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Article

Empowering professionalism in mission-oriented innovation

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Abstract

In the literature on mission-oriented innovation supply side and tech-oriented approaches have been complemented by broader and more inclusive societal approaches. Here, it is highlighted that both directionality and broad anchoring of diverse stakeholders across private, public, and civic domains are key to successful implementation. Still, it is unclear how these dimensions relate and unfold in practice. Using digital literacy in education as an example of mission-oriented innovation, this paper investigates what prerequisites and capabilities are needed to envision and govern such processes. Based upon a case study of innovative teaching practices in twenty-five classes at ten primary schools in Norway, the paper finds that the motivation, dedication, and engagement of the teachers is not primarily related to the digital technologies themselves, but to the professional and pedagogical anchoring of the digital teaching tools. The mobilization of the professionalism of the teachers is enabled by a process of balanced empowerment.

Key words: mission-oriented innovation; policy; governance; professionalism; digitalization; education

1. Introduction

In the literature on mission-oriented innovation policies (MIPs) it is highlighted that engaging both public, private, and civic sector actors is key to successful implementation (Kattel and Mazzucato 2018; Mazzucato 2018). But arranging for such balanced interactions may prove hard in practice as various stakeholders possess different skill sets and have diverging motivations and views upon both problems and solutions (Wanzenböck et al. 2020). At the same time the literature points at directionality as vital to transformative change and mission-oriented innovation (Weber and Rohracher 2012; Kattel and Mazzucato 2018). In sum this requires both a broad anchoring and mobilization of actors on the one hand, and a shared vision or direction for the desired innovations. This form of directionality on the one hand and broad anchoring among diverse stakeholders on the other constitutes a span that is so far scarcely investigated by the mission-oriented innovation literature. In consequence it is acknowledged as important to gain a better understanding of the relations and balance between directive and bottom-up interactions in mission-oriented innovation (Mazzucato 2017; Kattel and Mazzucato 2018; Mazzucato 2018).

Seeing digital literacy as a goal for educational policies this paper analyses digital transformation of education as a contemporary example of mission-oriented innovation. Ensuring digital literacy and skills for the 21st century constitutes one of the pressing challenges for many governments (Pellegrino and Hilton 2012). Scholars have emphasized that new digital technologies could potentially have a catalyzing role in accelerating educational innovations (Binkley et al. 2012; Zheng et al. 2016; Carretero et al. 2017; UNESCO 2017). The paper seeks to investigate what kinds of capabilities that are needed to envision and manage the contemporary societal challenge of digital transformation of education.

Traditionally, mission-oriented innovation has primarily been preoccupied with the technological dimensions, whereas the organizational and social aspects of innovation have received less attention (Nelson 2011; Martin 2016; Diercks et al. 2019). Nelson (2011) pointed out the puzzle that a country that has managed to send a man to the moon is still facing great difficulties when it comes to providing basic education and health services to overcome poverty. This is due to the intersectoral, social, and complex nature of these challenges, and there is seldom one solution that is widely agreed upon. The same can be said about the particular case of digital transformation of education, which has often been focusing upon the hardware and technological devices themselves rather than on the social aspects related to software, professional contents, and interactive teaching processes that these devices might enable (Warschauer 2010; Bano et al. 2018).

> . . .adoption of mobile technologies in school education is occurring without an empirical understanding of the complex, dynamic relationship between these technologies and the epistemological and pedagogical systems that underpin teaching and learning (Bano et al. 2018: 31).

Today most governments acknowledge the need to develop digital literacy, but there are uncertainties and disagreements around to what extent and how digital teaching tools should be implemented in education, and which underlines how there is often great contestation, complexity, and uncertainty in mission-oriented innovation (Wanzenböck et al. 2020).

The objective of this paper is thus to improve our understanding of the dynamics and governance of mission-oriented innovation through nuancing the relationship between 1) the development of new technologies and their socio-cultural and professional anchoring and embeddedness, and 2) the relationship between top-down directionality and bottom-up anchoring of stakeholders.

In order to shed light on these issues we use one particular project on digital transformation within education. The paper documents the testing and implementation of an innovative teaching tool enabling interactive teaching and learning in mathematics in twenty-five classes at ten primary schools in a Norwegian municipality. The teaching tool consists of both analogue and digital elements and aims at innovating learning of mathematics in early years in school. This initiative demonstrates an example of mission-oriented innovation, and we investigate how the implementation process plays out in practice throughout one academic year, and explore what capabilities are needed to envision and manage the contemporary challenges of digital literacy and implementation of novel technologies in education. The pilot project is based on testing out new technologies allowing for new and interactive teaching and learning practices. Moreover, the broad involvement of schools and teachers in this project makes the case suitable for shedding light on the identified gaps in the literature; i.e. the relationship between directional and bottom-up governance, and the social embeddedness of the introduction and implementation of new technologies.

In this sense, we aim at investigating the socio-cultural and epistemic preconditions for mission-oriented innovation, and how the notion of a directional policy (towards digital literacy) on the one hand can be paralleled by a networked and collaborative co-production approach on the other. In order to do so we use the notion of 'balanced empowerment' (Sundbo 1996) from the literature on service innovation which discusses how innovation is enabled by a dual approach of empowerment (agency) and control (structure). In a public sector context 'balanced empowerment' of innovation refers to how governments may restrain from power execution by delegating power to professional employees in the practice field (Fuglsang and Sundbo 2016).

The paper seeks to explore whether and how digitalization of education as an example of mission-oriented innovation takes the form of balanced empowerment. In doing so we perceive the teachers as professional employees in the practice field that should be empowered in the exploration and implementation of the new teaching tool. Moreover, the teachers possess a set of teacher beliefs referring to the teachers' pedagogical and professional reasoning which condition their motivation to take part in the innovative activities. The notion of professionalism refers to the teachers' common educational background and to their shared pedagogical values and work ethics. Parallel to the potential (bottom-up) empowering of the teachers we interpret the (top-down) project management of the implementation of the Dragonbox teaching tool as a structured way of ensuring systematic learning throughout the implementation process. Our primary focus will be on the role of teacher beliefs as an expression of their professionalism in balanced empowerment, and reflecting the importance of socio-cultural dimensions in mission-oriented innovation.

The research questions guiding the study are:

- Research question 1: Whether and how is teachers' professionalism mobilized and exploited in digitalization of education?
- Research question 2: What is the role of balanced empowerment in mission-oriented innovation in the educational context?

The paper is structured as follows: Section 2 outlines the conceptual building blocks for the study. Here theorizing on mission-oriented innovation, balanced empowerment, and digital transformation of education are the most central ingredients. In Section 3, the pilot project and the innovative teaching tool are presented. Section 4 presents the research design and methods applied, whereas Section 5 presents the findings from the study. Section 6 discusses the research questions through the theoretical framework applied. Finally, Section 7 sums up the main findings and concludes.

2. Theoretical framework

2.1 Mission-oriented innovation

In contrast to traditional theorizing on the dynamics of innovation and systems of innovation, more recent contributions within the literature on innovation and innovation governance have pointed out the need for a stronger element of priorities and directionality in order to accomplish certain societal missions or to arrive at more transformative system change to respond to the grand challenges of our time (Smith and Raven 2012; Weber and Rohracher 2012; Kuhlmann and Rip 2014; Mazzucato 2018; Schot and Steinmueller 2018). The notion of directionality involves selection and priority setting, and has thus introduced and emphasized a stronger element of politics into the understanding of systems of innovation and transformative change (Smith et al. 2005; Shove and Walker 2007).

Earlier there has been a shared perception in the literature that mission-oriented innovation has constituted a narrower and more technology-oriented and clearly defined form of innovation than transformative change, system innovation, or socio-technical transitions. The latter three are often perceived as more radical and referring to system change, i.e. more long-term and co-evolutionary processes of change in both technologies and entire systems of production and consumption. Such a view thus transcends stimulating innovation within the boundaries of existing systems. More recently, however, contributions in the literature have acknowledged the close relationship between mission-oriented innovation and system change and actualized a debate on how to make sense of the two in a fruitful manner (Mowery et al. 2010; Nelson 2011; Foray et al. 2012; Mazzucato 2017; Fagerberg 2018; Mazzucato 2018). It is being emphasized how traditional supply-side and technology-oriented research and innovation policies are deficient to address and tackle today's complex and integrated missions and societal challenges.

Mazzucato (2017, 2018) makes a distinction between old and new forms of mission-oriented innovation, where the old were defined by a small and centralized group of experts, oriented towards specified technology development, and where diffusion beyond these actors were of less importance. The new mission-

oriented innovation projects on the other hand are seen to comprise broader sets of actors involved in the definition of the direction of the mission, where the missions consist of both technical and societal objectives, and where diffusion of the solutions are paramount.

In line with Mazzucato, Diercks et al. (2019) show how the new generation of transformative innovation policies may contain diverse and varied approaches. On the one hand, narrow and tech-oriented mission innovation resembles a traditional science and technology policy logic. On the other hand, as narrow and supply-side innovation is insufficient to address the nature and complexity of contemporary societal challenges, broader and more inclusive societal approaches have a more articulated socio-cultural anchoring which requires changes in established behavioural habits and core societal systems. However, instead of maintaining such a dichotomy of narrow versus broad approaches, Diercks et al. (Ibid) call for a more nuanced understanding of how the technological and the socio-cultural aspects of transformative innovation relate in various practical contexts.

Moreover, Mazzucato (2017) distinguishes between grand challenges, missions, and portfolios of projects that involve different actors and sectors in bottom-up experimentation. In this sense missions and (mission) projects can be perceived as operationalizations of the broader grand challenges. Mission-oriented innovation is seen to constitute a narrower and more clearly defined form of innovation than what is required to address grand challenges, which are more complex and multi-faceted. In parallel with the ability to set missions it is seen as central to leave enough space for encouraging bottom-up experimentation across several types of public and private actors (Kattel and Mazzucato 2018). Missions should comprise a portfolio of R&D and innovation projects that allow for both success and failures. Associated with such a diversity is the insight that mission-oriented innovation often imply contestation, complexity, and uncertainty and diverging views on both problems and solutions (Wanzenböck et al. 2020).

Confirming the importance of diverse stakeholders in transitions, in a review of the main drivers behind Danish windpower, the German energiwende, and Norwegian electromobility, Fagerberg (2018) concludes that the social drivers of innovation have been more prominent than the technologies themselves, which have often been around for decades. Instead, the forces that seem to be the most powerful in determining the pace and scope of mission-oriented innovation and socio-technical transitions are associated with the social practices and interests of (local) user groups (Fagerberg 2018). Reflecting such a focus on the role of social movements for innovation, in a recent account of the introduction of the contraceptive pill, Leadbeater (2018) also emphasizes the importance of mobilizing social groups and movements in order to create legitimacy for mission-oriented innovations:

> In all innovation but perhaps especially in mission-driven innovation, the framing of the mission, the challenge it meets, and the values it embodies matter to how it is regarded (Leadbeater 2018).

A somewhat similar conclusion is arrived at in an earlier review of the policies underpinning energy-related technologies for combating climate change; i.e. agriculture, biomedicine, and information technologies in the USA and the UK. Here, Mowery et al. (2010) find that learning about new technologies in practical use should be emphasized stronger in public innovation and R&D policies. According to this study, the requirements for today's technology development differ fundamentally from earlier public policy programmes such as the Apollo programme or the Manhattan Project. Whereas these iconic mission-oriented programmes were oriented towards the achievement of particular and well-defined objectives and served the needs of a single public customer, todays policy programmes require widespread adoption by several types of actors across public, private, and civic sector (Mowery et al. 2010).

Parallel to the attention given to the R&D underpinning the development of new technologies, it is also highlighted that learning about how the technologies work in practise represents an important way to advance and diffuse the new technologies. Whereas prize competitions have previously been a central policy instrument for triggering new technology development, it is recognized that these may have limited effect in complex societal challenges. When addressing the potential uses and applications of new technologies, this requires good communication with the users of the technologies to be developed. Here, it is warned against the potential danger of assigning certain user groups too much power over the solutions to be tested out, as these may often be inclined to favour incremental innovations in existing solutions rather than radically new solutions. Public funding should prioritize moving the technological frontier rather than stimulating marginal improvements of existing technologies (Ibid.).

As today's challenges are seldom about arriving at one specific technology, it is emphasized how public policies should focus more on long-term public support improving learning abilities and absorptive capacities rather than aiming for a particular technological breakthrough. Moreover, public investments should be accompanied by private investments in the development of new technologies. It is also underlined how public policies may stimulate and trigger demand and widespread adoption of new technologies (Ibid). Here, innovative public procurement policies constitute a potentially powerful tool to boost the development and implementation of new technologies (Edler and Georghiou 2007; Aschhoff and Sofka 2009; Edquist and Zabala-Iturriagagoitiaa 2012; Edler and Yeow 2016; Bugge et al. 2018).

In parallel with the acknowledgement of the need for leadership, directionality, and priority setting in societal missions and socio-technical transitions, it is often highlighted that the solutions to pressing societal challenges must be found across sectors, technologies, and actors (Weber and Rohracher 2012; OECD 2015; Mazzucato 2017). This leaves us with a need for both vertical (i.e. top-down versus bottom-up) and horizontal coordination and negotiation. In the present case study such coordination comprises the school owners (i.e. the municipality), the school administration, the teachers, the pupils, the project coordinator, and the private developers of the innovative teaching tool.

2.2 Professionalism and balanced empowerment in mission-oriented innovation

In order to illustrate what contemporary mission-oriented innovation may look like in an educational context we borrow the notion of 'balanced empowerment' from the literature on service innovation and the notion of 'teacher beliefs' from the literature on technology integration in education. In the present study, these notions are thus applied to shed light on the exploration and implementation of innovative teaching practices enabled by digitalization. The Dragonbox pilot project constitutes a relevant example of innovative public procurement and of how new technology can be tested out across several stakeholders in a practical setting.

Mowery et al. (2010) emphasize that there is a need for public innovation policy programmes to balance between centralization and decentralization. On the one hand, they acknowledge the requirements of a centralized administrative structure for setting broader priorities and for being able to evaluate the performance and progress of the ongoing initiatives. On the other hand, they also underline the value of a decentralized structure of technology development in order to ensure anchoring of the initiatives broadly among diverse stakeholders.

Reflecting such a balancing between centralization and decentralization, the notion of 'balanced empowerment' is inspired by Giddens' (1984) structuration theory and refers to the capability of working within a dual structure of bottom-up (agency) and top-down (structure) forms of interaction (Sundbo 1996). The notion of 'empowerment' refers to 'the active involvement of employees in the innovation process' (Sundbo 1996: 398). The need to actively tap into the innovative potential of the employees rests in the insight that the employees constitute one of the central innovation resources in any organization.

> Without relying on experienced service providers to carry out policies and experiment with solutions in practice, policy actors may create few results in practice, because it is difficult for them to understand the practical context of innovation. (Fuglsang and Sundbo 2016: 228)

Such stimulation and involvement from public employees is also emphasized in theorizing on the importance of bottom-up engagement in public sector innovation (Borins 2001; Albury 2005; Windrum 2008; Arundel et al. 2015; Saidi et al. 2020). But the notion of 'balanced empowerment' not only reflects the need for both mobilization and engagement of employees, it also refers to controlling and integrating the innovative process into the existing systems of organisational learning on the other (Sundbo 1996; Fuglsang and Sundbo 2016). Although empowering the employees is crucial for exploiting the innovative potential of the organization, innovation should be seen as a process that can and should be organized and managed. Balanced empowerment therefore also comprises the organizational structures that control the innovative process and enable continuous organizational learning. A central challenge for management is thus to create and enable a dual organization—i.e. both encourage and induce innovative behaviour on the one hand, and control the innovative process on the other.

The notion of balanced empowerment is originally used in a private services context, and is here transferred onto public educational services. Although in principle there is a risk associated with transferring a concept from one context to another, and acknowledging that there are many differences between the private and the public sector, we believe that the core building blocks and dynamics of the concept are still applicable onto a public sector context.

In the innovation literature it has been emphasized how technological development is shaped by social, economic, and political forces. The development and implementation of new technologies often contains socio-cultural elements which implies requirements to alter social practices, values, and perceptions embedded in existing technologies and which—as opposed to the technologies themselves—are often hard to change (Kemp et al. 1998; Rip and Kemp 1998). The socio-cultural dimension of innovation is likely to take different expressions in various sectors. In this paper, we seek to study how this socio-cultural dimension takes form in education and how it affects the teachers' ability and professional motivation for engaging with digital devices and interactive teaching practices.

Exemplifying this socio-cultural dimension of innovation, the notion of 'teacher beliefs' has been highlighted as vital in the literature on integration and implementation of technology in education (Teo 2008; Scherer et al. 2015). In this paper, teacher beliefs are thus perceived as an expression of what professionalism means in the case of digitalization of education. Here, teacher beliefs refers to the teachers' pedagogical and professional reasoning and motivations for exploring new technologies such as digital teaching tools and altering their established teaching practices. It has been argued that teachers' beliefs do not only affect to what extent the teachers utilize novel tools and transform own practices, but they also seem to affect their pupils' learning outcomes (Davis 1989; Teo 2011). *Teacher beliefs* comprise several variables explaining attitudes, behavioural intentions, and use. Among others, teachers' computer self-efficacy (Siddiq et al. 2016), perceived usefulness of ICT (Pynoo et al. 2012), attitudes towards technology (Zhang et al. 2008), and perceived ease of use (Scherer et al. 2015) have largely been utilized in the literature to investigate teachers' acceptance and integration of new technologies (Scherer et al. 2019). While *computer self-efficacy* refers to the degree to which a person believes that he or she can perform a specific task using a computer (Compeau and Higgins 1995), the *perceived ease of use* refers to the degree to which a person believes that using technology would be free of effort. The variable *perceived usefulness* on the other hand refers to the degree to which a person believes that using technology would enhance his or her job performance (Davis 1989). Moreover, researchers have emphasized that to investigate teachers' individual- and perception-based characteristics such variables may not be used referring to technology in general, yet to the specific technological tool or system being investigated, tested, or implemented (Siddiq et al. 2016). This literature highlights an interest in the relationship between the teachers' inner motivations for testing out new technologies and solutions and their effects and outcomes. This has implications for how the teachers should be included and empowered in the development and implementation of new technologies by taking a bottom-up approach. Yet, this does not mean that one should exclude top-down elements from such processes.

In the case of digitalization of teaching and education, mobilizing and empowering the teachers in accordance with their teacher beliefs becomes paramount in order to arrange for a successful implementation of digital teaching devices in education.

2.3 The mission of digital transformation of education

This paper sees digital literacy as an example of contemporary mission-oriented innovation. Digital literacy is seen as critical to meet the challenges proposed by digitalization, and education is perceived as key to enabling its development (NOU 2015; Ilomaki et al. 2016). In the Norwegian national curriculum digital literacy is seen as 'a prerequisite for further learning and for active participation in working life and a society in constant change' (Norwegian Directorate for Education and Training 2012: 12).

The mission of arriving at digital literacy implies developing innovative and digital teaching tools and implementing these in various educational contexts (Redecker 2017). The mission of digital literacy is articulated through national policy documents top-down, but at the same time it requires mobilizing responses and involvement from private companies, municipalities, school administrations, teachers, and pupils. These different actors all take part in the gradual and iterative exploration, improvement and implementation of innovative teaching tools, and teaching practices. Together the

development of innovative teaching tools and the implementation of these in innovative teaching practices serve to transform education.

The status and integration of digital technology in education has changed profoundly over the last decade. This change is evident in many ways and at many levels in education, some examples are the increased availability of ICT resources at schools and access to internet (Zheng et al. 2016), the transition from paper-and-pencil to computer-based assessment (Scherer and Siddiq 2015), the increased focus on pupils' digital competence as an important 21st century skill (Binkley et al. 2012), and teachers' integration of ICT into classroom activities (Tondeur et al. 2008)—given that the teachers play a key role in developing pupils' digital skills (Siddiq and Scherer 2016). Yet other examples are massive open online courses (MOOCS), flipped classrooms, and digital and interactive teaching tools.

Several studies have closely followed and investigated the implementation of such digital transformation initiatives, e.g. the effects of one-to-one laptop classrooms on pupils' performance and motivation (Fleischer 2012), or how tablets affect young childrens' reading and writing skills (Genlott and Gronlund 2013). However, most such studies have been conducted from a pure educational point of view. Thus, there is a lack of studies investigating digital transformation of education from an innovation perspective.

The current developments in digital transformation of education have the potentials to cause major shifts in established educational practice (Sharples et al. 2016; Ferguson et al. 2017). Examples of such disrupting educational practices include '*flipped classroom*', where the pupils watch lectures at home and get help from their teachers at school. Another example is '*open educational resources*' (OER) which is educational material released with an open licence which means that they can be reused, remixed, revised, redistributed, and retained. Yet another example is '*immersive learning*', where the learning is intensified by bringing in vision, sound, movement, spatial awareness, and touch. These are examples of innovative and enriched teaching forms enabled by digital and interactive information technologies.

Moreover, the combination of digital technology and analogue (traditional) learning materials is often labelled *blended learning* (Hudson 2014) in the literature. One common definition of the concept is 'blended learning designates the range of possibilities presented by combining Internet and digital media with established classroom forms that require the physical co-presence of teacher and pupils', meaning that the combination of physical classroom presence and digital media activities is considered blended learning (Friesen 2012). As such, the introduction of digital and interactive teaching tools and practices in education does not necessarily mean a replacement of traditional teaching forms. Also, blended learning has proven to be particularly beneficial for developing pupils' subject knowledge rather than teaching with the use of *only* digital or analogue learning materials. Further, scholars have argued that to support constructive and efficient use of educational technologies they must be critically examined and evaluated (Hudson 2014).

Taken together, the theoretical perspectives presented above outline some core dimensions in studies related to mission-oriented innovation, and which we apply on the process of testing and implementing the innovative and interactive teaching tool *Dragonbox School* across the ten schools in a municipality outside Oslo in Norway. The term 'balanced empowerment' is key as it comprises both top-down leadership and control as well as bottom-up anchoring of socio-cultural practices and teacher beliefs of the user groups involved. This conceptual framing will be used to analyse the role of teacher beliefs in balanced empowerment. Teacher beliefs is seen as an expression of their professionalism and as reflecting the role and importance of socio-cultural factors in mission-oriented innovation. A central question is therefore whether and how the municipality and the school administration in charge of the project management has arranged for empowering the teachers and their teacher beliefs to take actively part in the testing and implementation of the teaching tool and its potential interactive practices.

3. A case study: digital innovation of teaching practices in mathematics

3.1 Organization of the project

In May 2016, the educational authority in a medium-sized municipality close to the capital region Oslo in Norway initiated a pilot project by deciding to try out the digital teaching tool *Dragonbox School*. The tool primarily focuses on teaching numbers as quantities or values instead of counting. Just before the summer holidays in mid-June the mathematics teachers in first grade were informed about the pilot. Already in August 2016 the piloting of the teaching tool was initiated. In sum, the time span from strategic decision to practical rollout was extremely short. In consequence, the teachers did not have time to prepare or learn about the teaching tool. Some however, spent parts of their summer holidays in July reading about and becoming familiar with the new teaching tool. However, the municipality organized the pilot consisting of (1) 10 monthly meetings, i.e. professional development course for the teachers involved; (2) one full time position for a project coordinator, and (3) a close dialog with the Dragonbox School developers.

The project coordinator had several tasks and responsibilities, which among others included planning and execution of the teacher development sessions, have contact with the municipality authorities, school principals, the teachers, and the company which delivered the teaching tool. Moreover, the coordinator was also assigned the role to bridge and facilitate the work of a research group (including the authors of this paper). The research group studied the organization and the implementation of the teaching tool into the classrooms, and documented the experiences of the actors involved in the project and the teachers' experience with and evaluation of the teaching tool.

The entrepreneur from the subcontractor was highly engaged with both the teachers, the municipality, and at the teacher training gatherings. One reason for this was partially that the municipality wanted to facilitate the learning process for the teachers, and second that the tool itself was not fully developed including all the teaching and learning material, and teacher assistance material (e.g. instructional material and resources). Hence, the case selected for the present study constitutes a development project rather than a research project, as it addresses testing, refining, and implementing a technology-based teaching tool in a new setting. As such the project is more about understanding the ways in which the teaching tool can be applied and utilized, and making necessary adjustments to established teaching practices and infrastructures in the schools participating rather than developing new technologies or solely implementing an existing and standardized tool. In this way, the social and organizational dimensions are more prominent than the technologies themselves in this study. Moreover, as mathematics is often seen as critical for understanding several topics in school, the present case appears to be a relevant example to study.

3.2 The teaching tool Dragonbox School

The *Dragonbox School* teaching tool challenges the traditional mathematical pedagogical and didactical thinking by emphasizing and promoting the learner's numerical understanding instead of counting in alphabetical order (Siddiq et al. 2017). This strategy has been considered critical, as pupils tend to struggle with mathematics when the numbers get more complicated and the operations get more advanced (Carraher and Schliemann 2007; Desoete et al. 2012). This pedagogical view on teaching mathematics is by no means novel in itself (Brissiaud and Sander 2010; Brissiaud 2016), yet it has been difficult to develop teaching practices and materials that makes it possible to teach mathematics according to these principles. Modern information technologies however have made it feasible to develop and implement such teaching and learning resources. Moreover, Dragonbox School consists of both digital and analog components as integral parts of the learning material, and therefore promotes blended learning (for more details, see Section 2.1).

These are some of the innovative and pedagogical thoughts underlying *Dragonbox School*. More concretely, Dragonbox School consists of a set of learning materials aimed at pupils in grade one mathematics, including two books ('The Book of Adventure' and 'The Book of Challenge'), figures (manipulatives which are small silicon bricks representing the numbers 1–10) named 'Nooms', and software (e.g. including tasks, games) which runs on tablets.

The teaching tool consists of several topics, and for each topic, the teacher can follow a step-by-step manual on how to move from one resource to another during class. This is meant to help the teacher take full advantage of how the topic is treated in all resources. The books, the tablet, and the Nooms refer to each other, and solutions in one resource may depend on activities in another resource. The unifying topic is the story about the 'Nooms'—ten creatures living on the planet Noomia. The pupils get to know these ten characters through the different resources; their personalities, what they like to do and experiences they have together. The main idea is that the pupils first develop a sense of the quantities of the ten Nooms and how these quantities relate to each other through joining or splitting. Gradually, the mathematical symbols and notations are introduced through the teaching and learning material.

The teaching tool has been tested at various niche user groups such as pupils with special needs in other countries such as France, Denmark, and the USA, yet this is the first time the teaching tool has been piloted systematically targeting entire student populations and presented in a research study.

4. Research design and methods

This study utilizes a mixed methods research design (Creswell and Plano 2011) as several data sources were used to gain contextual and in-depth understanding of the various respondent groups' views and perceptions of the innovation process, the implementation of the project, and the teaching tool. As shown in Table 1, the data collection consists of interviews with teachers and school management, observations in classrooms, a quantitative survey directed towards all teachers involved, as well as follow-up interviews with the teachers, the entrepreneur, and the coordinator of the pilot project. Also, we participated at teacher development courses and in a meeting with the municipal school administration. The data collection took place in the period August 2016 to May 2017. The data were triangulated in several ways as the different data sources were used to inform further steps in the data collection process. For instance, knowledge from the classroom observations and participation at the teacher training courses were used to develop interview guides to gain more detailed information and eventual corrections of our observations. Moreover, the key information from the interviews was used to develop the survey, of which the results were used to discuss issues in follow-up interviews to clarify and gain in-depth understanding.

4.1 Categories of balanced empowerment in digitalization of education

Building on the elements outlined in the theoretical framework we used four categories to operationalize the notion of balanced empowerment. These categories are named *bottom-up*, *top-down*, *product*, and *process*, and are thus reflecting important dimensions and core dynamics from the innovation literature. The four categories were used as guiding dimensions to detect and identify relevant perspectives to inform the study and to answer the research questions posed, i.e. how is teachers' professionalism mobilized and exploited in digitalization of education, and more broadly, what is the role of balanced empowerment in mission-oriented innovation in education. For each category, we iteratively developed indicators (see Table 2). These indicators were adapted and refined through the case-study, and included in the different data collection strategies.

4.2 Data collection and analysis

Table 2 shows an overview of the data collected in this project. Different data collection methods were used to triangulate (Tashakkori et al. 2015) the data to understand mission-oriented innovation in this study. In this sub-section, we further explain the different data sources and the methodologies surrounding them, including how the data were analysed and used.

4.2.1 Interviews

Interview is considered as a useful method for gaining insights into the experience(s) of events and actions taken by different people and in which they can share their understanding, views, and reflections (Mishler 1986). The conversation is central to the qualitative interview, and a key factor is the negotiation of one or more common discourses (Ibid). The purpose of the interviews was to gain insights into the various stakeholders' experiences with and evaluation of the implementation of the project (i.e. the process and the teaching tool). The interviews were semi-structured, meaning that some main questions and/or categories were developed in advance, allowing for follow-up questions and to let the respondents bring in other and unforeseen perspectives. The interview guide included questions which aimed at gaining knowledge with respect to the four categories presented above. However, the questions were developed to fit the target group during the interview, yet, mirroring the different groups involved in the project (e.g. teachers, school principals, head department of education in the municipality, etc.). Both focus group interviews and individual interviews were conducted, and the interviews were audio recorded with the approval from the informants. Moreover, the interviews were transcribed and analysed through the analytical categories outlined above.

4.2.2 Observations

We observed 11 classrooms, 1 h mathematic teaching in each class during the period November 2016 to March 2017. An observation guide was developed in advance to keep the attention to selected

Table 1. An overview of the data sources underlying this study, and when the data were collected.

The methodological approaches, respondent groups, and number of data sources during the school tear 2016/2017				
Meetings	Interviews	Teacher development courses	Classroom observations	Survey
Three meetings with the advisory board of the Dragonbox project (In the beginning, middle, and at the end of the school year) One meeting with the principals in the municipality (November 2016)	Ten focus group interviews with the teachers (throughout the school year) Two focus group interviews with the principals (in the beginning and at the end of the school year) Eight individual interviews with the teachers (throughout the school year)	Five courses (monthly throughout the school year)	Eleven classes (between November 2016 and April 2017)	Responses from forty teachers (response rate = 84%) (May–June 2017)

Table 2. Illustration of analytical framework.

Category	Dimensions	Indicators
Balanced empowerment	Bottom-up	Motivation, engagement, professionalism, pedagogy, pupils' learning, teacher beliefs
	Top-down	Support and facilitation of teachers' joint learning, experimentation and professional development, and strategy for the implementation of the innovative teaching tool
Innovation	Product	The blended teaching tool, professional educational content
	Process	Initiation, implementation, experience sharing, process support

focus areas (i.e. the analytical categories described in Section 4.1), as the method requires an accurate reporting of the course of events and processes in the classroom (Bordens and Abbott 2011). The observations were recorded by ticking off in an observation guide, and taking notes if incidents and other themes of relevance were observed. Also, time spent on different activities throughout the lesson observed was noted. At the end of each observation, we conducted short interviews with the teacher leading the class in cases we needed to clarify or deepen our understanding of something. Moreover, observations of the physical classroom in terms of how it was organized and what it contained (e.g. drawings, figures, and other objects for teaching mathematics) were made. The lessons observed lasted between 1 and 1.5 h. The aim of the observations was to see the use of Dragonbox in practice, how teachers use the learning material, and how they practically and pedagogically teach using Dragonbox. In addition, we wanted to understand how pupils use and learn with Dragonbox. The data were analysed in three steps. First, we went qualitatively through all observations and identifying the different activities during each lesson, and the extent to which and when different parts of Dragonbox Schools and/or other material was used in the lessons. Second, we noted the most common structure and activities across all lessons. Third, the uniqueness of lessons, in particular those activities, incidents, or other facets which differed from the rest of the observed lessons were identified.

4.2.3 Survey

Based on the objectives of the evaluation, information obtained from the initial interviews and observations, and applying theories of teacher beliefs as described earlier, we developed a survey aimed at all mathematic teachers in the municipality who were involved with the Dragonbox project and used it in their classes. Surveys are beneficial for obtaining information from a larger part of the target group (Fowler 2009). In our study, the overview enabled by the quantitative data thus complements the in-depth understanding acquired through the qualitative interviews.

In this study, the quantitative data provided a good insight into the teachers' beliefs (measured by items which covered variables related to their perceived usefulness, self-efficacy, and perceived ease of use), experiences, and evaluation of the implementation process and the interactive practices enabled by the innovative teaching tool. The survey included questions about the start-up phase, the teacher training sessions, the organization and the implementation of the project, and their assessment of various aspects of the implementation process and the tool itself. The teachers answered most of the questions by selecting one response category on a four-point Likert scale, e.g. from 'totally disagree' to 'totally agree'. In addition, the survey included some open-ended questions where the respondents could elaborate on their answers and share other reflections and/or opinions.

The survey was conducted from November 2016 to January 2017. In total, the survey was distributed electronically to the forty-seven math teachers who participated in the project, and obtained a response rate of 84 per cent, which is considered satisfactory. Eighty per cent of the teachers had taught mathematics earlier, while 16 per cent had not experience from teaching mathematics. Further, 47 per cent of the teachers reported experience from teaching mathematics at lower primary school level (grades 1–3), 29 per cent at grades 4–7, while 4 per cent reported experience from teaching mathematics at grades 8–10. Finally, the teachers involved in the project largely appear to be experienced mathematics teachers as 64 per cent reported that they have been teaching mathematics for six years or more, while 28 per cent reported three to five years. Only 8 per cent reported a mathematics teaching experience of 1–2 years. Nonetheless, this shows that the teachers involved in the testing and implementation of the innovative pilot project represents a diverse group.

4.3 Limitations

The study design has some limitations that should be mentioned. First, the fact that the pilot project was followed by a research group (including the authors) may have affected the set-up and organization of the process itself. For instance, such close scrutiny from researchers may have ensured a closer follow-up by the coordinating function than what would have been likely without such a research component in the set-up of the pilot. Yet, we believe that the presented organizational structure of the project (e.g. including several key actors with responsibilities at different levels and the openness to provide feedback and further develop the teaching tool) has to a large degree led to trustful results as the project was transparent, and cross-data from different actors and sources pointed towards the same key elements. Second, the present study constitutes a singular case study and may therefore not necessarily be representative for other educational contexts or for other sectors. Still, by covering twenty-five classes across ten schools and comprising both quantitative and qualitative methods we believe that the study has contributed to important insights that should be taken into account and inform future mission-oriented innovation projects and study designs.

5. Findings

Ensuring digital literacy and skills for the 21st century along with transforming and accelerating education can be seen as a mission to be accomplished by the municipalities who are responsible for primary school education. This mission can be perceived as comprising socio-cultural elements alongside the technology itself in the form of a need for empowering the teachers and ensuring that their teacher beliefs are taken into account in the innovative exploration and implementation of the digital teaching tool. Furthermore, it also involves other types of actors such as the school administration, the pupils, the private developer, and the project coordinator. This diversity of stakeholders reflects the characteristics of a new form of mission-oriented innovation where socio-cultural aspects are of equal importance with the technology itself and with a broad involvement of stakeholders (Mazzucato 2018).

The testing out and implementation of Dragonbox School constitutes an example of exploring innovative and interactive teaching and learning practices in an educational context—even though the teaching tool itself was unfinalized and represented unknown technology and territory for the teachers. In the following section, we present the empirical findings from the data collection.

The research team followed the implementation of Dragonbox School, across one school year. Thus, different data sources presented in Section 4.2 was collected at different time spots during the school year, between August 2016 and June 2017.

5.1 Teacher's experiences with and evaluation of the teaching tool

5.1.1 Initiation (August–October)

In the beginning of the school year, our data showed that most teachers found the novel tool motivating and fun for their pupils. With regard to what was challenging, the teachers reported diverse issues, such as how to manage and support the technical aspects related to charging and hardware, how to use the tool in a pedagogical sound way, engage pupils, provide adapted teaching for pupils at different levels, provide homework, and to support all pupils despite limited time and resources. The teachers reported challenges regarding the preparations and implementation of teaching with the tool in their classrooms. Mainly, they were frustrated about the short time they were given to get familiar with the teaching tool, given the complexity of the tool. About two out of five of the teachers felt that they were not given sufficient training in the technical aspects of Dragonbox in the initial phase. One in three stated that they did not experience support from the school management when trying to prepare for lessons using the teaching tool.

Dragonbox School consists of both digital and analogue components that the teachers are supposed to use interchangeably to support pupils' early number sense development. During the first meeting, the entrepreneur, who also leads the teacher development courses together with project coordinator, was understanding and supporting, and assured the teachers that they would learn to implement and manage the tool. He also offered the teachers to contact him, his team, or the project coordinator at any time for any help they would need.

Based on our observations from the first two teacher development courses, this first phase was primarily concerned with three key issues: 1) to explain and convince the teachers about the mathematical philosophy behind the tool; 2) team-building—including teachers, developers, and school administration, aiming to learn, manage, and implement teaching with the tool together; and 3) to support the teachers which included responding fast to teachers' inquiries and requests, swiftly implementing changes suggested by the teachers, and offering visits to support and showcase how to use the tool in a practical way in the classroom.

5.1.2 Mid-project status (November–February)

After two to three months into the project, the data from the teacher development courses and focus group interviews showed a slight change in teachers' focus, motivation, and perceptions regarding the tool. While they still reported frustration and stress, these experiences were now related to other factors than in the initial phase. Some teachers reported struggling with the advanced features of the app, and poor battery time in the tablets to run this. Others reported that they could not keep up the suggested pace, some chapters of the teaching guide were too extensive to get through in time in order to achieve the relevant learning goals. Others reported struggling with the teachers' handbook. None of the elements of the Dragonbox tool were in a final stage, all were changing and being developed throughout the pilot period. On the positive side, almost all teachers agreed that the tool was engaging and motivating their pupils. One teacher stated in an interview that '*the tool includes a lot which helps vary the classes*'. Several teachers emphasized the nooms in particular. One teacher enthusiastically expressed '*my pupils love the nooms, their diverse personalities and the tales—it is so much fun—and for me too!*'. The teachers were clearly enthusiastic about the tool. Most reported that it motivated their pupils, the mathematic stories in the books were interesting, engaging, and fun for the pupils. The mathematic games in the app were also very popular, and the pupils love working with them. In fact, a teacher mentioned '*for the first time I have experienced that all my pupils get sad when the mathematic class comes to an end*'.

An interesting finding at that time was that the teachers (and schools) appeared as a more varied group. The teachers' and moreover, the schools' profile became more apparent. While some schools had an articulated focus on digitalization, others were more concerned with different pedagogies of teaching mathematics. So even though they used the same tool, they clearly emphasized

different aspects of it. Moreover, some teachers felt burdened by the teachers' guide, which often presented step-by-step instructions. This clearly challenged their autonomy as teachers, and many started to mention that they were looking forward to be able to detach themselves from this instrumental way of teaching, and to be able to improvise more.

5.1.3 End-project status (March–June)

By the end of the school year, the mathematics teachers answered an online survey, and in addition, focus group interviews and two classroom observations were conducted. The survey aimed at approaching a larger number of teachers individually, and identifying the teachers' evaluation of the tool and the process at the end of the project. The teachers were asked about their experiences from teaching with the new teaching tool and how it resonated with their professional background and thinking. The results, as presented in Figs 1 and 2, show that the teachers are essentially satisfied when applying the new teaching tool in their working practices. Their answers confirm that the teaching tool strengthens the motivation of the pupils and is in accordance with their own professional identity and ambitions.

As shown in Fig. 1, close to all (thirty-eight out of forty) teachers stated that they 'agree' or 'strongly agree' that the teaching tool builds on good mathematical-didactical principles, and that they support the pedagogical principles underpinning the teaching tool. Moreover, three of four teachers stated that the teaching tool is suitable for adapted education (Fig. 1). Figure 1 shows that the teachers participating in the project overall evaluated the Dragonbox teaching tool overwhelmingly positively. This may well be because the tool represents a nice balance of digital and analogue elements that complement each other in a unique way, and it came with an extensive teaching guide. Moreover, all teachers agreed that the tool is innovative. In these ways, the teachers' experiences with and views on the product itself may help explain the successful mobilization and empowering of the teachers in the pilot project.

Additionally, teachers were asked about their experience from teaching with the tool and how it affected their pupils. As shown in Fig. 2, most teachers answer on the positive side of the scale (agree or totally agree) that Dragonbox works well for their mathematics teaching and the pupils become more motivated. This was an important aspect, and mentioned throughout the project period. Also, during our observations of the mathematics classes, we were surprised by the pupils' engagement. At the end of a 2-h long

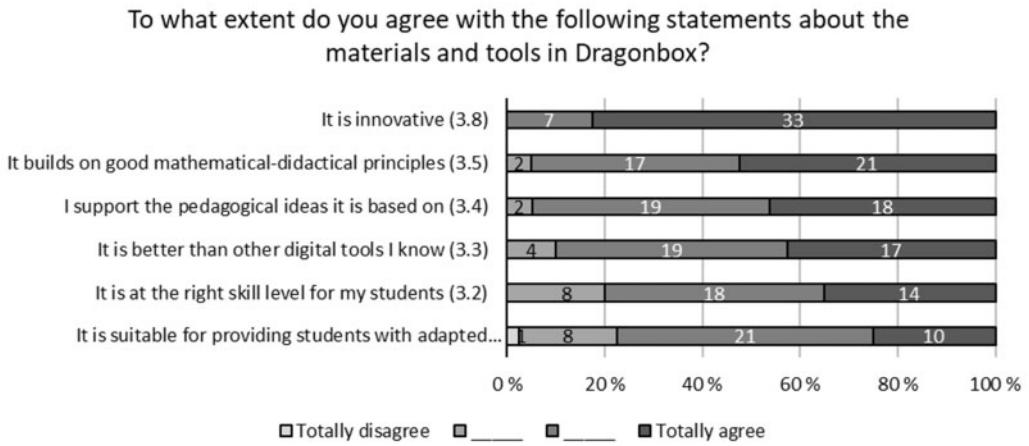

Figure 1. Evaluation of the Dragonbox School materials and tools. $N = 39–40$.

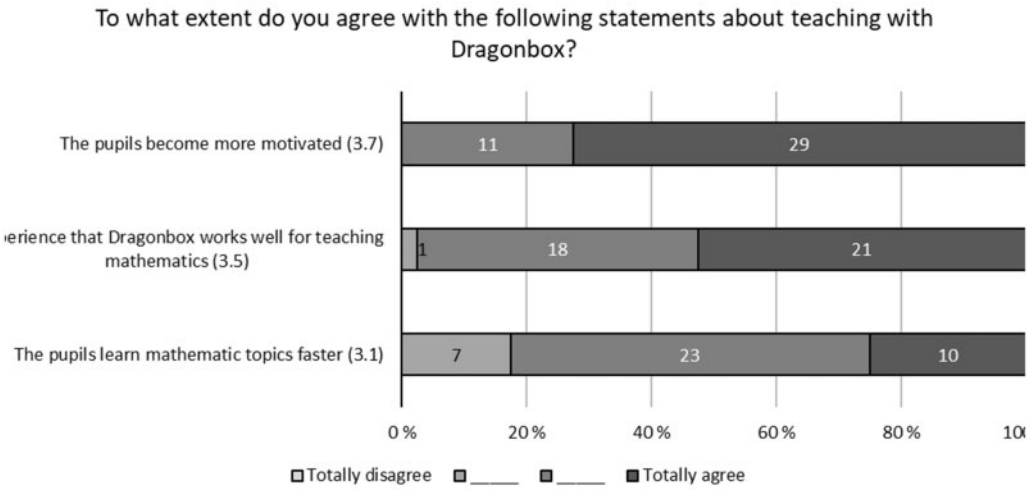

Figure 2. The teachers' experience and evaluation of teaching with Dragonbox School. $N = 40$.

mathematics class, surprisingly, a collective sigh from the majority of the pupils, and followed by '*Oh no is the class over?*' indeed corroborated the teachers claim that pupils become engaged and motivated. This may also relate to the notion of '*immersive learning*', where learning mathematics through the use of Dragonbox may be stimulating and intensified by bringing in vision, sound, movement, spatial awareness, and touch.

Also a large number of teachers agreed with the statement that their pupils learn mathematic topics faster than in traditional teaching. In an interview, one experienced teacher (who had taught mathematics for almost 20 years) told that she for the first time in her carrier had mathematical conversations in the first grade that she would normally expect in fourth grade. However, teachers also expressed concern with regards to pupils with learning difficulties, and questioned to what extent the tool would fit those pupils.

Figure 3 shows that almost 60 per cent state that they feel they can use their capabilities as a teacher when teaching with Dragonbox School, and an overwhelming majority (seven out of eight) state that they are in line with the teaching curricula when teaching with Dragonbox. On the other hand, the achilles heel for teachers in this project, seems to be the teaching guide which comes along with the comprehensiveness of the tool. As shown in Fig. 3, the teachers emphasize that initially they used the teaching guide that comes with the teaching tool extensively. Nonetheless, the majority signal that they imagine they will free themselves increasingly from the teaching guide in the time to come when they become more familiar with the functionality and possibilities of the teaching tool.

Overall, the teachers stated that they regard the quality of the teaching tools as good, and they wish to continue using the teaching tool the subsequent school year (Fig. 4). Oppositely, none wishes to return to the ordinary teaching prior to the introduction of Dragonbox. This was confirmed in the interviews, the teachers emphasized the quality of the tool and most importantly how it affected their pupils as weighing more than the extra efforts they

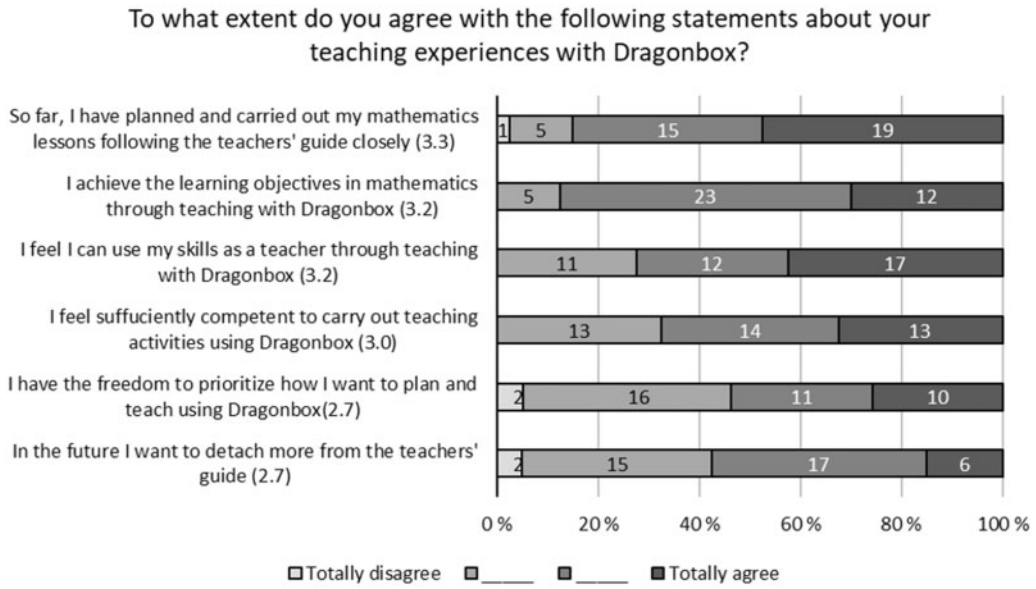

Figure 3. Teachers' experience teaching with Dragonbox School. $N = 39–40$.

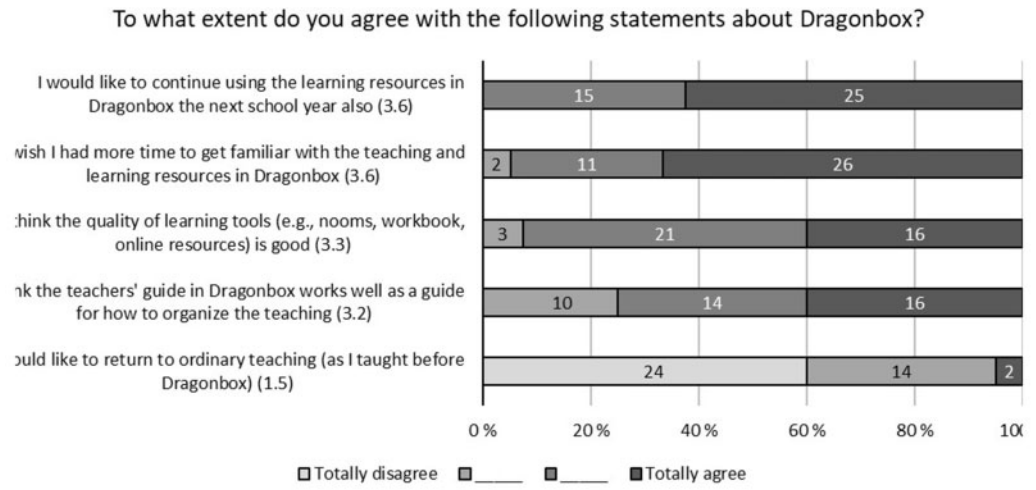

Figure 4. Teachers' overall evaluation of Dragonbox School. $N = 39–40$.

had to put into the preparations and implementation of their teaching with the tool.

5.2 Co-innovation: empowering the teachers in the implementation process

The teachers were also asked about the process of implementing the teaching tool and how it affected their working patterns. Results from the survey showed that the teachers had extensive intra-school collaboration in relation to the implementation of the new teaching practices. One may imagine that such collaboration locally represents important collegial support. At the same time, the results revealed that there is rarely collaboration between teachers across different schools.

In addition to this type of collegial support, experience sharing was also facilitated by the management and the project coordinator. The project was carefully oriented towards facilitating and supporting the teachers throughout the implementation period. The project management group had employed a project coordinator that ensured a close follow-up of the teachers and ensured the communication and information flow between the different groups involved.

In the survey, we found that the majority of the teachers (four out of five) contacted the coordinator or the entrepreneur during the implementation phase. This finding suggests that the process was closely followed up by the resource persons in the project. From our observations at the meetings we also saw how the coordinator and the entrepreneur played an important role in terms of facilitating sharing of experiences, frustrations, and questions between the teachers. In addition, the coordinator provided step-by-step information on how to teach a particular unit or topic at each teacher development course. Furthermore, for those teachers that needed additional support for different reasons (e.g. teachers' that felt uncomfortable or lacked sufficient digital knowledge), the coordinator visited and taught their pupils a whole lesson to demonstrate and provide real classroom teaching experience. From the interviews with the teachers it was apparent that for many teachers who were hesitant towards the project or struggled with adapting to the new technology this type of support was highly appreciated.

The entrepreneur behind the teaching tool was also actively engaged throughout the process of implementation and testing. The continuous incremental feedback from the teachers enabled his company to improve the teaching tool. The teachers on the other hand appreciated the availability and fast response from the entrepreneur, and in particular the low threshold to make contact if they encountered problems with any of the Dragonbox materials. In the interviews some teachers expressed this experience as being part of the development or refinement of the product, which made them feel ownership to the product.

> [...] even though it is demanding to learn to use a whole new tool it feels like we are part of developing it, part of the innovation—because everything we ask for—every change is implemented the next day or days!

Moreover, the entrepreneur was a passionate former teacher in mathematics, and helped guide and support the teachers throughout the project implementation period. The project coordinator was also a former teacher, which might have affected his ability to communicate with the teachers and to understand their needs, and to mobilize their professional motivation. Together they no doubt constituted a strong support team towards the teachers and helped ensure co-innovation among the actors involved.

5.3 New and innovative teaching practices

The implementation of the new teaching tool in mathematical teaching has contributed to innovation in education in many ways. First, the teachers' use and exploration of the new teaching tool contributed to improvements to the actual teaching tool itself through identifying: bugs in the program, lack of content and/or structure, further needs of teachers or students, and/or aspects that may not fit the age group or might be misunderstood. Moreover, requirements and suggestions for improvements from the teachers were met at high pace and quality as shown in the previous section. Moreover, it has resulted in new teaching methods. Through our observations of teaching in several mathematical classes and our interviews with the teachers, we found several commonalities across different teachers and schools: First, the implementation of the teaching tool led to more frequent use of mathematical conversations. A typical setting would be to gather the pupils in a circle around the digital blackboard and start the lesson by watching a short animated fairytale with the nooms as the main characters. The pupils were emotionally drawn into the story and the drama unfolding, and were very eager to engage in questions and discussions about how the protagonist could be rescued from the dangers encountered. The conversations then implied and revolved around various mathematical solutions to the drama. This form of joint conversation was then typically followed up with working individually, either analogue or on their digital tablets. Often, later during the class the pupils were asked to make their own mathematical stories in groups of two, which were later that day or week presented to the rest of the class. In the interviews, several teachers highlighted that this was the first time they experienced mathematical conversations with such young pupils.

This points to the next common innovative ingredient of the teaching practices, i.e. a more varied teaching. The digital tablet was by no means the main component in the teaching, as one might be inclined to believe. The teachers we talked to experienced that they were given a multitude of possibilities in organizing their teaching. They were given suggested guidelines in the teacher guide, or they could make their own structure for the lectures. Moreover, they could use the digital or analogue nooms included in the teaching tool, or they could make their own physical equipment. When the pupils create their own tools, they are expected to become more engaged, involved, and motivated to learn. We observed various examples where the pupils made their own blocks, figures, and threads with balls on to visualize different quantities. In addition to alterations across physical and digital formats, across all observations the teachers also varied between individual and group work.

The teachers reported that when they got accustomed with using the teaching tool through teaching they became increasingly convinced about the pedagogical philosophy behind it, and more eager to use it in their own way and create additional artefacts to teach their pupils quantities rather than counting.

6. Discussion

Seen against the categories introduced earlier on various forms of mission-oriented innovation distinguishing between old (narrow) on the one hand and new (broad) on the other hand (Mazzucato 2018), the present case may be interpreted as an example of a mix of old and new mission-oriented innovation, and thus exemplifying Diercks et al.'s (2019) call for broader categories to comprise more empirical nuances. The setting of direction (top-down) by national educational policies in terms of integrating digital literacy in the

curriculum and the local school administration in terms of selecting the actual technology and teaching tool to be tested and implemented reflects an old form of mission-oriented innovation, where objectives are identified and articulated (top-down) by a limited set of specific actors or organizations. On the other hand, the inclusion and empowerment of the teachers and practitioners in the exploration and implementation of the teaching tool resembles a new type of (socio-cultural) mission-oriented innovation where broad involvement, learning, and diffusion are key. In relation to the distinction between grand challenges, missions, and portfolios of projects as stated by Mazzucato (2018), the present case can be interpreted as an example of a 'mission project' that along with several other similar projects in other municipalities all contribute to the overall mission to ensure digital literacy, and that together with other missions targeting digital literacy all contribute to the grand challenge of ensuring good education to all.

At the outset of this paper, we posed two research questions to guide our study; i.e.

- Research question 1: Whether and how is teachers' professionalism mobilized and exploited in digitalization of education?
- Research question 2: What is the role of balanced empowerment in mission-oriented innovation in the educational context?

In the following the findings from the previous section will be discussed with respect to the research questions and through the analytical framework outlined.

6.1 Teachers' professionalism as a driver in digitalization of education

Although the project was initiated top-down, required broad anchoring among several types of stakeholders, and represented challenges and frustration throughout the process, a crucial success factor was the continuous support and engagement among the teachers. Addressing this aspect, research question 1 asks 'Whether and how is teachers' professionalism mobilized and exploited in digitalization of education?' This research question relates to the teachers professional and inner motivations to engage in and contribute to the successful testing and implementation of interactive mathematical teaching enabled by the innovative tool. In the present case, it refers to the socio-cultural dimensions of the new (technological) teaching tool, involving requirements for altering established routines and practices in teaching mathematics.

We have seen how Dragonbox affects and challenges the teachers' professional identities, ways of thinking and teaching practices. Throughout the project period, we observed at several seminars that the teachers were actively devoted to the sharing of experiences and joint learning. Here, both the coordinator and the entrepreneur played central roles in facilitating collective learning and exchange of knowledge and experiences, and in arranging for the improvement and further development of the teaching tool itself.

Based on the findings accounted for in the previous section, we may summarize that the pedagogical anchoring of the teaching tool resonated well with the teachers' professional and pedagogical thinking and ensured their continuous motivation and engagement throughout the testing and implementation process. The focus and enabling of understanding quantities in mathematics rather than a traditional sequential counting resembles the teachers' pedagogical thinking in mathematics and was enabled through the teaching tool. However, it should be noted that the positive results should not be confused with an easy process. Many teachers expressed frustration and stress during the initial interviews and the teacher training seminars, along with an increased burden with regard to planning of lessons and adopting new ways of teaching. Yet, in the follow-up interviews, they accentuated the cost–benefit aspects throughout the school year and explained their wish to continue using Dragonbox as they experienced having mathematical conversations with their first graders as they had never experienced before. Moreover, they emphasized that they felt they had developed further as professional teachers and could use the new pedagogical and didactical perspectives in other subjects as well. Most importantly, many felt their pupils benefitted from lessons built on the ideas of blended learning—'*which makes it all worth it*' as one teacher stated.

6.2 Balanced empowerment in mission-oriented innovation

The second research question asking 'What is the role of balanced empowerment in mission-oriented innovation in the educational context?' refers to the organization of the pilot project, and to the relationship between the setting of a direction for the innovation aimed at and the bottom-up coordination, empowerment, and anchoring among the teachers and other stakeholders involved. As such the implementation of new and interactive teaching practices balances between centralization and decentralization as described by Mowery et al (2010).

The entire project was led by the municipal school administration and can be perceived as an example of innovative public procurement stimulating the uptake and adoption of digital teaching tools in the educational sector. Addressing national priorities in the educational sector in terms of ensuring digital literacy (NOU 2015) the direction of the initiative was set out by the municipal school administration. In this way, the pilot project can be interpreted as having started as a top-down process.

But the pilot project also comprised a range of different actors that were brought together in frequent meetings and coordinated in order to arrange for joint learning and reflexivity throughout the process of testing and implementation. Both the pupils, the teachers, the school principals, the private contractor, the research team following and documenting the project, the school administration in the municipality, and the coordinator of the pilot project constitute various actors that in sum may be perceived as co-producing the innovation, i.e. the new and interactive teaching practices enabled by the innovative teaching tool. As such the project set-up reflects the need for involving various types of actors and stakeholders as prescribed in the literature (Weber and Rohracher 2012; Mazzucato 2017). Moreover, by choosing to implement digital devices in mathematical teaching through testing out of a concrete teaching tool, the project reflects the importance assigned to the value of practical testing in the innovation literature (Mowery et al. 2010).

Our findings suggest that the coordinator played a highly central role in facilitating the arenas for joint reflexivity, sharing of experiences and co-innovation across the teachers and the entrepreneur (Weber and Rohracher 2012). The way the project implementation was organized allowed for a successful empowerment, engagement, and involvement of the different user groups, which according to the literature is often seen as paramount in mission-oriented innovation (Fagerberg 2018).

Although the project was broadly anchored, the time frame was not necessarily the best guarantee for a successful project. The extremely short time horizon from decision (May 2016) to launch (August 2016) suggests that the project suffered from a lack of

preparations and resources from the participating schools. This was confirmed by the results from our survey, which uncovered dissatisfaction with the amount of training with the teaching tool and with the support from the school management in the initial phase. However, against all odds in terms of preparations, planning, and resources, the pilot project appeared to run quite smoothly and was met positively by the teachers (Siddiq et al. 2017).

7. Conclusions

Seeing digital literacy and skills for the 21st century as a mission for the educational sector, this paper has documented and demonstrated how digital transformation may look like and unfold in educational practice. The teaching tool implemented represents an innovation that may radically change teaching practices in mathematics and beyond.

Based on the experiences generated from this innovative project on digital transformation of education, the paper has reflected on the capabilities needed to envision and manage the contemporary digital transformation of education. With reference to the literature on balanced empowerment and mission-oriented innovation, the paper has documented and discussed how the present case can be conceptualized as balancing a centralized and top-down management on the one hand and a decentralized and bottom-up management on the other. The paper has emphasized the role and importance of teacher's beliefs and professional motivation in mission-oriented innovation.

Two main insights may be derived from the study: First, the case study has illustrated how a (top-down) direction for the mission was paralleled by a bottom-up anchoring of professionalism ensuring motivation and engagement. This balanced empowerment not only ensured the engagement and motivation by the teachers in implementing the solution in their teaching, it also contributed valuable inputs to eliminating flaws and refining the teaching tool under development. The balanced empowerment observed can thus be seen as an example of co-innovation, where the inputs and feedback from the teachers have given important impulses to the debugging and improvement of the teaching tool. Finally, and not least, although too early to tell, it might have affected the learning outcomes of the pupils positively.

Second, the motivation, dedication, and engagement of the teachers are not primarily related to the digital technologies themselves, but to the socio-cultural aspects relating to the professional and pedagogical anchoring of the innovative teaching practices. The results from the study have shown how the teachers believe in the pedagogical and professional ideas underlying the technology and the teaching tool. In the case of Dragonbox School this relates to the way the teaching tool allows for new ways of providing the pupils with a number sense—by use of quantities as opposed to traditional counting. The professionalism of the teachers—i.e. in this context how the teaching tool resonated with the teachers' professional and pedagogical experience and understanding—was key to understand their motivation and engagement in the present innovation project. The successful outcomes of the pilot project therefore appear to be much due to the teachers' beliefs in the teaching practices allowed for by the tool which fit well with their professional and pedagogical thinking and which ensured their motivation and engagement. This shows that even in cases of broader mission-oriented innovation typically characterized by working jointly towards some shared (societal) goals, the importance of professional, inner and socio-cultural aspects of professional motivation should not be underestimated.

In this sense, the paper has exemplified how mission-oriented innovation may comprise a synthesis of the former dichotomy of tech-oriented and socially inclusive approaches (Diercks et al. 2019), and it has documented the value and importance of an integrated and orchestrated approach along the principles of balanced empowerment in MIP.

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