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ORIGINAL PAPER

The meaning of meaningful learning in mathematics in upper-primary education

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Abstract
One of the ways in which schools try to improve students' motivation is through making learning meaningful for students. The concept of meaningful learning, however, has been defined in various ways in the literature. This small-scale in-depth study focused on meaningful learning in mathematics in upper-primary education. We investigated what teachers, according to their own views, undertake to make mathematics learning meaningful for their students. Two interviews (one stimulated recall) were conducted with five fifth-grade teachers from five Dutch primary schools that differed in terms of their schools' educational concept. Teachers' beliefs about the meaning of meaningful learning varied from students being able to understand what is learned to connecting with students' daily experiences. Teachers also differed in their self-reported pedagogical practices aimed at meaningful learning. They used different types of context, including activating prior knowledge, connecting to students' personal worlds, showing the value beyond school, goal setting for/with students, creating a context that is future-oriented, referring to the personal world of the teacher, applying the learning content in school, and creating cross-curricular context. Practices to foster and support meaningful learning included collaboration and dialogue, working independently and experiential learning. This study provides suggestions for embedding meaningful elements in the mathematics learning environment to stimulate students' learning motivation.

Keywords Context · Mathematics education · Meaningful learning · Pedagogical practices · Primary education

Introduction

Over the past decades, schools in many countries have implemented educational innovations with the aim of enhancing students' motivation and achievement (Hornstra et al. 2015; Stroet et al. 2016; Volet and Järvelä 2001). One of the ways in which schools try

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to improve students' motivation and achievements is through making learning meaningful for students (Loyens and Gijbels 2008; Van Rijk et al. 2017). Meaningful learning environments connect learning with the interests and needs of students and make students experience the value of learning activities beyond school (Newman et al. 1996; Roelofs and Terwel 1999; Van Oers 2009). Compared with traditional education, such environments are assumed to motivate students to greater effort and lead to better transfer of knowledge from the classroom to the outside world (Wilson 2012). Meaningful learning can be realised through using contexts to which students can relate (Van Oers 1998). Especially within the domain of mathematics, a contextual approach is broadly recognised as an important way of creating meaningful learning environments (Lui and Bonner 2016; Van Oers 1998; Verschaffel and Greer 2013). Concerning mathematics education, this entails not only the mere application of mathematical knowledge, but also embedding mathematics within a context that holds meaning for students. The concept of meaningful learning, however, has been defined in various ways in the literature and it also appears to have different meanings in educational practice. Yet, little is known about the ways in which teachers try to make mathematics learning meaningful. This study focused on teachers in Dutch primary schools and explored how they understand meaningful learning and which practices they undertake to make mathematics meaningful for students. Following Van Oers (2009), we particularly focus on the use of contexts.

Mathematics teaching in primary education

Whereas traditional forms of mathematics education focused on transmission of mathematical knowledge and concepts by repetition and memorisation (Stocks and Schofield 1997), over the past half century, instructional models emphasising meaning-, process- and problem-based approaches have gained popularity (Verschaffel and Greer 2013). Textbook methods have been developed that address the need for setting clear lesson goals and the use of visual models to scaffold students' learning and support students' mathematics development. Especially since the 1990s, there has been promotion of differentiated instruction, including the supply of additional support and feedback when students encounter difficulties with understanding mathematical concepts (Tomlinson 1999), and the use of contexts for learning and application of mathematics procedures (Boaler 1993). These developments in mathematics instruction have also been incorporated into Dutch teacher training. One of the most prominent examples is the instructional model of realistic mathematics education which focuses on problem-based mathematics learning and which became the primary instructional model in mathematics education in most Dutch primary schools (Van den Heuvel-Panhuizen and Drijvers 2013). In recent years, however, an increasing number of Dutch schools have adopted more-traditional mathematics methods again (e.g. Schmeier 2017). An analysis of schools with high performances in mathematics indicates that these successful schools incorporate elements of both types of approaches (Dutch Inspectorate of Education 2017). Moreover, a study by the Dutch Royal Academy of Science (KNAW 2009) found that the effectiveness of the two types of approaches did not differ and was mostly dependent on the quality of the teacher. In practice, most schools do not strictly adhere to one instructional model and incorporate elements of both types of approaches (KNAW 2009). Against this background we assume that different interpretations of meaningful mathematics education can be found in Dutch primary schools.

Theoretical approaches of meaningful learning

The assumption that learning that takes place in meaningful learning environments leads to deeper levels of understanding and is motivating for students is shared by different theories of teaching and learning (Loyens and Gijbels 2008; Mayer 2004; Wardekker et al. 2012). Even in more traditional teaching approaches, an important notion is meaningful learning that emphasises the cognitive processes by which students incorporate new mathematics knowledge into their existing knowledge structures. Yet, despite consensus about the use of context to realise meaningful learning in mathematics education, cognitive, socio-constructivist and sociocultural learning theories differ concerning the question in what types of 'contexts' meaning can emerge, as was pointed out by Van Oers (1998).

The *cognitive approach* emphasises the importance of taking the existing cognitive structure of the learner into account. In this view, meaningful learning emerges in the context of what the learner already knows. Therefore, teachers need to prepare the mathematics environment in such a way that it offers learners some cues that relate to their pre-existing cognitive structures and that can be used as an 'anchoring point' for embedding the newly learned material in the cognitive structure (Ausubel 1968). The teaching strategy of activating students' prior mathematics knowledge at the start of a lesson, and thus enabling them to build new knowledge on existing structures, is a practical translation of these insights and aligns with teaching approaches in mathematics that have been described as more-traditional or transmission-based (Lui and Bonner 2016).

In *socio-constructivist approaches*, contexts are seen as everyday social situations that make sense to the learner and that invite him or her to engage in an active process of knowledge construction. Roelofs and Terwel (1999) identified as characteristics of context in a constructivist learning environment complete task environments, connectedness to students' personal worlds, and an evident value of the learning activities beyond school. In mathematics education, one might think of the use of situations and activities that are familiar to students such as sharing candies or driving your bicycle. Many authors have elaborated on the themes distinguished by Roelofs and Terwel (1999). Some point at the value of working with 'real' problems that are experienced as relevant by students (Gijbels et al. 2006; Loyens and Gijbels 2008). Others emphasise that school tasks are experienced as relevant and meaningful if they align with students' personal goals (Boekaerts et al. 2006; De Corte et al. 2004). Research has also shown that students find learning meaningful in contexts where they are allowed to choose and determine their own learning objectives (De Corte et al. 2004). Next to a concern with context, socio-constructivist approaches also emphasise social interaction (i.e. communication and collaboration as conducive to creating meaningful learning contexts) (Roelofs and Terwel 1999; Roelofs et al. 2003).

Sociocultural approaches of learning define 'social learning' in a more-radical way; they do not see learning merely as acquiring knowledge and skills, but as improving students' participation in social practices (Van Oers 1998). Contexts aimed at meaningful learning, therefore, should not be focused on specific problem-solving tasks, but rather entail participation in actual or simulated 'social practices' (Volman and Ten Dam 2015). Sociocultural approaches also emphasise the importance of learning being relevant to the image that students have of their own past, present and future existence, while acknowledging that the acquisition of knowledge also could lead to changing this image (Wardekker et al. 2012). Through participating in activities that are socially meaningful, students acquire knowledge and skills that offer them possibilities to contribute to (and change) these activities, which in turn changes them as persons (Van Oers 2009; Vianna and Stetsenko 2011). For mathematics, a socio-cultural approach implies that mathematics is embedded in meaningful activities and typically not taught as a separate subject (Van Oers 2013).

It could be expected that different interpretations of and ways of aiming for meaningful learning in mathematics are found in schools with different educational concepts. The cognitive approach seems typical of regular schools. Some aspects of the socio-constructivist approach, such as using situations and activities that are familiar to students, have become mainstream in regular schools as well. Aspects such as students choosing and determining their own learning objectives and school tasks that align with students' personal goals are probably more often found in Montessori schools, where independent learning is highly valued. In the Netherlands, the aspects mentioned as typical for a sociocultural approach can be found especially in schools for Developmental Education, which are explicitly based on Vygotskian principles.

The present study

Although many teachers consider meaningful learning an important characteristic of education (Oostdam et al. 2007), little is known about how teachers try to make mathematics learning meaningful for their students. How teachers interpret and enact meaningful learning, however, not only depends on a teacher's personal views, but also to a large extent reflects the educational concept of the school. In the Netherlands, schools are relatively autonomous with regard to the design of their curriculum and the pedagogy they use. Therefore, schools can create learning environments according to their own pedagogical philosophy or educational concept, as long as they meet the 'core objectives' set by the government. This provides an interesting context for studying how teachers try to create meaningful learning environments, in particular through the use of contexts. This leads to our research question: *What can teachers, according to their own views, undertake to make mathematics learning meaningful for their students?*

In order to answer this question, we first explored which beliefs primary school teachers hold with regard to meaningful learning. That is, teachers can attach different meanings to the concept 'meaningful learning' that can be (partly) inspired by the educational concept of their school, and thus can align with different theoretical notions of meaningful learning. In turn, this can affect how they try to make mathematics meaningful for their students. Hence, we subsequently explored teachers' views about how they create meaningful learning environments for mathematics education.

Method

Participants

Five fifth-grade teachers from primary schools with different educational concepts and classrooms with different compositions across the Netherlands participated in this study. In grade five, students are 10–11 years old. Teachers from schools with different educational concepts were included in this study in order to increase the potential variation in beliefs and teaching practices for meaningful learning. The schools of the participating teachers worked from four different educational concepts: (1) Return-based education which resembles data-driven teaching and is characterised by setting and working towards clear goals and standards (Ledoux et al. 2009); (2) Montessori education which is described as a child-centred method focusing on autonomy, learning with concrete objects and through social interaction (Lillard 2005); (3); Waldorf education (Uhrmacher 1995), also known as Steiner education, which is based on Anthroposophical pedagogy and focuses on holistic learning to develop students' intellectual, emotional, practical and creative abilities; and (4) Development Education, a pedagogical approach based on sociocultural theory with students and teachers collaboratively working in the context of themes around which all learning is organised (Van Oers 2009). We anticipated that teachers from different schools would have different emphases related to meaningful learning in mathematics (e.g. Montessori teachers emphasising students' personal interest, Waldorf teachers emphasising meaning beyond school). All teachers were female. Table 1 shows the teachers' age, teaching experience, size of their class, the educational concept of their school and a characterisation of the composition of their class. The names of the teachers are pseudonyms to ensure their privacy.

Procedure

Schools were recruited in different parts of the Netherlands through convenience sampling. Teachers were informed that the study was on teaching mathematics and about the anonymous processing of the data before they gave active consent for participation. Parents were asked for permission to film mathematics lessons. For each teacher, a classroom observation and two interviews were conducted. First a semi-structured, in-depth interview was conducted about understanding the teacher's beliefs about meaningful learning and the teaching practices used for promoting meaningful learning. Then a mathematics lesson with fifth-grade students was observed and filmed. This was followed by a stimulated recall interview to provide a deeper understanding of teachers' practices with regard to meaningful learning, as well as their reasoning when making decisions related to meaningful learning in natural classroom situations.

Table 1 Details of participants

Name	Age (years)	Teaching experience (years)	Class size (students)	School concept	Classroom composition
Ilse	41	19	25	Return-based (R)	Mainly Turkish and Moroccan
Mara	24	3	28	Return-based (R)	Mainly Dutch
Carmen	28	6	24	Montessori (M)	Mainly Dutch, some Turkish and Moroccan
Suzan	34	10	27	Waldorf (W)	Mainly Dutch
Tanja	37	12	16	Developmental (D)	Mainly Dutch, great diversity in ability level

Data collection

In-depth interviews

The in-depth interviews began with an open-ended question about what teachers consider meaningful learning to be and why they believe meaningful learning is important or not. After the open question, the researcher showed the teachers four cards with each describing a teaching practice related to meaningful learning in the literature. Three of these concerned a way of creating context: *activating prior knowledge, connecting to students' personal worlds* and *showing the value beyond school.* The fourth referred to *working collaboratively.* The themes on the cards were intended as a stimuli for going deeper into key issues identified in the theory section of this paper. The teachers were asked if they recognised these practices as aspects of teaching for meaningful learning, to reflect on these aspects (providing room for interpretations that fit different theoretical approaches) and whether they could mention additional aspects of teaching for meaningful learning. The teachers were also asked whether and how they implemented these aspects into their own mathematics lessons.

Stimulated recall interviews

For each teacher, one mathematics lesson was video-recorded. For teachers with different grade levels in one class, only the mathematics activities with fifth-grade students were recorded. The video-recordings focused on the actions of the teachers. Fragments of the recorded lesson were used in a stimulated recall interview that was conducted after the observed lesson. During this interview, the researcher and the teacher watched and discussed fragments of the recorded lesson together. The researcher selected fragments in which she identified teaching practices for meaningful learning or situations that lend themselves to such practices but were not used as such by the teacher. The number of fragments varied for different teachers. The researcher encouraged the teacher to 'think aloud' and to articulate what beliefs, thoughts, ideas and goals were the basis for the choices made by the teacher at that time (Lyle 2003).

In both the in-depth interviews and the stimulated recall interviews, we asked teachers about their teaching practices, including the use of textbooks, without distinguishing what contributions to meaningful learning were in or suggested by the textbook and what the teachers themselves added.

Data analysis

All interviews were transcribed for analysis. Units of meaning (referred to as statements), referring to a consistent theme or idea, were distinguished. This could be a few words, or a single sentence, or various sentences that formed a chain of arguments.

Analysis of the in-depth interviews

We had anticipated the teachers' views and self-reported practices to more or less reflect the educational concept of the school where they were teaching. Therefore we started the analysis by looking for differences between the teachers in how they interpreted the four practices of teaching for meaningful learning. However, the views and practices described by the teachers were very varied and did not clearly reflect the educational concepts of the schools. Therefore, we shifted the focus of the analysis to finding themes in the ways in which teachers aimed to make mathematics education meaningful. In the results section, we therefore focus on describing teachers' views and practices with regard to meaningful learning. We also describe the few instances in which teachers' answers appeared to reflect the educational concept of the school. In this analysis, the four practices of teaching for meaningful learning that had been used in the interviews were used as sensitising concepts in a grounded theory approach (Glaser and Strauss 2017). We coded teaching practices and the beliefs associated with them that fitted these aspects, as well as additional practices and beliefs related to meaningful learning that were mentioned by the teachers. Hence, the analysis was based on a combination of deductive and inductive coding. Through a procedure of constant comparison of incident to incident, incident to category, and category to category, new categories emerged. See "Appendix 1" for the categories of the final coding scheme.

To ensure the trustworthiness of our approach, several methods were employed (Creswell and Miller 2000). An *audit trail* was carried out in which another experienced researcher observed the coding actions and decisions of the first author step by step, and critically asked her about the choices that she had made. In addition, another experienced researcher also scrutinised the coding process of two interviews coded by the first author. A *member check* was performed by asking the teachers who participated in the study to read the transcribed interviews critically to check whether they agreed on the content.

Analyses of the stimulated recall interviews

Content analysis (Miles and Huberman 1994) was used to analyse the data from the stimulated recall interviews. The analysis was based on the coding scheme that was obtained in the previous phase ("Appendix 1") and aimed at providing a more-detailed picture of the pedagogical practices of the teachers and their reasoning behind them. The first author and a trained researcher both coded 20% of the interview data independently. Cohen's Kappa was 0.66, indicating substantial agreement (Hallgren 2012). The results were used to further specify the categories in "Appendix 1". Finally, the results of the two interviews were combined to answer the research questions.

Quotes from both the in-depth interviews and the stimulated recall interviews are used in the results section as illustrations of the themes that emerged from the data.

Results

We first discuss the themes that emerged in the parts of the interviews that addressed what meaningful learning means for teachers. Then we present teachers' self-reported practices for meaningful learning; the themes from our analysis are used for structuring this section.

Teachers' beliefs about meaningful learning

Before discussing teachers' views about how they try to make mathematics meaningful for students, we first explored what teachers considered to be 'meaningful learning' because they can attach different meanings to this concept, which subsequently could explain differences in their enactment of their beliefs. As mentioned before, we did not find the educational concepts of the schools clearly reflected in teachers' views on meaningful learning. Teachers' beliefs regarding meaningful learning contained both similar and differing elements. Aspects that were typical of each of the theoretical approaches were mentioned, with teachers placing different emphases as we had expected, but not in the way we had expected.

There was general agreement among the teachers that learning is meaningful when students *understand* what they learn and for what purpose they are learning. Also the teachers agreed that, in order to enhance understanding, it is necessary to provide *contexts*. However, teachers differed in exactly what was meant by understanding and in what way and why a connection with students' experiences was considered important. Ilse's explanation of understanding as 'getting the learning content in one's head' clearly reflected a cognitivist perspective, as might be anticipated from a teacher who works in a return-based school:

> Meaningful learning, for me is about students who understand all types of concepts and learning strategies. So from very concrete, tangible material to 'a trick in the head'. With instruction about the numerator and the denominator, you first take real pizza's into the classroom. The second step is to use tangible materials which are not pizza's but look like them. The next step could be to calculate without having tangible materials. The final step is that students understand in their heads what they are doing. (Ilse-R)

According to Carmen, understanding means that students are able to relate to the learning content. In explaining this, she referred to both the Vygotskian concept of the zone of proximal development and the cognitivist principle of building on students' prior knowledge:

> Meaningful learning means that students understand what it is about, that what they learn is in their world. And just outside it. So in the zone of proximal development. So that what they already know will be extended with information from the teacher or with materials. (Carmen-M)

In terms of 'connecting' to students' experiences, in addition to connecting new knowledge to prior knowledge, Tanja emphasised that the learning content should also be connected to students' personal interests, a position that is aligned with a socio-constructivist approach:

> Meaningful learning for me is connecting to what students already know and to what they do not already know. But also connecting to the interests of students. In mathematics, for example, you can count in the context of a football game instead of just count with boring numbers on paper. So you give it meaning because you connect it to something. (Tanja-D)

Mara added the element of applicability of the learning content or, in other words, the value of what is learned beyond school:

> I think learning is meaningful if what they are learning means something for what they do in life. So if you give an instruction with math, the students must be able to do something with it. And they must also understand that link. So that, when they do a particular calculation, they know why they do it, why it is convenient. For example, when you give an instruction on fractions, you use the example of a bag of candy that you have won and that you want to share in the classroom, to make students understand how they can divide without counting out one by one. (Mara-R)

Suzan's account of understanding included two elements that are easily interpretable in light of the Waldorf educational concept of her school: on the one hand, the experience of better understanding the world in which one lives and, on the other hand, being aware of one's development:

> Meaningful learning, I think is when what we are doing in the classroom makes sense. When […] the world in which they live becomes meaningful for the students themselves, the learning content comes alive for students and for me. […] Students experience they move forward, and make steps forward. Students feel, not that they are kept busy, but really proceed in their development. (Suzan-W)

Teachers' self-reported practices for meaningful learning

Although teachers' conceptions of meaningful learning more or less aligned with different theoretical notions and the educational concepts of their schools, the practices that they described could not be linked as clearly to specific theories and concepts. The teachers considered all aspects that we had defined a priori as being important for meaningful learning. In the interviews, they complemented as well as specified the aspects of teaching for meaningful learning. We did not find between teachers consistent patterns of differences that could possibly be explained by their different beliefs or by the educational concept of the school for which they worked.

Figure 1 contains an overview of the different ways of creating meaningful learning in mathematics mentioned by the teachers. Most of these refer to ways of providing students with context around the mathematics content or concepts (i.e. the kind of elements that the learning content is being connected with). Eight different *types* of contexts could be distinguished, with the last three aspects in the table referring to teaching methods that are considered to *foster or support* the use of contexts.

Below we first discuss the ways of creating context that we used as a priori aspects of teaching for meaningful learning in mathematics, followed by ways of creating context that

Types of meaningful learning contexts
Creating context by activating prior knowledge*
Creating context by connecting to students personal world*
Creating context by making clear the value beyond school*
Creating context by setting goals for or with students**
Creating context by applying mathematics in school**
Creating a future-oriented context**
Creating context trough referring to the personal world of the teacher**
Creating context by including cross-curricular elements**
Ways to foster or support meaningful learning
Creating context by collaborative work*, complemented with dialogue **
Creating context by experiential learning**
Creating context by working independently**

*found in the literature

** added in the interviews

Fig. 1 Ways of enhancing meaningful learning were added by the teachers. Based on the interviews and the classroom observations, we explain why teachers found these aspects important and how they enacted them in their mathematics lessons.

Activating prior knowledge

All teachers said that they tried to activate students' prior knowledge, because this is an important condition for successfully teaching new knowledge. When prior knowledge is activated, students recognise what they already know and thus their existing knowledge becomes a context to which they can connect new knowledge. The observations confirmed that activating prior knowledge is part of the teachers' routines. During the recorded lesson of Suzan-W, for example, she worked with her students on surface calculations. In the stimulated recall interview, Suzan explained:

> When we started this topic about surfaces this week, […] I asked the students 'write down what you already know about surfaces. How do you figure out what you need, when you go to the store?' (Suzan-W)

Connecting to students' personal worlds

According to all teachers, connecting to students' interests and what they experience in their lives has positive effects on learning mathematics. It leads to students' involvement, enthusiasm, wanting to begin a task, alertness and wonderment:

> We always start small. Close to the world of the student whereby it gets meaning. (Tanja-D)

> Work with the experiential world of students as a starting point! That too is really part of our educational concept, that the teacher connects to what is present in the child. (Suzan-W)

Making clear the value beyond school

The teaching practice of making clear the value of learning content beyond school was used by all teachers to make mathematics meaningful. To clarify the value of mathematics, teachers referred to contexts such as shops, sports and calculations that deal with money:

> So I took two students to the store last year. And then I gave the assignment differently, 'look where you get a 25% discount'. (Ilse-R)

> I always discuss the value beyond school directly with them, otherwise there is always a student who asks; 'why do we have to learn this?'(Carmen-M)

Setting goals for or with students

In addition to the aforementioned practices aimed at creating context, all five teachers mentioned 'creating context by goal setting for or with students' as a key practice of teaching for meaningful learning. According to the teachers, it motivates students to know what mathematics skills they will acquire or which particular mathematical problem they will learn to solve. In addition, setting goals can encourage students to become aware of their own goals:

> It creates students full of expectations. For example: 'and then soon there is a very difficult calculation that we can do in a very smooth way. […] (students):'Huh, how are we going to learn this?' (teacher): 'Yes, we'll find out how to do that'. (Suzan-W)

According to some teachers, goal setting also helps students to gain insight into the sub-steps towards the learning goal and to evaluate their own learning process. Some teachers added that they also have students set their own goals to work towards:

> And if I give the students the task of working on the computer they first have to write on a note what they want to learn […] If they have to set their own goals they are more motivated. (Ilse-R)

When watching the recorded lessons, we observed that only two of the five teachers actually set explicit goals with the students at the beginning of the lesson and reflected on these goals at the end of the lesson. The three other teachers briefly mentioned at the beginning of the class what the students were going to do during that lesson.

Applying mathematics in school

Some teachers mentioned that they consciously used the school, which of course is part of students' life world, as a context where mathematics could be applied. Examples included distributing pens or notebooks, creating groups, counting scores during physical education, or handing out treats to classmates on one's birthday:

> We had a poem project by Hans Kuiper. We had six books of Hans Kuiper and one by another poet, so 6/7 was Hans Kuiper and 1/7 was another poet. And the students themselves came up with it. (Ilse-R)

Suzan-W said that she reacted to spontaneous contexts that she and her students encountered in school:

> But sometimes something happens in school or in the classroom interaction which I think is awesome. Than we can do something with it, because it adds something to the content of the lesson. (Suzan-W)

Creating a future-oriented context

Creating a future-oriented context was mentioned as a teaching practice aimed at meaningful learning by all five teachers. It pertains to the value of what is learned beyond school, but explicitly links this to students' future:

> 'I do not know if you want to go shopping by yourself in the future, but then it might be smart to start listening to my explanation of money because…'. And then they surely get started. (Tanja-D)

In the recorded lesson of Ilse-R, we observed how she focused her practices on creating future-oriented contexts:

> I asked at some point, "Why should you really do this?" At that time they said "for the test". Then I said "but why do you actually learn this?" And then they came up

> with, "for later" and "for a good job." […] It was indeed the lesson right before the test. It was a last repetition before they can make the test, but the test is of course no end goal. (Ilse-R)

In the lesson of Tanja-D, one of the students focused attention on the usefulness of the learning content for their future, saying: "We have to learn this mathematics skill, because, in the future, if we are in the Czech Republic, we cannot cycle towards Tanja either."

Using examples from the personal world of the teacher

Several teachers drew on their own personal life to create context, which can be seen as another way of making clear the value of what is learned beyond school. In the in-depth interview, Ilse-R mentioned how she enhances meaningful learning through telling students about experiences from her own life beyond school:

> I said yesterday during mathematics 'I went to Amsterdam, which was 40 km, it took me 20 min. How fast did I drive?' Because they find it interesting that I go to Amsterdam. I do not like Amsterdam at all, which they know well. So it is a laugh anyway when I go to Amsterdam. (Ilse-R)

Also other teachers used examples from their personal life to create context:

> I often take an example of myself, like that I have refurbished the bathroom. Calculating surfaces is useful, otherwise you have to drive back to the construction store eight times because every time you find out, 'ahh, not enough again'. (Tanja-D)

Including cross-curricular elements

Tanja-D and Carmen-M mentioned how they create context through drawing attention to cross-curricular elements in their mathematics lessons. According to the teachers, this helps students to place the learning content into a larger context and it facilitates transfer to other areas:

> I think it also has to be cross-curricular in order to be meaningful. So that the knowledge students learn does not stay with one subject, but that they apply it in other subjects. In this way the learning content gets real significance. Then they make connections. It sinks in and they see that the learning content not only belongs to math. (Carmen-M)

Tanja indicated that thematic work makes cross-curricular work more feasible:

> So, we try to design the activities of a theme in such a way that we use as many subjects as possible. (Tanja-D)

Collaborative work and dialogue

Teachers reported various reasons why they saw collaborative work as a way to create context and make mathematics content meaningful for students. These reasons mainly come down to creating a social context. When collaborating, students can learn from each other, help each other, complement each other, and learn from explaining to each other:

> If you can explain it yourself, it really becomes something of yourself. (Mara-R)

Dialogue between teacher and student was also identified by the teachers as a way to give meaning in an interactive way, with students being active and involved.

Experiential learning

All teachers considered experiential learning to be an important way to make mathematics meaningful for students. Experiential learning approaches are designed to involve students working with specific tasks or problems. Mara-R explained how experiential learning creates a context to which the teacher can refer back, namely, the experience of students when they learn and understand something:

> A drawing tells the students nothing about a cubic metre. Because it is much bigger than they think. I gave the students the assignment to measure the school in groups. So they can feel how much space there is in a cubic metre or how many square metres the floor is. […] Experiential methods are important especially if you use them in the beginning. Like with cubic metres. I'm not going through the entire school again. But I can refer back: 'Do you remember when we measured the school? (Mara-R)

Suzan-W, Tanja-D and Carmen-M argued that experiential learning contributes to meaningful learning because what students learn is concrete and visible for them:

> Doing research by going out is much easier for these children and it also makes a more lasting impression. You're not going to forget when you hear a gentleman tell about the Second World War. Or when you walk along the monuments. Yes that will be remembered much more. (Tanja-D)

Working independently

Working independently was reported by all five teachers as a way to facilitate meaningful learning, because students can give meaning to learning materials when they process them independently at their own pace:

> The aim of the Montessori theory is that you let the students work independently as much as possible, and that you do not interfere if they have no questions. So it may happen that students continue with the learning material before they have had instruction about it. (Carmen-M)

Discussion

In this small-scale in-depth study, we aimed to gain insight in what teachers, according to their own views, undertake to make mathematics learning meaningful for their students. In particular, we wanted to explore how teachers understand meaningful learning and the practices that they undertake to create meaningful learning environments in mathematics. Teachers showed great diversity in their perceptions of what meaningful learning of mathematics is, therefore reflecting different theoretical notions. The goals that teachers aimed to reach through meaningful learning varied from fostering students' understanding of what is learned and why it is learned, to connecting with students' experiences in real life. Teachers also differed in their pedagogical practices aimed at creating meaningful learning contexts for learning mathematics. However, the practices that teachers described could not be linked as clearly to particular theories. Furthermore, analysis failed to reveal distinct variation in perceptions and practices of meaningful mathematics learning that are related to different educational concepts. All teachers endorsed the importance of the types of context that we found in the literature (Roelofs et al. 2003), namely, *activating prior knowledge, connecting to students personal worlds,* and *showing the value beyond school*. Teachers were able to explain why they thought that these practices contributed to meaningful learning and they gave examples of how they used these in their mathematics lessons. However, the teachers also mentioned additional pedagogical practices that they used to make learning meaningful for their students. All five teachers mentioned *goal setting for or with students* as a way of enhancing meaningful learning. The same holds for *creating context that is future-oriented,* which was seen by all five teachers as a specification for making clear the value of the learning content beyond school. *Creating context through the personal world of the teacher* and *creating context aimed at applying mathematics in school* were proposed as important ways to achieve meaningful learning by three of the five teachers. Finally, *creating cross-curricular context* is an aspect of meaningful learning, according to some teachers, because it enables students to place mathematics in a larger context.

In the literature, *working collaboratively* is considered to be an effective way of making the learning environment meaningful (Roelofs and Terwel 1999). This was endorsed by all teachers. Additionally, several teachers mentioned that they use *dialogue or conversation* between teacher and student(s) as a method to create meaningful contexts. In addition to collaborative work, some teachers also emphasised that *working independently* can help students to give meaning to mathematics. If students can work with the learning material or practice skills in their own pace, they can achieve a better result. Additionally, all teachers considered *experiential learning* to be an important way to make mathematics meaningful for students.

The practices of the teachers in this study could not be categorised into specific theoretical perspectives or clearly related to one educational concept. Teachers seemed to work more or less eclectically by combining teaching practices that are inspired by a cognitive and socio-constructivist perspective, whether they work in a Montessori, Waldorf, Developmental education or return-based school. This is in line with the conclusions of the 2009 KNAW study that showed that both traditional models, focusing on explicit instruction, and elements of constructivist models were widespread in Dutch primary schools and in teacher education. Teaching practices that fit a sociocultural approach, however, were mentioned less frequently. An explanation for this might be that the cognitivist and socio-constructivist approaches are easier to implement ad hoc than a sociocultural approach, which requires more-fundamental restructuring of the curriculum and, moreover, aims for different student outcomes (Van Oers 1998). Although the Dutch government allows great autonomy in teaching methods, it evaluates schools on performance outcomes, which also could impede schools in implementing a more-sociocultural approach in their curriculum.

Some limitations of the present study need to be mentioned. Although only five teachers participated in our study, their selection nevertheless yielded a variety of perspectives and approaches. Nevertheless, in the future research, we suggest including a larger number of teachers from different approaches and interviewing teams of teachers in focus groups, especially because we cannot exclude the possibility that the beliefs and practices of the teachers in our study were atypical for the educational concepts of their schools or that the teachers were not very good at identifying what is unique about their school's approach.

Another limitation concerns the domain-specificity of this study's results, which only apply to mathematics. Future research could examine whether similar results are obtained for other domains. In addition, the present study focused only on the perceptions of teachers and what they consider to be meaningful for their students. Future research could focus on the perceptions of students, whether what they find meaningful aligns with the perceptions of teachers, and whether the practices mentioned by teachers indeed enhance students' motivation (e.g. Loyens and Gijbels 2008; Van Rijk et al. 2017).

Conclusion

In this study, we aimed to contribute to insights in learning environments for meaningful learning by bringing together different strands of literature that all focus on meaningful learning, but from different theoretical perspectives (i.e. cognitivist, socio-constructivist and sociocultural), and to use these in examining how teachers actually go about shaping learning environments that make mathematics meaningful for students. Our results provide insights into teachers' beliefs about meaningful learning, into the diversity of teaching practices that they use to try to make mathematics learning meaningful for their students, and into aspects of the multifaceted character of meaningful learning. Our analysis resulted in a categorisation of ways to make mathematics meaningful, some of which were previously distinguished in the literature, but others of which were not, especially not at this level of detail. The findings indicate that, for future research, a broader conceptualisation of meaningful learning should be used in order to encompass the diversity of practices that meaningful learning can consist of. The present study also specified ways in which teachers try to make learning meaningful for their students. Hence, the findings of this study can inform teachers and teacher educators about the various ways in which they could create meaningful learning environments.

Appendix 1

Final coding scheme

Creating context by activating prior knowledge	Teacher discusses with students what they already know about the subject Teacher discusses what students have already learned in previous lessons on this subject, and lets students tell about it

Creating context by setting goals for or with students	Teacher makes students aware of the purpose of the lesson and/or a teaching unit, including what students will be able to do and understand Teacher develops with student(s) goals to be achieved Teacher and student discuss differentiated goals that match the individual student
Creating context by making the value beyond school clear	Teacher discusses with students how students can apply what they learn in their daily lives beyond school (e.g. calculating discounts or interest for a youth account, being on time for an appointment, etc. General contexts are used to represent the importance of what is learned (e.g. situation on the market, school, vacation, sports, professions, etc.)
Creating context by applying mathematics in school	Mathematics is applied to contexts at school, including the square, gymnasium, school gardens
Creating a future-oriented context	Teacher discusses with students how they can use what is learned in their future lives (buying a car or house, laying carpet, knowledge for specific professions, etc.)
Creating context by connecting to students personal world	Teacher connects with interests and hobbies of students and lets students tell about it Teacher uses examples in line with the daily lives of students, such as telling the time, family, friends, sports, shopping, appointments, etc
Creating context through the personal world of the teacher	Teacher uses examples from his/her own life as context
Creating context by including cross-curricular elements	Teacher refers to the learning in other subjects, where it is applied consciously and actively by students Teacher discusses with students the cross-curricular meaning of the learning content
Experiential learning	The teacher uses assignments for which students have the opportunity to experience for themselves and explore (e.g. measuring the school, information surveys on the Internet, baking together and weighing ingredients, etc.)
Collaborative work	The teacher uses collaborative methods for which students can work together in small groups or pairs
Working independently	The teacher uses methods in which students can work independently
Mathematical dialogue or conversation between teacher and student(s)	Dialogue between teacher and student or within group of students on the subject or mathematics strategy that students use, and why and how they use it

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