

To Gain Knowledge of How to be Challenging: Preschool Mathematics Professional Development

Ola Helenius

NCM, Gothenburg University

Troels Lange

Western Norway University of Applied Sciences

Maria L. Johansson

Luleå University of Technology

Tamsin Meaney

Western Norway University of Applied Sciences

Anna Wernberg

Malmö University

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The use of freely-available web-based materials in professional development has rarely been investigated in mathematics education research. In this article, the responses to a survey by 267 preschool teachers about their use of online professional development materials are described. The web materials were based on a design model and the survey results are compared with its principles which focus on content, tasks and relationships. The results show that some of the content in the written materials was considered difficult to understand. Nevertheless, the requirement to work on the material in groups and to carry out tasks in their own preschools supported the teachers to develop a more comprehensive understanding of the content over time. Generally, the teachers found the material valuable for gaining knowledge about mathematics for young children that they could implement as tasks to challenge children in their preschools.

Keywords: web-based professional development • preschool teachers • survey studies • Bishop's six mathematical activities

Professional Development in Mathematics Education for Swedish Preschools

Curriculum reform is leading to governments setting up professional development (PD) programmes to raise the pedagogical content knowledge of mathematics teachers (see for example, Joubert & Sutherland, 2009), sometimes using information and communication technology (Dede, Ketelhut, Whitehouse, Breit, & McCloskey, 2009). Sweden is no exception with the government initiating a national PD project in 2012 targeting teacher at all pre-tertiary levels of the education system (Boesen, Helenius, & Johansson, 2015). In this paper, the results are described from a survey of 267 preschool¹ teachers, who at the time of the survey had completed

¹ In this paper, *preschool* is the translation used for *förskola*, which is the Swedish name for the institution for early childhood education and care for 1-5-year old's in Sweden. *Förskola* literally means *before school*.

at least one third of the web-based materials, which the authors had designed in 2013 on behalf of Skolverket, the Swedish National Agency for Education. In particular, we explore how the design principles for the materials seemed to connect to the teachers' experiences of using the materials.

We consider that a study of teachers' perceptions of the usefulness of web materials will be of interest to those elsewhere in the world, who wish to implement large scale mathematics PD programmes, particularly for preschool teachers. Sweden shares many similarities with other countries in how mathematics is incorporated into early childhood education and care. Therefore, the views of Swedish preschool teachers can inform the development of web materials elsewhere.

There are many similarities regarding the role of preschools in Australia, New Zealand and Sweden but also some differences (see Oberhuemer, 2005). Unlike the situation in Australia (Baxter, 2015) and New Zealand (New Zealand Ministry of Education, 2015), almost all Swedish children attend preschools from ages 1 to 5 years during work hours (Skolverket, 2015). Usually the adults who work in preschools have a preschool teaching degree or a certificate from a course from the last three years of high school (Skolverket, 2015). This is similar to the situation in New Zealand (New Zealand Ministry of Education, 2014) but not necessarily the case in Australia (Dowling & O'Malley, 2009). Like both Australia (Australian Government Department of Education, Employment and Workplace, 2009) and New Zealand (New Zealand Ministry of Education, 1996), Sweden has a curriculum² for preschools which includes mathematical goals (Skolverket, 2011). Nevertheless, it is only since the reform of the teacher education in 2011 that mathematics education courses became mandatory in the university-based, preschool teacher education programmes. Regardless of their staff's qualifications, preschools are responsible for providing mathematics learning opportunities. As is the case in Australia (Australian Government Department of Education, Employment and Workplace, 2009) and New Zealand (New Zealand Ministry of Education, 1996), learning is seen as being connected to play and presumed to be built on children's interests (Skolverket, 2011). The Swedish approach to working with the whole child has been described as the 'social pedagogy tradition' and this is different to the 'readiness for school' tradition adopted in Australia and New Zealand amongst other countries (Bennett, 2005).

A workforce with limited mathematics education in their teacher education, but needing to provide mathematical learning opportunities, is an obvious target for PD. Most PD occurs in face-to-face situations with facilitators, who design and deliver workshops/courses for teachers (see for example, Perry, Dockett, & Harley, 2007). In Sweden, Skolverket had previously provided PD about mathematics to preschool teachers through face-to-face courses set in universities (see for example, Helenius, Johansson, Lange, Meaney, Riesbeck, & Wernberg, 2015b). The decision to provide web-modules to deliver mathematics PD materials from 2012 to teachers in situ was seen as necessary for reaching more teachers (Boesen et al., 2015). As Dede et al. (2009) stated:

The need for professional development that can fit with teachers' busy schedules, that draws on powerful resources often not available locally, and that can create an evolutionary path toward providing real-time, ongoing, work-embedded support has stimulated the creation of online teacher professional development (oTPD) programs. (p. 9)

Still, the use of online materials for PD in mathematics education is not common, and analyses of their usefulness are rare. If online PD is investigated, it generally focuses on discussions between teachers (see Niess, van Zee, & Gillow-Wiles, 2010; Stephens & Hartmann, 2004). This research

² Government-level documents that specify pedagogy and goals for early childhood education are labelled in a range of ways, e.g. framework (Australia), curriculum (New Zealand), "learning plan" (Sweden; "läroplan"). In this paper, we use curriculum as a collective term for these kinds of documents.

begins an investigation of the usefulness of online PD materials, particularly for preschool teachers, who often have limited opportunities for the sorts of PD available to school teachers.

Designing Web Modules for Preschool Teachers

To produce the web-modules, Skolverket required researchers from different universities to collaborate and provided strict guidelines for the structure of the material (Boesen et al., 2015; Skolverket, 2012). The web-module for preschool teachers had 12 parts, which were to take preschool teachers about 18 months to complete with 4 parts being covered each half year. Each part contained four sections with set functions: A individual studies, B group discussion and planning, C enactment/observations in own teaching situations, and D group discussion and follow-up. The materials consisted of texts and videos to be read and watched in Section A, questions to be discussed in Section B, suggestions for tasks to be done with children and documentation to be collected in Section C, and reflection questions about the learning in Section D. In our survey, we wanted to understand how the teachers considered that these materials contributed to their learning about mathematics and their work with children.

In previous research (Helenius, Johansson, et al., 2015c), we developed retrospectively a design model (Figure 1) from our decision-making during the production of the first third of the materials. We had done this because there had been a dearth of information about designing PD materials. Fishman, Marx, Best, and Tal's (2003) model was the exception and provided a frame for our thinking. Their model was about PD materials for school teachers and, when compared with our own decision-making, it became clear we needed to rethink the decision making process (Helenius, Johansson, et al., 2015c).

Our design model has 3 components: PD tasks for the teachers to undertake, content deemed as important for teachers to understand, and the relationships the teachers were engaged in. The questions in Figure 1 guided the later development of the PD material for the 12 parts. For example, as we wrote questions to facilitate discussions between the teachers in Section D, we kept in mind our relationship as the authors of the materials with the teachers. Our intention was to support the teachers to share unsuccessful as well as successful experiences, because we considered these would require deeper reflections about their learning and work with children.

In producing the materials, we considered that the choice of content drove the decision making about the other two components. Content learning, which could be discipline and pedagogical knowledge, has often been noted as providing the justification for PD programmes (Joubert & Sutherland, 2009). Prediger, Quasthoff, Vogler, and Heller (2015) emphasised the importance of content decisions in regard to PD stating that they must be both empirically and theoretically grounded. Yet, "participants in professional development can often come away with unintended learning that can include misconceptions or otherwise problematic understandings of the intended content" (Fishman et al., 2003, p. 647). In order to minimise this possibility, the other two components, tasks and relationships, needed to be developed simultaneously.

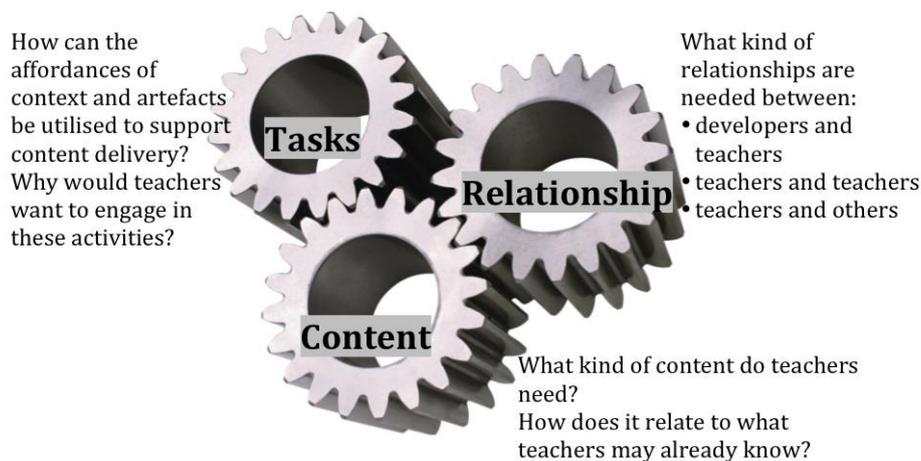


Figure 1. Model for designing professional development material.

To determine what content to include, we drew on previous mathematics education research. This was done with caution as much of this research focused on preparing children for school (see Clements & Sarama, 2007). Therefore, we had to consider carefully how to place relevant content in contexts that were in alignment with the holistic philosophy of the curriculum (Skolverket, 2011), familiar to Swedish preschool teachers. Consequently, the content was framed using Bishop's (1988a) six mathematical activities (Playing, Explaining, Locating, Designing, Measuring and Counting³; see Table 1), on which the goals for mathematics in the preschool curriculum are implicitly based (Utbildningsdepartementet, 2010). Bishop (1988a) argued that the six activities were universal for any culture, and although his original discussion of these activities was not about what young children did, they provide a useful framework, particularly when preschools follow a social pedagogy tradition (Bennett, 2005). Our own research about Bishop's six activities and young children formed the basis of the ideas we imparted in the material Helenius, Johansson, Lange, Meaney, Riesbeck, and Wernberg. (2016); Helenius, Johansson, Lange, Meaney, and Wernberg (2015a, 2015b, 2016); Johansson, Lange, Meaney, Riesbeck, and Wernberg (2012, (2014); Meaney (2014, 2016). Prediger et al. (2015) stated that empirical findings should be sifted through to determine what should be included in PD. In our case, the decision to use Bishop's six activities as the theoretical basis for understanding mathematics in preschools in our research and the subsequent decision to use it for the PD has focused our research on understanding the implications of this theoretical positioning.

³ The words denoting the mathematical activities are capitalised to distinguish them from their everyday meaning

Table 1

Bishop's (1988b, pp. 182-183) description of the Six Mathematical Activities and their corresponding questions (Bishop, 1988a)

Activity	Description	Question
Playing	Devising, and engaging in, games and pastimes, with more or less formalised rules that all players must abide by.	How?
Explaining	Finding ways to account for the existence of phenomena, be they religious, animistic or scientific.	Why?
Locating	Exploring one's spatial environment and conceptualising and symbolising that environment, with models, diagrams, drawings, words or other means.	Where?
Designing	Creating a shape or design for an object or for any part of one's spatial environment. It may involve making the object, as a 'mental template', or symbolising it in some conventionalised way.	What?
Measuring	Quantifying qualities for the purposes of comparison and ordering, using objects or tokens as measuring devices with associated units or 'measure-words'.	How much?
Counting	The use of a systematic way to compare and order discrete phenomena. It may involve tallying, or using objects or string to record, or special number words or names.	How many?

The second component in the design model is the choice of PD tasks. The tasks include watching videos, discussing texts and implementing mathematical learning situations with children. The tasks are connected to the content, but not just as a 'deliverer', where teachers are asked to implement some aspect of the discussed content, which Fishman et al. (2003) described as 'enactment'. Rather, the tasks are intended to provoke teachers' reflections on their current practice and knowledge and relate these to new content. McGraw, Lynch, Koc, Budak, and Brown (2007) found that professional discussions about cases presented through multi-media "can involve interplay between theoretical and practical knowledge" (p. 117). We considered that discussions about texts in relationship to watching videos would provide shared experiences to support the discussions, which could then be expanded and elaborated on once teachers had implemented mathematical situations in their own preschools. Therefore, the PD tasks are something that teachers enact but also reflect on to gain more insights than are possible from merely reading about new content.

The final component is the decisions to do with nurturing relationships both through the PD and in preschools, as a relationship of trust between teachers is vital for learning together. As well, in some of the pedagogical content discussions, particular kinds of relationships with the children were promoted. Teachers may need to reflect on how this pedagogical knowledge relates to their practices. Consequently, the material has to mediate between a scientific and a cultural (practical) perspective. As designers, we also needed to develop a relationship with the teachers through the materials to support the teachers' interpretation of theories, ideas and experiences. Many preschool teachers would have extensive experience about supporting children's participation in mathematics activities and we needed to respectfully make connections to this to support their reflections.

The three components in our model have similarities with Zaslavsky and Leikin (2004) elaborated version of *the teaching triad*, which they used to discuss the work of mathematics

teacher educators. They represented the nested nature of mathematics teacher educators' work by indicating that challenging content provided to mathematics teachers should be based on teaching triad for mathematics students (challenging content for mathematics students, management of student learning, and sensitivity to students). This is similar to our view that content needed to include both discipline and pedagogical knowledge. According to Zaslavsky and Leikin (2004), mathematics teacher educators must also manage the overall pathway of mathematics teacher learning and be sensitive to the teachers that they were working with. In the PD material, every fourth part focused on the preschool teachers' reflections on their documentation, collected during previous content-focused parts. These three documentation parts were to support teachers to reflect on how new learning is connected to earlier learning both in the PD and in their work in preschools. Our inclusion of these tasks was to contribute to developing pathways for teachers' learning. Sensitivity to teachers was in alignment with the focus on relationships in the design model, although this component also included awareness of others, not just the mathematics teachers.

As outlined earlier, decisions about one component in the design model affected the other two. Our intention with the PD materials was that the teachers would gain relevant experiences for improving their mathematical engagements with young children. By undertaking the PD in small groups as suggested by Skolverket, we anticipated that the contributions from the three components would merge together. We wanted what Benz (2016) found in her research on face-to-face PD, that "preschool teachers were able to use the shared space of the reflection meetings to discuss all the different aspects of professional competencies" (p. 431). The survey was intended to find out whether this was the case.

The Survey

In order to evaluate the usefulness of the PD materials for preschool teacher via the three components of the design model, an online survey was conducted. The decision to use a survey was connected to the preschool teachers' context, specifically the social pedagogy approach to preschool work, which does not consider it appropriate to test children on specific content knowledge. Our focus was on the impact of the PD materials on teachers' learning and how this changed their ways of engaging with children. The survey was conducted between March and May, 2016 and involved 267 teachers, who at the time of the survey had completed at least 4 out of the 12 parts of the module and who were still involved in the programme. Therefore, teachers would have been engaged in the PD for at least 6 months. The teachers were recruited through contacts at municipalities where many preschools were involved in the PD. Recruiting teachers who had completely finished the PD was likely to be difficult because they would no longer be in contact with municipality organisers

There were 29 questions of which 18 were multiple choice and the other 11 open-ended (see appendix). The questions were based on a pilot survey, which investigated the value of the videos in the web module from the perspective of the design model (Helenius, Johansson, et al., 2015a). The results of the pilot study contributed to us broadening the questions to be about all the materials and to include a specific question about the time needed to do the PD. According to Desimone (2009, p. 190) "teacher surveys that ask behavioural and descriptive, not evaluative, questions about the teachers' professional development experiences and teaching have been shown to have good validity and reliability". Although we did ask an evaluative question about how much the teachers valued the different sections, we followed this up by asking clarifying open-end questions about how the PD materials contributed to the preschool teachers' learning and changing practices in regard to the content, the tasks, and the relationships. For example, we asked about how important the different sections (A, B, C, D) of the part were to the teachers'

learning with multiple choice questions and then followed up with open-ended questions about why this was the case.

Results and Discussion

According to the survey responses (see Table 2), 72% of the teachers had been teaching for more than 10 years and 54% of the teachers had not completed any mathematics education courses in their teacher education. 15% of the teachers had only completed the first 4 parts of the PD, which focused on the mathematical activities of Playing and Explaining. A further 73% had also completed the second set of 4 parts, focused on Designing and Locating, and 12% had also completed the third and final 4 parts, which focused on Measuring and Counting. A large majority, 82%, had a PD facilitator, provided by the municipality, whose main role, according to the participants, was to ensure that the teachers had access to the materials and organise the discussion sections.

Table 2
Sample Characteristics

Q1 How long have you been a preschool teacher?			Q2 How much mathematics did you have in your teacher education?			Q5 How many parts of the module for preschool have you completed?		
< 5 years	30	12%	None	132	54%	Part 1-4	39	15%
5-10 years	43	17%	15 credits*	102	41%	Part 5-8	184	73%
> 10 years	187	72%	30+ credits	12	5%	Part 9-12	29	12%
Answers	260			246			252	
No answer	7			21			15	

* 60 credits equal one year of full-time study

The responses from the remaining multiple choice questions are discussed in relationship to the components in the design model in Figure 1: Content, tasks and relationships. The themes identified in the answers to the open-ended questions about teachers' changing of practices are provided in the final results section.

Content

The questions in the design model to do with content were: What kind of content do teachers need? How does it relate to what teachers already know? As noted earlier, the content information was based on Bishop's six activities, but to support connections to what the teachers already knew, we included specific parts about reflecting on the documentation they kept as they were learning. The titles of the 12 parts were:

1. An introduction to Bishop's 6 mathematical activities
2. Playing
3. Explaining
4. Documenting what the child can do
5. Introduction to Locating and Designing
6. Locating
7. Designing
8. Documenting for teacher planning

9. Introducing quantifying
10. Measuring
11. Counting
12. Documentation for supporting the work environment.

Even if they had some mathematics education in their teacher education, teachers generally found the content new and interesting. For example, P60 wrote in response to Q23 "I am thinking more about mathematics and have more understanding of what the children actually do when they play and act in the everyday. It feels like I have more knowledge about why I do certain activities with the children".

Figure 2 show which parts were appreciated the most and least by the teachers as a percentage of the number of teachers who had completed that part. In their responses, many teachers identified more than one part, particularly in response to the question about the part they appreciated the most. Some also made generic statements that they appreciated none or all the most or the least. These can be seen on the far right of the graph. These answers indicate that on the whole, all teachers could connect with at least something in the module.

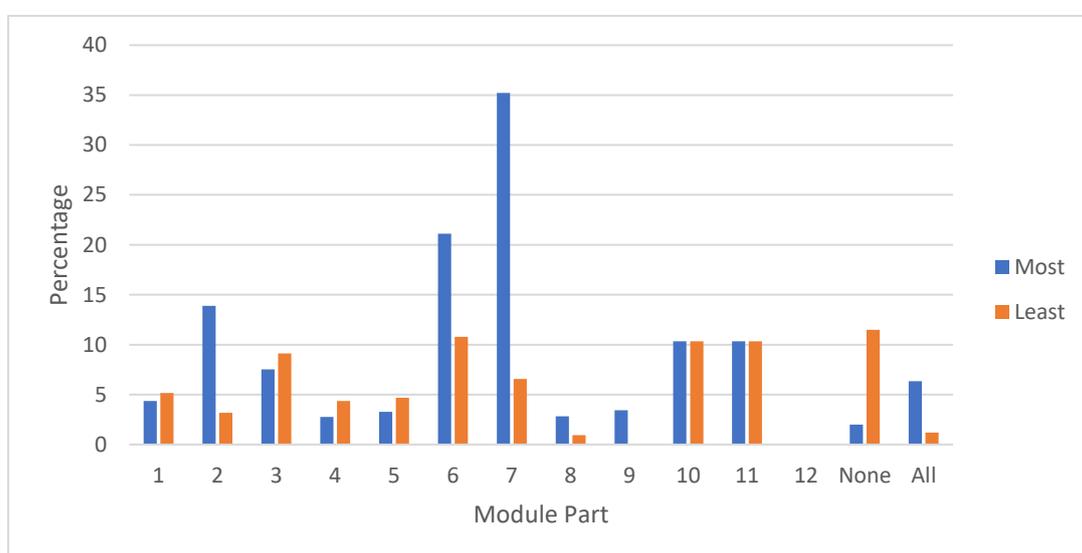


Figure 2. The participants' most and least appreciated parts as a percentage of the number of teachers who had completed the part (Q8 and Q10).

Given that the number of teachers varied for each of the parts, the graph in Figure 2 can only be used to provide an indication of two interesting trends. The first is that generally there are similar proportions of teachers who appreciated the most and the least the different parts, except for parts 2, 6 and 7. Part 2 was on Bishop's mathematical activity Playing, where more teachers appreciated it the most (14%) than appreciated it the least it (3%). This was interesting because the ideas presented in the web module about Playing had been noted as being difficult for teachers to understand by a facilitator (Svensson, 2015). When Playing was mentioned in the answers to these questions, it was most often indicated as being new to the preschool teachers, as for example, "All parts have contributed to the final development, but especially the part about Playing was an eye-opener" (P31, Q8).

There were several responses that made the point that some ideas from the earlier sections did not become clear to them until after they had completed more parts of the module. For

example, P208 wrote (Q8), “It is difficult to say just one part, but now that we have come to part 8, I feel that many pieces fall into place. One begins to see a red thread in it all”. For some, the difficulty with the beginning parts was the newness of doing PD. P193, who had done 8 parts, appreciated the first parts the least (Q10) because “one has not really started with tasks and you feel stressed”. Therefore, it may be that teachers’ evaluations of the parts change as they continue the PD because their understanding increased.

The teachers also answered two multiple choice questions, in which they could select more than one alternative about what contributed to their appreciating a part the most or the least. The alternatives came from the results of the pilot study (Helenius, Johansson, Lange, Meaney, Riesbeck, & Wernberg, 2015a). The results from these questions are provided in Table 3.

Table 3
The number of participants choosing the provided reasons for most or least appreciated part (Q9, Q11)

	I learnt the most/least from completing it	The written texts and videos made it easier/harder to understand the message	The tasks with children clearly showed/did not show how much mathematics they can do	The discussions with colleagues facilitated (not) my understanding
Most ($n=211$)	69 (33%)	49 (23%)	138 (65%)	99 (47%)
Least ($n=155$)	69 (45%)	81 (52%)	26 (17%)	12 (8%)

The most common reasons chosen for appreciating a part were that the teachers considered that what they were asked to do contributed to them seeing how much mathematics the children could do and that the discussions with colleagues facilitated understandings. In alignment with these results, the most common reasons for not appreciating a part were the other two choices; that the written texts and videos made it difficult for the teachers to understand the content and that they learnt the least from working with the part.

In the open-ended questions, several teachers noted that they needed their learning from their PD to be directly relevant to their work in preschools. As P239 stated (Q8) “Locating and Designing suited our group of children. We, educators, became aware that this way of working was also mathematics”. The link between the content and the tasks that introduced the teachers to the content are discussed in more detail in the next section.

Tasks

The tasks were spread across the four sections, A, B, C, D, in each of the 12 parts. The questions that we asked ourselves as designers of the tasks in the materials was: How can the affordances of context and artefacts be utilised to support content delivery? Why would teachers want to engage in these activities? From the survey, we wanted to find out in what ways the teachers deemed the tasks useful, or not, specifically in regard to their learning and changing of practices.

The teachers were asked what had contributed the most to their learning (Table 4) and what had hindered their learning (Table 5). With these multiple-choice questions, the teachers could mark more than one response. For each type of task, they were also asked how important it was for their learning. The teachers evaluated the tasks for each section differently but indicated that it was the combination of tasks that had the biggest impact on their learning.

Table 4
The tasks that the teachers considered contributed the most to their learning (Q6, n=255)

	Texts and videos	Discussion with colleagues	Trying out tasks with children	Documentation of own and children's learning
Number of responses	53 (21%)	201 (79%)	141 (55%)	76 (30%)

In Table 4, the teachers indicated that of the tasks in the PD, engaging with the texts and videos contributed the least to their learning. On the other hand, talking to their colleagues was identified as making the most contribution. This is consistent with the 43% of teachers in Table 5 who found the texts too hard and the 30% who found the videos not relevant. P147's comment (Q13) about the materials indicates the frustration that some teachers had with the written materials, but also how they were supported in understanding the texts by discussions with their PD facilitator and colleagues: "Texts and tasks have generally been extremely vague, difficult to interpret and generally awkwardly formulated. The videos were often worse. After discussion with colleagues and supervisors, you got help to understand what should be done".

Table 5
Hindrances to Learning (Q7, n=245)

	Time to do PD	Texts too hard	Videos not relevant	Tasks too difficult to implement	Tasks not appropriate for children's group	Discussions not helping learning
Number of responses	204 (83%)	105 (43%)	73 (30%)	51 (21%)	52 (21%)	3 (1%)

In Table 5, the lack of time for doing the PD was noted by 83% of respondents. This need for more time to do the PD had also been noted in the pilot study (Helenius, Johansson et al., 2015a), where teachers wrote in a lack of time, even when they were not asked specifically about it. In Table 4, only 21% of teachers nominated the written materials as the most useful source of learning. It is perhaps not surprising that reading difficult texts would be considered too hard if teachers have limited preparation time. This can be seen in P109's comment (Q13) "Got a new mindset. But it really took time to get everything in. Had to read the text and watch the videos several times." Nevertheless, as can be seen in Figure 3, reading texts and watching videos were still ranked highly as contributing to their learning by the majority of teachers.

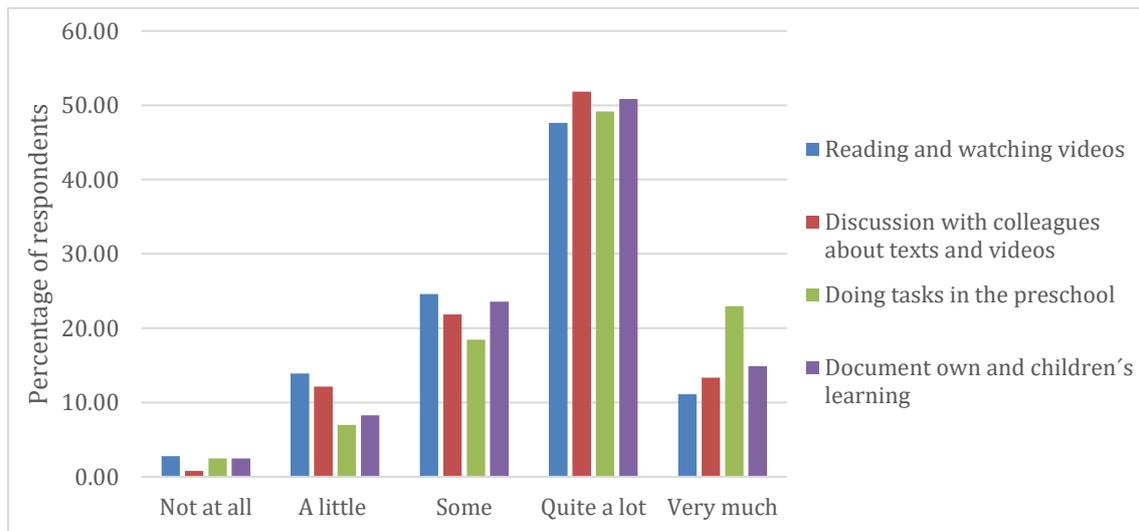


Figure 3. Contribution to learning by percentage of respondents (Q12, $n=252$; Q14, $n=247$; Q16, $n=244$; Q18; $n = 242$).

Although, in Figure 3, reading and watching videos can be seen as being less valued than doing tasks in their preschools, the differences are small in how the teachers considered they contributed to their learning. More than half the respondents, 59–72%, saw each set of tasks as contributing “quite a lot” or “very much” to their learning. Fewer than 3% of respondents considered that the tasks did not contribute at all to their learning.

Benz (2016) noted the need for joint reflections on the tasks in order for professional understandings to be deepened. Therefore, discussing with colleagues is important when the content presented in texts and videos is difficult. It was interesting to find that there were also many comments about the tasks to do with interacting with children. Relationships about mathematics are discussed in the next section.

Relationships

In the design model (Figure 1), we considered that there were a number of different relationships that needed to be mediated through the PD materials. In particular, we were concerned with the relationship between ourselves, as the developers, and the teachers; the teachers with other teachers; and the teachers with others such as children and parents. In many ways, we considered that nurturing relationships through the content and the tasks was the most challenging component because we could not speak directly to the teachers. Instead, we had to nurture the different relationships through how we presented the content and the tasks.

Table 6

From working with the module, do you consider that your previous experiences were useful? (Q20, $n=245$)

	Not at all	A little	Some	Quite a lot	Very much
Number of responses	3	21	27	128	66
% of number of respondents	1	9	11	52	27

Table 6 shows that almost 80% of the teachers considered that their previous experiences in preschools had been useful, and hence valued, as they worked with the PD materials. There were 48 comments to the follow-up question (Q21), which asked the teachers to give an example of how their previous experience had been useful or not. These comments were varied but most felt that their previous experiences supported them to understand the new material, because they could recognise the situations described in the texts and the videos.

I think that all my experience helps me to understand and recognise the examples provided in the module, for example in the video snippets, even if they were not applicable to the group of children I was working with during the Mathematics Initiative [the PD]. (P42, Q21)

Some teachers also felt that their experiences supported them to choose situations to do with the children which were at an appropriate level for them, "Easy to choose 'tasks' challenging the children just right when I have a lot of experience" (P124, Q21). Many of the teachers referred to their previous learning, either while completing their teacher education or in subsequent PD programmes. For example, P134 stated (Q21) "Bishop's Playing activities are close to Fröbel's pedagogy which is dear to my heart".

The teachers also used their previous experiences to reflect on their new learning and its value.

Since I am also a primary school teacher and have experience with mathematics at school, I know what is coming, that is, what problems or difficulties that one usually encounters. The Mathematics Initiative has been a way to prevent them. I have worked with number in pre-school but not so much with the other concepts based on Bishop's, so it has given me many ideas about what mathematics is and how many questions/thoughts/hypotheses that can pop up both with me and the children. (P2, Q21)

These and other comments suggested that the materials did mediate between ourselves, as the authors, and the teachers because the videos, texts and choice of situations, for enacting with children, supported them to use their previous experiences to make sense of the new material. The teachers also seemed to consider that the materials and tasks contributed to them building relationships with others.

In the pilot study of the use of videos (Helenius, Johansson et al., 2015a), we had found that the teachers had considered the videos in the PD materials as contributing to relationship building between themselves and their peers but did not see them as contributing to building other relationships, such as with parents. The results from question 22, 24 and 26, combined in Figure 4, indicate that the teachers saw the PD as developing their relationships with children, with peers and to a lesser extent with parents. Relationships with parents are not discussed explicitly until the final parts of the module. As only 12% of teachers had completed all 12 parts, those teachers still working with the earlier parts may not have felt that they had gained much information on this.

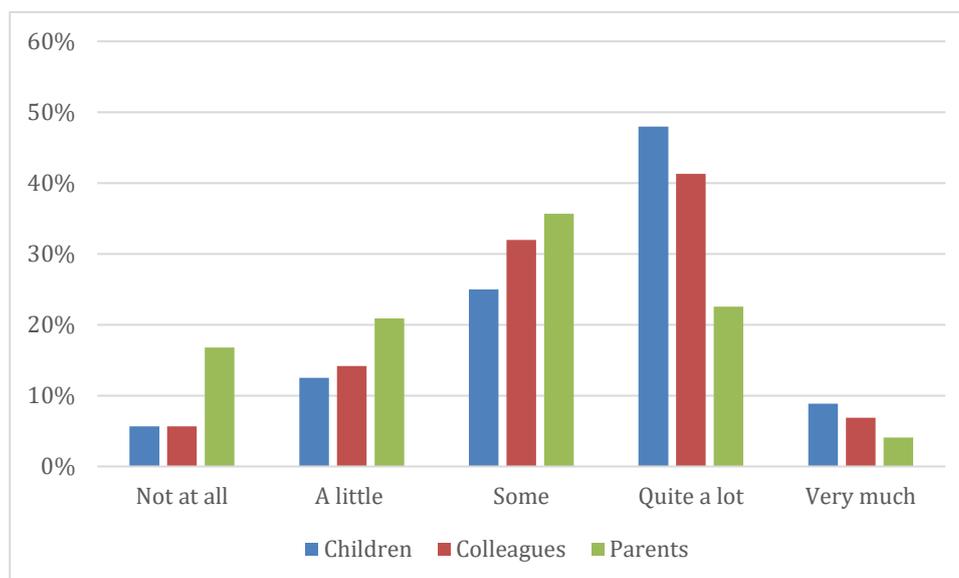


Figure 4. From working with the module, do you consider that your relationships with children/colleagues/parents around mathematics has changed? (Q22, n=248; Q24, n=247; Q26, n=244)

Relationships with fellow teachers were mentioned frequently as providing support in making sense of, especially, the written materials with the consequence that the teachers discussed mathematics more in their preschools. The design of the material did seem to contribute to this kind of reflection. P18 commented (Q25) "We have an open discussion about the everyday mathematical concepts that we use daily. [We] strengthen each other in various thoughts, environments and how we should proceed and that we look forward and challenge ourselves and the children." The relationships between teachers seemed to be connected to the mathematical content in the materials. Some teachers noted the difficulty with trying to discuss the ideas with teachers who had not participated in the PD, "Not all in my work team did the Mathematics Initiative and it was very difficult to have discussions with those who did not think in the 'new' way" (P69, Q25).

The teachers appreciated trying out tasks with the children and many said that this gave them a better understanding of children's thinking, "I feel that with the small children, it is quite difficult mathematics, but they thought that it was fun, for example, designing with a natural object" (P196, Q23). This indicates that when the teachers tried out the mathematical situations even if their previous experiences suggested that they were too hard, the children's responses gave them new insights. Several teachers mentioned that they now asked children more questions, for example, they "question the children's thinking more" (P47, Q13), and "dare to question the children" (P187, Q13). Some stated that their relationship to children around mathematics had changed because of their participation in the PD and the content they had learnt:

I have caught sight of things that I have not thought about before as mathematics. How important it is to name, to be active in various ways in the children's activities/ doings and to gain knowledge of how to challenge further on the basis of Bishop's ideas. (P200, Q23)

Although Figure 4 shows that the relationship building with parents was not considered by the teachers to have improved as much as their relationship with children or with peers, the PD did affect teachers' possibilities for talking with parents. Many teachers wrote that they gained ways

to talk about children's engagement with mathematics, "How nice it was that you could bring in the parents in the preschool activity and see how they view mathematics and that you can explain to them that mathematics is not just counting" (P10, Q27) or noted more response from parents "Parents comment more on what we are doing and tell what the children show at home" (P97, Q27). Yet, some teachers felt they were unsuccessful in making the mathematics the children were doing visible to parents. "We talk about what we do with the children in mathematics. We also put up documentation but we get very little feedback from parents" (P266, Q27). Nonetheless, generally the teachers reported that the parents felt that they talked more about mathematics since the teachers had been part of the PD. Some teachers connected this to their professional practice, "For parents, mathematics is counting. But when they looked at our documentation about, for example, Locating, they realised that it is mathematics. Being able to talk to the parents and explain the underlying purpose is to act professionally" (P151, Q27). In Helenius, Johansson, et al. (2015a), we found that the teachers did not view the videos included in the PD materials as contributing to relationships with parents. The results of this survey show that when all the tasks and materials are viewed together, there does seem to be some changes in these relationships. Still, the relationship building seemed to be based only on what the children were doing in the preschool, it did not seem to include hearing from parents about what the children did at home.

Practices

Desimone (2009) stated that behavioural and descriptive survey questions about PD supported the reliability and validity of the results. We also took the need for ensuring reliability and validity of results from this survey seriously, particularly in relationship to changing teacher practices. In the previous sections, we included some examples that the teachers gave about specific aspects of the PD materials. We also analysed in more detail three open-ended questions, 13, 15 and 17, about how specific tasks – reading and watching the texts and videos individually, discussing the texts and videos with others, enacting tasks in their preschools – affected teachers' practices. Five themes were identified in the responses:

Theme 1: Gaining new ideas about mathematics;

Theme 2: Improving their professional practice;

Theme 3: Gaining other understandings;

Theme 4: Getting tips and ideas from others; and

Theme 5: Practices in preschools improved theoretical understandings

Table 7 provides details of the numbers of responses for each theme across the responses to the three questions. More than half of the teachers, 55-61%, responded to the questions. Of the responses, about two thirds were coded at a theme. Very few responses were coded as indicating more than one theme. For example, for Question 13, only three responses were multi-coded and categorised in the different themes. A check was made to determine if it was the same teachers who made comments connected to the same theme across the three questions, but this proved not to be the case. This suggests that parts of the web materials mentioned in the different questions provoked a variety of responses from the teachers.

Table 7

Number of responses per question and percentage of sample ($n=267$); number of responses coded per theme in each question and percentage of responses to question; number and percentage of responses coded per theme across all responses

Question	Responses	Theme 1	Theme 2	Theme 3	Theme 4	Theme 5	Coded responses
Q13 texts, videos	164 (61%)	67 (40%)	22 (13%)	19 (12%)			108 (64%)
Q15 discussions	147 (55%)	12 (8%)	16 (11%)	56 (38%)	15 (10%)		99 (67%)
Q17 enactment	157 (59%)	21 (13%)	21 (13%)	32 (20%)	3 (2%)	30 (19%)	107 (68%)
All responses	468 (100%)	100 (21%)	59 (12%)	107 (23%)	18 (4%)	30 (6%)	

The first three themes were prominent in the responses to all three questions. In responses to questions 15 and 17, the remaining themes appeared, although there were only relatively small percentages of respondents who gave responses which were categorised as these themes.

Theme 1 was about how the teachers saw mathematics in new ways and about being able to put mathematical words on activities that they did with the children. For example, P113 stated (Q13) "I became aware of all the mathematics inherent in the preschool activity and what can be applied to the development of mathematics". In previous research (Helenius, Johansson, Lange, Meaney, Riesbeck, & Wernberg, 2015b), we had noted similar responses from preschool teachers about learning about Bishop's (1988a) mathematical activities in another kind of PD. The six mathematical activities seemed to provide teachers with a language to discuss their work with children. There were more comments connected to this theme in responses to the question 13 about the tasks of reading the texts and watching the videos individually than there were to other tasks. Despite being identified as the tasks that contributed the least to their learning (see Table 4 and Table 5), the texts and videos seemed to be the main source for learning about mathematics in preschools. The teachers' reflections about their experiences in preschools supported them to make sense of the new content.

However, sometimes the view about seeing mathematics in their work with children extended to a discussion of mathematics being everywhere. For example, P220 stated (Q13) "I got a different view of mathematics, and saw that it was present almost everywhere. We also use new concepts together with the children, for example the words Designing". The possibilities for discussing with children what they do as mathematics, or in this case Designing, is valuable. On the other hand, comments about mathematics being everywhere which provided no specific examples concern us, because they do not indicate that teachers can make explicit connections for children. Nevertheless, only from analysing the work of preschool teachers would it be possible to identify how theoretical understandings are put into practice and if survey responses about mathematics being everywhere should be something to be concerned about.

Theme 2 consisted of the comments that the teachers made about their professional practice. For example, P42 stated (Q17) "They got us to try to adapt and change the activities to suit the children's group we worked with. In that way, we got to reflect and then we also learned more". Comments about professional practice also included learning from the children about what they could do, so that the teachers could find ways to challenge them "To catch sight of the child's/children's skills right now and how we can challenge them on the basis of the activity" (P200, Q17). As noted in the section on relationships, challenging children was often connected

to the questions that the teachers asked the children, "Reflecting on how important it is to be prepared as a teacher and how I pose questions to the children and not to have too many children with whom I do the activity" (P204, Q17). Challenging children was also something that was seen as enjoyable for both the teacher and the children, "Both I and the children learn things together and at the same time it's fun to be challenged" (P210, Q17).

Theme 3 was about gaining other understandings, such as pedagogical understandings or understandings connecting theory to practice. For example, P182 stated (Q13) "Connect theory and practice. Get 'aha experiences'". Most responses to question 15 about discussions with colleagues were categorised as this theme. These responses did not specifically mention mathematics, although they sometimes mentioned making sense of the texts and videos by talking with their colleagues, "Good with shared collegial discussions. Learn from each other, see different things that come up for discussion" (P189, Q15). Many of the comments about discussion with colleagues were about the usefulness of hearing different ideas. Yet, time was noted as an issue in order to gain the most from these discussions, "Time has been a little short in this particular part for it to have provided full benefit. But they have brought more perspectives" (P168, Q15).

Theme 4 appeared in comments connected to Question 15 and had some similarities with theme 3. However, the ideas that the teachers gained came from the practical experiences of other teachers. P220 stated "In conversation with colleagues, you got many new tips and ideas". Similarly, P250 stated, "Good to immerse yourself in text and video talk in discussion with colleagues themselves. Good to share with others, get tips and ideas from each other, that one can then work on and test in one's own children's group". Our concern with comments about gaining tips is that they may not indicate that theoretical understandings are contributing to adopting new practices. The learning may stay on enacting and not on reflecting through their theoretical understandings about what the children were likely to be learning. Although question 17 was directly about trialling ideas out in preschools and thus opened up possibilities for discussing tips and practical ideas, only three teachers made such comments. One of these was "It has brought up ideas and interest in practicing or testing certain activities with children which would not otherwise have been done" (P127). Responses to trialling tasks in preschools were spread more evenly across the other 4 themes.

Theme 5 only appeared in responses to question 17 and was about how enacting practices in the preschools led to better understanding of the theoretical ideas in the materials. For example, "One will more easily remember the meaning of the difficult words if you use them in different tasks in practice" (P188), "Adapting the activities in practice, make it more concrete" (P86). Teachers also commented that the connection between theory and practice was not always easy to see:

It is my everyday so that if I have everything in theory, but can't manage to transform to my children's needs and knowledge, then I feel that I have failed. But in these cases, I have sometimes had to simplify the tasks based on where the children are at and then it has been very rewarding. (P151)

In the moment when you did it, it was fun and educational. You would like to do it more times but in the current situation of staff reduction it is sometimes forgotten/prioritised away. (P100)

These comments indicate that only providing theoretical understanding may not result in teachers changing their practices. As well, other aspects connected to their work situation, such as having time and the support of others were likely to have an impact on teachers making sustained changes to their practices. Nonetheless, it will only by following teachers in preschools that it will be possible to determine how PD materials contribute to changed practices.

Conclusions

The results show that the teachers were able to evaluate the usefulness of the PD materials, through both closed and open responses to a survey. The multiple-choice answers provided some information about the content, the tasks, and relationships, giving a general impression of what they found valuable in the texts, videos, discussions with colleagues and trialling learning possibilities with children. The open-ended questions provided more details and helped to unpack some of the inconsistencies, particularly about the texts and videos which were described by some teachers as difficult to understand. It seemed that if the teachers have time and opportunity to discuss the videos and texts with others, both before and after trialling tasks with children, then they could better understand the theoretical ideas and connect them to their practices. Nonetheless, not all preschool teachers were able to use the materials to make these connections. As we are in the process of revising the materials for Skolverket, we take on board the need to rewrite the texts and improve the connections to the videos.

In regard to the usefulness of online materials in PD programmes, providing tasks in which teachers need to work with others does seem to support them to make sense of complex theoretical ideas and build their professional relationships. Overall, the teachers who responded to the survey indicated that they had gained new understandings and practices from working with the material. Of course, it must be noted that the sample may be biased as the teachers who gained nothing from completing the PD may not have responded to the survey.

Yet it seemed to us, that the results suggest that as a set of design principles, the model for developing web-based PD materials did result in materials that supported preschool teacher learning. The interconnectedness of the components was evident in the survey responses. The content, Bishop's six activities, was at the centre of many teachers' comments about the PD, regardless of the question. Bishop's six activities seemed to provide the teachers with possibilities to see their current work in new ways and this provided them with incentives to ask the children more challenging questions about what they were doing. The exception was when the teachers wrote about discussions with peers. In these responses, many teachers did not mention mathematics. Yet, when the teachers were asked explicitly about their relationships with their peers, children and parents, mathematics was the focus for many, suggesting that changes to the relationship were driven by new mathematical understandings.

In considering the more general question about evaluating web-based PD materials, our results provide some insights into what can be evaluated and what cannot. Fishman et al. (2003) stated that an evaluation of a PD programme cannot rely purely on the completion of surveys and that this kind of data should be just one type of input. Further research is needed to see whether the length of time that the teachers work with the materials improves teachers' understanding of the texts, both new and old. There is also a need for follow-up work in preschools to understand better if and how the teachers changed their practices in regard to engaging children in mathematics. This is part of a wider research programme that we are already conducting. Nevertheless, Fishman et al. (2003) did note that surveys can and do supply important information which when considered also with other data can be informative of the impact of the PD. We consider that the results of our survey provide interesting pointers to others intending to design online PD materials.

Changes in technology and increasing willingness by governments for teachers to attend PD is likely to result in more online PD materials being made available. Yet, little research has been done about the theoretical understandings needed for designing these materials or on evaluating their usefulness to teachers (Joubert & Sutherland, 2009). In this study, we have begun a discussion about these issues by both presenting our design model and having teachers provide an indication of how this material contributed to their learning about mathematics in preschools

and to them changing their practices. The findings support Prediger et al. (2015) that choice of content should be the driving force for developing PD.

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Appendix

A translated text version of the online survey.

1. How long have you been a preschool teacher?
 - a. < 5 years
 - b. 5-10 years
 - c. 10 years
2. How much mathematics did you have in your teacher education?
 - a. None
 - b. 15 credits [60 credits equal one year of full-time study]
 - c. 30+ credits
3. Was there a facilitator of your work on the PD module?
 - Yes
 - No
4. If you had a facilitator, what was their main role:
 - a. To ensure all participants had access to the material and organise the meetings
 - b. To facilitate the discussions in Moment B and D
 - c. To support the trialling of practical tasks in Moment C
 - d. To evaluate the documentation completed with each part
 - e. Other _____ ...
5. How many parts of the module for preschool have you completed?
 - a. Part 1-4
 - b. Part 5-8
 - c. Part 9-12
6. What would you consider had the most impact on your learning from completing a part? (You can mark more than one response)
 - a. The materials
 - b. The discussions with colleagues
 - c. Trying out tasks with the children
 - d. Documenting own and children's learning
7. What would you consider limited your possibilities for learning? (You can mark more than one response)
 - a. Time for engaging in the materials and discussions
 - b. The written materials were too hard to understand
 - c. The videos were not relevant
 - d. The suggested tasks were too difficult to implement

- e. The suggested tasks were not appropriate for the children that you work with
 f. The discussions did not support your learning
8. Of the parts that you have completed, which one did you appreciate the most? _____
9. Why did you appreciate it the most? (You can mark more than one response)
- Learnt the most from completing it
 - The written material and videos made it easier to understand the ideas in the part
 - The tasks with the children clearly showed how much they knew about mathematics
 - The discussions with other teachers facilitated understanding the ideas in the part.
10. Of the parts that you have completed, which one did you appreciate the least? _____
11. Why did you appreciate it the least? (You can mark than one response)
- Learnt the least from completing it
 - The written material and videos were hard to understand
 - The tasks with the children showed very little about what they knew about mathematics
 - The discussions with other teachers did not facilitate understanding about the ideas in the part.
12. Moment A included some texts to read and videos to watch. How useful were these in supporting your learning?
- Not at all A little Some Quite a lot Very much
13. In what way, did they make you change your existing practices? _____ ...
14. Moment B involved you discussing the texts and videos with others. How useful were these discussions in supporting your learning?
- Not at all A little Some Quite a lot Very much
15. In what way, did they make you change your existing practices? _____ ...
16. In Moment C, you had to try out different activities in your preschool. How important were they for your learning?
- Not at all A little Some Quite a lot Very much
17. How did the tasks make you change existing practices? _____ ...
18. Moment D required you to document yours and the children's learning. How important was this documenting for your learning?
- Not at all A little Some Quite a lot Very much
19. In what way, did it make you change your existing practices? _____ ...
20. From working with the module, do you consider that that your previous experiences were useful?
- Not at all A little Some Quite a lot Very much
21. Please provide an example: _____ ...
22. From working with the module, do you consider that your relationships with children around mathematics has changed?
- Not at all A little Some Quite a lot Very much
23. Please provide an example: _____ ...
24. From working with the module, do you consider that your relationships with colleagues around mathematics has changed?
- Not at all A little Some Quite a lot Very much
25. Please provide an example: _____ ...
26. From working with the module, do you consider that your relationships with parents around mathematics has changed?
- Not at all A little Some Quite a lot Very much
27. Please provide an example: _____ ...

28. From working with the module, do you consider that you have gained new insights into how different artefacts can be used to develop children's mathematical understandings?

Not at all A little Some Quite a lot Very much

29. Please provide an example: _____ ...

Authors

Ola Helenius

NCM, Gothenburg University; Box 160, 40530 Göteborg, Sweden

email: ola.helenius@ncm.gu.se

Maria L. Johansson

Luleå University of Technology, Department of Arts, Communication and Education; 971 87 Luleå, Sweden

email: maria.l.johansson@ltu.se

Troels Lange

Western Norway University of Applied Sciences, Møllendalsveien 6-8, 5009 Bergen, Norway

email: trl@hvl.no

Tamsin Meaney

Western Norway University of Applied Sciences, Møllendalsveien 6-8, 5009 Bergen, Norway

email: tme@hvl.no

Anna Wernberg

Malmö University, 205 06 Malmö, Sweden

email: anna.wernberg@mah.se