**Teacher Practice and Pedagogical Competence Building in a Digitally Permeated Learning Environment**

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**Abstract:** Teachers in Danish primary schools face new professional challenges because digital learning environments are changing the professional practices regarding pedagogy, classroom management and the agency, roles and relationships between students and teachers. This paper presents the results from a qualitative research and development study conducted as an action research-based case study. The study aimed to explore the impact on teachers’ practice in a digitally permeated learning environment and to identify areas for their competence building. The research questions were as follows: 1) What options and constraints affect students’ potential as active learners? 2) How do students perceive the learning objectives of the activities in question? 3) How do feedback and process-evaluation improve students’ ability to actively contribute to their own learning process? The study took place over the course of one week in January 2016 at a large Danish provincial primary school. The learning design was student-centred and open, aiming to invite students to actively contribute and take responsibility for their own digital and multimodal productions within various subjects or interdisciplinary topics. As action research, the researcher and the teachers collaboratively discussed the emerging challenges regarding the students' ability to take on responsibility and agence, and explored new practices and methods. The anthropological data collection methods included observation and thick description, informal conversations, meetings, interviews, video documentation and the collection of various artefacts. The study identified three learner strategies. These emerged in relation to the combined digital learning environment as well as the open and student-centred learning design. The study found that teachers’ awareness of and attitude toward the learners’ strategies and their way of inquiring into the students’ work and reasoning were more important teacher competences than digital skills when facilitating the students’ learning in a digitally permeated learning environment. Based on the findings, the paper presents areas for further teacher competence building.

**Keywords:** Digital learning environment, teacher competence building, learner strategies, tinkering, learning design

**1. Background**

This project was part of a larger project named ‘Development of technological and digital high-level competences within and across subjects in four collaborating primary schools’funded by the A. P. Møller Foundation (called the ‘APM-project’), while the present project is referred to as a sub-project. The sub-project took place at the largest of the four schools (1,000 students at an instutition comprising pre-school through ninth grade). The APM-project was the latest in a series at this particular school; over the last 5–6 years, it has aimed to strengthen the collaboration between its management, teachers and students regarding school development (Sørensen, Brandt, Thomsen, Ranthe, Gudiksen and Bergstedt, 2016) and has moved from traditional management to management as co-creation. That is, the management defines a framework with clear demands for involvement, ownership and reflection (Nygaard and Löfvall, 2016). The participants collaborate in this to drive school development as an iterative process integrated into everyday school practice. *Den Store* *Danske* (Danish Dictionary) defines iteration (Larsen, 2017) as repetition, and it distinguishes iteration in static (predictable) systems from iteration in dynamic (unpredictable) systems. Iteration as a concept is introduced here because it is central to the present school development framework and to designs for learning theory (Dirckinck-Holmfeld, 2002; Gynther, 2010; Sørensen and Levinsen, 2014). Social systems encompassing learning design processes are characterised by being dynamic and therefore unpredictable. Ongoing iterations repeat acts and activities, but they always do so in new forms, as each iteration produces new experiences and insights.

Embedded in this overall iterative thinking, under another project entitled ‘LearningTechLab (LTL)’ that focuses on innovation, design and technology, the school has worked with teacher competence building based on experimental lab frameworks (Sørensen et al, 2016) that aim to explore the robustness of hypotheses regarding learning design practices. Within inherently dynamic, unpredictable systems, no answers are given and mistakes become drivers for learning. The ambition is that students will learn to seek challenges rather than easy solutions. Specifically, and in line with the co-creation principle, the school has aimed to motivate and involve students as learning designers. That is, the teachers design open frameworks in which the students act as co-creating learning designers of concrete projects (Sørensen and Levinsen, 2014) that combine problem-based learning (PBL), digital production and technology (Sørensen, Audon and Levinsen, 2010).

Working with frameworks, participation, design and iterations implies not knowing what will emerge. This is true for both the school’s overall approach to co-creation and to specific learning situations. What emerge are transformations of the participants’ mutual positioning and agency, which concurrently change what is/is not possible. In order to anchor useful experiences and practices, and to encourage learning for the future, these processes demand evaluations, reflections and modifications of the actual framework and practice before launching any new iterations. According to these principles, the LTL project iterated through evaluations based on certain questions: What does it take to produce learning environments that allow students to fully exploit their learning potential? How can we define frameworks without limiting creativity? How can we set clear learning objectives for individual students? How do we manage feedback and evaluation? (Antvorskov Skole, 2016). Additional questions further this evaluation: How do we develop learning designs that challenge all students through clear classroom management, self-reflection, peer response and teacher response? The questions all demand observation, reflection and agency in order for teachers to frame meaningful evaluations and learning outcomes.

The APM-project was designed as teacher competence building regarding subject-based learning design, learning objective management and using technology related to the school’s traditional subjects. The activities were integrated into the school’s everyday practice during a school year. The design aimed to facilitate the teachers’ and the students’ learning regarding technology and the school’s learning design through iterations, anchoring the produced learning within the school’s learning and evaluation culture. The cases presented in the following sections are related to the present sub-project.

**2. Research design**

In line with the co-creation strategy and the experimental lab framework (Sørensen et al, 2016), the sub-project was collaboratively designed between the researcher, the teachers and the management. One class was followed intensively at each level, and the aforementioned team agreed on how to combine observations and interventions into practice. The design had a double purpose: 1) to uncover transformations that bore importance on future competence building, and 2) to identify and perform interventions that challenged the teachers’ learning design practice. The framework and approach (and thereby the researcher’s focus) were defined by the LTL project:

* Possibilities and limitations for the students’ unfolding of their learning potential
* Flexibility of the learning design with regard to creativity
* How clear the learning objectives appear to the students
* The quality of project feedback and evaluation

The sub-project followed three grade levels: Third grade, who worked with green energy; fourth grade, who worked with green energy and a LEGO mindstorm; and seventh grade, who produced learning games.

In relation to methodology, the combination of co-creation and a future-oriented view of development meant that the research design became explorative. The research design was based on practice action research that implied close collaboration between participants and researchers; it was also based on dialogic action research that focused on development processes involving participants and researchers (Argyris and Schön, 1996; Nielsen and Nielsen, 2010). Action research allows researchers to change position between observation and participation. As participants, researchers may adopt a teacher position (if justifiable) – a position that provides access to deeper insights into the students’ reasoning in concrete situations. These insights may help formulate the interventions, hereafter referred to as *obstructions.* Obstructionsas a method for teacher competence building implies that the researcher, based on observations in concrete situations, suggests changes to the teacher’s practice. The method depends on mutual trust, respect and maintaining a professional distance. Therefore, the researcher must never directly interfere with the teacher’s practice.

This variable researcher position facilitates two types of obstruction: 1) ‘*on-the-fly’ obstructions* are suggestions made by the *participant* in relation to smaller challenges; they are performed immediately, and 2) *pre-planned obstructions* take their outset in complex challenges and unpredictable incidents that are observed by the *observer*. These obstructions are co-created at meetings that are pre-planned into the overall action research framework. If an obstruction affects the teacher’s framework and practice largely, it is co-created in detail in relation to when and how to bring the obstruction into play, and how to retreat to a comfort zone if the hypothesis behind the obstruction produces inexpedient consequences. At the same time, the meetings function as a method for knowledge sharing.

The context is complex and dynamic, creating the challenge of how to embrace the complexity. Johnson and Onwuegbuzie (2014: 16) recommend a pragmatic and pluralist mixed methods approach to data collection: ‘. . . [the] bottom line is that research approaches should be mixed in ways that offer the best opportunities for answering important research questions’, which means that mixed methods can be designed as a repertoire that does not necessarily include quantitative methods (Creswell, 2008). Data are collected using observation, interviews, photo and video, descriptions of space, minutes, conversation notes and materials. The data are then analysed using meaning condensation in order to identify themes (Creswell, 2008; Kvale and Brinkmann, 2008).

The following section presents the project findings and highlights areas of attention related to the main themes derived from the LTL project. The themes include the following:

* Student strategies
* Teachers’ facilitation (framework, evalution practice and feedback)
* Practice in relation to the learning design framework and clear objectives

**3. Student strategies**

When learning designs aim to empower students as learning designers, the students make choices to exclude and include various strategies (e.g. non-verbal and bodily strategies when they manage their projects and solve emerging challenges). Such strategies are rarely seen in traditional school settings where students are supposed to be still, quiet, maintain focus on the teacher and perform the teacher’s assignments (Fink-Jensen, Jensen, Kragh-Müller and Mørck, 2004). The open framework empowers students to use the informal competences (e.g. as project makers and project managers) that they obtain through play (Sørensen, Audon and Levinsen, 2010). Such strategies are about touching and doing (exploring), impulses (creativity), making up (designing), rules for playing (project management), the play itself (collaboration) and material/immaterial and verbal/non-verbal means of expression (communication, aesthetics). These strategies relate to bodily ideals of classroom management and do not align with formal setups in which they are often perceived as illegitimate (Gebauer and Wulf, 2001; Juelskjær and Staunæs, 2014).

In relation to digital production, the students’ strategies match the affordances offered by the digital resources. That is, visual interfaces allow the users to intuitively figure out what actions are possible, and this immediately available manipulation of means of expression and media allows for fluidity and provides instant feedback (Rodgers, Sharp and Preece, 2011; Sørensen and Levinsen, 2014). When students as learning designers are situated in digitalised learning environments, the technology amplifies or reduces transformations, which open frameworks bring into the context (Ihde, 1978, 1990; Verbeek, 2005). Here, two student strategies stand out: simuling and tinkering (Ackermann, Gauntlett, Wolbers and Weckström, 2009). These strategies stem from the students’ informal competences. A third strategy, formal strategy, draws on the students’ experience with formal teaching environments and school culture (Hetmar, 2004).

Simuling draws on digital game experience; here, children learn to create and act within alternative worlds with their own rules (Ackermann et al, 2009: p. 14). Simuling differs from simulating, which means reproducing dimensions of reality (e.g. flight simulators). When simuling, the students expect to play, manipulate and get instant feedback. They also expect access to undo things, which integrates iteration into their agency. In school, simuling becomes a challenge because ‘the more we rely on tools as our extended memories, the less we go back to debug. We build on top!’ (Akermann, 2013: 126). That is, students tend to unreflectingly ‘build on top’ rather than reflectively debug. In learning theory, ‘build on top’ aligns with trial and error, while debugging aligns with learning by doing. This implies that students need the teacher to facilitate debugging and reflection in order for them to learn.

Tinkering – defined here as a combined reflective and material approach to learning through doing things to things – draws on general play experience (Ibid: 51-52). Children have always collected things, created things, done things with things and exchanged things. Digital resources tend to amplify such actions (Ihde, 1978, 1990; Verbeek, 2005) thereby expanding children’s agency through digital production, programming and control in addition to recycling (sampling, remix, mash-up) and iteration. In school, tinkering requires the maintenance of the students’ motivation to combine digital resources and schoolwork. The formal strategy addresses the fact that some students ‘have learned to do school’ and draws on typical teacher-centred teaching: The teacher initiates, the students respond and the teacher evaluates (Hetmar, 2004). The formal strategies become a challenge because they appear appropriate from the teacher’s point of view, but in reality they may not necessarily be appropriate.

Simuling appears as optimism: ‘Let’s see what happens’ and ‘we’ll find out when we need to’. Tinkering appears as just that – tinkering with things. Both strategies are characterised by non-verbal and bodily communication, and usually, students cannot articulate clear conceptions of process or product. The design, along with the idea of the product, emerges gradually through iterations. From the teacher’s point of view, simuling and tinkering appear challenging, as a long time may pass with apparently ‘nothing’ happening:

From seventh grade: Two boys have tinkered with their game-board and play checkers for a long time. They do not say much but show things to one another, point and change the board and checkers. It is difficult to see whether they are idle or develop their game design as a part of their preoccupation with the material aesthetics.

Observations show that teachers most frequently intervene by correcting and instructing rather than inquiring about the students’ rationale. If the students are not idle, the teacher interventions appear incomprehensible, and in the worst case, demotivating for the students. In addition, the teachers do not discover the co-creating power of learning in the aestethic dimension (Buhl and Ejsing-Duun, 2013). For some students, the initial tinkering tranforms into unreflective build on top. Observations show that these students are often satisfied with products containing errors as long as they are not too prominent. In these cases, instruction and correction does not help, as it is the strategy, not the errors, that stops the learning. Other students transform tinkering into targeted and reflected debugging. They are able to sketch products, foresee challenges, think strategically and explore. When they change their strategy, their method tends to approach the formal strategy. Here, observations show that the teachers stop interfering, as the students’ work ‘looks good’.

Simuling and tinkering are characterised by non-verbal and bodily communication. Observations show that in order to bypass the lack of articulation, teachers ask control questions rather than have dialogues with the students. The students react with silence when they feel tested, especially when they are trying to ‘figure something out, we do not really know what is’ and therefore have not yet articulated their ideas.

The formal strategy emerges when students try to fulfil what they expect the teacher demands, play it safe and aim for reproduction rather than experimentation. Typically, they sit quietly at a table, speak in low tones and produce a linear plan that they follow meticulously. Accordingly, when students use the formal strategy within an open framework, they deselect informal, explorative and experimental methods. They orient toward solving tasks rather than exploring problems. The teachers do not interfere, and will not discover if the students are not working well, as in the following example:

From third grade: Three girls work with solar cells and search about solar energy on the Internet. They have ended up among planets and solar systems and write about the Asteroid Belt. One of the girls wonders: ’What are those belts? What do they have to do with solar energy?’ The girl can see something is wrong. However, the others ignore her troubles and refer to the fact that the teacher said they worked dilligently.

In these cases, the obstruction aimed to challenge how teachers pose questions in order to obtain relevant knowledge and thereby produce meaningful groundings for deciding upon possible teacher interventions. Well-functioning questions included the following: Tell me about what you’re doing. How did you find out about that? How do I get wiser by using your [game, video, etc.]? What could you do to find out? What can you do? How do you know if you can be satisfied with your work? These questions are generic and therefore useful in many contexts.

**4. Teachers’ facilitation of students’ work**

As long as teachers are novice classroom-managers of open learning designs, their ambitions on behalf of the students’ product are too high, and they expect the students to use formal strategies. When simuling and tinkering students do not fulfil these expectations, the teachers turn to micro-management. In practice, the teachers begin to boss the students around, instruct or take over, thus depriving the students of agency.

From fourth grade: The students assembled an electric motor from a kit with an English manual. The students combined tinkering, looking at illustrations in the manual and guessing. Based on simuling, they expected to be able to undo actions. However, the electromagnetic laws, which were unknown to the students, have to be followed for the motor to work. Therefore, problems occurred that the students did not stand a chance to solve.

Although the teacher provided the students with agency, the complexity of the assembly kit maintained the students in a build on top strategy. Here, the teacher obstruction aimed at providing just-in-time information (e.g. how to wind the cords) and to articulate everyday concepts in order to scaffold the students’ debugging strategy. Here, YouTube videos and concepts such as short circuit and loose connections made sense to the students. Alternatively, the teacher would have to assemble the motor, not the students.

The school used the ‘Design to Improve Life – Innovation’ modelfor its open learning designs (<http://designtoimprovelife.dk/>) as a frame for the students’ self-management. Observations revealed that the model was used as a recipe to obtain the product rather than as a framework to manage emerging unpredictable processes. Additionally, this interpretation pushed the students from focusing on the process toward focusing on the product. This appeared in the form of a lack of reflection and depth in the students’ work. For example, the students in seventh grade spent a lot of time perfecting their 3D-printed play checkers whithout paying attention to what made them ‘good’ play checkers. In this case, the obstruction challenged the teachers to initiate discussions with the students about what it meant to develop a prototype. In general, this is about the students’ need to articulate and form the product at various stages of emergence, from the idea to stages of prototypes to the final product, in order to better understand the production process and the subject-related learning process.

The students took more time filling out evaluations than they did evaluating the quality of their design in relation to the relevant criteria. When asked what they needed to finish their board game, the answers were quantitative: ‘We miss 35% of our question cards’ rather than qualitative: ‘We need to check whether our questions are good questions’ (as drivers in the game). From the participant researcher position, the students’ conceptions of evaluation criteria and objectives were indeed unclear. This finding gave rise to the following theme about objective-oriented learning.

**5. Working with learning objectives**

In the teachers’ coffee-room, posters on the wall remind the teachers of actions related to learning objectives and visible learning. During a coffee break, four teachers expressed their difficulties in conveying objectives and finding ways to manage dialogue with the students about the objectives. Consequently, even though the teachers tried to provide the students with agency, they did not succeed. They ended up using the formal method, where they conveyed and the students consumed without taking ownership. Observations showed that the students could not remember what they were doing or why. If they became unfocused, they could not return to their work without the teachers’ support. Informal conversations revealed students’ lack of basic conceptions of the framework, objectives and relevant evaluation criteria. In other words, they did not have a clue about what they were doing or why they were doing it:

From third grade: The students were only able to explain their work as a row of actions: ‘I cut out the drawing and glue it on the poster’. When asked what the drawing represents: ‘It is a robot-cat’. ‘Why a robot-cat?’ ‘I don’t know’. ‘What is the purpose of the poster?’ ‘I think it is something about a competition and a judge’.

Another example shows how the students forgot the purpose of their work. The teacher did not notice, as the students used the formal strategy:

‘We work with solar cells and carbon dioxide. And here are the bacteria’. ‘Tell me about the bacteria and the solar cells’. ‘They are dangerous’. The student gets up and point at their brainstorm poster: ‘This is what we work with – everything is connected’. What role the bacteria, which took up a lot of attention in the group, played in their production remained uncertain.

The classroom walls contained posters with learning objectives aimed at helping the students and teachers to work with objectives. In order to make the objectives relevant to the students, the posters were personalised with statements, e.g. ‘I can use methods from the Design to Improve Life model’. However, the statements only invite yes/no answers. How are students expected to determine if they fulfil the statement? For example, does ‘can use’ mean that the students: 1) follow the model systematically, 2) recognise their practices as steps in the model and name the practices and steps, or 3) understand which practices a certain step implies?

In order to challenge the dialogue about objectives and evaluation criteria, the obstruction leaned on a competence that the teachers have already mastered but cannot imagine using in other contexts. This is the form of dialogue, the teachers use to discuss conflict resolution with the students and it features the same kind of generic questions that were introduced above: How do you find out? What can you do? How do you find out if you can be satisfied? How do you know if the objectives are fulfilled? Using such questions in a co-constructing class dialogue, the students achieve agency and ownership. As they emerge, the objectives are recorded and shared via posters or online.

As the teachers became accustomed to involving the students in co-creation, the objectives became clearer to the students, who in turn were able to maintain the framework and their own forward progression. In addition, the ‘Design to Improve Life’ modelbegan to make sense in terms of the order of activities and their correlations. Instead of instrumentally following the steps, the students began to interprete the steps as qualitative indicators of their working process and the emerging product. That is, when the objectives became evaluation criteria and the students took ownership, they used the evaluation criteria as a tool to frame their working process. It also became easier for the teachers to manage the students’ agency.

From fourth grade: A girl brings her manuscript for a telephone call to different companies to the teacher. The calls aim to provide sponsors for the groups’ project. She wants to tell the companies that the class works with green energy. When the teacher asks about green energy, ‘What if they ask you?’, she answers, ‘I don’t know’. ‘Well, how could you find out? – What about the Internet – the learning objectives? Try that’.

Observations show that the students gradually began to articulate and explain what they were doing and why. During an informal conversation, a girl from third grade explained about photosynthesis and the demands for their written report: ‘It must not be grownup-language’. The group had copied ‘. . . environment and health are connected . . .’ from the Internet, and discussed how it should be paraphrased in their own words. In addition, more academically weak students began to contribute to the iterative improvement of the prototypes. We saw the students actively use the shared objectives as evaluation criteria when deciding how to proceed – further, they were able to resume work after dropping out. Therefore, the dropouts transformed from disturbances to being recreative breaks (like growups going to the coffee machine), as seen from the teachers’ perspective. The teachers expressed that the new attention on students’ strategies and transformed way of posing questions allowed them to feel safer and dare to experiment with the open framework.

**6. Discussion**

The researcher’s presence in the classrooms made it possible to capture the teachers’ practices, the students’ understanding, the shared context and the relation between these as well as the dissemination of objectives, awareness of objectives and students’ agency. Thus, the research approach revealed and identified the teachers’ practices, representing important dimensions of the teachers’ competence building when they restricted the students’ empowerment and agency. The teachers were keen to provide empowerment and agency to the students in the digitally permeated and open learning environment, and they were competent in using technology. However, when such a context displays ‘leftovers’ from teacher-centred teaching, it is reasonable to expect more challenges at schools where the teachers are less experienced. Accordingly, this study contributes to the field of teacher competence building by pointing out the important challenges in relation to implementing open learning designs and new technology.

The sub-project revealed basic challenges for teacher competence building, as the majority of the teachers were characterised as being ‘leftovers’ of teacher-centred teaching that needs to be unlearned if they are to comply with the open learning designs. ‘Leftovers’ appear with the teachers’ unawareness of the students’ simuling-, tinkering- and formal strategies and their different demands for teacher intervention. They also appear when the teachers find it difficult to perform explorative dialogues with students and regress to correction, instruction or controlling questions. Accordingly, competence building implies: 1) learning to master explorative co-creating dialogues that transform learning objectives into evaluation criteria, or 2) mastering explorative inquiry that identifies the students’ rationale and strategies and thereby the appropriate teacher intervention.

When the ‘leftovers’ operate unconsciously, they counteract the teachers’ intentions to empower the students and the principles of open learning designs. At the present school, the ‘leftovers’ counteracted the basic objectives of the LTL project because the students were pushed toward solving tasks rather than solving problems. Therefore, in teacher competence building, it is important to design activities that create awareness of blind spots as ‘leftovers’ in order to develop practice. Such processes reach deep into many teachers’ professional identity, and school management in general must accept that such transformations may take time. Teacher competence building demands that the management, in line with co-creation, provides space for the teachers to experiment with and to develop learning design forms, methods and practices under safe conditions.

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