Mathematics Student Teachers' Metaphors for Technology in Teaching Mathematics

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Content

Abstract

While the metaphors for mathematics and for teaching mathematics have received some attention, there is a lack of research on metaphors for technology. This study sought to investigate mathematics student teachers' metaphors for technology in teaching mathematics. Based on metaphor theory and two theories of technology, the author analyzed 60 student teachers' metaphors for technology. The findings reveal that student teachers' views of using technology in mathematics teaching are ambiguous. The instrumental view of technology was dominating the data. Although the participating student teachers seem mainly to have a positive attitude towards technology, they need adequate opportunities in teacher education to explore the pedagogical and educational use of technology.

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1 Introduction

Technology and computer-aided learning materials are nowadays an essential part of modern mathematics teaching. Technology can help the teacher to visualize mathematical concepts and give immediate feedback for students. Moreover, computer-based tools can help students to manipulate mathematical graphs and figures, and execute calculations that either cannot be done manually, or are too slow to calculate by hand. Therefore, knowledge of technology and computer-based resources is important for a future mathematics teacher. (Asikainen, Pehkonen & Hirvonen, 2013.)

Recently, the question of what mathematics teachers need to know in order to be able to integrate technology into their teaching has received much attention (see Mishra & Koehler, 2006; Akkoç, Bingolbali, & Ozmantar, 2008).

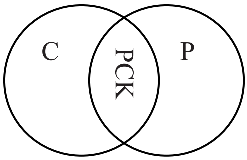

Figure 1 Shulman's pedagogical content knowledge (PCK) 1987

Pierson (2001) added a technology component to Shulman's (1987) PCK framework (figure 1) and described 'Technological Pedagogical Content Knowledge (TPCK)' as a combination of three types of knowledge: (1) content knowledge, (2) pedagogical knowledge, and (3) technological knowledge including the basic operational skills of technologies. Later illustrated as an intersection of three knowledge categories: technological, pedagogical and content by Mishra and Koehler (2006) (figure 2). Akkoç et al. (2008) propose, that the TPCK framework can guide teacher educators to design courses concerning technology as a part of mathematics teacher education programmes.

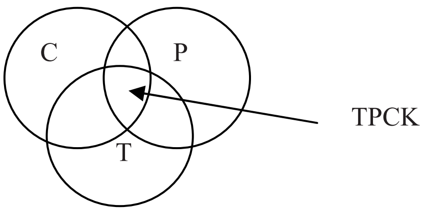

Figure 2 Mishra's and Koehler's technological pedagogical content knowledge (TPCK) 2006.

And further on, since many pre-service teachers might not have learnt their mathematical content with technology, they suggest that school mathematics should be revisited using various technological tools.

The teachers' characteristics play an important role in adapting technology in their teaching. According to Becta study (Becta, 2004), which reviewed the research literature on 'barriers to the uptake of ICT by teachers', a number of teacher-level barriers were identified. A very significant determinant of teachers' levels of engagement in ICT is their level of confidence in using the technology. Teachers with little or no confidence in using computers in their work will try to avoid them altogether. Levels of confidence are directly affected by the amount of personal access to ICT that a teacher has, the amount of technical support available, and the amount and quality of training available. Teachers are sometimes unable to make full use of technology because they lack the time needed to fully prepare and study materials for lessons. Besides technical faults with ICT equipment are likely to lead to lower levels of ICT use by teachers. Sometimes a total resistance can be seen in teachers' actions. Teachers are unwilling to change their teaching practices. Teachers who do not realise the advantages of using technology in their teaching are less likely to make use of ICT.

In Finnish context using technology in mathematics teaching polarized the teachers' responses. Some teachers thought that technology is important and can help students to learn. Others were more skeptical and emphasized the teacher's role in guiding. (Asikainen et al., 2013.)

2 Teachers Beliefs about Using Technology in Mathematics Teaching

Teachers' beliefs about mathematics, its learning and teaching are reflected strongly in the way they teach. Reflection is assumed to play a key role in change of practice and many researchers see a cyclical relationship between changing beliefs and changing practices. (Kagan, 1992; Lerman, 2002; Wilson & Cooney, 2002.) Already in the 90's Veen (1993) suggested that whether teachers use or not use computers depends on two basic factors: the school level and the teacher level. At the school level the principals are responsible for financial, organizational and moral support and they should provide a long-term perspective. Instead, at the teacher level the teachers adopt new media if they can use them in accordance with their existing beliefs and practices. By then the only major study to examine the relationships among teachers' epistemological beliefs, pedagogical beliefs, and their instructional uses of technology was conducted as a part of an evaluation of the Apple Classrooms of Tomorrow

(ACOT) project (Yocum, 1996) The study indicated that teachers tend to adopt new classroom practices based on whether the assumptions underlying the new practices are consistent with their personal epistemological beliefs (Yocum, 1996).

More recent studies suggest that there is a parallel between a teacher's student-centered beliefs about instruction and the nature of the teacher's technology-integrated experiences (Judson, 2006; Totter, Stutz, & Grote, 2006). In Becker and Ravitz's (2001) study, the results show that computer use among teachers is related to more constructivist views and practices and to changes in practice in a more constructivist-compatible direction. Burton (2003) also showed in her study with elementary teachers that this development can happen two-way. Professional development experiences involving technology will also facilitate a change in teachers' beliefs regarding teaching and learning towards a more student-centered focus. This may reflect the teachers' believes about their role. A traditional role will change to that of facilitator and partner in inquiry. Also Totter, Stutz and Grote (2006) suggest that teachers who adopt a student-oriented constructivist teaching style are more likely to make use of new technology in classrooms, and vice versa. They present some teachers' key characteristics, which influence the use of new media in classrooms. Positive influencing factors are openness to change, willingness to cooperate and constructivist teaching style. Moreover, negative influencing factors are lack of time, lack of ICT confidence and lack of ICT competence.

3 How to Categorize Teachers' Views of Using Technology in their Mathematics Teaching?

Chen (2011) provides two theories of technology as a framework for looking at the use of technology in mathematics teaching. According to the instrumental view of technology, the technology is seen as a tool or device assisting students to learn. It is an independent entity in this learning process. Teachers regarded technology as morally neutral and good in the class if used appropriately. Technology was also seen as empowerment while performing complex calculations, showing connections among different representations, and visualizing mathematical concepts. On the other hand according to the substantive view of technology, it represents an autonomous cultural system and acts to shape human perception and actions. Teachers in Chen's study (2011) regarded technology as inevitable and thought that it was their responsibility to equip their students with technology skills.

Gilbert and Kelly (2005) categorize attitudes towards technology pointing at emotions. Technology was seen either as a frontier, and a tool for exploration, or as a frontline, an attack and a defense. In White's (2004) study he proposes five teachers views of technology: a demon, a servant, an idol, a partner, and a liberator. When technology is seen as a demon, teachers actively oppose and decline to integrate technology into their teaching. Teachers feel either afraid or not willing to learn. When technology is seen as a servant, teachers assimilate technology in their teaching but into their existing instructional practices. If technology is seen as an idol, the emphasis is upon the teaching about computers rather than with computers. If technology is more like a partner, the students are actively engaged in working with data, and making meaning of their results. The technology has changed not only how students learn but also what they learn. When technology is seen as a liberator, technology is organizing and structuring the education itself.

In their study Levin and Wadmany (2006) provide a profound overview on technology and teacher change. Their findings reveal that following multi-year experiences in technology-based classrooms, teachers' educational beliefs changed quite substantively, yet revealing rather multiple views than pure beliefs. The categories used were (1) technical interest, (2) communicative or practical interests, and (3) emancipatory knowledge interest. A technical knowledge interest is being realized when technology is perceived as a means of practicing knowledge, skills, understanding, or competency, and when the context is not considered particularly relevant. When technology is serving a practical interest, then its role is in communication and interpretation. The emancipatory view of technology's role according to Levin and Wadmany (2006) involves the pursuit of knowledge or capacity to become conscious of the ways in which knowledge is constructed.

This study aims to find out the needs for support and encouragement the student teachers have in using technology in their mathematics teaching, and survey mathematics student teachers' views of technology by using metaphors. The research question is: What kind of views expressed with metaphors do the pre-service mathematics teachers have of using technology in their teaching?

4 About Metaphors and Metaphor Theory

Metaphors are significant in teacher education. They provide insights into complex concepts of teaching and learning and thus provide a window into the comprehension of teachers' personal experiences. The word 'metaphor' has its roots in Greek and is based on word *metapherein*, meaning to transfer or carry. That means that something is carrying across, and thus by metaphor we denote that something is, in some sense, something that it literally is not. As metaphors focus on similarities, they can be used to express views of the nature of technology. While they provide a way of talking about current views of technology, metaphors can open up new ideas of thinking about these perceptions. (Lakoff & Núñez, 2000.)

Metaphors are not mere words or expressions. Instead they are ontological mappings across conceptual domains. “Mappings are not arbitrary, but grounded in the body and everyday experience and knowledge.“ (Lakoff, 1993, p. 245). Also a metaphor is not just a matter of language, but of thought and reason. “Metaphor is fundamentally conceptual, not linguistic, in nature.” (Lakoff, 1993, p. 245). The challenge in using metaphors is the different knowledge and different experiences that people bring in while telling something via metaphors. Like Lakoff (1993, p. 245) proposes “metaphorical mappings vary in universality; some seem to be universal, other are widespread, and some seem to be culture specific”, and “metaphor is mostly based on correspondences in our experiences, rather than on similarity”.

While metaphors involve understanding one domain of experience in terms of a different domain of experience, metaphors can allow student teachers to understand and express abstract matters in concrete ways, and as Noyes (2006) points out that metaphors can reveal hidden beliefs of mathematics and help teacher educators to create conflict situations that might shift the meanings of mathematics. Reeder, Utley and Cassel (2009) argue that if experiences in teacher education programmes are to bring about meaningful transformation for pre-service teachers, teacher educators must provide opportunities for students also to critically examine their own thinking and beliefs about teaching and learning.

5 The Study

This study was conducted among pre-service mathematics teachers during their didactical course in the beginning of 2013. In this chapter the secondary school teacher preparation programme in Finland is shortly introduced. After that the data gathering and instruments are brought forward.

5.1 Educational setting

In Finnish secondary school, teacher preparation is a 5-year programme (3 BA and 2 MA). The students major in one subject, and minor in one or two other subjects (e.g. mathematics major, and chemistry and physics minor). This means that the students take education as minor and these teacher’s pedagogical studies (60 ECTS) can be taken within one academic year. Usually the students do their pedagogical studies at the end of their BA-studies. The programme gives general teacher qualifications to teach children (7th grade, 12-13 years), young people (secondary school) and adults in educational institutions offering general, vocational and adult education. Moreover, according to programme objectives, the future teachers gain a starting point to develop into a professional who plans, implements, evaluates, and develops teaching. In pedagogical studies the student teachers have to combine content knowledge, knowledge related to education and different learners, pedagogical content knowledge (i.e. knowledge of how to teach, study and learn the subject), and knowledge about school practices into their own pedagogical practical theory.

5.2 Method

Data for this study was gathered from 60 mathematics student teachers in January 2013. By then the student teachers in this study had been able to familiarize themselves with nearly half of their pedagogical studies, namely the first mathematics methods course and student teachers' first practical classroom experiences. The assignment was: the student teachers were asked to determine a statement "technology in mathematics teaching is", and to continue with an explanation of why it is so. They were not asked to identify themselves in their texts, so the texts remained anonymous. Still, only the metaphors with students' permission to use as data were gathered for this study.

The analysis was made in two phases: firstly, mere inductively, categories driven by the data; secondly, based on selected theory and previous studies. At first, all metaphors were read through thoroughly and five categories were formed. The metaphors were placed in categories exclusively, and a short description of categories was developed. Only three metaphors could not be categorized, merely because they were not true metaphors; they were ether lacking the metaphor word or the explanation. At this stage of analysis metaphors were assessed independently by the author. The five categories were:

(1) Useless: the metaphor expressed reluctance to use technology in mathematics teaching

(2) Over-advertised: the metaphor reflected the usefulness of technology but at the same time downplayed its role in teaching

(3) Tentative: the metaphor stressed that technology requires tackling, or it requires competencies, and it was not fitting for every teacher

(4) Good servant but bad master: the metaphor introduced both good and poor features of using technology in mathematics teaching

(5) Technology believer: the metaphor praised the technology and its role as a savior.

After the categories were formed and the descriptions were written down, an assistant classifier was used. Once independent data analysis was completed the findings were compared for inconsistencies and worked collectively to reconcile some of the inconsistencies. After categorization, categories could be arranged in order in respect of emotional aspects; the one end of the axis was anxiety and the other was enthusiasm. In the study of Gilbert and Kelly (2005) these end-points were called frontline and frontier (c.f. .White, 2004).

At the second phase of analysis the metaphors were categorized again, but this time the dimension was weather technology was seen as a tool or it has intrinsic value or value in itself. These categories were adopted from Chen (2011), who provides two theories of technology as a framework for looking at the use of technology in mathematics teaching: the instrumental view of technology and the substantive view of technology.

6 Analysis and Results

Some of the metaphors were rather clear-cut, but some were opened up to various possible interpretations. The categorization was exclusive, so each metaphor was counted as one. There were 60 metaphors in total at the beginning of analysis, and three of them were left out of analysis, because they were not true metaphors. After the first reading only the metaphors categorized the way that both classifiers could agree on were accepted as data (see table 1). This resulted that the number of metaphors decreased from 60 to 37 metaphors.

Table 1 Classifiers' categorizations and the data that was selected.

Category	Useless	Over-advertised	Tentative	Good servant but bad master	Technology believer	To-tal
Both classi-fiers agreed	3	5	8	13	8	37
Classifier 1	3	6	17	19	12	57
Classifier 2	11	9	12	15	10	57

Following examples explain the differences between classifiers. The metaphor "Technology in mathematics teaching is like an SLR camera. Basically, a good device, but only a very few know how to use it right" was one of those metaphors in between categories. Classifier 1 was stressing the part "a good device, but" and categorized the metaphor in category 3. Classifier 2 stressed the part "a very few know" and categorized it in category 2.

Sometimes differences appeared when the first classifier was looking at the explanation and the second was stressing the metaphor. For example "Technology in mathematics teaching is a spice. When used incorrectly it can ruin even good ingredients, but well used it will take the remaining food ingredients to a new level". Classifier 1 categorized it in category 4, because of the explanation, and classifier 2 in category 3 because of the metaphor word that was used.

After the first categorization the same metaphors were categorized again but this time according to the role of the technology, weather technology has an intrinsic use or only use as a tool. Only the metaphors both classifiers were agreeing were selected to this analysis and the number of metaphors declined from 37 to 27 (see table 2).

Table 2 Technology metaphors categorized according to the role of the technology.

Category	Useless	Over-advertised	Tentative	Good servant but bad master	Technology believer	Total
Intrinsic value	0	2	3	0	5	10
Tool	2	3	2	10	0	17
Total	2	5	5	10	5	27

Most of the metaphors (17/27) were describing technology as a tool. However, all the metaphors in category *good servant but bad master* were tool metaphors (10/27), and all metaphors in category *technology believer* were metaphors where technology was having an intrinsic value (5/27).

Only 2/27 metaphors were categorized in the category of *useless*. Both of them were expressing the role of the technology as a tool. "Technology in mathematics education is a magician's smoke. Magician's smoke prevents the audience to see exactly what is going on. Sometimes the use of technology, in particular the terrible, cumbersome CAS calculators, can come between the student and the content and the student does not understand what he is doing or what he is seeing, and his attention goes to finger at the device." In these metaphors the technology was only interfering with the learning and teaching of mathematics.

One of the metaphors in category *over-advertised* was: "Technology in mathematics teaching is a Swiss pocket knife. With it one is able to do anything, and still it is rarely used." Almost half of these metaphors (2/27) were stressing the role of the technology as tool. One of the metaphors (3/27/) in this category expressing the intrinsic value of technology was “Technology in mathematics teaching is offering unlimited possibilities. However, no one is able to fully take advantage of them. Technology has advanced so rapidly, that it seems that teachers do not have time to follow the development.”

In category *tentative* where 5/27 metaphors were categorized, some of the metaphors were manifesting of how much work the technology requires the teacher to do. “Technology in mathematics teaching is like gardening. It requires time and dedication, in order to get the perfect result.” This metaphor was expressing the intrinsic value of technology. Some metaphors in this category were expressing the uncertainty of technology. “Technology in mathematics teaching is a journey into the unknown, because you never know what can be found in front of you, or when the journey ends.” Like the previous metaphor also this is stressing the intrinsic value of technology. The metaphors in this category were also expressing the know-how teachers’ need, when they are planning to use technology in their teaching. “Technology in mathematics teaching is a flash drive. It is of no use if one cannot use it.” This metaphor was also expressing the role of the technology as a tool.

The metaphors (10/27) in category *good servant but bad master* were metaphors where the role of the technology was seen as a tool. “Technology in mathematics teaching is a dishwasher. Nice device that saves time and effort, but is not necessary.” ”Technology in mathematics teaching is a good servant, but a bad master. It takes too easily the focus away of the subject being taught.” “Technology in mathematics teaching is like electricity in summer cottage. Without it, it’ll be fine, but yes, it’s a little miserable and dreary in the long run.”

The last category was *technology believer*. All 5/27 metaphors in this category were stressing the intrinsic value of technology. “Technology in mathematics teaching is like the child’s first step. It must be taken in order to go ahead.” “Technology in mathematics education is like getting additional senses. It is like getting more eyes and more ears to use.”

7 Discussion

The results of this study indicate that mathematics student teachers views of using technology in their teaching are moderately positive. When only affective categories were taken into account, no less than 61.7 % of metaphors were positive or fairly positive. When the role of the technology as an intrinsic value or as a tool was determinative 74.1 % of metaphors were positive or fairly positive. Weather these student teachers will use technology in their teaching in the future is still uncertain. Like in Becta study (2004) and also in the study of Totter, Stutz and Grote (2006) negative influencing factors are lack of time, lack of ICT confidence and lack of ICT competence. Even 63.0 % of the metaphors were describing technology in mathematics teaching as a tool. This was also the case in Chen's (2011) study. Hopefully, like in Levin's and Wadmany's (2006, p. 174) three-year study the teachers who could integrate technology in their teaching to long-term basis developed their "viewing technology as a technical tool to seeing it as a partner that can empower the student, teachers and the learning environment".

The present study is significant and relevant for several reasons. First, it offers an important contribution to the exploration of teachers' professional growth when integrating technology component into student teachers' reflective practice. Second, it gives us teacher educators a view of mathematics student teachers' beliefs of technology and its usefulness in mathematics education. This study also revealed how difficult is to categorize metaphors. The person writing the metaphor may have totally different view on the chosen metaphoric expression. For example the flash drive, if one uses it all the time, it is a necessity and one might be surprised if someone else is not able to use it. For somebody else it would be a device not so often used, and almost useless. Depending on classifiers own interests and his cultural background the words get different meanings. This is why the metaphors are so intriguing and the metaphor theory continues to interest researchers.

8 References

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