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Tools, rules and teachers: The relationship between curriculum standards and resource systems when teaching mathematics

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ABSTRACT

In this article, we explore the relationship between teacher practice, technological infrastructure, and national curriculum standards using one teacher's experience as outset for theoretical exploration of relations between curriculum and technology in digital learning platforms. We present a project testing a learning platform that connects national standards with specific learning objectives. The example is analyzed using both curriculum theory and documentational genesis. This case shows how the intentions of the national curriculum standards becomes an integrated part of the teachers' documentational genesis within the learning platform. Rules and national curriculum standards become parts of the teachers' resource systems together with the learning platform, and this combination influences planned and enacted curricula and impact teachers' work in ways not easily predicted.

1. Introduction

In recent years, a new type of learning management system, or *learning platform*, has been implemented in schools both in Denmark (Danmarks Evalueringsinstitut, 2016; Jørnø & Gynther, 2018; Misfeldt et al., 2018; Tamborg & Allsopp, 2018; Undervisningsministeriet, 2015; Undervisningsministeriet, 2014) and internationally (Freeman, Adams Becker, Cummins, Davis, & Hall Giesinger, 2017; Gueudet, Pepin, Sabra, & Trouche, 2016). Here, we understand learning platforms as digital systems that are developed for educational purposes to be used by teachers for planning, teaching and/or evaluating their lessons, and/or for students' educational activities. Like many other types of digital learning platforms, the Danish platforms enable teachers to share and collaborate on teaching sequences, collections of resources, and the administrative processes of teaching such as progress reports and grades that can be shared, stored, and downloaded from the platform. The focus of this article is the pedagogical consequences of the presence of such platforms in the classroom. We explore this from an ergonomics perspective, meaning the interactions between design and use of curriculum resources (Choppin, Roth McDuffie, Drake, & Davis, 2018). Two types of resources are explored in this paper—a technical platform and the national curriculum standards.

In Denmark, digital learning platforms have been introduced and implemented over the last three years to support objective-oriented teaching. The Danish government endorsed objective-oriented teaching through recent school reform and the revision of national curriculum standards for compulsory schools. This approach to teaching was informed by and based on research showing that visible objectives for students improve their learning outcomes (Hattie, 2009; OECD, 2016; PISA, 2012), which, however, have

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been criticized (Rømer, 2018; Skovmand, 2017). In practice, this reform involved a specification, for each subject, of the knowledge, skills, and competencies students should have acquired at the end of a given school year. The resulting combination of the deployment of a technological infrastructure and an increased focus on specific pedagogical ideas provide the context of our investigation. We focus on a project that we have conducted to develop digital tools to support objective-oriented teaching. On one hand, this case is highly specific to and situated in the Danish context; on the other hand, it allows us to investigate one example of the ways in which the promises, affordances, and limitations of digital technologies and the political, legislative, and scientific development of teaching practice can and will work together to influence teachers' work.

The existing research on digital platforms for primary and lower secondary education seems to focus primarily on the general aspects of education and schooling, devoting less attention to how digital platforms influence specific subjects (such as mathematics) and relate to particular curriculum standards (Tamborg, Bjerre, Andreasen, Albrechtsen, & Misfeldt, 2017). Previously, researchers in mathematics education have rightfully argued that the evolution of curricula in recent years has tended to integrate technologies into mathematics curricula and curriculum standards (Trouche, Drijvers, Gueudet, & Sacristán, 2013). In a way, Danish learning platforms represent a completely opposite movement: one in which the curriculum is integrated into the technologies that teachers are supposed to (or even required to) use. The learning platforms implemented in Denmark, including the prototype we investigate in this article, embody the Danish national curriculum standards that form the legislative foundation of compulsory school teachers' work. In this sense, they exemplify a configuration of technology and curriculum standards that differs from what is investigated in the mainstream literature on technology in mathematics education.

To describe and understand this configuration, we build on theoretical insights from two knowledge traditions, namely theory about curriculum use (Remillard, 2005) and the theoretical approach entitled documentational genesis (Gueudet & Trouche, 2009). The first of these knowledge traditions considers the relationship between the official and planned curriculum and teachers' enactment of this curriculum. Here, the focus is on the differences between the intentions of a specific curriculum and the planning and enactment of that curriculum (Remillard, 2005). The latter is developed to study the interrelations between resources (both digital and analogue) and teachers' work and focus on how and when they control and adapt resources for their own purposes while the affordances of these resources simultaneously affect both their practice and their conceptions (Gueudet & Trouche, 2009).

We begin this article by describing a recent school reform in Denmark that has led to the development of new curriculum standards and ambitious investments in digitalization. We then introduce the theoretical lenses that we use and the development project that constitutes the empirical basis of the article. In this project, we focus on one short, but critical, case describing a teaching sequence in which a teacher wishes to change the learning objectives for his teaching during the teaching sequence, but feels tensions and pressures related to conducting these changes within the learning platform.

We use this case as a basis to develop theoretical insights regarding how teachers interpret curriculum standards mediated by technological platforms. A main insight from the analysis is the need for a lens that adds a legislative layer to the understanding of the dialectics between digital tools and teachers' work and considers how digital platforms might interfere with teachers' interactions with resources, whether new or old. In that sense, the article attempts to extend the documentational genesis of teachers' tool use to actively relate to the roles of curriculum standards, rules, and political decisions and their coexistences with digital tools.

2. New curriculum standards, school reform, and digitalization

In 2014, a new set of curriculum standards was implemented in Danish compulsory schools as part of a larger school reform (Undervisningsministeriet, 2015). These new curriculum standards differ from the previous national curriculum standards in two ways. First, whereas the old curriculum standards referred to a number of different aspects of desired change in pupils (e.g., knowledge, skills, understanding, ways of working mathematically, etc.), the new curriculum standards focus on learning objectives and competencies. This change was manifested in a combination of schematically presented learning objectives, as well as a focus on competencies as developed in the Danish Competencies and Mathematics Learning (KOM) project (Niss & Højgaard, 2011). The new curriculum standards are organized in a systematic structure in which four general *competence areas* are subdivided into *pairs of knowledge and skills* to be learned by students. The curriculum standards are presented in either a matrix form or a hypertext structure on the Ministry of Education website[1]. In Fig. 1, the structure of the new learning standards is shown, and in Fig. 2, we describe the details regarding how the mathematical competencies are represented in the new Danish curriculum standards. The national curriculum standards for mathematics consist of four overall competence areas: (1) mathematical competencies, (2) numbers and algebra, (3) geometry and measures, and (4) statistics and probability. These four areas are broken down into themes and, further, into pairs of knowledge and skills showing the envisioned progression in each theme.

The implementation of these curriculum standards has occurred in the context of both a larger school reform requiring teachers to teach more lessons per week and an initiative for longer school days. The implementation prompted a breakdown of negotiations surrounding teachers' working conditions, leading to distrust between teachers on one side and politicians and school owners on the other (Mathiasen, 2017).

In concert with the new curriculum standards, the Ministry of Education recommended that teachers enact *objective-oriented teaching* and use clearly stated *learning objectives* (or *learning goals)* for their school activities. Some teachers experienced this new focus on objective-oriented teaching, goals, and competencies as a radical shift in how they were required to teach (Krogh & Holgersen, 2016).

[1] https://www.emu.dk/modul/matematik-fælles-mål-læseplan-og-vejledning

Matematik

Færdigheds- og vidensmål (efter 3. klassetrin)

See fig. 2.

UNDERVISNINGS MINISTERIET

Kompetence-område	Kompetencemål	Faser	Færdigheds- og vidensmål											
			Problembehandling		Modellering		Ræsonnement og tankegang		Repræsentation og symbolbehandling		Kommunikation		Hjælpemidler	
Matematiske kompetencer	Eleven kan handle hensigtsmæssigt i situationer med matematik	1.	Eleven kan bidrage til løsning af enkle matematiske problemer	Eleven har viden om kendetegn ved undersøgende arbejde	Eleven kan undersøge enkle hverdagssituationer ved brug af matematik	Eleven har viden om sammenhænge mellem matematik og enkle hverdagssituationer	Eleven kan stille og besvare matematiske spørgsmål	Eleven har viden om kendetegn ved matematiske spørgsmål og svar	Eleven kan anvende konkrete, visuelle og enkle symbolske repræsentationer	Eleven har viden om konkrete, visuelle og enkle symbolske repræsentationer, herunder interaktive repræsentationer	Eleven kan deltage i mundtlig og visuel kommunikation med og om matematik	Eleven har viden om enkle mundtlige og visuelle kommunikationsformer, herunder med digitale værktøjer	Eleven kan anvende enkle hjælpemidler til tegning, beregning og undersøgelse	Eleven har viden om konkrete materialer og redskaber
		2.									Eleven kan vise sin matematiske tænkning med uformelle skriftlige noter og tegninger	Eleven har viden om forskellige former for uformelle skriftlige noter og tegninger		
		3.	Eleven kan løse enkle matematiske problemer	Eleven har viden om enkle strategier til matematisk problemløsning	Eleven kan tolke matematiske resultater i forhold til enkle hverdagssituationer	Eleven har viden om sammenhænge mellem matematiske resultater og enkle hverdagssituationer	Eleven kan give og følge uformelle matematiske forklaringer	Eleven har viden om enkle matematiske forklaringer			Eleven kan anvende enkle fagord og begreber mundtligt og skriftligt	Eleven har viden om enkle fagord og begreber	Eleven kan anvende digitale værktøjer til undersøgelser, enkle tegninger og beregninger	Eleven har viden om metoder til undersøgelser, tegning og beregning med digitale værktøjer

Kompetence-område	Kompetencemål	Faser	Tal ❗		Regnestrategier ❗		Algebra	
Tal og algebra	Eleven kan udvikle metoder til beregninger med naturlige tal	1.	Eleven kan anvende naturlige tal til at beskrive antal og rækkefølge	Eleven har viden om enkle naturlige tal	Eleven kan foretage enkle beregninger med naturlige tal	Eleven har viden om strategier til enkle beregninger med naturlige tal	Eleven kan opdage systemer i figur- og talmønstre	Eleven har viden om enkle figur- og talmønstre
		2.	Eleven kan anvende flercifrede naturlige tal til at beskrive antal og rækkefølge	Eleven har viden om naturlige tals opbygning i titalssystemet	Eleven kan udvikle metoder til addition og subtraktion med naturlige tal	Eleven har viden om strategier til hovedregning, overslagsregning samt regning med skriftlige notater og digitale værktøjer	Eleven kan beskrive systemer i figur- og talmønstre	Eleven har viden om figur- og talmønstre
		3.	Eleven kan genkende enkle decimaltal og brøker i hverdagssituationer	Eleven har viden om enkle decimaltal og brøker	Eleven kan udvikle metoder til multiplikation og division med naturlige tal	Eleven har viden om strategier til multiplikation og division	Eleven kan opdage regneregler og enkle sammenhænge mellem størrelser	Eleven har viden om sammenhænge mellem de fire regningsarter

Kompetence-område	Kompetencemål	Faser	Geometriske egenskaber og sammenhænge		Geometrisk tegning		Placeringer og flytninger		Måling ❗	
Geometri og måling	Eleven kan anvende geometriske begreber og måle	1.	Eleven kan kategorisere figurer	Eleven har viden om egenskaber ved figurer	Eleven kan beskrive egne tegninger af omverdenen med geometrisk sprog	Eleven har viden om geometriske begreber	Eleven kan beskrive objekters placering i forhold til hinanden	Eleven har viden om forholdsord, der kan beskrive placeringer	Eleven kan beskrive længde, tid og vægt	Eleven har viden om længde, tid og vægt
		2.	Eleven kan kategorisere plane figurer efter geometriske egenskaber	Eleven har viden om geometriske egenskaber ved plane figurer	Eleven kan tegne enkle plane figurer ud fra givne betingelser og plane figurer, der gengiver enkle træk fra omverdenen	Eleven har viden om metoder til at tegne enkle plane figurer, herunder med et dynamisk geometriprogram	Eleven kan beskrive og fremstille figurer og mønstre med spejlingssymmetri	Eleven har viden om metoder til at fremstille figurer og mønstre med spejlingssymmetri, herunder digitale værktøjer	Eleven kan anslå og måle længde, tid og vægt	Eleven har viden om standardiserede og ikke-standardiserede måleenheder for længde, tid og vægt samt om analoge og digitale måleredskaber
		3.	Eleven kan opdage sammenhænge mellem plane og enkle rumlige figurer	Eleven har viden om geometriske egenskaber ved enkle rumlige figurer	Eleven kan bygge og tegne rumlige figurer	Eleven har viden om metoder til at bygge og tegne rumlige figurer	Eleven kan beskrive positioner i et gitternet	Eleven har viden om angivelse af placeringer i gitternet	Eleven kan sammenligne enkle geometriske figurers omkreds og areal	Eleven har viden om måleenheder for areal

Kompetence-område	Kompetencemål	Faser	Statistik		Sandsynlighed	
Statistik og sandsynlighed	Eleven kan udføre enkle statistiske undersøgelser og udtrykke intuitive chancestørrelser	1.	Eleven kan anvende tabeller og enkle diagrammer til at præsentere resultater af optællinger	Eleven har viden om tabeller og enkle diagrammer	Eleven kan udtrykke intuitive chancestørrelser i hverdagssituationer og enkle spil	Eleven har viden om chancebegrebet
		2.	Eleven kan gennemføre statistiske undersøgelser med enkle data	Eleven har viden om enkle metoder til at indsamle, ordne og beskrive enkle data		
		3.	Eleven kan gennemføre statistiske undersøgelser med forskellige typer data	Eleven har viden om enkle metoder til at indsamle, ordne, beskrive og tolke forskellige typer data, herunder med regneark	Eleven kan udtrykke chancestørrelse ud fra eksperimenter	Eleven har viden om chanceeksperimenter

❗ Se bilag for opmærksomhedspunkter

Fig. 1. The curriculum (or national curriculum standards) for grades 1 through 3 in mathematics. The four horizontal bars describe the competence areas, each of which consists of between two and six pairs of knowledge and skills, typically divided into progressing levels.

Competence area	Competence goal	Stages	Goals for skill and knowledge	
Mathematical competencies	The student can act appropriate in situations involving mathematics		Problem solving	
		1	The student can contribute to the solution of simple mathematical problems	The student knows characteristics of investigative work
		2		
		3	The student can solve simple mathematical problems	The student knows simple problem solving strategies
Numbers and algebra	The student can develop methods for calculation with natural numbers		Numbers	
		1	The student can use natural numbers to describe amount and order	The student knows of simple natural numbers
		2	The student can use natural numbers with multiple digits to describe amount and order	The student knows of the natural numbers construction in the decimal number system
		3	The student can recognise simple decimal numbers and fractions in everyday-situations	The student knows of simple decimal numbers and fractions.

Fig. 2. A translated part of the curriculum for grades 1 through 3 in mathematics.

The Danish Ministry of Education funded a development research project to explore the possibilities of supporting the implementation of the curriculum using technology (Misfeldt, 2016). To develop the theoretical points of this paper, we draw on an empirical situation. In the following section, we describe this project and the technology we developed to support teachers' use of the new curriculum. We will then introduce the theoretical foundations from which the points made in this paper is elaborated and then describe the empirical situation.

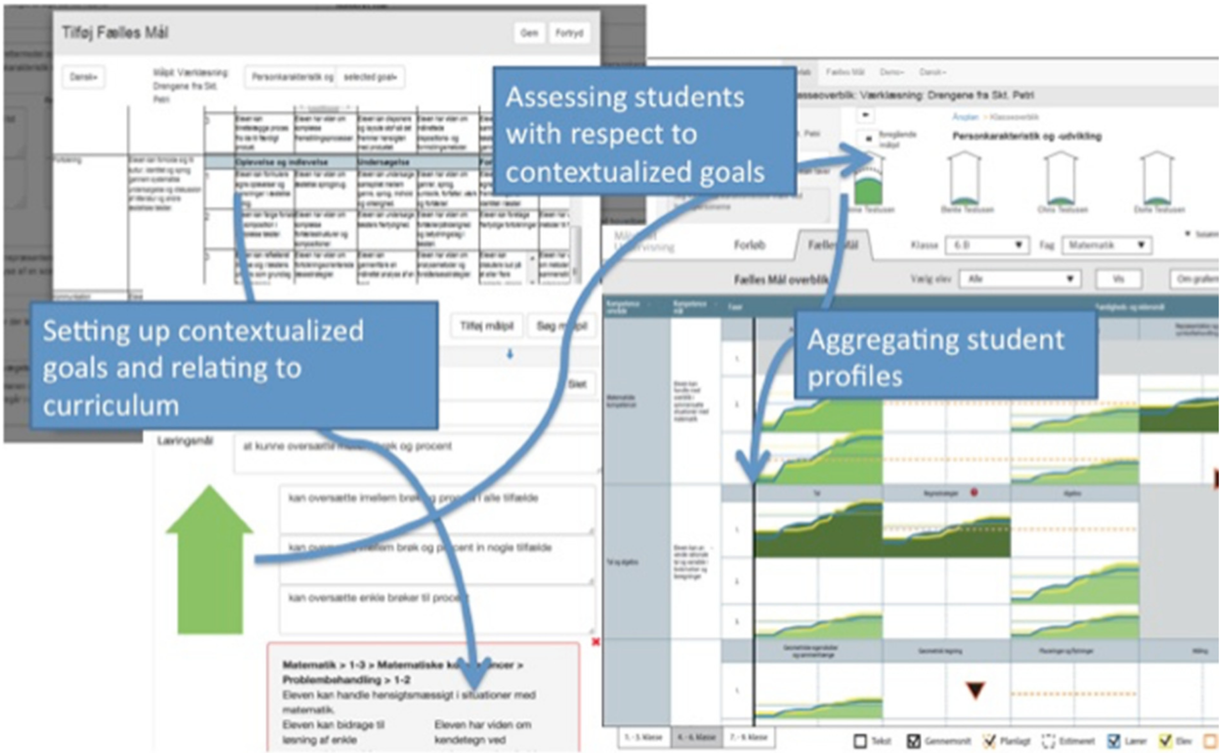


Fig. 3. The functionality of the Goal Arrow. The left side of the figure shows how teaching is planned by setting up learning objectives and relating them to the national curriculum standards. The right side shows how the learning objectives are evaluated and how this information generates a profile for comparison against the curriculum standards.

3. Development of a digital infrastructure: the goal arrow

The context of this study is a design-based research project developing and testing the Goal Arrow tool, which supports teachers' work with objective-oriented teaching using the new Danish national curriculum standards. The tool was designed to help teachers express their own learning objectives for a class, articulate how these objectives relate to the national curriculum standards, and evaluate students' progress in relation to the defined teacher objectives and the national curriculum standards (Misfeldt, Bundsgaard, Slot, Hansen, & Jespersen, 2015).

Teachers' workflow of planning and conducting lessons with the Goal Arrow begins with choosing learning objectives or Goal Arrows (bottom left of Fig. 3) and relating them to the Danish curriculum standards in a popup window (top left of Fig. 3). Each learning objective can then be evaluated on the level of individual pupils (top right of Fig. 3). This input is used to create an overview of the extent to which national curriculum standards are met on both an individual and a class-wide level (lower right of Fig. 3).

The Goal Arrow was designed to support teachers in choosing local learning objectives and using the national curriculum standards to maintain and oversee pupils' performance. It was also intended to provide a structured way of working with the national curriculum standards without imposing the curriculum standards to such a high degree that the teacher loses autonomy in planning and conducting lessons. The Goal Arrow thereby integrates the learning objectives from the national curriculum and provides teachers with a structure to interpret and organize these objectives. With regard to this structure, we consider the Goal Arrow a mediator of the curriculum standards.

The Goal Arrow is designed to be used by both teachers and students. Teachers can use it to plan lessons and particularly to choose learning objectives for a lesson or a sequence of lessons. They can use these objectives in their assessment of the students and to generate an overview of student performance over a period of time and in accordance with a specific set of learning objectives. These objectives are the teachers' interpretation of the national curriculum that thereby work as proxies for the objectives in the national curriculum.

In the student interface of the Goal Arrow, students can view the specific learning objective they are working with in ongoing lessons, and they can follow their progress over time according to the learning objectives specified by the teacher. In this sense, one of the aims of the Goal Arrow is to provide with information about the purpose and objective(s) of the activities and lessons in which they were engaged.

It is important to note that neither teachers nor students at any time in the project were held accountable for their work in or with the Goal Arrow. From the outset, the Goal Arrow design was that only teachers and students (and not school management) would have access to the content in the platform; however, the researchers involved in the project could extract data from the technology for research purposes. Teachers could however use the tool to monitor whom of their students might be lagging behind with regard to specific areas of the curriculum.

4. Theoretical framework, research question and approach

In this paper, we analyze a case from the project described above. Before we describe this case, we will introduce in some detail the theoretical frameworks that the case helps us contrast and compare. These frameworks have been developed within two fields of research: studies of the relationship between teachers' work and curriculum standards and studies of the role of resources in teachers' work.

4.1. Curriculum standards, rules and teachers work

We distinguish between curriculum standards and curriculum materials in the following way. Whereas we consider curriculum standards to be a more general term that refers to the legal documents that describe the content and/or learning objectives in compulsory schools, we consider curriculum materials to be various textbooks, instructional resources, and other resources used by teachers in their daily teaching. In most cases, the legal foundation for teachers' work is rooted in some form of curriculum standards, which are always designed to influence teaching and learning (Egan, 1978). For this reason, curricula design is based on ideas about how teachers should use curriculum, but these ideas may be different among curricula from different contexts (Biesta, Priestley, & Robinson, 2015). The fact that conceptions of curriculum use is reflected in curriculum design is clearly illustrated in the analyses of Westbury (1998) who argues that such contrasts among different perspectives on curriculum use can be seen between the American and the German curriculum traditions (both from the 19th century). According to Westbury, a centrally developed curriculum was focal in building a school system from scratch with limited access to well-educated teachers in America in the 19th century. Hence, what Westbury (1998) refers to as the American curriculum described in detail what should be taught, the order in which it should be taught, and how it should be taught, positioning teachers as members of the workforce in an industrialized school organization. In the German tradition, by contrast, teachers were expected to interpret the curriculum and make decisions concerning what was appropriate to teach and how in their specific contexts. This perspective of teachers as autonomous interpreters of the curriculum is reflected in Germany's suggestive curriculum (Westbury, 1998).

This example shows how curriculum design is linked to conceptions of the use of curricula and ideas about teachers' work and professionalism. In line with this thinking, recent research has criticized the international trend of object-oriented curriculum reforms[2], which the Danish reform exemplifies (Biesta et al., 2015). This critique suggests that objective-oriented curricula inflict teachers with performative pressure to steer their teaching towards externally pre-defined learning objectives (Biesta et al., 2015). Therefore, it is argued, the agents of change in such curriculum reforms are the curriculum standards themselves and not the teachers who are instead reduced to mere curriculum implementers (Biesta et al., 2015). In this sense, objective-oriented curricula can be seen as new public management versions of the American curriculum tradition.

The influences of curriculum design, structure, and content on teachers' work is not, however, direct or causal as it, to some extent, is suggested by the literature mentioned above. Like any other "technology," curricula are brought into *use* by people and organizations (e.g., schools, teachers, classrooms, and students) with intentions and cultural norms. Remillard (2005) however showed that the literature on mathematics teachers' use of curricula is often vague or implicit in its conceptualization of this problem, as the term "curriculum use" can refer to very different conceptions of a relation to a curriculum (e.g., "subverting to," "drawing on," "interpreting," or "participating with"). Based on the findings of her review, Remillard (2005) suggested conceptualizing curriculum use as a *participatory relationship* between the teacher and the curriculum that includes the elements in the model below.

This framework acknowledges elements like the voice and look of a curriculum as important factors, but it also accounts for the beliefs, knowledge, and perceptions of the teacher and the context in which the curriculum is used as factors that shape, constrain, or contribute to teacher–curriculum interactions (Remillard, 2005). The voice of a curriculum is "how the authors or designers are represented and how they communicate with the teacher and the students" (Remillard, 2005, p. 233). As Remillard (2005) showed, the voice of a curriculum can manifest through certain grammatical structures that enforce authority. In this paper we use the notion of voice in a more general manner as we do not assume that the voice resides exclusively in the curriculum, but might also appear in the technology mediating the curriculum, in this case the Goal Arrow.

The framework also distinguishes between planned and enacted curricula, acknowledging these as related but fundamentally different. In so doing, the framework provides a nuanced approach that allows us to investigate teachers' use of curricula as an interaction shaped by both the teacher and his/her context and the characteristics of the used curriculum.

4.2. Resources and teachers' work

The second theoretical framework used to analyze the case is the approach entitled documentational genesis, which was developed to study teachers' appropriation, selection, and design of teaching resources, considering the resources and their usage in this process. This framework is informed by instrumental genesis (Rabardel & Bourmaud, 2003) and extends this theory's distinction

[2] By objective-oriented curriculum reforms, we refer to curriculum reforms that foregrounds learning objectives rather than the content of the curriculum.

between artifacts and instruments (Rabardel, 1995) by a distinction between resources and documents (Gueudet & Trouche, 2009). Rabardel and Bourmaud (2003) defined an artifact as a cultural social construct that offers mediations of human activity, while an instrument was defined as the product of a subject's use of the artifact for certain activities with a certain objective. The idea is that an artifact becomes an instrument when it is used by a subject. This process is called instrumental genesis and both results in a change in the mediating artifact and the activity the artifact is used for. These two opposite processes (the shaping and the being shaped) are referred to as instrumentation and instrumentalization (Haspekian, 2005), which is the process in which the subject's use of an artifact shapes the artifact, while instrumentation is the process where the artifact shapes the subject's activity (Gueudet & Trouche, 2009).

Whereas artifacts and instruments mainly have been used to study the relation between technology and students mathematical work, the conception of resources in documentational genesis is broad and includes teaching materials, national curriculum standards, student products, and collaborations with other teachers (Gueudet & Trouche, 2009, p. 200). When teachers combine one or more resources for a particular didactical use, this process yields a document (Gruson, Gueudet, Le Hénaff, & Lebaud, 2018). As in instrumental genesis, teachers' work with resources in what is considered a dialectical process in which a teacher's work may modify or influence both the resource used (instrumentalization) and the ways in which the resource influences the teachers' way of performing tasks (instrumentation) (Gueudet et al., 2016). Documentational genesis thereby foregrounds the interactions between teachers and resources, with a particular focus on how both teachers and resources are transformed by their interactions with one another (Visnovska, Cobb, & Dean, 2012). We consider this approach as a theoretical framework within the field of curriculum ergonomics as it allow us to investigate the interaction between the design and use of curriculum resources (Choppin et al., 2018).

In this paper, the documentational genesis does not require a clear *a priori* distinction between curricula and learning platforms; rather, it focuses on what resources (curricular or digital) the teacher uses and how the use of these resources is instrumentalized and instrumented. By incorporating Remillard's (2005) concept of curriculum use, we are also able to account for how a teacher's beliefs, knowledge, and interpretation of the curriculum shape, constrain, or in other ways contribute to this process and, thus, to the enactment of curricular rules and resources.

Building on the knowledge tradition described above, we thereby consider the relation among curriculum standards and digital platforms in the work of teachers as an interplay between the voice of the curriculum and of the digital platform and a documentational genesis process. By doing so, we are able to investigate how the voice of the curriculum is integrated and represented in the digital platform used by the teacher, and how this influence the teachers' interaction with curriculum resources.

4.3. Research question

The overall purpose of our research is to understand the processes involved in teachers' use of technology that mediates curriculum standards. More specifically, we aim to investigate one teacher's adoption of the Goal Arrow in a case where he changes the learning objectives after teaching the lesson. In relation to this case we will answer the following questions:

1 Which instrumentations and instrumentalizations occur when this teacher interacts with the curriculum through the specific digital learning platform used? What is the relationship between the teachers' documentation work and his participation with the curriculum through a digital learning platform?
2 Building on this case, we then ask how the technological and legislative aspects of the use of resource systems interacts and develops a theoretical understanding of digital learning platforms that mediate national curriculum standards.

We believe the answers to these questions can shed light on what we consider a blind spot in the documentational approach, while also allowing us to discuss an emerging type of technology (at least in Denmark) for implementing curriculum standards and using these aspects to structure teachers' work and collaboration.

Our strategy towards answering the questions is in one sense developed around one specific incident that happened in relation to testing the Goal Arrow. Informed by the theoretical terms defined above, we have analyzed one teacher's experience using the Goal Arrow by identifying instrumentations and instrumentalizations. Subsequently, we investigated the genesis and the locus of these processes to explore what caused them and where they happened. Furthermore, we consider the planned and the enacted curricula as two related but spatially and temporally different processes. We used the distinction between these processes to qualify the temporal aspect of the teacher's interaction with the platform throughout planning lessons, teaching them, and evaluating and redesigning them. This distinction worked as an approach to identify changes and the causes of these changes between the planned and the enacted curriculum in the case.

On the methodological level, this means that we are conducting a critical case study (Flyvbjerg, 2006) in order to support a theoretical discussion enriching our understanding of possible interplays between technological and legislative aspects of learning platforms that mediate national curriculum standards. According to Flyvbjerg (2006), p. 230), a critical case can be defined as "having strategic importance in relation to the general problem." In contrast to randomly selected cases, a critical case is chosen from circumstances that are either particularly favorable or particularly disadvantageous. The case used in this paper is critical in the terminology of Flyvbjerg (2006)) in that it is generated within a project where the participating teachers worked with digital platforms under the best thinkable conditions; they had time specifically allocated to get to know and work with the digital platform, they had access to extensive support from both their colleagues and expert researchers, and they had a positive predisposition toward the platform. These are all conditions that we deemed necessary to avoid many other issues that are known to lead to dissatisfaction with the use of platforms (De Smet, Bourgonjon, De Wever, Schellens, & Valcke, 2012; Selwyn, 2011; Underwood & Stiller, 2014).

According to Flyvbjerg (2006), p. 231), critical cases allow for generalizations of the sort; "if it is valid for this case, it is valid for all (or many) cases." For us it is enough to recognize that it is valid for some cases. The logic of the critical case chosen for this paper is thereby that the difficulties experienced by this teacher are possible among teachers in other contexts. This characteristic makes the critical case a solid foundation for theory building.

4.4. Example Case: the legitimacy of changing learning objectives

The case from which we build the theoretical points of this paper occurred in the 2014–2015 school year, which was at the beginning of the school reform and the changes described above. The context was the described Goal Arrow research and development project. The interventions in the project were conducted a year after the breakdown in negotiations between the teachers' union and local Danish governments and the first year in which the new curriculum standards produced by the school reform were available. Over a period of three months, the teachers experimented with using the Goal Arrow tool. The support was organized as seven meetings with the same group of 7–15 teachers and two or three researchers. Each meeting lasted three hours, and the main content of the meetings was preparation and evaluation of teaching using the Goal Arrow tool.

This paper adds to the knowledge already generated in the project by using a case of a teacher's experience of using the Goal Arrow to develop theoretical understandings of the relationship between teachers, resource systems, and digital platforms. The specific case used in this paper is based on an incident observed by one of the authors of this paper at a meeting held during the project at one of the participating schools. At the meeting, a teacher expressed uncertainty about whether his decision to change learning objectives and indicators of learning in the middle of a course was legitimate. The case was documented through an interview with the teacher who has approved our description of the situation used in this paper.

At a meeting held during the project, a teacher who participated in the project shared that he had "cheated" in his use of the Goal Arrow, but that he felt that it was necessary in the given situation. This led to an on-site interview with the teacher in an effort to understand the experience of "cheating" the system. The interview was recorded and summarized. In the following excerpt, the main aspects of the teacher's experience are described (translated from Danish). The teacher expressed that he had to change the learning objectives along the way. He was unsure whether it was okay, but found it necessary to do so. The interesting thing about the case is that the teacher was unsure whether it is okay to change characters and goals when he comes into contact with reality, thus denying the processes that take place in the class and "go with the flow" as he says. (This description has been approved by the teacher and has since been documented by interview.)

The teacher in question works in an inquiry-based learning tradition, and it is thus not uncommon for him work with more or less open-ended activities. By inquiry-based teaching, we refer to collaborative and exploratory, student-driven activities, where students use mathematics to critically engage in everyday problems (Artigue & Blomhøj, 2013). Open-ended activities refer to the fact that the teacher has not predefined a given path for the student learning, but that his/her main work is to support the student-driven activities (Bruder & Prescott, 2013). The topic in question in this case was a lesson the teacher had recently taught in which his students (approximately 12 years old) were working on a project based on developing mathematical board games (inspired by the Creative Digital Mathematics project) (Misfeldt & Zacho, 2016). Prior to the lesson, the teacher had planned the teaching sequence by using the Goal Arrow to write the lesson content and learning objectives. The teacher had imagined that, during the lesson, the students would develop games and make rules for the games that somehow related to the coordinate system. He had decided that the lesson should focus on developing the students' mathematical communication competencies and that the students' development of game rules could be understood by others and would address this objective. Prior to the lesson, therefore, the teacher specified an overall learning objective and specific learning objectives on three differentiated levels (see Fig. 5[3]).

However, as the students worked on their games, the teacher found that their work took an unexpected turn. Specifically, the students began to design adaptations to the game, Battleship. This trend spread throughout the class, first without the teacher's interference, but later with his endorsement. The students became interested in developing in-game mathematical innovations, such as an x-laser that cleared a whole row and a quadrant bomb that cleared an entire quadrant (see Fig. 5).

In response to this trend, rather than sticking to his original learning objectives, which related poorly to the students' approach to the task, the teacher acknowledged the students' innovative approach to developing Battleship and supported the students by teaching them about the coordinate system. Because of this, after the lesson had been carried out, the teacher decided to change both the indicators of learning and parts of the original learning goal. The new learning goal was as shown in Fig. 6.

It was the legitimacy of this change that the teacher expressed uncertainty about during the meeting. This was in spite that the documentation templates from the school where the teachers work showed that he had considered the teaching sequence to be a success and subsequently distributed this lesson plan to his colleagues upon their request.

Further, the teacher explained that he considered the new learning objectives to be "better" and more accurate than the old ones—both in the sense that they are more aligned with the actual outcome and in the sense that they suggest a more genuine and valuable mathematical outcome. One can of course challenge the idea that the lesson is successful because a first approximation of a successful lesson might be that this is a lesson where the objectives are met. But using such a definition would not be aligned with teachers experience and articulation, and furthermore, it would make the problem that case illustrates, namely the doubts that may arise concerning the legitimacy of changing learning goals if a lesson takes an unexpected direction, disappear. When asking if the teacher should stick to the same goal throughout the course or if it is legitimate to adjust the course, goals, and specific goals along

[3] Retrieved from https://www.emu.dk/omraade/gsk-l%C3%A6rer/ffm/matematik/4-6-klasse/matematiske-kompetencer-obligatorisk

the way or even after the lesson, we cannot define success as sticking to the initial learning objectives.

4.5. Differences in conceptions of learning objectives

In the above case, the teacher seemed to be under the impression that using learning objectives for teaching required him to follow certain kinds of rules and that redefining the learning objectives after the lesson was “cheating.” Before we proceed to a more detailed analysis of this case, we find it important to stress that not every teacher experienced the same conceptions. The results of both the survey and the interview study showed remarkable differences in teachers’ experiences with and interpretations of working with learning objectives. This was particularly evident in a strong polarization between teachers who considered the curriculum and learning objectives to have a negative impact on their teaching and those who perceived a positive impact (Hansen & Petersen, 2018). While such a significant divide might seem odd, the qualitative interviews provided the important insight that the teachers in the project had rather different interpretations of the curriculum standards, what a learning objective is, and how curriculum standards-based learning objectives should be used (Carlsen et al., 2016). While some teachers considered learning objectives to represent clear, predefined, and unchangeable statements of what students should know or be able to do after a lesson, others viewed them as preliminary aims that set an initial direction for their teaching, but that might be changed over the course of a lesson (Misfeldt & Tamborg, 2016). These conceptions raised divergent opinions regarding whether the learning objectives in the new curriculum restrained teachers’ opportunities to deviate from how a lesson had been planned (Misfeldt & Tamborg, 2016) or increased teachers’ awareness of when a change of plans was needed (Carlsen et al., 2016). It seemed that it was these different conceptions of learning objectives that led to the divergent experiences among the teachers identified in the survey. According to Remillard (2005), the term curriculum can be understood as a participatory relationship where the teacher uses a curriculum by *interpreting* it in a particular way.

The teacher and the case presented above provides an interesting situation as this teacher’s beliefs about good teaching collides with his conception of learning objectives and the inherent rules of using them. On the one hand, he felt the need to modify his teaching according to how the students’ engaged in the lesson. On the other hand, the was under the impression that using learning objectives involved complying with a certain set of rules. Thus, the case points to the importance of investigating teachers’ conceptions of what rules or intentions underlie the technology and resources they use. We will explore this phenomenon in more detail as we analyze the case and investigate the relationship between the studied teacher’s documentation work and his interpretations of the rules and regulations of the curriculum.

5. Understanding the case as resources, enactment, and rules

In his planning of the lesson, the teacher designed a lesson in the Goal Arrow that included the activity of creating board games using the coordinate system, using the national curriculum standards relating to mathematical communication and geometry as a resource. Using the Goal Arrow interface, the teacher linked (1) his planned activity, (2) his envisioned outcome, and (3) the national curriculum standards (illustrated in Fig. 4). This can be viewed as a process of instrumentalization in which the teacher incorporated both a tool (the Goal Arrow) and a curriculum (the national curriculum standards) to plan a specific activity not inherently described by either the tool or the curriculum.

Furthermore, this situation of planning illustrates a specific way of complying with objective-oriented teaching. In objective-oriented teaching, as described by the Danish Ministry of Education, teachers should move from considering what students should *do* to considering what students should *learn* (Undervisningsministeriet, 2015). The Goal Arrow is designed to support teachers in interpreting and re-articulating generic curriculum standards into more concrete learning objectives.

By combining activities and resources (left side of the screen) with goals and curriculum standards (right side of screen), the Goal Arrow planning interface invites a dialogue between student activities and learning objectives, rather than a dogmatic objective orientation. Hence, the documentational genesis that we see in the planning phase has several positive features. This is the case as the platform supported the teacher’s use of learning objectives to qualify his choice of which tasks and resources to include in the lesson. The teacher’s planned game design activity was mediated by the Goal Arrow and qualified by the specified learning outcomes and

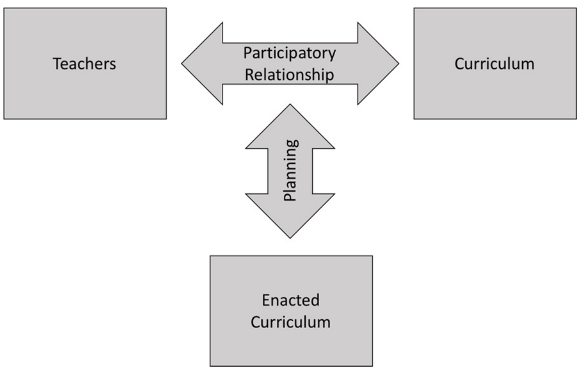
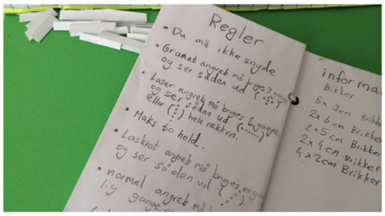


Fig. 4. The participatory relationship between teacher and curriculum, according to Remillard (2005), p. 235).

Overall objective: The students should develop a game to be used by the other students in the class that builds on knowledge about the coordinate system.
1) The game should be playable by fellow students under the guidance of a student from the group that made the rules.
2) The game should be playable with a combination of support from a person from the creating group and from the written rules.
3) The game should be playable by another group based simply on written rules in the form of a guide.



Student-written rules

- You may not cheat.
- Grenade attacks can be used 3 times and look like this [illustrative dots].
- Laser attacks can be used 2 times and look like this [illustrative dots] or [illustrative dots] the entire row.
- Maximum 2 teams
- Laskrot attacks can be used once and looks like this [illustrative dots].
- Regular attacks can [...]

Fig. 5. (A) The Goal Arrow made by the teacher prior to the teaching sequence. These three goals addressed the overall national standard that “Students can act appropriate in situations involving mathematics”. (B) An example of rules the students developed that led the teacher to revise the lesson objectives.

Overall objective: The students should be able to apply their knowledge of coordinate systems by developing and testing a game.
1) The rules of the game should enable players of the game to apply their mathematical knowledge of the coordinate system when playing.
2) The pupils themselves should develop and adjust game rules to create their own rules based on their mathematical knowledge of coordinate systems.
3) The students should be able to understand how the rules influence the gameplay.

Fig. 6. The Goal Arrow made by the teacher after the teaching sequence.

relations to curriculum standards.

In practice, the pupils engaged with the teacher's plan in a way that differed from his expectations. Instead of focusing on communicating the rules of their board games, they became deeply engaged in creating innovative adaptations of the Battleship game using and challenging their knowledge about coordinate systems. This means that the core of the students' discussions came to revolve around the coordinate system, which was not anticipated by the teacher.

This approach was highly mathematically relevant, but was not foreseen by the teacher and, hence, did not fit the learning objectives the teacher specified when he planned the lesson. Changing the learning objectives along the way according to experiences in the classroom have long been considered a common part of an iterative approach to teaching where a teacher begins with one learning objective before a lesson and modifies or specifies this objective after the lesson (Smith & Stein, 2015). However, this case illustrates that the Goal Arrow makes it difficult for the teacher to engage in this iterative process. This is because he believes that changing the objectives in the Goal Arrow is cheating.

The teacher's response to the students' innovative approach to the lesson was to "go with the flow" and change the design of the lesson according to what he considered to be meaningful in the situation. The documentational genesis in the enactment phase, hence, involved the teacher instrumentalizing (ie. the teacher modifies the rules of Battleship to correspond to the mathematical goals) the students' work with the Battleship game to teach specific aspects of the coordinate systems not included in the initially planned curriculum. Specifically, this related to expressing subsets of the plane (points, diagonal, horizontal and vertical lines) using coordinates and equations. In this process, the students' unanticipated approach to the planned lesson constituted a resource that the teacher used to change both the course of the lesson and the plan in the Goal Arrow. The teacher's insecurity concerning the legitimacy of this action, however, provides us with interesting insights.

At first glance, the case appears to simply illustrate the difference between a planned and an enacted curriculum, which is a recognized distinction in the research literature (Remillard, 2005). The lesson took an unplanned direction, but was still well conducted in the sense that the students were highly engaged in meaningful mathematical activities, the teacher considered the lesson to be successful and that the teacher successfully distributed the lesson plan to his colleagues. Similar unanticipated situations happen every day in classrooms, and the difference between planned and enacted curriculum is accepted by most teachers. In this sense, the teacher's insecurity is difficult to interpret, and could be just a coincidence that had little to do with the learning platform. However, when we examine the case in more detail, both technical and legislative aspects of the situation offer explanations of the teacher's reaction. The case suggests that the platforms mediation of curriculum standards and outcome-oriented pedagogy has everything to do with the confusion in this specific example.

On a technical level, the planning and enactment phases of the Goal Arrow are connected through an active evaluation of students' performance in relation to planned learning objectives. In this sense, the Goal Arrow hardwires the relations among planned, enacted, and evaluated objectives and even connect these to the national curriculum standards. Though the intention of the Goal Arrow is to support teachers in keeping track of their plans, the example suggests that this might lead to an unintended instrumentation that constrains the teacher's ability to embrace and assign value to aspects of the enacted curriculum that are not specified in the planned curriculum. In other words, the Goal Arrow, in the case presented here, inhabits a voice that leads the teacher to believe that the objectives are final and imperative. The fact that such interpretation has happened in one specific instance says little about how pervasive the problem is or if the problem is relevant in other technological contexts. There are, of course, technical ways to address for this problem in relation to the specific Goal Arrow software (for example, it is possible to make a posteriori learning objective and results as an integrated part of the teacher workflow). However, the case offers the insight that learning platforms that specify relations among planned, enacted, evaluated, and valued curricula in ways that affect documentational genesis and can lead to unforeseen and unwanted instrumentations of teachers' work.

On the legislative or political level, the focus of both the national curriculum standards and the ministry on objective-oriented teaching also suggests an explanation for the teacher's insecurity. Though these aspects are important factors, we do not find them sufficient to explain the case presented in this paper. The teacher's experience of having to follow certain rules when using the Goal Arrow could be considered an instrumentation of the teacher's work caused primarily by objective-oriented teaching, rather than the technical implementation of the Goal Arrow. However, instrumentation is a process that is commonly described as caused by the *properties* of resources[4] (Verillon & Rabardel, 1995), which is not entirely the case in the studied situation. One can ask if the presented case comprises a good example of a critical case, and if so, what this means in terms of the conclusions that we can build on it. The specific incidence is of course rather unique, but a number of new technologies mediate political decisions about curricular issues in school, and hence that the interplay between legislative and technological aspects of such technologies can be complex and unforeseen is very likely to happen in other techno-political constellations since the existence and implementation of such technologies is a likely consequence of digitalization, automation, and technological support for the documentation work. In that sense, the case can act as a critical case for the problem of technological mediation of curriculum standards and other types of rules and regulations in schools. The case is relatively sparse in the data and information that we have provided; however, it is clear in the problem that the teacher experienced. This problem is then used for comparing and contrasting theoretical categories.

The results of the survey and interview conducted in the context of the research and development project from which the case

[4] Verillon and Rabardel (1995) argued that artifacts (as opposed to natural objects) possess cultural and historical dimensions because they are constructed with a particular purpose and a particular way of fulfilling this purpose in mind. For this reason, they argued that the design of an object, and thereby its properties have inherent possibilities and limitations related to conducting a task, which has implications for the activity in which it is used.

originated suggests that objective orientation and learning objectives are concepts that teachers interpret in many different ways (Misfeldt, 2016). Hence, what instruments a given teacher uses is largely dependent on his understanding of and priorities in relation to all available resources, including objective-oriented teaching, learning objectives, and national curriculum standards. These interpretations cannot be understood without considering the technologies that mediate such curriculum standards. The case in this paper indicates that integrating the Goal Arrow into a teacher's resource system can have constraining implications of the teacher's engagement with other elements of the resource system. This is an example of how the voice of the Goal Arrow instrumented the teacher's interpretation of the inherent rules at play when using the curriculum. The voice of a curriculum refers to how curriculum authors and designers are represented in the curriculum and, in particular, how they communicate with the teacher. In this case, the voice of the Goal Arrow prompts a dogmatic interpretation of objective-oriented teaching suggesting that the teacher should specify learning outcomes prior to teaching and prioritizes a focus on those intended outcomes over a focus on other meaningful outcomes that might emerge during enactment of the activities. This voice of the Goal Arrow is in concert with the voice of curriculum standards that suggest targeting predetermined descriptions of skills, knowledge, and competencies within a given area of mathematics. In the focal case, these voices worked in harmony with the voice of the Goal Arrow to suggest precise and predetermined relations among learning objectives, curriculum standards, and learning outcomes that resulted in the teacher's concerns regarding an illegitimate teaching practice.

6. Conclusion

The main purpose of this paper has been to answer the two following research questions:

1 Which instrumentations and instrumentalizations occur when teachers interact with a curriculum through a digital learning platform?
2 What is the relationship between teachers' documentation work and their participation with the curriculum through a digital learning platform?

We have explored these questions by studying a teacher's use of a digital platform to support a mathematics teacher's work in planning, conducting, and evaluating teaching. Analyzing a case from a large-scale project showed how the platform instrumented a teacher's activities in an unintended way by suggesting that the teacher's well-functioning teaching process was not legitimate. The reason for this instrumentation is not solely technical, and we have used the concept of the voice of the platform to describe both the political intentions that have been built into the digital platform and the Danish national curriculum standards, which translates into specific requirements of conducting objective-oriented teaching. The voice of the Goal Arrow suggests that the teacher needs to specify learning objectives prior to instruction and evaluate the lesson according to those *a priori* objectives, which made it difficult for the teacher to modify the lesson according to the experiences in the classroom. We have both seen examples of instrumentations and instrumentalizations. Regarding instrumentalizations, the teacher managed to link the planned activity with his envisioned outcome and the national curriculum standards. In this process, he incorporated both a tool and a curriculum to plan a specific activity not inherently described by either the tool or the curriculum.

However, we also saw that technical structures and political regulations work together to instrument the teacher's work in a way that make it difficult to fully understand the consequences. In this sense, the paper has identified a critical aspect of curriculum ergonomics and showed how interactions between design and use of curriculum resources may be affected by the political intentions of a curriculum as they are integrated and represented in technical infrastructure. The analysis is based on a case, and even though secondary data is included, the situation calls for more focused data collection and analysis on the interplay between platforms and regulations such as national curriculum standards. This phenomenon also suggests a theoretical potential in relation to the ergonomics of curriculum resources by extending the thinking around the relation among documentational genesis and the notion of voice in teachers' work with digital technologies that mediate curriculum standards or curriculum resources. This would contribute to understanding the implications of technologies such as learning platforms on teachers' work with resources. Documentational genesis and instrumental genesis, the latter of which is a main theoretical foundation for documentational genesis, have the advantage of not reducing artifact-mediated activities to one-sided processes that over-emphasize the importance of either the properties of the artifact or the actions of the subject. However, when the technologies of the mathematical classroom become loaded with the legislative and political intentions of national curriculum standards, we must augment the sensitivity of the documentational genesis towards the dialectics between material and activity to also cover the dialectics between legislative foundations and teachers' plans, enactments, and evaluations. In this article, using Remillard (2005) concepts of planned and enacted curricula and curriculum voice, we have attempted to use the documentational approach to understand an example of such a learning platform.

References

Artigue, M., & Blomhøj, M. (2013). Conceptualizing inquiry-based education in mathematics. *Zentralblatt für Didaktik der Mathematik, 45*(6), 797–810.
Biesta, G., Priestley, M., & Robinson, S. (2015). *Teacher agency: An ecological approach.* London, UK: Bloomsbury Academic.
Bruder, R., & Prescott, A. (2013). Research evidence on the benefits of IBL. *Zentralblatt für Didaktik der Mathematik, 45*(6), 811–822.
Carlsen, D., Hansen, R., & Tamborg, A. L. (2016). Læreres målforståelser. (Teachers' understanding of learning objectives). *Læremiddel. dk*.
Choppin, J., Roth McDuffie, D. A., Drake, C., & Davis, J. (2018). Curriculum ergonomics: Conceptualizing the interactions between curriculum design and use. *International Journal of Educational Research.* Published online September 29th at https://www.sciencedirect.com/science/article/pii/S0883035518305603.
Danmarks Evalueringsinstitut (2016). *Implementering af digitale læringsplatforme: De første erfaringer [Implementation of digital learning platforms: The first experiences].*

Retrieved fromhttps://www.eva.dk/sites/eva/files/2017-08/Implementering%20af%20digitale%20laeringsplatforme.pdf.
De Smet, C., Bourgonjon, J., De Wever, B., Schellens, T., & Valcke, M. (2012). Researching instructional use and the technology acceptation of learning management systems by secondary school teachers. *Computers & Education, 58*(2), 688.
Egan, K. (1978). What Is Curriculum? *Curriculum Inquiry, 8*(1), 65–72 Taylor & Francis Ldt.
Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry, 12*(2), 219–245.
Freeman, A., Adams Becker, S., Cummins, M., Davis, A., & Hall Giesinger, C. (2017). *NMC/CoSN horizon report: 2017 K–12 edition*Austin, TX: The New Media Consortium.
Gruson, B., Gueudet, G., Le Hénaff, C., & Lebaud, M.-P. (2018). Investigating teachers' work with digital resources. A comparison between teaching mathematics and English. *Revue suisse des sciences de l'éducation, Société suisse pour la recherche en éducation (SSRE) (Swiss Journal of Educational Sciences) (Fribourg), 40*(2).
Gueudet, G., & Trouche, L. (2009). Towards new documentation systems for mathematics teachers? *Educational Studies in Mathematics, 71*(3), 199–218. https://doi.org/10.1007/s10649-008-9159-8.
Gueudet, G., Pepin, B., Sabra, H., & Trouche, L. (2016). Collective design of an e-textbook: Teachers' collective documentation. *Journal of Mathematics Teacher Education, 19*(2), 187–203. https://doi.org/10.1007/s10857-015-0331-x.
Hansen, T. I., & Petersen, C. K. (2018). Måling af læringsmål. [Measurement of learning objectives]. *Kognition og Paedagogik, 28*(107), 22–39.
Haspekian, M. (2005). An "instrumental approach" to study the integration of a computer tool into mathematics teaching: The case of spreadsheets. *International Journal of Computers for Mathematical Learning, 10*(2), 109–141. https://doi.org/10.1007/s10758-005-0395-z.
Hattie, J. (2009). *Visible learning: A synthesis of over 800 meta-analyses relating to achievement.* London, UK: Routledge.
Jørnø, R. L. V., & Gynther, K. (2018). Hvordan kan teknologi påvirke pædagogiske og didaktiske praksisser? En analyse af en case vedrørende implementeringen af digitale læringsplatforme i Folkeskolen [How can technology influence pedagogical and didactical practices? An analysis of a case concerning the implementation of digital learning platforms in the primary and lower secondary compulsory school]. *Læring og Medier [Learning and Media], 10*(18), 1–20.
Krogh, E., & Holgersen, S. E. (2016). Forord. [Preface]. *Cursiv, 1*(19), 5–9.
Mathiasen, A. (2017). *Søren og Mette i benlås [Søren and Mette in a leg lock].* Denmark: Copenhagen: Politikens forlag.
Misfeldt, M. (2016). *Digitalt Understøttede Læringsmål: Udviklingsprojekt med demonstrationsskoleforsøg vedr. it i folkeskolen (Slutrapport) [Digitally supported learning goals: Development project with demonstration school experiments concerning IT in the primary and lower secondary compulsory school (End rapport)]* (1st ed.). København: Institut for Læring og Filosofi, Aalborg Universitet.
Misfeldt, M., & Tamborg, A. L. (2016). Læringsmålstyret undervisning og målforståelser—statiske og dynamiske mål [Learning goal oriented teaching and goal understanding - static and dynamic goals]. *Cursiv, 1*(19), 113–139.
Misfeldt, M., Bundsgaard, J., Slot, M. F., Hansen, T. I., & Jespersen, M. (2015). A digital tool supporting goal-oriented teaching in classrooms. A. Jefferies, & M. Cubric (Eds.). *Proceedings of 14th European Conference on e-Learning eCEL-2015,* 388–395.
Misfeldt, M., Tamborg, A. L., Qvortrup, A., Petersen, C. K., Svensson, L.Ø., Allsopp, B. B., et al. (2018). Implementering af læringsplatforme: Brug, værdier og samarbejde [Implementation of learning platforms: Use, values and collaboration]. *Læring og medier [Learning and media], 10*(18), 1–21.
Misfeldt, M., & Zacho, L. (2016). Supporting primary-level mathematics teachers' collaboration in designing and using technology-based scenarios. *Journal of Mathematics Teacher Education, 19*(2–3), 227–241. https://doi.org/10.1007/s10857-015-9336-5.
Niss, M., & Højgaard, T. (2011). *Competencies and mathematical learning: Ideas and inspiration for the development of mathematics teaching and learning in Denmark.* Roskilde: IMFUFA: Roskilde university (red.) IMFUFAtekster, Nr. 485.
OECD (2016). *The definition and selection of key compentencies (DeSeCo) Executive Summary.* Retrieved fromhttp://www.oecd.org/pisa/35070367.pdf.
PISA (2012). *Assessment and analytical framework: Mathematics, reading, science, problem solving and financial literacy.* 2013Paris: OECD.
Rabardel, P. (1995). *Les hommes et les technologies; une approche cognitive des instruments contemporains [Humans and technologies: A cognitive approach for contemporary instruments].* Paris, FR: Armand Colin.
Rabardel, P., & Bourmaud, G. (2003). From computer to instrument system: A developmental perspective. *Interacting With Computers, 15*(5), 665–691. https://doi.org/10.1016/S0953-5438(03)00058-4.
Remillard, J. T. (2005). Examining key concepts in research on teachers' use of mathematics curricula. *Review of Educational Research, 75*(2), 211–246. https://doi.org/10.3102/00346543075002211.
Rømer, T. A. (2018). *A critique of John Hattie's theory of visible learning. Educational philosophy and theory*1–12. https://doi.org/10.1080/00131857.2018.1488216 published online June 25th at.
Selwyn, N. (2011). 'It's all about standardisation' – exploring the digital (re)configuration of school management and administration. *Cambridge Journal of Education, 41*(4), 473.
Skovmand, K. (2017). *I bund og grund—lærerprofessionens didaktik? [Basically - The teaching profession's didactic?] (Doctoral dissertation).* Retrieved fromDenmark: DPU, Aarhus University. https://www.statsbiblioteket.dk/au/#/search?query=recordID%3A%22sb_6350422%22.
Smith, M. S., & Stein, M. K. (2015). *5 practices for orchestrating productive mathematics discussions.* Reston, VA: National Council of Teachers of Mathematics.
Tamborg, A. L., & Allsopp, B. B. (2018). Mapping situations in implementing learning platforms. In A. L. Brooks, E. Brooks, & N. Vidakis (Eds.). *Interactivity, game creation, design, learning, and innovation* (pp. 435–444). New York, NY: Springer International Publishing.
Tamborg, A. L., Bjerre, A. R., Andreasen, L., Albrechtsen, T., & Misfeldt, M. (2017). *International litteratur om digitale læringsplatforme [International literature on digital learning platforms].* Copenhagen, DK: The Danish Ministry of Education.
Trouche, L., Drijvers, P., Gueudet, G., & Sacristán, A. I. (2013). Technology-driven developments and policy implications for mathematics education. In M. A. (Ken) Clements, A. J. Bishop, C. Keitel, J. Kilpatrick, & F. K. S. Leung (Eds.). *Third international handbook of mathematics education* (pp. 753–789). New York, NY: Springer New York. https://doi.org/10.1007/978-1-4614-4684-2_24.
Undervisningsministeriet (2015). *Hvad er forenklede Fælles Mål? [What are simplified Common Goals?].* Retrieved fromhttps://www.emu.dk/modul/hvad-er-forenklede-fælles-mål#.
Undervisningsministeriet (2014). *Læringsmålstyret undervisning i folkeskolen – Introduktion til forenklede Fælles Mål og læringsmålstyret undervisning. [Objetive oriented teaching in compulsory schools – an introduction to simplified common goals] [S.l.]: Undervisningsministeriet.* Retrieved fromhttp://docplayer.dk/413571-Laeringsmaalstyret-undervisning-i-folkeskolen-introduktion-til-forenklede-faelles-maal-og-laeringsmaalstyret-undervisning.html#download_tab_content.
Underwood, J. D. M., & Stiller, J. (2014). Does knowing lead to doing in the case of learning platforms? *Teachers and Teaching Theory and Practice, 20*(2), 229–246.
Verillon, P., & Rabardel, P. (1995). Cognition and artifacts: A contribution to the study of thought in relation to instrumented activity. *European Journal of Psychology of Education, 10*(1), 77–101.
Visnovska, J., Cobb, P., & Dean, C. (2012). Mathematics teachers as instructional designers: What does it take? In G. Gueudet, B. Pepin, & L. Trouche (Eds.). *From text to "lived" resources: Mathematics curriculum materials and teacher development* (pp. 323–341). Dordrecht, NL: Springer. https://doi.org/10.1007/978-94-007-1966-8_17.
Westbury, I. (1998). Didaktik and curriculum studies. In B. B. Gundem, & S. Hopmann (Eds.). *Didaktik and/or curriculum: An international dialogue* (pp. 47–78). New York, NY: Peter Lang.