Student teachers' needs and preferences for a technology preparation course

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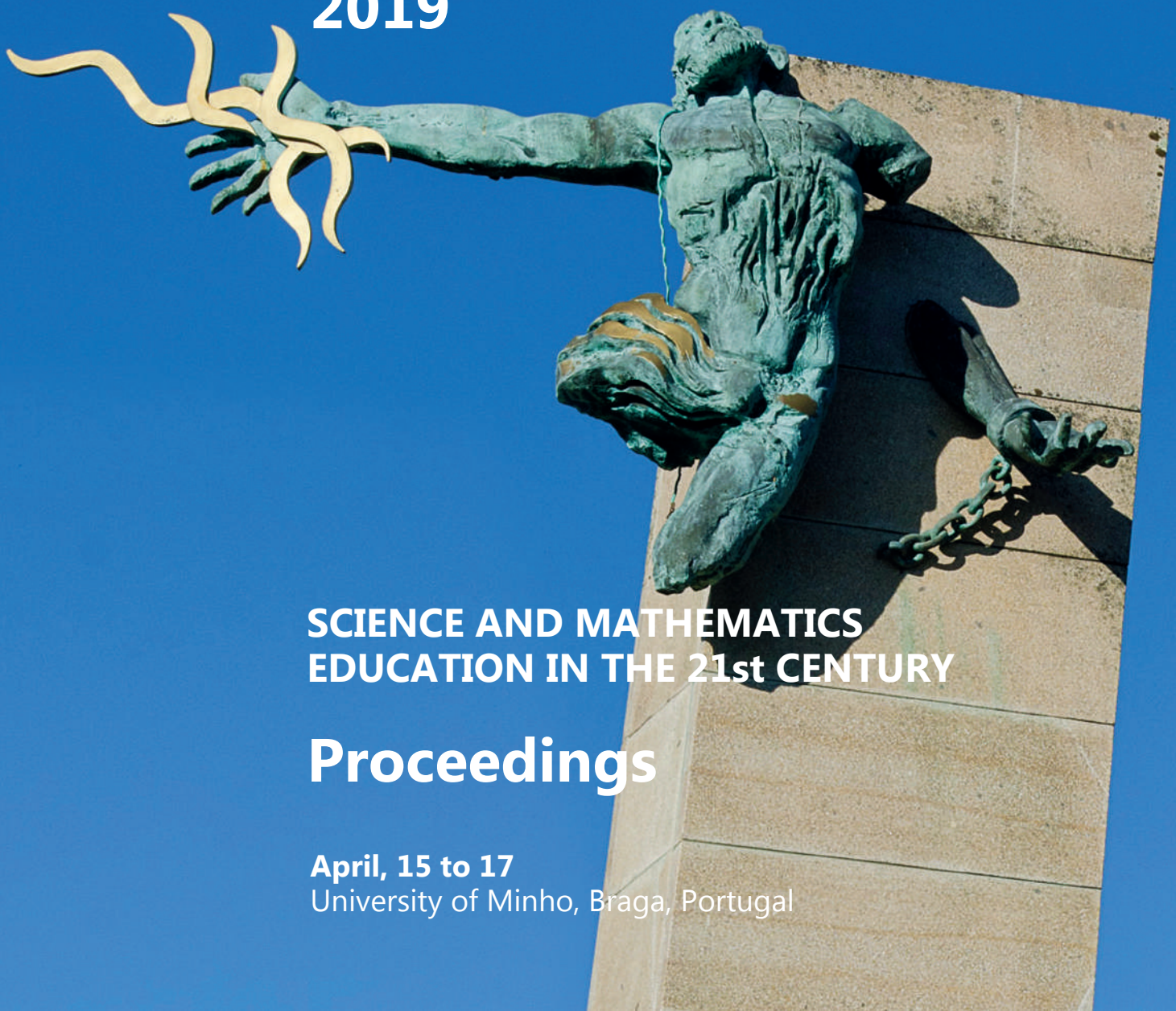

SCIENCE AND MATHEMATICS EDUCATION IN THE 21st CENTURY

Proceedings

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Science and mathematics education in the 21st century

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Introduction

The University of Minho, Braga, Portugal, hosted the 2019 Winter Conference of the Association for Teacher Education in Europe (ATEE), which took place from 15th to 17th April.

The ATEE Winter conference is one of the three ATEE conferences which are organised every year, the others being the Spring conference and the Annual conference. The Winter conference is usually organized by one (or more) of the several ATEE Research and Development Communities (RDCs). This Conference was organized by the RDC on Science and Mathematics Education, which is one of the longest-standing and most active RDCs.

The Conference focused on Science and Mathematics Education in the 21st Century. It is fully accepted that, nowadays, Science and Mathematics Education is an area of interest to policy-makers worldwide. The area is relevant not only for the ongoing scientific and technological development of modern, globalized and digital societies, but also for citizenship education and the sustainability of the Planet. Moreover, it contributes to the full development of the individual learner. Science and Mathematics teachers, teacher educators and researchers can therefore help to make a difference beyond the classroom.

However, Science and Mathematics Education is under pressure. It has been unable to develop good levels of literacy and numeracy, to lead enough youngsters to engage in science and technology careers, and to overcome many people's dislike and even fear of the subjects. Thus, the Conference aimed at promoting forward-looking approaches that combine engagement and enjoyment with effectiveness in developing knowledge and skills, and hence fostering ways of overcoming the challenges that the area has been facing. The Conference was a forum to enhance deep and multicultural discussions on issues like: innovative approaches to teaching science and mathematics; technologically enhanced science and mathematics education; science and mathematics education and the STEM agenda; science and mathematics education in multicultural and inclusive schools; science and mathematics teacher education in a changing world; and 21st century assessment in science and mathematics education.

Two Keynotes addressed and elaborated on the conference theme. A Panel offered an opportunity for getting some insight into ways forward with regard to the challenges that science and mathematics education face in the present century. Two Plenary presentations highlighted European and Portuguese policies for Science and Mathematics Education.

Over seventy papers and posters were presented at the Conference. The abstracts of the paper and poster proposals were blind refereed by at least two members of the Conference Academic Committee and many of them were reviewed and improved by their author(s) before being accepted. Altogether, they offered a rich and multifaceted picture of the Conference theme.

Twenty-one full papers (fourteen related to paper presentations, and seven to poster presentations) were submitted and fifteen (ten related to paper presentations and five to poster presentations) were accepted for inclusion in the Proceedings. It should be noted that, even though full papers were submitted to a double peer review process, the content and ideas conveyed by them as well as the language used are the authors' own responsibility.

The organisers of the Proceedings would like to express their gratitude to the Conference Academic and Organising committees and to all the people, institutions and organisations that, in various ways, sponsored the Conference. However, special thanks are due to ATEE and to the RDC on Science and Mathematics Education for trusting the conference organizers, and to the University of Minho for hosting and supporting the Conference.

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Student teachers´ needs and preferences for a technology preparation course

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Abstract: In this study, we investigate, through a questionnaire, in-service student teachers' needs and preferences in a master program for a course about learning with technology. Results show that about half of the student teachers would like to have such a course and about one third has doubts about it. The reasons provided by students with different needs and their preferences for the content, learning activities and teacher support are discussed in this paper, as well as implications for the design of teacher preparation programs.

Keywords: in-service teacher education; teacher preparation program; technology integration; TPCK

Introduction

There has been much debate about what in-service student teachers need to know with regard to learning with technology and how they are supposed to develop this knowledge (Koehler & Mishra, 2005). Teacher education programs need to focus 'on developing an understanding of the complex set of interrelationships between artefacts, users, tools, and practices.'. In other words, developing technological pedagogical content knowledge (TPCK). Research (Fu, 2013; Tondeur, van Braak, Ertmer, & Ottenbreit-Leftwich, 2017) shows teacher preparation programs have beneficial influence on teachers' attitudes and beliefs about the use of technology in practice. However, this does not mean teachers change their practice. In fact, it remains a challenge to turn positive intentions and TPCK-knowledge into classroom practice.

As many other higher education institutions, the master teacher education department of the Amsterdam University of Applied Sciences (AUAS) struggles with this problem. Until 2018, the subject digital pedagogies was part of the discipline mathematical pedagogy and there was no specific course for preparing in-service student teachers for learning with technology. In addition, there were no defined directions within the institution to guide the teacher educators in the development of such a program. For that reason, the department decided to investigate student teachers' needs for a teacher preparation course about TPCK-knowledge and use the results to design a new course.

In this paper, the results of part of the larger research are presented and discussed. They provide insight in student teachers' needs and dispositions for developing TPCK-knowledge that can be of interest beyond our institution.

Theoretical background

Development of TPCK

The TPCK framework (Koehler & Mishra, 2005) emphasizes the interplay of three bodies of knowledge needed for a good integration of technology into practice: knowledge

about content (C), pedagogy (P), and technology (T). Technological pedagogical content knowledge is a kind of knowledge that goes beyond the use of the three components. It e.g. requires an understanding of the representation of concepts using technologies; pedagogical strategies; knowledge about students' pre-knowledge and difficulties and how technology can help some of the problems that students face. High-qualified teachers should have an understanding of the relationships between these matters and be able to use this understanding in their practice.

In this line of thought, the development of TPCK-knowledge in teacher preparation programs should consider the TPCK-components in relation to each other and not in isolation. Moreover, learning to reason explicitly about how ICT can support specific pedagogical strategies can contribute for this to happen (Heitink, Voogt, Fisser, Verplanken, & van Braak, 2017). However, as we discuss next, there are other aspects that influence the development of TPCK-knowledge.

Factors that matters in technology integration

In a research review about how teachers integrate technology in the classroom Fu (2013) points a number of factors influencing technology integration in practice. These factors were grouped in external and internal factors. *External factors* include technology availability, technical support, time to develop instruction, curriculum, school culture, and pressure to prepare students for exams. *Internal factors* include knowledge, understanding and skills of technology use, beliefs and attitudes toward technology integration, intention or motivation to use ICT and technology self-efficacy.

According to the review, the most common external factors impeding technology integration included lack of access to computers and software, insufficient time to plan instruction and inadequate technical and administrative support (Chen, 2008). Some external factors were positively associated with technology integration such as the availability of technology and technical support. Fu claimed that technology availability and support are important to technology integration.

Among the internal factors, the most relevant factors are teachers' beliefs and confidence in utilizing technology and understanding about technology use. Chen (2008) findings show that in some cases teachers lack of theoretical understanding could explain the inconsistency between teachers expressed beliefs and the teachers' practices. For example, almost all teachers in Chen's study reported high agreement with constructivist concepts, however, in practice teachers implemented the policies on the basis of their own interpretation and understanding. Chen also found that teachers' beliefs and contextual factors may affect each other. For example, a school culture that uses tests to motivate students will reinforce some teachers' traditional beliefs that value knowledge transmission. Teachers' beliefs concern also the discipline they are teaching. In a multiple case study, Niess (2005) examined the TPCK of five pre-service student teachers who followed a science and mathematics teacher preparation program. He found out that their development of TPCK was related with how they view the integration of technology and the discipline they were teaching. These and other contextual factors may explain some teachers' unwillingness or hesitation to allow students spend more time exploring content on their own with technology. Therefore, variables such as teachers' attitudes, beliefs and confidence can be seen as strong predictors for teacher and student technology use.

Tezci (2011) investigated the role of internal factors and external factors on the level of technology usage by pre-service teachers. As Chen (2008), the researcher found out that internal and external factors were related to each other and to technology usage level. For

instance, teacher's perception (internal factor) of school climate and support were found to be relatively low. Support is however considered to be an external factor that influence effective technology integration. Perceived support in Tezci's (2011) study was also found to be correlated with internal factors, including attitudes towards computers and the Internet, self- confidence, and knowledge. The researcher concludes that: "effective ICT integration requires a school culture and support (an external factor) that provides its pre-service and in-service teachers with the necessary knowledge and experience (internal factors) regarding effective and successful ways to integrate ICT into classroom activities" (p. 496).

Several researchers have investigated the link between teachers' pedagogical beliefs and their educational uses of technology. In a recent review of research on this matter, Tondeur et al. (2017) selected and analysed 14 studies. Their findings suggest that the relationship between pedagogical beliefs and technology use comprise a bi-directional relationship. Based on these studies they claim that "the integration of technology in classroom educational processes has the potential to change teachers' beliefs towards more student-centred, constructivist beliefs. But also, constructivist beliefs lead to use of technology that support the development of 21st century skills." Thus, technology can also be beneficial to teachers with teacher-centred pedagogical beliefs. Within these results, the authors remark it is important to note the iterative process of learning to teach with technologies: beliefs lead to actions and actions lead to the development of reconstructed beliefs. They conclude that, regardless of teachers' pedagogical approaches, teachers find value in using technology when it aligns with their current pedagogical approaches. Therefore, technology should be introduced in teacher preparation programs in ways that align with their actual approaches and values because this increases the likelihood that teachers will integrate and use technology in their practice.

Technology preparation or programs and teacher education

Research (Fu, 2013) also shows that internal factors and relationships between internal and external factors can be influenced through participation in technology preparation courses or programs. For instance, after a semester-long technology literacy course, the preservice teachers in Abbott and Faris (2000) developed more positive attitudes towards computers because of the instructional approaches, meaningful assignments requiring technology, and supportive faculty. See Fu (2013) for more examples.

Teacher preparation programs can also impact technology integration by engaging teachers in design-based activities (Laurillard, 2012; Koehler & Mishra, 2005) because it helps teachers to develop a flexible and situated knowledge of the value of technology for learning. In this approach, teachers may work collaboratively to develop technological solutions for authentic pedagogical problems or in re-designing their lessons or course materials in ways that the use of technology improves learning.

Research questions

Tondeur et al. (2017) suggest that technology should be introduced in ways that align with teachers' current practices. Based on our theoretical framework and following this suggestion we investigated what are the needs of in-service student teachers for a technology preparation course during the study. The research questions that guide the investigation are: what is the need for in-service student teachers of mathematics for a course about digital pedagogy during their study? (RQ1); what is in-service student teachers' preference for the content, learning activities, and type of teacher support? (RQ2).

Method

Participants

The participants were students of a three-year master course for Mathematics Teacher in secondary education. The in-service student teachers teach mathematics at the secondary level. They typically work 3-4 days a week in a school and follow the master teacher program one day a week, on Thursday. All student teachers (N=84) were invited to participate in the research by their teacher and/or coordinator of the department via email. About 40% of the student teachers (n=34) took part in the study.

Instrument and data collection

An online questionnaire was used to investigate the research questions. The questionnaire was developed by the researcher together with two other teacher educators. It consists of 16 open and multiple-choice questions, in which respondents may add information and explain their answer if they wish to. The questionnaire investigated: student teachers' use of technology in their education (questions 1-5); *needs for a course* on digital didactics (question 6); their *preference for content, learning activities, form* and *guidance* of the course (questions 7-13) and suggestions and wishes for a measure of involvement in the design process (questions 14-16). I report in this paper only the results of questions 6-13 because they concern the research questions. The other results are published in the project report, which can be requested from the author.

Data analysis

The results of multiple-choice questions are automatically translated into tables and graphs. By the analysis of the open questions and explanations by the multiple-choice questions, we applied open coding in the following way: (i) The author and a student assistant encoded all answers independently of each other and defined provisional categories; (ii) the coding and the categories were discussed and adjusted; (iii) the author re-coded all answers according to the agreed categories and, where needed, the categories were more sharply defined; (iv) the coding was discussed with the student assistant and adapted until agreement was reached.

Results

In-service student teachers need for a course digital pedagogies

The question about students' need of a course about digital pedagogies was investigated with a multiple-choice question followed by a request to explain their choice (question 6). The students could select one of the following options: "Yes, I want to follow the course"; "I doubt about it"; "No, I don't want to follow the course." Thirty-two students of the thirty-four answered the question and twenty-two explained their choice. These explanations were analysed as described in the method section. We came to a number of categories presented together with the results in Table 1.

Results show that about half (53%) of the student teachers would follow the course. Most of the reasons presented by students were related to internal factors. Like to improve knowledge or ability. An example of an answer of this type is:

'I am curious about the opportunities that I do not know."

Table 1. Question 6, students' needs and reasons to follow a course

Answers choice	**Students (*n*=32)**	**Reasons presented (categories)**
Yes, I want to follow the course	17 (53%)	more knowledge / skills (*n*=6) practical examples to use (*n*=1) hints to apply school wide (*n*=1) other (*n*=1)
I doubt	11 (34%)	depending on the offer (*n*=3) little time/ workload (*n*=3) doubt the benefits of a course (*n*=2)
No, I don't want to follow the course	4 (13%)	little time/ workload (*n*=3) attends further training or has support at school (*n*=1) already feels competent (*n*=1)

Other reasons concerned appliance to school practice:

> "You take the time to deepen your knowledge, and you will probably get a lot of material."
> "I would like to hear new ideas and suggestions on how to apply them school-wide."

About one-third (34%) of the student teachers doubts about following a course. Three students would attend the course if the content suits their interest and level. One student wrote:

> "As long as it is deepening for me. I want to know the content of the course beforehand, on the basis of which I would make a choice."

Three students mentioned little time/workload:

> "I doubt because I have little time for a course. I would rather take such a course when I have finished my study."

And two students mentioned having doubts about the benefits of a course because it will probably not solve the problems they experience. For instance, one student refers to the value of the course with regard to acquiring more knowledge, but it will not help the lack of technical affordances at his school:

> "Often the digital boards do not work or hardly do it. The question next is it worth to make two variants of a lesson in case the technology doesn't work? On the other hand, I find it interesting to know more about the possibilities of technology."

Only four students stated not intending to follow the course. Two of these students referred to little time/workload. One student that his school already provides support:

> "In the school where I teach much attention is paid to this."

One student considers himself already competent and does not feel the need to learn more about it.

Preferences for content and learning activities

The students' preference for content and learning activities was investigated through questions 7, 8 and 9. All three questions were multiple-choice with the possibility to choose one or more options and to explain the given answer.

At question 7, three options for the course content were given: practical knowledge and abilities; background and theoretical knowledge; technical abilities. Results showed that almost all students (94%) prefer practical knowledge. Technical abilities were chosen

by about half of the students (52%) and theoretical knowledge was the less chosen content (39%).

Question 8 investigated in more detail student's preference for content by asking about the subject matters that could be handled in the course. Based on the literature we pulled up a list of possible topics. Figure 1 presents these topics and summarises the answers of the thirty-two students who answered the question. The two most chosen subjects were learning about tools for mathematical learning (74%) and designing lessons for learning with technology (65%). Topics regarding the use of technology for assessment (summative or formative) were chosen also by many of the respondents. The less chosen topics were open online education, chosen by one single student and innovative or adaptive technology (four students).

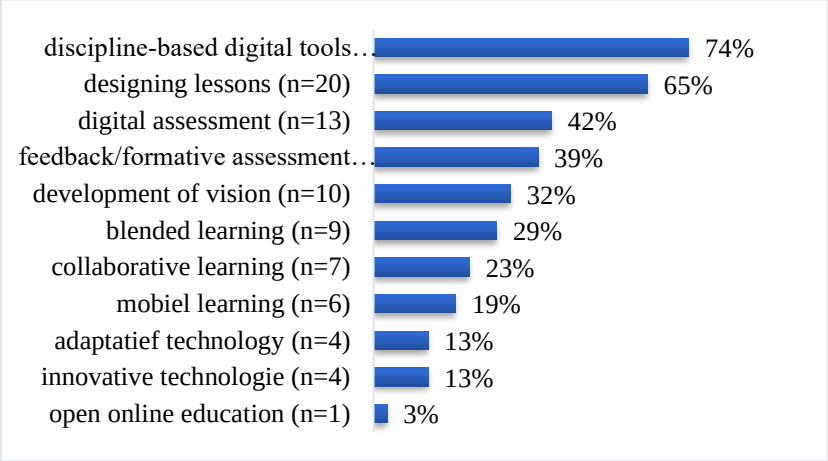

Figure 1. Question 8 (What subjects would you like to see in the course?)

Question 9 investigated the students' preference for learning activities. The students could choose more than one activity from the list presented in Figure 2. None of the 30 students who answered the question added other learning activity. The only student who added a comment stated that the activities should be related to mathematics. The most chosen activities were developing digital education (70%) and following guest lectures (53%). The less chosen were participation in webinars and reading texts (two students).

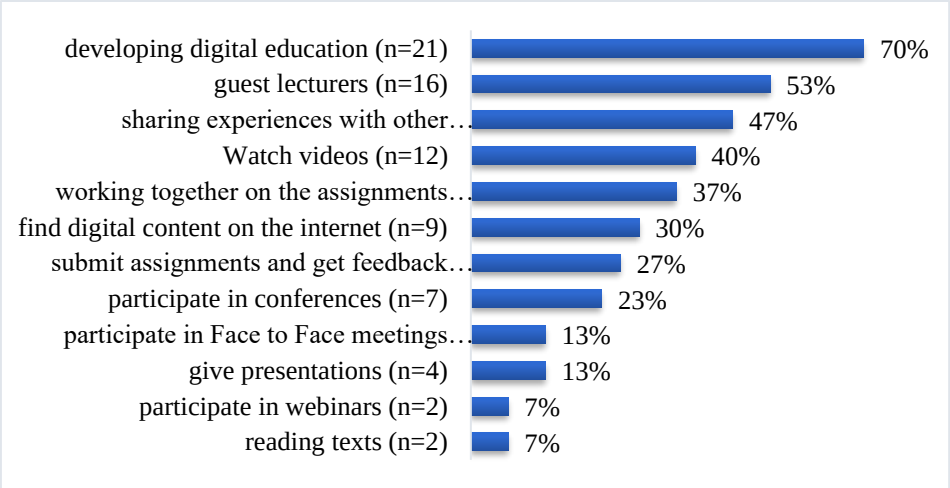

Figure 2. Question 9 (What learning activities would you like to see in the course?)

Preferences for teacher support

When asked about what kind of teacher support would you like to see in the course (Question 13, open question) students mentioned: face-to-face guidance (27%); lectures/coaching led by an expert or practice-oriented person (23%); and involving feedback from the teacher (23%). Less mentioned forms of support involved blended and online guidance (respectively 4% and 12%) and interaction with others (8%). These results suggest students have a preference for face-to-face forms of learning. Some students explicitly stated to prefer someone from mathematics: "From an expert in technologies in mathematics (not in general)". The results are presented in Figure 3.

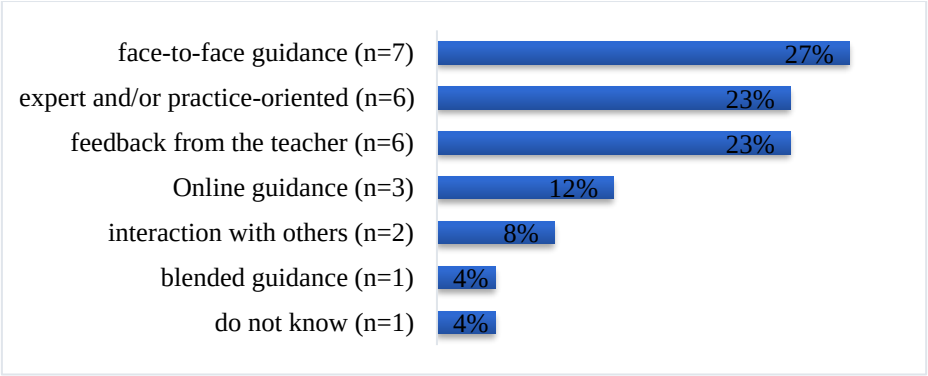

Figure 3. Question 13 (What kind of teacher support would you like to see in the course?)

Other results

Questions 10-12 inquired students' preferences for the form and duration of the course. The results are very varied and some students found it difficult to give beforehand how long the course should be.

Discussion

The role of internal and external factors in students' needs for a course

Our first research question is about the needs of in-service student teachers of mathematics for a course about digital pedagogy during their study. Understanding in-service student teachers' needs can help to choose for content and strategy. It also provides a more significant insight on students' knowledge, problems, and shortcomings. The results show that about half of the students would follow the course.

The motivation to follow, or not, a course is very varied. Looking at the results through the lens of internal and external factors, we found that all the reasons presented by students who wish to follow a course concerned internal factors. Those were: increasing or deepening knowledge or skills, getting materials and practical examples to use and hits to apply school wide. Students who doubt about following a course referred to both external and internal factors. External factors were little time, workload and already following training at the school. Internal factors referred to having doubt about the benefits of a course, depending on the content or because they already feel competent. These results are in line with previous research. Insufficient time to plan instruction is one of the most pointed external factors that influences technology integration (Fu, 2013; Chen, 2008) and motivation, need of knowledge and self-efficacy are internal factors referred in several studies (Fu, 2013). Our results suggest external and internal factors may play a different

role in student teachers' motivation to follow a course. For instance, the factor time is repeatedly mentioned in a negative way and as an external factor while the factor knowledge is frequently used in a positive way and as internal factor. However, one could equally see the factor time as positively influencing technology integration by thinking about having enough time for or wanting to expend more time with learning with technologies. Fu (2013) points out that external and internal factors can be both negatively and positively associated with technology integration. Moreover, internal and external factors are related and influence each other.

Putting research into practice (part 1)

As mentioned before, it remains a challenge to turn positive intentions and TPCK-knowledge into classroom practice (Tondeur et al., 2017). Higher education can contribute to this by developing efficient teacher preparation courses that assist teachers to establish the connection between theoretical and practical knowledge. Based on our results, I suggest including thinking about the interplay between internal and external factors in teacher preparation programs. Especially during the course for in-service student teachers, the terminology could be used as a framework to think about possible factors that play a role by their own and each other's motivation. In an initial stage this could be used as a way to provoke awareness with the expectation that at long term, thinking in these terms would help teachers to develop own strategy to cope with internal and external factors and when possible turn negative factors into more positive ones. Naturally, I am aware that this will not be enough for some teachers who work in schools with a considerably diverse pedagogical orientation. As Cobb, Zhao, & Dean (2009) state: "[...] it is important to take account of the institutional setting in which the collaborating teachers work when pursuing such an agenda because the professional development goals conflict with the current instructional priorities of most schools and districts' (p. 192).

Some suggestions provided by Cobb et al. (2009) on how to work with school administrators to advance student-teacher ability to address internal and external factors include: opportunities to participate in formal professional development activities, opportunities to participate in informal professional networks and assistance from a school-based mathematics coach.

Preferences for the design of a course from a students' perspective

The second research question investigated student teachers' preferences for the content of a course, learning activities and type of teacher support. The most preferred course design included content knowledge much close to student teachers' actual practice, such as discipline-based tools, designing lessons and assessment. More innovative themes like new technologies and open online education were the less chosen subjects. The fact that these themes may be too far from student teachers' daily practice can be a reason behind their choice. Another reason can be that the student teachers due little time and high workload (typically they teach 3-4 days a week during their study) give priority to themes that they find usable for practice above more innovative themes. These results are in line with Niess (2005) results in which teachers' beliefs about the integration of technology into practice was a critical factor. Teachers who had difficulty in integrate technology into practice also had difficulty in recognizing the value of this technology for their teaching. This does not imply, of course, that the in-service student teachers are not open to innovative practices. In fact, the majority of the reasons given by the student teachers who want to follow a course were the development of new knowledge.

Putting research into practice (part 2)

Some questions on what new teachers typically need for technology integration include recognizing the interplay between the technology and content domain and teaching with a focus on students learning (Niess, 2005). As Niess points out at the start of a student teaching experience, the student teachers are usually focused on their own teaching and they think less about their students' learning and thinking. Teacher preparation programs should challenge their students to go beyond their 'habitual' way of thinking. Taking this in consideration and based on student teachers' preferences, we propose a number of directions for the design of a teacher preparation course.

In the first place, the content-knowledge and learning activities should be predominantly practice-oriented and theoretical or technical parts of the course should be explicitly connected or embedded in practice. In this way, we expect that students recognize the interplay between technology and mathematical content. Moreover, by proposing activities that emphasize their student's interpretation of the concepts when using technology, we expect that student teachers focus on students' understandings.

Secondly, it could be possible for student teachers to select technological knowledge that is relevant to them. A way to make this possible is to propose assignments that can be approached at different levels. Also, the duration of the course should meet the goals and content of the subject matter, so for learning more theoretical oriented (parts of) subjects it is suitable to have lectures of an exact duration in a certain time and for more technical or practical subjects, it can be more adequate to allow extended sessions of one full or half a day and space in time.

Finally, student teachers have a clear preference for a teacher educator experienced in the use of technology. This can be achieved through e.g. encouraging teacher educators to regularly and reflectively experiment with innovative technologies and pedagogies within mathematics education, collaborate with other teacher educators and professionals and inviting experts for lectures. Teacher educators can be challenged to experiment with innovative technologies and pedagogies for instance when enrolling in technology-based curriculum-reform projects or when collaborating with innovative schools or network of schools that plan for technology integration.

Final remarks

Concluding, in this study we discuss the results of a questionnaire about in-service student-teachers' need and preference for a course about digital pedagogies; we suggest a number of directions for developing a course based on these results and offer some recommendations to put these results into practice. One primary result is the suggestion to include thinking about the interplay between internal and external factors in teacher preparation programs. Moreover, the study provides empirical evidence that many teachers (in our case in-service student teachers) need opportunities to deep and extend their TPCK-knowledge. In-service student teachers' preference for a course seems to be practiced-based guided and innovative content is much less preferred than more traditional content and learning activities. These results are in line with previous research on teachers' integration of technology in classroom practice (Niess, 2005) and they extend these results for in-service student teachers.

This study also has some limitations. The results refer to a single teacher education department in one university and therefore should be carefully interpreted when transferred to other contexts. Another limitation concerns the closed character of a questionnaire. Although there were open questions and it was possible for the respondents to explain or

extend their answers, it was not possible for the researchers to question through, as it would be possible in interviews. In spite of these limitations, we believe our findings can be useful for teacher educators and researchers interested in developing and revise their courses. They can also be useful for faculty managers who plan for curriculum development.

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Interdisciplinary tasks: Pre-service teachers' choices and approaches

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Abstract: This study focusses on the criteria used by pre-service teachers of Mathematics to choose interdisciplinary tasks. The pre-service teachers' knowledge is assumed as the basis of the actions taken and used as the origin of the choices and approaches observed. The study adopts a qualitative and interpretative methodology and the data were collected using class observation and interviews. The analysis is guided by the Application and Pedagogical Content Knowledge, a model inspired on TPACK (from Mishra and Koehler) and MKT (from Ball and colleagues). The conclusions point to an appreciation of the mathematical part of the tasks and to a devaluation of the remaining components. This suggests difficulty in articulating and integrating different domains of knowledge and points to a fragmented view of the potential of using mathematical applications.

Keywords: applications; mathematics; pre-service teachers; teachers' knowledge

Introduction

Most of the problems we can find in the reality are related to more than one area of disciplinary knowledge. This means that they can be considered as interdisciplinary problems. However, when these problems are approached in school, that approach tends to focus on the knowledge of one specific subject. Many times, the procedural aspects of that specific subject become the central part of the problem and everything else is ignored, simplified or even removed from what was a real situation. The result can be a task that is no longer a problem, neither an interdisciplinary task.

In this study, a set of tasks with a real context was given to a class of pre-service teachers taking a course on didactics of mathematics at a master program for future secondary mathematics teachers. The pre-service teachers were asked to choose three tasks from that set of tasks and develop a lesson plan explaining how they will use the tasks in lessons of mathematics.

The main goal of the study is to characterize the pre-service teachers' choice of tasks and the related professional knowledge. It was specifically intended to: (1) Identify the criteria used by the pre-service teachers to select the tasks; (2) Analyse what these options suggest in terms of their professional knowledge. Pre-service teachers' knowledge is assumed as the basis of the actions taken; an analysis of the tasks chosen and the related reasons are assumed as a way to access their professional knowledge.

Theoretical framework

Interdisciplinarity

The literature offers a variety of ways of understanding interdisciplinarity. Drake (1991) considers the integration of two or more disciplines, assuming interdisciplinarity as one type of integration. And Williams et al. (2016) describe this type of integration as an approach where two or more disciplinary contents are considered at the same time. This

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