What can be Learned from Comparing Performance of Mathematical Knowledge for Teaching Items found in Norway and in the U.S.?

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Abstract
This paper reports from a Norwegian research project, where a U.S. developed model for teachers' mathematical knowledge for teaching (MKT) was studied. Part of this project included the adaption of MKT measures developed in the U.S. to gauge teachers' MKT. We present results from a pilot study where 149 Norwegian teachers were tested, and where 10 teachers were interviewed in 5 focus group interviews. We discuss how these measures can be used as a tool in relation to professional development of teachers in Norway.

Introduction

Teachers play an important role in determining the quality of graduates, and there is widespread agreement that teachers' understanding of content matter is important for their teaching (Askew, 2008). Still, exactly what knowledge teachers need to have in order to teach is continually discussed (e.g. Hill, Schilling, & Ball, 2004; Rowland & Ruthven, 2011). Researchers at the University of Michigan in the U.S. have contributed to this discussion by developing a framework referred to as "mathematical knowledge for teaching" (MKT. Ball, Thames, & Phelps, 2008). From studies of mathematics classrooms they have identified specific tasks that are involved in mathematics teaching and the mathematical demands behind those tasks (ibid.). Based on this, they have developed measures of teachers' MKT. Their studies have shown that a high MKT score among teachers can be positively associated with increased learning by their students and with higher quality of instruction (Hill et al., 2008; Hill, Rowan, & Ball, 2005).

Knowledge about the topics that teachers struggle with is useful when preparing professional development programs (Hill, 2010). Some research has already been done within this area in the U.S., but there is a need for more research concerning in-service teachers' MKT in other countries. Investigations of how the MKT measures can be used in professional development of teachers in other countries will be an important contribution to this field of research. This paper aims to contribute to an investigation of how the MKT measures can be used in professional development of teachers in Norway. When attempting at using these measures in connection with professional development of teachers, it is interesting to learn more about the connection between teachers' MKT score and their teaching experience. It is also interesting to learn more about the connection between the amount of professional development that teachers have had and their MKT ability. Our research question for this paper is:

> What is the connection between teachers' MKT, their experience and professional development?

This question is virtually impossible to approach on a general level, but we investigate these connections in a sample of Norwegian teachers and discuss possible implications of these findings.

Theoretical Background

After having developed the MKT framework, Ball and her colleagues (2008) have developed items that can be used to measure teachers' MKT. These measures include forms of teaching-specific knowledge (Hill, 2010). One such aspect of MKT is related to purely mathematical knowledge which is specific to the work of teaching or "specialized content knowledge" (Ball, Thames, & Phelps, 2008). Hill (2010) recommends that specialized and pedagogical content knowledge (Shulman, 1986) have particular focus in professional development.

The MKT framework, is a further development of Shulman's (1986) model of teacher knowledge. The MKT model (see Figure 1), which is still in development, consists of a number of knowledge domains describing two of Shulman's initial categories in more detail.

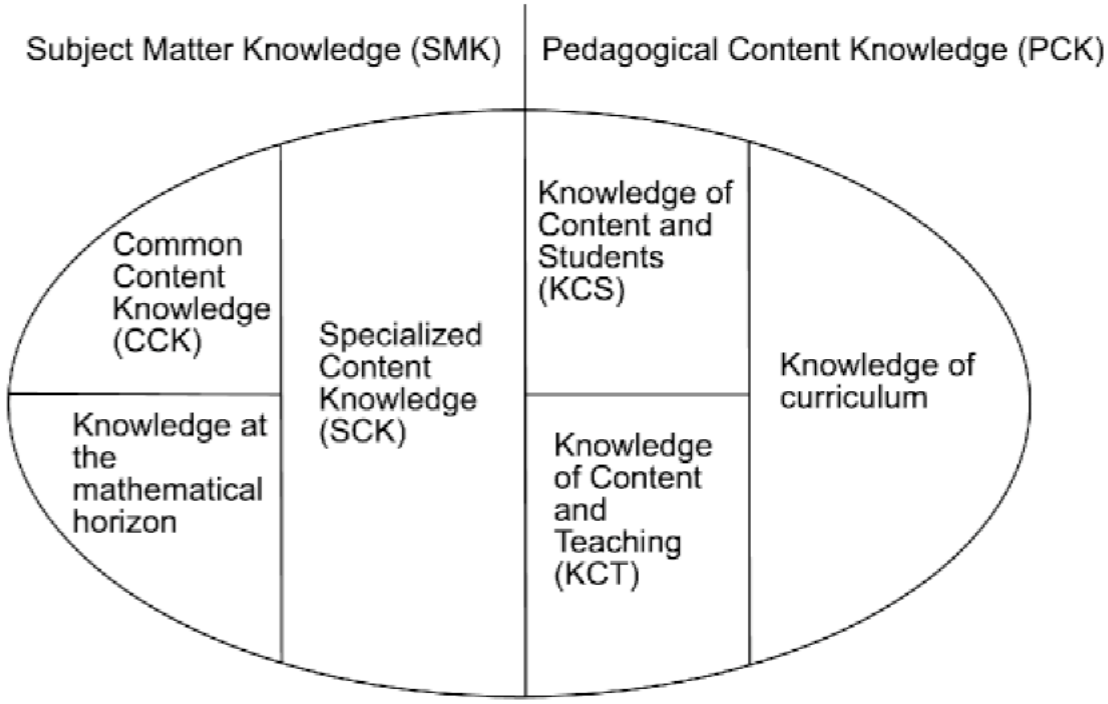

Figure 1: Domains of MKT (see Ball et al., 2008, p. 403 for a definition and discussion of the domains)

The assessment of practicing teachers' knowledge is not a widely accepted practice (e.g. Hill, Sleep, Lewis, & Ball, 2007), at least not in Norway (Lysne, 2006). The goal of Hill and her colleagues (2007) is to move the debate concerning assessment of teachers ". . . from one of argument and opinion to one of professional responsibility and evidence" (ibid., p. 112). To make advances in developing instruments to study teachers' knowledge, a set of agreed-upon, reliable and valid methods for assessing teachers' MKT is required (Hill, et al., 2007). This is in line with Shulman's (1986) initial aim, which was to develop tests where those educated to teach would get high scores.

Hill, Sleep, Lewis and Ball (2007) argue that assessing teachers' knowledge:

> ". . . can be done in ways that honor and define the work of teaching, ratify teachers' expertise, and help to ensure that every child has a qualified teacher. Doing so requires carefully constructed instruments that take seriously the work of teaching and that can be used at scale" (ibid., p. 150).

Hill and colleagues (ibid.) see further development of the MKT measures as one attempt to attain this goal. These measures can, to a certain extent, help in-service educators to identify teachers' lack of knowledge (e.g. Hill, 2010) and thus identify opportunities for teachers to learn (Hiebert & Grouws, 2007). Research so far has indicated that the MKT instrument can be relevant for use in professional development in the U.S., but little has been done to investigate its use in other countries. Norwegian teacher education has until recently certified teachers to teach any subject in grades 1-10, and this differs from the situation in many countries. It is therefore interesting to investigate if the U.S. developed measures can give the same useful information when used in a Norwegian context and if the measures can be a relevant tool for in service educators planning professional development.

Methods

After having decided to use the MKT measures in Norway, our first step was to translate and adapt measures for use in a Norwegian context. The 2004 elementary form A (MSP_A04) from the LMT project[1] was translated and adapted (Mosvold, Fauskanger, Jakobsen, & Melhus, 2009). The process of translating and adapting items was conducted based on recommendations from Delaney and colleagues (2008). When the entire set of items was translated, a pilot study was conducted. The pilot study included a quantitative as well as a qualitative part. Mathematics teachers at our partner schools were invited to participate (grade 1 to 10), and 142 teachers from 17 schools participated in the initial phase. In a second phase two new partner schools were added, and the number of participating teachers was extended to 149. In the quantitative part of the study, all participating teachers completed the test individually. All tests were conducted at the teachers' respective schools, and the testing situation was organized in order to be as similar as possible. Among the participating schools, teachers at five schools were selected for participation in semi-structured focus group interviews (FGIs). These interviews were held directly after the teachers had completed the test, and ten teachers participated in the interviews altogether.

The final form used consisted of two parts. Part 1 included the translated and adapted MKT items[2], a total of 61 items (30 item stems). Of the 61 items, 26 items were from the content domain number concept and operations (NCOP), 19 from geometry (GEOM), and 16 from the domain patterns functions and algebra (PFA). In Figure 2, one of the released items is shown in order to illustrate the nature of the items.[3] This item asks teachers to respond to a mathematical task situated in a teaching context. In part 2 of the form, teachers were asked about factual information concerning their gender, their teaching experience, their mathematical background, and their participation in professional development courses.

The MKT items are meant to relate to the underlying MKT construct and can be viewed as one possible operationalization of the construct. An item response theory (IRT) model can serve as a link to the observed latent world (Edwards, 2009). A basic idea in IRT is that an observed item response is a function of person properties and item properties (ibid.). To estimate teachers' MKT score and item characteristics, we have, in the same manner as initially done in the U.S., used a two parameter IRT model.

[1] See http://sitemaker.umich.edu/lmt

[2] For sake of simplicity, we refer to items from the LMT project as "MKT items" in this paper.

[3] The items used in the test are not released and not available for publication.

2. Imagine that you are working with your class on multiplying large numbers. Among your students' papers, you notice that some have displayed their work in the following ways:

Student A	Student B	Student C
35 x 25 125 +75 875	35 x25 175 +700 875	35 x25 25 150 100 +600 875

Which of these students would you judge to be using a method that could be used to multiply any two whole numbers?

	Method would work for all whole numbers	Method would NOT work for all whole numbers	I'm not sure
a) Method A	1	2	3
b) Method B	1	2	3
c) Method C	1	2	3

Figure 2: Example from the set of released items (Ball & Hill, 2008).

We have used the program BILOG-MG (Zimowski, Muraki, Islevy, & Bock, 2003) for the estimation of teachers' MKT score and testing of IRT models. For the calculation of correlations, we have used PASW Statistic 18 (formerly known as SPSS statistics).

Results

In our analyses of the data, we looked for correlations between the teachers' MKT score and answers in Part 2 of the form. First, we did not find any significant correlation between teachers' MKT and their experience. When taking a closer look at the number of years they had worked as teachers, however, we found out that our data sample consisted of a rather experienced group of teachers with 80 percent of the teachers having more than six years of work experience. Only 1.4 percent from this convenience sample of teachers was in their first year of teaching.

Second, we studied correlations between teachers' MKT and the grades in which they where teaching. Here we found that there was a significant correlation between the level in which the teachers had teaching experience and their MKT score. Teachers with experience from grades 5-7 or 8-10 (or both) had significant higher MKT score than those with experience only from grades 1-4 (p-value < 0.0005), but the correlation factor was low (Pearson correlation 0.462). If we looked at 1-7 teachers as one group and compared to teachers with

experience in grades 8-10, the latest group had significant higher MKT (1.005) and with higher correlation factor (Pearson correlation 0.522, p-value < 0.005).

Third, we studied the correlation between teachers' MKT score and the number of days they had participated in professional development in the years they had worked as teachers. This variable only informed about the total number of days with professional development, and did not say anything about when this professional development took place or what kind of professional development this was. First we considered teachers that had participated in professional development as one big group and compared their MKT score with teachers that had never participated in any professional development program. We did find that this group had a significantly higher MKT score (0.349 higher) compared to teachers without any professional development, but the correlation was weak (Pearson correlation 0.194, p-value < 0.05). Second we grouped the respondents into 6 subgroups: Those who had a) 1-5 days of professional development; b) 6-10 days; c) 11-15 days, d) 16-20 days; e) 21-25 days and e) more than 25 days of professional development. For all of these subgroups we found that the correlation between teachers MKT score and professional development was close to what was found for the big group. However, the subgroups containing teachers with more professional development (e.g. group d), e) and f)) had on average a higher MKT score (0.541 for group d), e) and f)).

Concluding Discussion

In previous analyses, we found that the Norwegian adapted item characteristics are strongly correlated to what is reported in the U.S. (Jakobsen, Fauskanger, Mosvold, & Bjuland, 2011). For item difficulty, the correlation was strong (0.804, p-value < 0.0005). We have also found strong correlation between teachers' MKT in the three content areas (ibid.). Building upon these results we have now analyzed the correlation between the teachers' experience and their MKT score.

We studied a convenience sample of relatively experienced teachers. Despite the limitations of this present study, it has given some indications of issues that should be further investigated. A larger and representative sample of teachers should then be studied.

The results from our study indicate that teachers with experience in teaching higher grade levels have stronger MKT. It should be emphasized, however, that the results from our study cannot be used to argue that experience from higher or varied grade levels produces higher MKT score, only that there is a correlation.

In our study we did not gather information about what kind of professional development courses the teachers had taken or when. The weak correlation between professional development and MKT can thus be interpreted as an area that needs to be investigated further. From our data, we cannot say if there was a change in teachers' MKT after taking part in professional development. Future studies should be conducted in order to learn more about what kind of professional development courses produce stronger MKT, and more generally to investigate the connection between professional development and the development of MKT.

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