Surveying mathematics preservice teachers

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Preservice teachers begin their mathematics teacher education with a set of understandings about different aspects of mathematics education which will affect their engagement with mathematics teacher education courses. However, very little is known about these understandings. In this paper, the design of a survey to find out about specific aspects, emphasised in the new Norwegian curriculum, is described along with initial results from 96 preservice teachers. The results suggest that using scenarios can provide relevant information about PTs' understanding about different aspects of teaching mathematics. These results may provide teacher educators with potential starting points for planning their own teaching.

Keywords: Preservice teachers, argumentation, multilingual classrooms, digital tools, modelling.

Introduction

In this paper, we describe the design of a survey and the initial results from its first implementation. The focus of the survey was on preservice teachers' understandings about argumentation, critical mathematics education, ICT and modelling in multilingual mathematics classrooms, which contribute to a 4-year research project, *Learning about teaching argumentation for critical mathematics education in multilingual classrooms* (LATACME). The main aim of LATACME is to document in a systematic way what supports and hinders preservice teachers (PTs), for the first seven years of school, to learn about teaching argumentation for critical mathematics education in multilingual classrooms. By asking the PTs to complete a survey at the beginning of their first compulsory mathematics education course and then again at the end of their second compulsory course, we anticipate being able to document if learning about these aspects of mathematics teaching had occurred. Initial results from the survey also provide teacher educators with input for planning of activities to increase PTs' understanding of these aspects.

LATACME is a response to a perceived need to improve the current teaching in Norwegian schools (Bergem, Kaarstein, & Nilsen, 2016), with a requirement that PTs "have knowledge about and an understanding of multicultural society", including "awareness of cultural differences and being able to use these as a positive resource" (National Council for Teacher Education (NRLU), 2016, p. 9). With a new curriculum coming into operation from August 2020, there is a need for teacher education to provide opportunities for PTs to increase their understanding of aspects of mathematics teaching to do with "reasoning and argumentation" and "modelling and application", two of six "core elements" and "digital skills" as one of five "basic skills" (Utdanningsdirektoratet, 2019).

In the new curriculum, there is also a focus on democratic competencies, which we link to critical mathematics education (CME). In describing CME, Skovsmose (1994) stated that teaching and learning should be oriented towards "the goal of providing students with opportunities to develop their critical competence in the form of qualifications necessary for their participation in further democratisation processes in society" (p. 61). This resonates with the new curriculum, where "critical thinking" is identified as a key value for mathematics and involves "critical evaluation of reasoning and argument" that "can prepare students to make their own choices and to address important issues in their own lives and in society" (Utdanningsdirektoratet, 2019, p. 1). Although our project focuses on a range of aspects making it complex, teachers are also expected to respond to this range in their own classrooms and so dealing with the complexity is something that we as teacher educators as well as researchers must deal with.

In order to ensure that the survey focuses of the aspects which are the core of our project, in this paper, we describe how we designed the survey and some initial results from its first application. Our aim for doing this is to illustrate some of the complexity in developing a survey that tries to identify what PTs know about a range of aspects to do with mathematics teaching. In another paper at this conference, we provide more extensive details of the results of the first survey.

Literature review

There is a large amount of research on PTs' mathematical knowledge (Ponte & Chapman, 2008), but less research has been undertaken on PTs'understandings about pedagogical issues connected to mathematics education. This meant that there was limited research, both in Norway and elsewhere, on which to draw in identifying how PTs' understanding of core aspects could be investigated. Due to limited space in this paper, we describe the most relevant of the earlier studies.

In Norway, Thomassen (2016) found that PTs in their fourth year of their teacher education paid attention to and critically reflected on multiculturalism and the education of minority language students, in group discussions. The PTs claimed that they lacked possibilities to focus on this topic in their teacher education, in regard to subject teaching. In Rangnes and Meaney (2021 forthcoming) the PTs noticed how Grade 2 multilingual students, when working with modelling tasks, managed to pose mathematical problems, identify appropriate measurement tools for solving the problems and develop their understandings of different aspects of measurement. In this outdoor modelling activity, the multilingual students were described as skilful when using concrete materials to solve problems, but when the same students worked with textbooks indoors and used concrete materials, they were described as lacking mathematical skills and their home language was not considered a resource.

Stylianides and Stylianides (2009) explored elementary PTs' constructions and evaluation of proofs, which we considered to be related to our focus on mathematical argumentation. Across the semester, the PTs collectively identified criteria for a "good" proof. These criteria included that the proof had to address the question or the posed problem and had to be correct, focused, detailed and precise, as well as clear, convincing and logical. The language, representations, and definitions had to be understood by the people to whom the proof was addressed. Besides, the proof should convince a sceptic and not require the reader to make a leap of faith. In the proof, key points had to be emphasized and pictures or other representations had to be used appropriately.

The situation with PTs and modelling is complex. PTs have been found to lack strong mathematical modelling skills, including how to reflect on and present their results from their models (Sen Zeytun, Çetinkaya, & Erbas, 2017). Yet, Naresh, Poling, and Goodson-Espy (2017) noted that PTs could design modelling tasks based on CME for students from 5 to 14 years old, even though they found this challenging. However, teachers may not be inclined to include mathematical modelling tasks in their teaching as Maaß and Gurlitt (2009) found that teachers preferred tasks that were more likely to provoke one answer and one solution path than tasks that were more open.

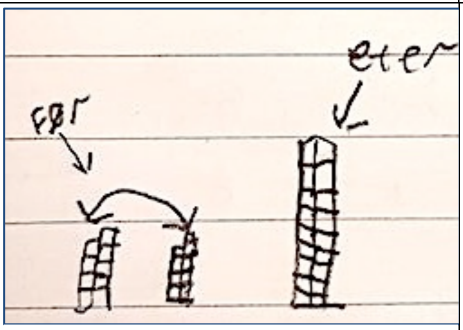
At the same time, concerns have been raised about PTs' understanding about how to use digital technologies in their learning and teaching of mathematics (Starčič, Cotic, Solomonides, & Volk, 2016). After interviewing teacher educators and preservice teachers, Instefjord (2014) suggested that the focus in teacher education should be "towards appropriation of a digital competence that embraces awareness of how technology can be used critically and reflectively in the process of building new knowledge" (p. 328), rather than a focus on the technological aspects of using specific digital tools. There is, therefore, a need to consider how PTs make critical decisions about the integration of digital tools into mathematics education.

Our review of previous research, presented briefly here, suggested that PTs were more likely to show their understandings about the different aspects of mathematics education, if these were presented in scenarios. Therefore in the survey questions, we provided examples of students' work, teacher lessons or policy decisions and then asked the PTs to respond to specific questions about them.

The survey

The survey was developed across the five stages, identified by Maaß and Gurlitt (2009): determining the rationales for the design of the survey; determining an initial draft set of questions; pilot study of the survey; feedback from an expert group on the questions; and using the survey to determine its reliability.

In the first stage, the rationales for the design needed to be determined. These included focussing on the trends across the cohort, rather than on individual student changes, and so no demographic or personal information was collected. Instead the design focused on determining PTs' understandings about the different LATACME topics. Table 1 provides an overview of the 51 claims connected to the eight themes, from the final version of the survey, with the research which inspired them.

Theme #	Theme content	Items
T1	The understandability, completeness and mathematical correctness of explanations (Stylianides & Stylianides, 2009) from 4 students in Year 4 (9–10 year olds) about why the sum of two odd numbers is an even number, e.g. "I can follow and understand Camilla's explanation".  **Figure 1 Camilla's explanation (Ure, 2018)**	1a–1l 12 items
T2	Argumentation tasks in mathematics teaching, e.g. "Students should at least once a week work with tasks that require them to justify a mathematical connection (as for example about odd and even numbers in topic 1)".	2a–2d 4 items
T3	Mathematical modelling for students in years 1-7 (Naresh et al., 2017), e.g. "Students in Grades 1-4 are too young for modelling to support them to increase their critical awareness about the use of mathematics in society".	3a–3h 8 items

Theme #	Theme content	Items
T4	Digital tools and mathematics teaching, e.g. "Digital tools improve students' ability to argue in and with mathematics" (Starčič et al., 2016)	4a–4d 4 items
T5	Mathematics teaching in multilingual classrooms (Thomassen, 2016), e.g. "Students may use their home language for their learning".	5a–5h 8 items
T6	A teaching project for Grade 4 in which students collected and sorted garbage in the beginning and in the end of the year and represented their findings in a diagram (Naresh et al., 2017), e.g. "The next lesson in the class should be about how to make the diagram better by stating the units on the y-axis and separate the bars".	6a–6c 3 items
T7	A teaching project for Grade 5 about air pollution in the city (Skovsmose, 1994), e.g. "The project would take too much time from teaching and would not give us the opportunity to get through everything we are supposed to cover in the textbook".	7a–7i 9 items
T8	The possible actions PTs would take in an imagined scenario in which the government has decided that students can only speak Norwegian in mathematics classes (Thomassen, 2016), e.g. "you send a written message home to those parents who do not speak Norwegian at home where you describe the change in policy and call upon the parents to speak Norwegian when they help their children with homework".	8a–8c 3 items

Table 1: Themes, examples of claims and the number of items in each topic in the survey

As with all surveys (see Maaß & Gurlitt, 2009), the time needed to complete it had to be limited, while still gaining the most relevant information. We, therefore, chose to ask the PTs to express their degree of agreement with each claim on a Likert-scale comprising the options "disagree completely", "disagree moderately", "neither agree nor disagree", "agree moderately", "agree completely", and "don't know". Christoffersen and Johannessen (2012) stated that Likert-scale questions should have five choices and a "don't know/not applicable" option. This allows the Likert scale to be seen as a "nominal variable with many values" and hence open to a wider range of statistical tools and procedures than for a nominal variable with less-than-5 values (Christoffersen & Johannessen, 2012, p. 135). As it is recommended that sensitive questions should be in the middle (Christoffersen & Johannessen, 2012), we did this both across the survey and within individual questions.

To contribute to the second stage of the survey development (Maaß & Gurlitt, 2009), a small group of the authors of this paper proposed a set of questions. As shown in Table 1, potential questions came from the findings and the identification of relevant scenarios in previous research. For example, to gain insights into PTs' understandings of mathematically correct, complete and understandable argumentation (see T1 in Table **1**), examples of Grade 4 students' argumentation from a Master thesis (Ure, 2018) provided a real scenario from PTs' future work in mathematics classrooms.

The potential set of questions were then taken to a wider group, which included teacher educators who would teach the compulsory mathematics education courses for Grades 1-7 teachers or who had taught similar courses in the previous teacher education programme. In Maaß and Gurlitt's (2009) process, this is the fourth stage. However, we moved it forward as we wanted to ensure the cohesion of the project by involving as many people as possible in the development of the survey. The wider group was asked to discuss the usefulness of the questions for gaining relevant information from the PTs, if the questions needed to be modified and in what ways. Suggestions from the discussions included the need for an argumentation example written in another language (T1 in Table **1**). It was also suggested that in an example of a mathematics task in which children would consider where they lived in regard to air quality (T7 in Table **1**), that PTs should be asked about ethical aspects involved in CME projects. The wider group' comments contributed to the revisions of the questions.

Step three in Maaß and Gurlitt's (2009) process was a pilot study of the survey. This was undertaken with a group of PTs from an earlier cohort who would not be part of the actual study. The pilot study resulted in an identification of ambiguities in some of the questions. Consequently, these questions were rewritten so that they becamse clearer. It also resulted in the removal of questions that did not seem to give useful information, such as "elevene bør diskutere hva som er en god forklaring i hver undervisningsøkt" (students should discuss what is a good explanation in each teaching session" from T2 in Table 1. The order of the questions was also changed so that there was a reduced chance of PTs being misled to think that a particular response was expected. As well, the number of items were reduced.

The final stage in Maaß and Gurlitt's (2009) process for developing a survey was to use the survey to determine the reliability of the instrument. As our purpose for having PTs complete the surveys were different to those of Maaß and Gurlitt, we instead considered whether the results provided useful information. An initial descriptive analysis of the results is provided in the next section with more detailed results connected to a cluster analysis provided in another paper.

Data collection

In the teacher education for grades 1-7, PTs have two mandatory mathematics courses of 15 ECTS each. The courses are taught in their 2nd and 3rd semesters and integrate mathematics and mathematics education. The results discussed in this paper come from the survey which was administered at the beginning of the 2nd semester, that is after one semester of teacher education including a practicum period, but before exposure to mathematics teacher education.

The survey was made available electronically and did not provide access to the PTs' IP addresses. The PTs were provided with a link on the Learning Management System in the first week of the semester. Of the approximately 200 PTs in the cohort, 96 chose to complete the survey.

Results and discussion

In this section, we provide responses to questions that are representative for each of the five foci: argumentation; modelling; digital tools; critical mathematics education; and multilingual classrooms. In the calculations, PTs who chose "Don't know" were not included. To indicate the results for argumentation, we use the example of Camilla's explanation, given in Table **1**, Theme 1.

Item	Mean	SD
1a) I can follow and understand Camilla's explanation	4.54	0.74
1b) Camilla's explanation is incomplete	2.85	1.17
1c) Camilla's explanation is mathematically correct	3.99	0.92

Table 2: Mean and standard deviation for an argumenation task

The PTs were generally positive about all four of the school students' argumentation examples about odd and even numbers. In Table **2**, they were mostly positive about being able to follow and understand the argumentation, even though Camilla's pictorial argument contained only the words «før» (before) and «et[t]er» (after), as the responses had a very high mean and a small standard deviation. The PTs were neither very positive or negative about the completeness of Camilla's argumentation, with the mean being close to 3 – neither agree nor disagree – and a large standard deviation. These results seem in alignment with the PTs at the beginning of their work on proof in the research by Stylianides and Stylianides (2009).

Theme 7 (see Table **1**) included a lesson plan about a project on air pollution that used a colour-coded map of a city to show air quality in different areas. It also included a question about the use of tolls on roads as a way of reducing the number of cars and improving the air quality. The PTs were asked about different aspects of the project, which covered all five aspects of LATACME.

Item	Mean	SD
7a) This project would be too difficult for students who do not speak good Norwegian because they would not be able to justify their answers. (multilingual classrooms/argumentation)	3.08	0.97
7b) Students in 5th grade are not able to interpret the map and diagram. (mathematical modelling)	2.65	0.96
7c) I would not have used this project in my teaching because the students would find it too extensive. (mathematical modelling)	2.93	1.02
7d) This project will facilitate the students' introduction to basic areas of mathematical modelling. (mathematical modelling)	3.44	0.72
7e) I would not have used the question of tolls (iii) because it would be too difficult for the students to work out such a plan. (CME)	3.25	1.04
7f) Students in 5th grade must know or first learn the concepts of average and range in order to understand what the project is about.	3.43	0.93
7g) It seems strange to let students in 5th grade describe how they would use a PC or tablet in this project (digital tools)	3.01	0.98
7h) The project would take too much time from teaching and would not give us the opportunity to get through everything we are supposed to in the book. (mathematical modelling)	2.60	1.09

Item	Mean	SD
7i) The project is ethically unjustifiable because there may be students in the class living in polluted areas. (CME)	2.56	1.02

Table 3: Means and standard deviations for responses to Theme 7

Table 3 shows that the PTs were much more uncertain about how children would respond to this project and its value in regard to different aspects on mathematics teaching that they were to the children's written argumentation. The means are closer to 3 with small standard deviations. In all items, a larger percentage of the respondents replied, "Neither agree nor disagree" or "Don't know". The PTs indicated a slight tendency towards considering the project as being good for supporting students' understanding of modelling as well as needing to understand basic statistical concepts before starting the project. The PTs were only slightly convinced that the project was ethically sound. However, the trends are small. Given that these PTs were at the beginning of their mathematics education courses, their uncertainty about different aspects to do with their teaching is predictable and it will be interesting to see if there are changes at the end of the two compulsory courses. There is some ambiguity in the responses, suggesting that the PTs at this time were conflicted about ensuring that the school students completed work in the textbook and seeing this project as a good introduction to modelling.

Results such as these provide opportunities for developing activities in our teacher education that use these uncertainties to develop rich discussions about how to incorporate the different aspects into mathematics classrooms. The consistencies in the results across the questions related to the same LATACME topic suggests that the questions did provide us with valid responses to determining PTs' understandings about these topics.

Conclusion

The aim of LATACME is to make changes to our compulsory mathematics education courses for those who want to be teachers of grades 1-7 and so we want to support our PTs to gain the necessary set of understandings about what is required to be a mathematics teacher. In order to know if we have achieved this in our teacher education, we need to find out what changes occur in PTs' understanding about different aspects of mathematics education. Changes in the results from the survey over time provide just one set of data from the range of data that we are collecting during our project. In this paper, we have described the process of developing the survey, following the stages described by Maaß and Gurlitt (2009). We suggest that the transparency in describing each step in the process is important, especially in large projects such as ours where many teacher educators are involved. It is also important for those who may be interested in the results in relationship to their own teacher education courses or who want to adapt it to suit a different set of rationales.

Although our initial results are not startling, they do suggest that using scenarios can provide relevant information about how PTs respond to a range complex issues that confronts them in their process of becoming teachers of mathematics. This provides teacher educators with potential starting points for planning their own teaching, such as discussing how to incorporate mathematical modelling problems so that it covers aspects to do with, for example statistics, that would normally be taught through the textbook.

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References

Bergem, O. K., Kaarstein, H., & Nilsen, T. (2016). *Vi kan lykkes i realfag: resultater og analyser fra TIMSS 2015.* Oslo: Universitetsforlaget. https://www.idunn.no/vi-kan-lykkes-i-realfag

Christoffersen, L., & Johannessen, A. (2012). *Forskningsmetode for lærerutdanningene*. Oslo: Abstrakt.

Instefjord, E. (2014). Appropriation of digital competence in teacher education. *Nordic Journal of Digital Literacy, 9*(4), 313–329.

Maaß, K., & Gurlitt, J. (2009). Designing a teacher questionnaire to evaluate professional development in modelling In V. Durand-Guerrier, S. Soury-Lavergne & F. Arzarello (Eds). *Proceedings of the Sixth Congress of the European Society for Research in Mathematics Education* (pp. 2056–2065). Lyon: Institut National de Recherche Pédagogique. http://ife.ens-lyon.fr/publications/edition-electronique/cerme6/wg11-02-maab.pdf.

Naresh, N., Poling, L., & Goodson-Espy, T. (2017). Using CME to empower prospective teachers (and students) emerge as mathematical modellers.In A. Chronaki (Ed). *Proceedings of the 9th international conference of mathematics education in society* (pp. 749–759). Volos: University of Thessaly.

National Council for Teacher Education (NRLU). (2016). *National guidelines for the primary and lower secondary teacher education programme for years 1–7.* UHR Universitets og høgskolerådet. https://www.uhr.no/temasider/nasjonale-retningslinjer-for-larerutdanningene/

Ponte, J. P., & Chapman, O. (2008). Preservice mathematics teachers' knowledge and development. In L. D. English (Ed.), *Handbook of international research in mathematics education* (pp. 223–261). New York: Routledge.

Rangnes, T. E., & Meaney, T. (2021 forthcoming). Preservice teachers learning from teaching in multilingual classrooms. In N. Planas, C. Morgan & M. Schütte (Eds.), *Classroom research on mathematics and language*. London: Routledge.

Sen Zeytun, A., Çetinkaya, B., & Erbas, A. K. (2017). Understanding prospective teachers' mathematical modeling processes in the context of a mathematical modeling course. *Eurasia Journal of Mathematics, Science and Technology Education, 13*(3), 691–722. doi: 10.12973/eurasia.2017.00639a

Skovsmose, O. (1994). *Towards a philosophy of critical mathematics education*. Dordrecht: Kluwer.

Starčič, A. I., Cotic, M., Solomonides, I., & Volk, M. (2016). Engaging preservice primary and preprimary school teachers in digital storytelling for the teaching and learning of mathematics. *British Journal of Educational Technology, 47*(1), 29–50. doi: 10.1111/bjet.12253

Stylianides, A. J., & Stylianides, G. J. (2009). Proof constructions and evaluations. *Educational Studies in Mathematics, 72*(2), 237–253. doi: 10.1007/s10649-009-9191-3

Thomassen, W. (2016). Lærerstudenters kommentatorkompetanse om flerkultur og undervisning av flerspråklige elever drøftet i lys av kritisk multikulturalisme. *Acta Didactica Norge, 10*(1), 1–18.

Ure, F. K. (2018). *Argumenterande skriving på barneskulen: Ein analyse av elevar sine argumenterande matematikktekstar på 4. og 7. trinn* (Master thesis). Bergen: Høgskolen på Vestlandet.

Utdanningsdirektoratet. (2019). *Læreplan i matematikk 1.–10. trinn*. Oslo: Utdanningsdirektoratet. https://www.udir.no/lk20/mat01-05