To gain knowledge of how to be challenging: Preschool mathematics professional development

The editors will enter dates here. Received: / Accepted:   
© Mathematics Education Research Group of Australasia, Inc.

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. However, the requirement to work on the materials 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 materials valuable for gaining knowledge about mathematics for young children that they could implement as tasks to challenge the children in their preschools.

**Keywords** Web-based professional development, preschool teachers, survey studies, Bishop´s 6 mathematical activities

# Professional development in mathematics education for Swedish preschools.

Curricula 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 level of the education system (Author). In this paper, the results are described from a survey of 267 preschool[[1]](#footnote-1) teachers who used at least one third of the web-based materials, which we 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 were related to the teachers´ experiences from 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 about the role of preschools between 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), which 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 curriculum 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 in Sweden. 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 policy 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 without mathematics education in their teacher education, but needing to deliver 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. Perry, Dockett, and Harley (2007) provide a description on such a project in Australia. In Sweden, Skolverket had previously provided PD about mathematics to preschool teachers, through face-to-face courses set in universities (see for example, Author). 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 (Author). 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 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 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.

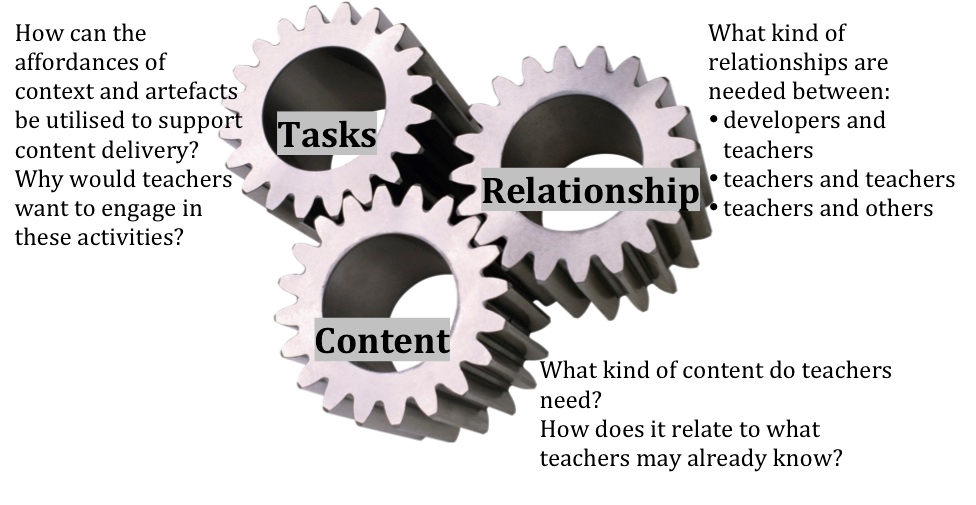
# Designing web module for preschool teachers

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 films 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 (Author), 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, with Fishman, Marx, Best, and Tal´s (2003) model being the most relevant. Their model was about PD materials for school teachers and when compared with our own decision-making did not closely reflect what we had done (Author).

The 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 needed to nurture. The questions in Figure 1 guided the later development of the PD material for each section of the 12 parts. For example, in asking reflective questions in Section D, we kept in mind our relationship as the authors of the materials with the teachers, as we wrote questions to facilitate discussions between the teachers. Our intention was to support the teachers to share unsuccessful as well as successful experiences as we considered these were likely to support deeper reflections on the teachers´ learning and their 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 it must be both empirical and theoretical. However, “participants in professional development can often come away with unintended learning that can include misconceptions or otherwise problematic understandings of the intended content” (Fishman, Marx, Best, & Tal, 2003, p. 647). In order to minimalize this possibility, the other two components had to be developed simultaneously.



*Figure 1*. Model for designing professional development material

We drew our understanding on what content to include from previous mathematics education research. However, much of this research focused on preparing children for school (see Clements & Sarama, 2007). Hence, 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 (1988) 6 mathematical activities (Playing, Explaining, Locating, Designing, Measuring and Counting[[2]](#footnote-2)), on which the goals for mathematics in the preschool curriculum are implicitly based (Utbildningsdepartementet, 2010). Although Bishop’s (1988) 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 6 activities and young children formed the basis of the ideas we imparted in the material and includes Author. Prediger et al. (2015) stated that empirical findings should be shifted through to determine what should be included in PD. However, 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.

The second component in the design model is the choice of PD tasks. The tasks include watching films, 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 further insights, than are possible from merely reading about new content.

The final component is the decisions to do with nurturing relationships, both within the PD and in preschools. A relationship of trust between teachers is vital if they are to learn together. As well, the pedagogical content in the PD materials does at times promote particular kinds of relationship with the children. 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 need to develop a relationship with the teachers through the materials in order to affect how the teachers interpret the theories, ideas and experiences in them. Preschool teachers may 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, we include 3 parts focused on the preschool teachers´ reflections on the documentation that they collect during the 3 previous content-focused parts. These documentation parts are to support teachers to reflect on how new learning is connected to earlier learning, both in the PD and in their work in preschools. We, therefore, see our inclusion of these tasks as developing the pathway of teachers´ learning. Sensitivity to teachers seems to be in alignment with our focus on relationships. However, the relationships component in the design model includes 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 be merged together. We wanted what Benz (2016) found in her research in 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 via the three components of the design model, the usefulness of the PD materials for preschool teacher, 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 had completed at least 4 out of the 12 parts of the module, that is at least 6 months of work with the PD but who were still involved in the programme. 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 were no longer in contact with municipality organisers

There were 29 questions of which 18 were multiple choice and the other 11 open-ended. In developing the survey questions, we followed the advice of Desimone (2009):

Answers to survey questions are best used to answer defined, discrete questions about frequencies and trends, specific features of professional development, and instructional time spent on specific content and practices. Teacher surveys that ask behavioral and descriptive, not evaluative, questions about the teachers’ professional development experiences and teaching have been shown to have good validity and reliability. (Desimone, 2009, p. 190)

Although we did ask 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 to ask the teachers why this was the case. 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 (Author). 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.

# Results

According to the survey responses to questions 1-5, almost 70% of the teachers had been teaching for more than 10 years and 53% of the teachers had not attended any mathematics education courses in their teacher education. 15.5 % of the teachers had only completed the first 4 parts 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 11.5% had completed all 12 parts, which focused on Measuring and Counting. A large majority, 82%, had a PD facilitator whose main role, according to the participants, was to ensure that the teachers had access to the materials and organise the discussion sections.

The responses from the remaining multiple choice questions are discussed in relationship to the components in the design model in *Figure 1*: content, the tasks and the 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 6 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 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; and
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, P212 wrote “I already have so much mathematics thinking with me from training. How incredible is the importance of mathematics and how much fun it can be!”

Figure 2 show which parts were appreciated (“uppskattad”) 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.

Given the different number of teachers who completed the parts, the graph in Figure 2 can only provide an indication of trends. There are 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 (14%) than did not appreciate 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, based on the teachers´ documentation (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).

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, “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 common thread in it all”. For some, the difficulty with the beginning parts was the newness of doing PD. P193 stated “thought that it was the most difficult to get into it in the beginning of the first parts, because one has not started properly with the material and feels stressed”. Therefore, it may be that teachers´ evaluations of the parts change as they continue the PD as a result of their understanding increasing. 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 (Author). The results from these questions are provided in Table 1.

Table 1

The number of participants choosing the provided reasons for most or least appreciated part

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | I learnt the most/ least from it | The written texts and films 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 | 49 | 138 | 99 |
| Least (*n=155*) | 69 | 81 | 26 | 12 |

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 films 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 kindergartens. As P239 stated “Locating and Designing suited out group of children. We, educators, became aware of 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 that the teachers had to do were situated in 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? We, therefore, wanted to find out in what ways the tasks were deemed as useful, or not, by the teachers, specifically in regard to their learning and impact on them changing their practices.

Table 2

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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Texts and videos | Discussion with colleagues | Trying out tasks with children | Documentation of own and children´s learning |
| Number of responses | 53 | 201 | 141 | 76 |
| % of number of respondents | 21 | 79 | 55 | 30 |

The teachers were asked what had contributed the most to their learning (Table 2) and what had hindered their learning (Table 3). For 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. Figure 3 shows the results for all four questions (Questions, 12, 14, 16 and 18). The teachers evaluated the tasks for each section differently but indicated that it was the combination of tasks which had the biggest impact on their learning.

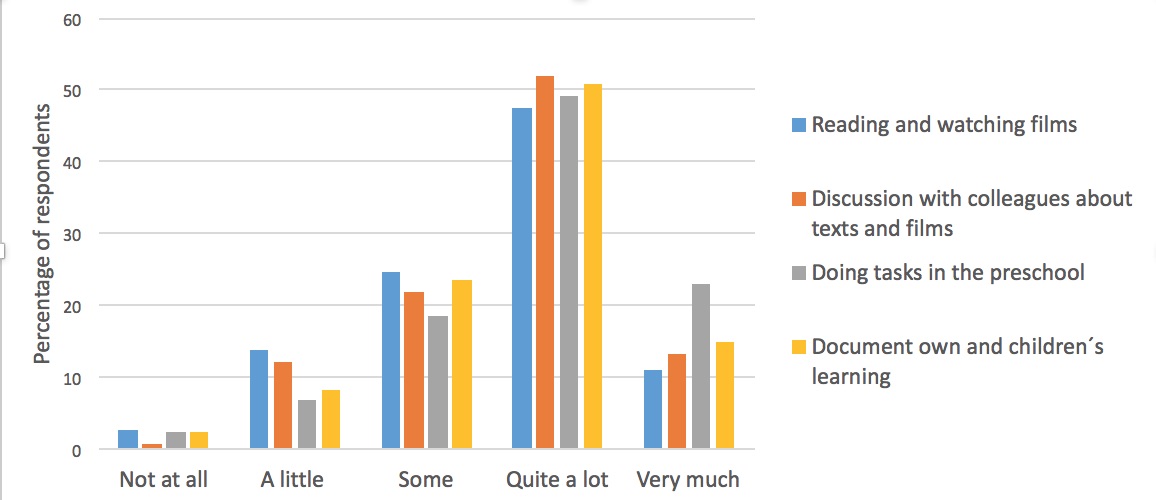
In Table 2, the teachers indicated that of the tasks in the PD, engaging with the texts and videos contributed the least to their learning. On the other hand, talking to their colleagues was identified as making the most contribution. This is consistent with the 43% of teachers in Table 3 who found the texts too hard. P147´s comment 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 films were often worse. After discussion with colleagues and supervisors, you got help to understand what should be done.” However, the view that the texts and films were hard to interpret was partly contradicted in the responses to the questions how well the different tasks supported the teachers´ learning as can be seen in Figure 3.

Table 3

Hindrances to learning (n=245)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Time to do PD | Texts too hard | Film not relevant | Tasks too difficult to implement | Tasks not appropriate for children´s group | Discussions not helping learning |
| Number of responses | 204 | 105 | 73 | 51 | 52 | 3 |
| % of number respondents | 83 | 43 | 30 | 21 | 21 | 1 |

In Table 3, 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 (Author), where teachers wrote in a lack of time, even when they were not asked specifically about it. In Table 2, only 21% of teachers nominated the written materials as the most useful source of learning. It is perhaps not surprising that if teachers have limited preparation time, then reading difficult texts would be considered too hard. This can be seen in P109´s comment “Got a new mindset. But it really took time to get into everything. Got to read the text and look at the films several times.” However, as can be seen in Figure 3, reading texts and watching the films were still ranked highly as contributing to their learning by the majority of teachers.



*Figure 3*. Contribution to learning by percentage of respondents.

In Figure 3, although reading and watching films 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, 60–70%, saw each set of tasks as contributing “quite a lot” 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 films is difficult. It was interesting to find that there were also many comments about the tasks to do with interacting with children. These relationships around 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 the children and with 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 4

Teachers´ responses to question 20 about how their previous experience was valued (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 4 shows that almost 80% of the teachers considered that their previous experiences in preschools had been valued as they worked with the PD materials. There were 48 comments to the following question which asked the teachers to give an example of how their previous experience had been valued, 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 films.

I think that all my experience helps me to understand and recognize the examples provided in the module, for example in the films, even if they were not applicable to the group of children I had to work with in the mathematics initiative. (P42)

Some teachers also felt that their experiences supported them to choose situations to do with the children which was at an appropriate level for them, “Easy to choose moderately challenging "tasks" to the children when I have a lot of experience” (p. 124). Many of the teachers referred to their previous learning, either while completing their teacher education or in subsequent PD programmes. For example, P134 stated “Bishop´s Playing activities is 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 a primary school teacher and also has experience of 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 the children and me on the road. (P4)

The teachers’ comments suggested that the materials did mediate between ourselves, as their authors, and the teachers, because the films, texts and choice of situations to try out 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 (Author), 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 last third of the module. As only 11.5% of teachers had completed all 12 parts, with the rest still working on earlier sections, they may not have felt that they gained much information on this from the materials.

*Figure 4*. How much did working with the PD allow you to develop your relationships?

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. P20 commented “We have an open discussion about them every day, 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, “All my work team did not do the Mathematics Initiative [the PD] and it was very difficult to have discussions with those who did not think the "new" way” (P69).

The teachers appreciated trying out tasks with the children and many said that this gave them a better understanding of children´s thinking, “I thought that it was quite difficult mathematics for the small children but they thought that it was fun to design with a natural object, for example” (P196). This indicates that when the teachers´ previous experiences suggested that the mathematical situations would be too hard but they tried them out anyway, the children´s responses gave them new insights. Several teachers mentioned that they now asked children more questions, for example, they “question the child's thinking more” (P47), “dare to question the children more” (P187). 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 the things that I have not thought about for mathematics before. How important it is to name concepts, to be active in various ways in the children's activities/campaigns and to gain knowledge of how to be challenging, on the basis of Bishop´s ideas. (P200)

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 seem to affect teachers´ possibilities for talking with parents. Many teachers wrote that they gained ways to talk about the children´s engagement with mathematics, particularly about how they could use the documentation to support children´s learning, “We talk about what we do with the children in mathematics. We also set out documentation and we get quite a bit of feedback from parents” (P266). Some teachers noted that it was difficult to make the mathematics the children were doing visible to parents. P230 stated “Since it is quite complicated, I have not gone into detail. But overall conversation and some tasks that the child did I have explained, for instance Locating and Designing. We have done many maps of our environment.” 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 realized that it is mathematics. Being able to talk to the parents and explain the underlying purpose is to act professionally” (P151). 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 the parents about what the children did at home. In Author, we found that the teachers did not view the videos included in the PD materials as contributing to relationships with parents. However, when all the tasks and materials are viewed together, there does seem to be some changes in relationships from completing the PD.

## Qualitative results

Desimone (2009) stated that behavioural and descriptive survey questions about PD supported the reliability and validity of the results. In the previous sections, we have included some responses where we asked teachers to provide examples about specific aspects of the PD materials. However, to provide a broader understanding of these descriptive and behavioural responses, we chose to analyse in more detail three open-ended questions, 13, 15 and 17, about how specific tasks–reading and watching the texts and films individually, discussing the texts and films with others, doing tasks in their preschools–affected teachers´ practices. Three themes were prominent in the responses to all the open-ended questions, but in responses to questions 15 and 17, other themes also appeared. The themes were:

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

Theme 5: Practices in preschools improved theoretical understandings

Table 5 provides details of the numbers of responses for each theme across the responses to the 3 questions. Very few responses were coded as indicating more than one theme. For example for Question 13, only 3 responses were multi-coded and then included in the different themes.

Table 5

Number of responses per theme and per question

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Question | Theme 1 | Theme 2 | Theme 3 | Theme 4 | Theme 5 |
| 13 | 67 | 22 | 19 |  |  |
| 15 | 12 | 16 | 56 | 15 |  |
| 17 | 21 | 21 | 32 | 3 | 30 |

As can be seen across the questions, the proportion of responses changed. Fishman´s exact text was used to see if there was any relationship between the amount of mathematics education in their teacher education and the preschool teachers´ responses coded as a specific theme. No correlation was found at any level of significance. A check was also made to determine if it was the same teachers who made comments connected to the same theme across the three questions. However, this was not the case. For example, P220 made comments which were categorised as different themes for each of the three questions. This suggests that parts of the web materials mentioned in the different questions provoked different responses from the teachers.

Theme 1 was about how the teachers saw mathematics in new ways and about being able to put mathematical words on things that they did with the children. For example, P113 stated “I became aware of all the mathematics inherent in the work activity and what can be applied to the development of mathematics”. In previous research (Author), we had noted similar responses from preschool teachers about learning about Bishop´s (1988) mathematical activities. Our conclusion was that providing information on the six mathematical activities provided teachers with a language to make sense of their work with children. There were more comments connected to this theme in responses to the question about the tasks of reading the texts and watching the films individually than there were to other tasks. As mentioned earlier, the texts and films seemed to be the main source for learning about mathematics in preschools, but 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 “I got a different view of mathematics, and saw that it was almost everywhere. We also use new concepts together with the children, for example, the words used for 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 everywhere which provided no specific examples concern us, because they do not indicate that teachers are able to make specific connections for the children. Nevertheless, it is only from analysing the work of the preschool teachers that it will be possible to know exactly how theoretical understandings are put into practice and whether the short answers about mathematics being everywhere in the online survey should be something to be concerned about.

Theme 2 consisted of the comments that the teachers made about their professional practice. The most responses for this theme came when the teachers were discussing trying things out with the children. For example, P42 stated “They got us to try to adapt and change things to suit the children's group we worked with, that way we got to think extra and we also learned more then”. 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). As had been noted in the section on relationships, challenging children was often connected to the questions that the teachers asked the children, “Thinking of how important it is to be prepared as a teacher and how I ask questions to the children and not to have too many children that I do the activity with” (P204). 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 simultaneously it's fun to be challenged” (P210).

Theme 3 was about gaining other understandings, such as pedagogical understandings or understandings connecting theory to practice. For example, P182 stated “Connect theory and practice. Get the "a-ha 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 films by talking with their colleagues, “Good shared collegial discussions. Learn from each other, different things that come up for discussion” (P189). Many of the comments about discussion with colleagues were about the usefulness of hearing different ideas. However, for the discussions to be valuable, time was noted as an issue, “Time has been a little short in this particular part for it to have provided full benefit. But they have brought more ideas” (P168).

Theme 4 appeared in comments connected to Question 15 and had some similarities with theme 3. However, the ideas that the teachers gained did not seem to be strongly connected to the ideas in the PD materials, but rather from the practical experiences of other teachers which arose in the discussions. P220 stated “In conversation with colleagues got many new tips and ideas”. Similarly, P250 stated, “Good to talk with colleagues immerse themselves in text and film. Good to share with others, get tips and ideas off 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, only three teachers made comments which were classified as being about tips and ideas. One of these was “It has brought up ideas and interest to practice or test certain activities with children who would not otherwise have done” (P127). It could have been expected that there would have been more comments in this category because of the connection to enacting. However, trialling the tasks in preschools provided responses that 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 easily remember the difficult meaning of the words if they are used in different tasks in practice” (P188), “Getting the practical application activities make it more concrete” (P86). However, teachers also commented that the connection between theory and practice was not always easy to see:

It is my everyday circumstance that I have everything in theory, but can´t manage to respond 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 task based on where the children are and when it has been very rewarding. (P151)

In the moment when you did it, it was fun and educational. People want to do it more times but in the current situation of human failure sometimes it is 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 are likely to have an impact on teachers making sustained changes to their practices. However, 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 of the survey show that the teachers could provide a lot of information about their views on the usefulness of the PD materials. 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, films, 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 films which were described by some teachers as difficult to understand. It seemed that if the teachers have time and opportunity to discuss the films and texts with others, both before and after trialling tasks with children, then they can understand the theoretical ideas and connect them to their practices more easily. Of course, not all preschool teachers will be able to use the materials in this way to make these connections. As we are in the process of revising the materials for Skolverket, there is a clear indication that we should rewrite the texts and improve the connections to the films.

However, in regard to the usefulness of online materials in PD programmes, it is clear that complex ideas should not be simplified if this is likely to cause the theoretical understanding to be watered down. Providing tasks in which teachers need to work with others to make sense of the ideas does seem to support them and improve their professional relationships. As a set of design principles, the model for developing web-based PD materials seemed to be effective. 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.

The interconnectedness of the components was clear in the responses from the teachers. 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 allowed the teachers 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 engaging in. The exception is when the teachers wrote about the task of discussing 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.

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 the 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.´s (2015) that choice of content should be the driving force for developing PD.

However, Fishman et al. (2003) clearly state 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 of many sets in order for a comprehensive evaluation to be done. Further research is needed to see whether the length of time that the teachers work with the materials provides more insights and improves teachers´ understanding of the texts, both new and old. There is also a need for follow-up work in preschools to better understand how the teachers changed their practices in regard to engaging children in mathematics. This is work in progress. However, 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.

# References

*Author refer to 11 references involving one or more of the authors in different constellations.*

Australian Government Department of Education‚ Employment and Workplace. (2009). *Belonging, being and becoming*. Commonwealth of Australia.

Baxter, J. (2015). *Child care and early childhood education in Australia*. Melbourne: Australian Institute of Family Studies. Available from: https://aifs.gov.au/publications/child-care-and-early-childhood-education-australia

Bennett, J. (2005). Curriculum issues in national policy-making. *European Early Childhood Education Research Journal, 13*(2), 5–23. doi: 10.1080/13502930585209641.

Benz, C. (2016). Reflection: An opportunity to address different aspects of professional competencies in mathematics education. In T. Meaney, O. Helenius, M. Johansson, T. Lange & A. Wernberg (Eds.), *Mathematics education in the early years: Results from the POEM2 conference, 2014* (pp. 419-435). New York: Springer International Publishing. doi: 10.1007/978-3-319-23935-4\_23.

Bishop, A. J. (1988). *Mathematical enculturation: A cultural perspective on mathematics education*. Dordrecht: Kluwer.

Clements, D. H., & Sarama, J. (2007). Early childhood mathematics learning. In F. K. Lester (Ed.), *Second handbook of research in mathematics teaching and learning* (pp. 461–555). Charlotte, NC: Information Age.

Dede, C., Ketelhut, D. J., Whitehouse, P., Breit, L., & McCloskey, E. M. (2009). A research agenda for online teacher professional development. *Journal of Teacher Education, 60*(1), 8–19. doi: 10.1177/0022487108327554.

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher, 38*(3), 181–199. doi: 10.3102/0013189x08331140.

Dowling, A., & O'Malley, K. (2009). *Preschool education in Australia*. Melbourne: Australian Council for Educational Research. Available from: http://research.acer.edu.au/policy\_briefs/1/

Fishman, B. J., Marx, R. W., Best, S., & Tal, R. T. (2003). Linking teacher and student learning to improve professional development in systemic reform. *Teaching and Teacher Education, 19*, 643–658. doi: 10.1016/S0742-051X(03)00059-3.

Joubert, M., & Sutherland, R. (2009). *A perspective on the literature: CPD for teachers of mathematics*. [online]. National Centre for Excellence in the Teaching of Mathematics. Available from: <https://www.ncetm.org.uk/files/387553/RECME_Literature_Review.pdf>

McGraw, R., Lynch, K., Koc, Y., Budak, A., & Brown, C. A. (2007). The multimedia case as a tool for professional development: an analysis of online and face-to-face interaction among mathematics pre-service teachers, in-service teachers, mathematicians, and mathematics teacher educators. *Journal of Mathematics Teacher Education*, *10*(2), 95-121.

New Zealand Ministry of Education. (1996). *Te Whāriki*. Wellington: Author. Available from: http://www.education.govt.nz/assets/Documents/Early-Childhood/te-whariki.pdf

New Zealand Ministry of Education. (2014). *Teachers in early childhood*. Wellington: Author. Available from: https://www.educationcounts.govt.nz/\_\_data/assets/pdf\_file/0013/54202/Teachers-in-early-childhood-education-20140314.pdf

New Zealand Ministry of Education. (2015). *Participation in early childhood education*. Wellington: Author. Available from: https://www.educationcounts.govt.nz/\_\_data/assets/pdf\_file/0011/9956/Participation-in-early-childhood-education-report.pdf

Niess, M. L., van Zee, E. H., & Gillow-Wiles, H. (2010). Knowledge growth in teaching mathematics/science with spreadsheets: Moving PCK to TPACK through online professional development. *Journal of Digital Learning in Teacher Education, 27*(2), 42-52.

Oberhuemer, P. (2005). International perspectives on early childhood curricula. *International Journal of Early Childhood, 37*(1), 27–37. doi: 10.1007/BF03165830.

Perry, B., Dockett, S., & Harley, E. (2007). Preschool educator's sustained professional development in young childen's mathematics learning. *Mathematics Teacher Education and Development, 8*, 117-134.

Prediger, S., Quasthoff, U., Vogler, A. M., & Heller, V. (2015). How to Elaborate What Teachers Should Learn? Five Steps for Content Specification of Professional Development Programs, Exemplified By “Moves Supporting Participation in Classroom Discussions”. *Journal für Mathematik-Didaktik*, *36*(2), 233-257.

Skolverket. (2011). *Curriculum for the Preschool Lpfö 98: Revised 2010*. Stockholm: Skolverket.

Skolverket. (2012). *Matematiklyftet [Mathematics lift]*. Stockholm: Skolverket. Available from: http://matematiklyftet.skolverket.se

Skolverket. (2015). *Skolverkets lägesbedömning 2015*. Stockholm: Skolverket. Available from: http://www.skolverket.se/publikationer?id=3432

Stephens, A. C., & Hartmann, C. E. (2004). A successful professional development project’s failure to promote online discussion about teaching mathematics with technology. *Journal of Technology and Teacher Education, 12*(1), 57-73.

Svensson, C. (2015). Preschool teachers' understanding of playing as a mathematical activity. In K. Krainer & N. a. Vondrová (Eds.), *Proceedings from Ninth Congress of the European Society for Research in Mathematics Education (CERME 9), 4th -8th February Praque, Czech Republic* (pp. 2003–2009). Prague, Czech Republic: Charles University in Prague, Faculty of Education and ERME.

Utbildningsdepartementet. (2010). *Förskola i utveckling - bakgrund till ändringar i förskolans läroplan*. Stockholm: Regeringskansliet.

Zaslavsky, O., & Leikin, R. (2004). Professional development of mathematics teacher educators: Growth through practice. *Journal of Mathematics Teacher Education, 7*(1), 5-32.

## Authors

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 olds in Sweden. [↑](#footnote-ref-1)
2. The words denoting the mathematical activities are capitalized to distinguish them from their everyday meaning [↑](#footnote-ref-2)