexity instead of reducing it. The teachers' dream of interconnectivity comprises the following:

- Open or total access, in which interconnectivity allows them to ensure greater inclusion, not only of students, but also of parents.
- They are not dreaming about a particular app to include all functions, but rather a diverse eco-system of apps that all interconnect to allow for greater monitoring and retention, as well as a faster way to plan curriculum and spend more time teaching than planning.

The teachers share a common understanding in their dream of an interconnected praxis that prevents common activity breakdowns, regardless of teaching subject. Such an interconnected praxis would for example be useful for didactical designs and would remove the need to extend the functionality of the media tablet in order to teach. Sufficient reduction of breakdowns is a prerequisite for collaboration that is sometimes being overlooked in CSCW research.

The teachers exhibit a rich understanding of the variety and vastness of technological possibilities. They are not thinking about media tablets as technology per se, but its interrelation with content and pedagogy (new wicked forms of digital didactical designs), and they dream about realizing the potential which technology has created for this potential. We speculate that it is because *their* reality has proven that the present praxis with media tablets is prone to increase complexity.

The general promise that the use of technology helps to 'make life easier' and reduces complexity was not what the teachers experienced. Instead, the teachers experience breakdowns, which they must learn how to navigate before the media tablets will aid in the reduction of complexity and reach a state in which they take part in the classroom ecology as functional organs. The media tablet is thought of as a tool, but is not easily functional as such, in Leontiev's [32] terms, a "functional organ" where the users do not experience the technology, but perceives it as an integrated extension of their thoughts and bodies.

The study has some limitations through its heterogeneous methods across the cases, trading rigorous inter-case comparability for inter-method triangulation. Despite different types of data, there is basis for the importance of interconnectivity, whose vastness we try to describe. However, we must remain open for the possibility that there are sectors in Scandinavian schools where media tablets are experienced differently. For instance, even if there is much talk of the "New Nordic School", there may be strong national differences between media tablet use in Denmark and the other Scandinavian countries, as educational systems sometimes become quite nationally idiosyncratic. Furthermore, we have not focused our observations on beforehand on "interconnectivity". Close studies on whether and how teachers use it as a concept in their didactic practice would add to this study.

We studied how the innovative teachers handle the increasing complexity. These explorative characteristics are not seen in the previous empirically based literature of media tablets. We learned that they have the same problems and plenty of breakdowns during the teaching practices in classrooms – not only technical problems, but also design challenges related to teaching aims, learning activities and assessment. The difference is that the innovative teachers see themselves as *jongleurs* of different didactical and technical elements; they test their ideas and try them during the teaching practice. When they have technical problems they ask their students to help them. They do not see themselves as experts of everything; they know that sometimes their students have the knowledge to solve a breakdown.

Our data reminds us of the fact that there will be plenty of breakdowns already in the social situation of a classroom itself. Students will make errors, forget their material, and so on. In the Scandinavian classroom there is a tradition of relative "frihed under ansvar" (it means teaching within a degree of freedom with responsibility), and this will also lead to some breakdowns of disciplinary nature. So any situation where complexity is successfully managed is not characterized of smooth flow of conflict-free activity. Rather, it will be characterised by activity where breakdowns of collective activity occur, which are then reinstated or even reconstructed, either by the teacher, by the students, or in combination. We have demonstrated how this complexity increases when media tablets are used in classroom teaching.

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