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Translating and Adapting the Mathematical Knowledge for Teaching (MKT) Measures: *The Cases of Indonesia and Norway*

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Abstract

This paper examines issues of translating and adapting an instrument that aims at measuring mathematical knowledge for teaching in Indonesia and Norway. The instrument was created for use in the U.S., and we discuss problematic and challenging issues of translation and adaptation. Two items from the released items pool were translated using a common framework modified from a previous study to exemplify critical issues that need to be resolved prior to using such instrument in another country. Themes identified in this study include a) minor challenges due to cultural differences; b) the use of technical language in schools; c) incommensurable contexts across countries; and d) the use of mathematical models.

Keywords: cross-national comparison, instrument translation, instrument adaptation, mathematical knowledge for teaching

Introduction

There is a growing interest and need to develop valid and reliable instruments to measure teachers' knowledge of mathematics due to a climate of increased accountability. Few scholars will dispute that teachers' knowledge of mathematics is one of the most important influences on teaching practices and eventually on what students learn (Ball, 1990; Ball, Lubienski, & Mewborn, 2001; Hill, Ball, & Schilling, 2008; Hill, Blunk, Charalambous, Lewis, Phelps, Sleep, & Ball, 2008). Thus, the availability of measures to reliably assess what teachers know holds promises for further understanding factors contributing to this knowledge and thus inform teacher education programs. Moreover, with the increased attention to comparative studies in mathematics education in the past decades, examining the quality of teachers' mathematical knowledge in different countries may provide insights on improving students' achievement (An, Kulm, & Wu, 2004; Cai, 2005; Ma, 1999). However, the scope of cross-national studies on teachers' mathematical knowledge has been limited to a few countries, and these selective countries perform well when compared to the United States on international comparison (e.g., An et al., 2004; Cai, 2005; Ma, 1999; Stigler & Hiebert, 1999; Zhou, Peverly, & Xin, 2006). Widening the range of these studies to incorporate more countries, including developing countries, may be useful to reach a greater understanding of the teaching and learning of mathematics. This article reports an initial stage

of such endeavor by examining issues of translation and adaptation of a U.S. based instrument for measuring teachers' mathematical knowledge in Indonesia and Norway, where the focus is on the challenges faced and problems encountered when using this instrument in different cultural settings. To illustrate the underlying complexity of the translation process of such instrument, a case study was conducted in which two items were translated and adapted for use in the two countries, and are discussed in this article.

Bradburn and Gilford (1990) suggest that using existing test instruments for international comparative studies is beneficial in that there is linkage to other ongoing studies. However, Emenogu and Childs (2005) remark that even when rigorous processes of translation, verification, and field-testing are followed, translation may introduce measurement non-equivalence. Differences may occur, not only due to language differences, but also variability in teaching practices. For instance, curriculum differences such as the sequence of mathematics courses, the time spent on topics, availability of textbooks and other materials may cause differences in the relative item difficulty of measures (Emenogu & Childs, 2005). Understanding the context of the intended country where the measures are to be used is therefore deemed necessary.

One set of measures for teachers' mathematical knowledge that has been widely studied and shown to be successful in the United States is the Mathematical Knowledge for Teaching (MKT) measures (Learning Mathematics for Teaching Project, 2006)[i]. Researchers from other countries have been interested in using these measures, and attempts to adapt the MKT instrument have been conducted in Ireland where Delaney (2008) points to some possibilities as well as some problematic issues. The process of translating such items is far from straightforward, and there are several issues to be aware of when attempting such endeavor (cf. Delaney et al., 2008). The Irish project has lately been followed by similar attempts in Ghana (Cole, 2009), South Korea (Kwon, 2009), Indonesia (Ng, 2009) and

Norway (Mosvold & Fauskanger, 2009; Mosvold, Fauskanger, Jakobsen, & Melhus, 2009). The MKT measures were not built for the purpose of comparing the knowledge of teachers in the U.S. with that of teachers in other countries, say Indonesia or Norway. However, investigating the adaptability of these measures in other countries would be worthwhile for future studies to compare teachers' knowledge across nations. Such attempts would have to pay close attention to the possible challenges and pitfalls in the process of translation and adaptation. If there are significant differences, it is important to figure out whether these differences are related to the translation process, to cultural differences, or to other aspects.

Such challenging questions were raised in a symposium session at the 2009 Annual Meeting of the American Educational Research Association, in which the authors of this article took part. We discovered that although our projects so far had been carried out without any direct contact or co-operation, the challenges that we had faced were quite similar. As a follow-up to the above mentioned symposium session, we decided to go deeper into a discussion of the experiences that we had gained in our projects, with a particular focus on issues related to translation and adaptation of the MKT items. Through the discussions in this article, we hope to contribute to the field with recommendations and suggestions for future research. Although our discussions and recommendations concern the use of the MKT measures in particular, we believe that our findings might influence other similar projects in different areas of research as well.

The following is the research question that we will discuss in this article:

> What challenges were encountered in the process of translating and adapting the MKT measures for use in Indonesia and Norway?

Theoretical background

Mathematical knowledge for teaching (MKT)

Research from the last 15 years indicates that "the mathematical knowledge of many

teachers is dismayingly thin" (Ball, Hill, & Bass, 2005, p. 14). When analyzing 700 first and third grade teachers (and almost 3000 students), researchers found that the teachers' knowledge had an effect on the students' knowledge growth (Hill, Rowan, & Ball, 2005). Stigler and Hiebert (1999) claim that: "Although variability in competence is certainly visible in the videos we collected, such differences are dwarfed by the differences in teaching methods that we see across cultures" (p. 10). But even though research indicates that teachers' knowledge might have a positive influence on students' learning, it is not obvious what the content of this knowledge is.

Both studies referred to in this article made use of the MKT items that were developed by researchers at the University of Michigan in relation to the LMT project. Theoretically, the MKT construct follows Shulman's (1986) efforts to define the theories concerning subject matter knowledge (SMK) and pedagogical content knowledge (PCK). The categorization of the various components of teacher knowledge has evolved from Shulman's original proposal, where he distinguished between SMK, PCK, and knowledge of curriculum. In the LMT project, this model evolved into a model of MKT (Figure 1).

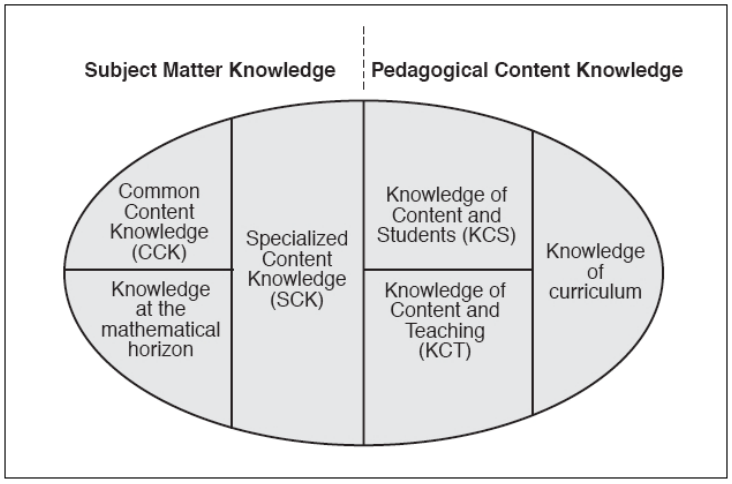

Figure 1. Domains of Mathematical Knowledge for Teaching (Ball, Thames, & Phelps, 2008, p. 403).

These domains were identified through psychometric analyses, but the MKT items

were developed based on teaching practices (studies of videos from classrooms) in the United States. Although the items focus on tasks of teaching, which is supposed to be of a universal nature, the items may not translate to other countries. Consider what Ball and colleagues (2008) identify as mathematical tasks of teaching in the U.S.:

- Presenting mathematical ideas
- Responding to students' "why" questions
- Finding an example to make a specific mathematical point
- Recognizing what is involved in using a particular representation
- Linking representations to underlying ideas and to other representations
- Connecting a topic being taught to topics from prior or future years
- Explaining mathematical goals and purposes to parents
- Appraising and adapting the mathematical content of textbooks
- Modifying tasks to be either easier or harder
- Explaining the plausibility of students' claims (often quickly)
- Giving or evaluating mathematical explanations
- Choosing and developing usable definitions
- Using mathematical notation and language and critiquing its use
- Asking productive mathematical questions
- Selecting representations for particular purposes
- Inspecting equivalencies

(Ball, Thames, & Phelps, 2008, p. 400)

Upon close examination, some of these tasks may be foreign to teachers in other countries. In some Asian countries, for instance, student questioning is not endorsed, and thus, responding to students "why" questions might therefore not be a relevant task of teaching. As another example, many countries have a national curriculum and there may not be many variations among textbooks. In some countries, teachers are expected to use the textbook as a prescriptive manual, and thus there is no room for *appraising or adapting mathematical content from the textbooks*. These examples indicate that the translation and adaptation of measures such as the MKT is not straightforward and requires careful scrutiny in order to be used successfully in another setting. There may also be differences within each task of teaching. *Presenting mathematical ideas* might be a task of teaching that applies worldwide, but the choice of words may be different for one setting than another. This makes the translation of MKT items challenging.

Issues of translation and adaptation of the MKT measures

Historically, translation of texts between cultures was a matter of substituting each word in the original language with an equivalent word in the new language, and this is often referred to as interlinear translation. Such ideas about translation have been important for translators for centuries, in particular with reference to translation of sacred texts like the Bible, where faithfulness to the original text has been of utmost importance. These ideas have changed, however, and translation has become more focused on preserving the functional equivalence of a text. Also, there is an agreement that different strategies of translation have to be used for different types of text (Lefevere & Bassnet, 1998). This is true for translation of test items as well, where it is not only a matter of finding equivalent word in an interlinear manner. Translation errors are known to be a major reason why some items function poorly in international tests of students' knowledge (see Adams, 2005). At the same time, studies normally provide little information as to how measurement instruments are translated and adapted for use from one country to another (e.g., Ma, 1999). Publications resulting from such studies typically present little to no description about translation issues arising in the research, particularly in the case of measures of teachers' knowledge (Delaney et al., 2008).

The process of translating the MKT measures into a different language is not only a matter of word choice. It is also of importance to adapt the measures for use in a cultural context that is quite different from the original intended setting. This is particularly crucial with the MKT items, since they were not originally created for use outside the U.S. Although the items aim at covering tasks of teaching (supposedly to be of a universal nature), they are strongly grounded in the practice of teaching mathematics, which may vary across countries. Therefore, it is necessary to include experts of teaching in the process of translating and adapting the items.

After the translation process, an instrument should continue to measure the same characteristics that it originally intended to measure (Geisinger, 1994). The idea of ensuring

construct equivalence is therefore an important methodological goal for translating the MKT measures into another language. Singh (1995) suggests six steps in establishing construct equivalence. The first three of these (functional equivalence, conceptual equivalence, and instrument equivalence) should be established prior to using the measures for data collection (Singh, 1995; Delaney, 2008). The first, functional equivalence, relates to whether or not a construct serves the same function in all the countries where the instrument will be used (Singh, 1995). Conceptual equivalence refers to the question of whether or not a construct means the same across cultures (Delaney, 2008). Finally, instrument equivalence is related to both the format and the content of the items. Instrument equivalence is established when the items in the instrument are equally interpreted in other cultural settings as well as the initial targeted population (Singh, 1995).

Delaney and colleagues (2008) argue that since the MKT is defined as "the mathematical knowledge needed to carry out the work of teaching mathematics" (Ball, Thames, & Phelps, 2008, p. 395), the notion of MKT serves the same function in every country where mathematics is taught. Using logical argument, they deducted that since teachers anywhere will require some forms of mathematical knowledge in order to teach their students, it is self-evident that the construct of MKT satisfies the requirement of having functional equivalence, despite possible differences in curricula, teaching traditions, or expectations from education systems (Delaney et al., 2008). In terms of conceptual equivalence, the Irish research team examined the MKT construct more closely by studying the work of teaching in Ireland. They compared their work to conceptions of the work of teaching that informed the development of MKT. These researchers also studied literature about the construct, and they analyzed items based on the construct. They found relatively minor differences in their analysis. Finally, for instrument equivalence in the Irish study, a focus group consisting of Irish teachers and mathematicians scrutinized the items and

proposed changes to make the items culturally fit (Delaney et al., 2008). Based on the result of this focus group and subsequent interviews with respondents, only two items were identified to cause differences in interpretation by the Irish teachers.

Therefore, judging from the functional, conceptual, and instrument equivalences, the adaptation of the U.S. based MKT instrument in Ireland was relatively successful. One possible explanation might be that these two countries share similarity in language. This proximity of language may have facilitated the smooth exchange of ideas and conceptions about teaching between the U.S. and Ireland. However, the adaptation of the MKT construct may face more challenges when it comes to other countries where English is not the primary language of instruction. Further studies are necessary to examine equivalence of the MKT across countries where there exist differences in language. This article describes an initial effort to examine the translation of the MKT items in Indonesia and Norway where languages other than English are used.

Delaney and colleagues (2008) contribute significantly in the area of instrument adaptation by developing categories of changes for translating the MKT instruments for use in another setting. These categories are 1) changes related to general cultural context; 2) changes related to the school context; and 3) changes related to mathematical substance; and 4) other changes. General cultural context changes included changing people's names to make them familiar to teachers in the new setting, adapting non-mathematical language, and changing culturally specific activities to be familiar to the teachers in that particular country or cultural contexts. The second category refers to changes in language used related to the cultural context of school or to the education system in general. Although these two categories of changes do not affect the mathematical substance of the items and therefore were unlikely to compromise the validity of the measures, they are important so that teachers in another setting are not distracted by terms or contexts to which they are not accustomed

(Delaney et al., 2008). The third category of change is related to the mathematical substance of the items, and consisted of changes of units of measurement, changes to the mathematical language that is used in schools, changes to representations commonly used in schools, and changes to anticipated student responses. Finally, other changes that do not fit the previous three categories are placed under "other changes".

In addition to the above four categories, two additional categories came out of the Norwegian study: (1) Changes related to the translation from American English into Norwegian (also applicable to Indonesian) and (2) Changes related to political directives (see Mosvold et al., 2009). The first of these additional categories could also fit well within the fourth category ("other changes") above, but it was included as its own category to emphasize the added complexity of translating to a different language rather than only adjusting to a different cultural setting, which was the challenge for Delaney and his colleagues (2008) in the Irish study. Some items include words and phrases that are simply problematic to translate, and such changes were placed in this category. The second additional change was especially related to the Norwegian context, and it was included to emphasize a challenge that was special to the Norwegian study. The Norwegian Department of education decided that the organization of students in traditional classes should no longer be the norm, and the word "group" replaced the word "class" in most official documents. This was not simply a challenge related to school culture, since some teachers continued to talk about classes of students, whereas some were very conscious about the change.

In order to understand the cultural influence on item translation and adaptation, we present the education contexts for the two countries involved in our study below.

Educational contexts of Indonesia and Norway

Indonesia and Norway are different in many respects. Norway, being a relatively small country with a population of 4.7 million, is among the wealthiest countries in the world.

Indonesia, on the other hand, is a larger country with a population of 223 million, and it is often categorized as a developing country (Mullis et al., 2008). In international studies like TIMSS and PISA, students from both Indonesia and Norway are low performing in mathematics. Despite differences in terms of socioeconomic and political structures, the two countries have somewhat similar challenges when it comes to students' performance in mathematics.

Like many countries, Indonesia and Norway are undergoing efforts to improve their education. The instructional practice in Indonesian classrooms is characterized as mechanistic, with teachers tending to dictate formulas and procedures to their students (Armanto, 2002; Fauzan, 2002; Hadi, 2002). The prevailing method of teaching-as-telling creates a passive learning atmosphere, where misconceptions frequently emerge (Armanto, 2002). In Norway, some similar issues seem to be prevalent. Although the 1997 curriculum reform focused more on projects, group work and guided discovery (KUF, 1996), classroom instruction remained traditional, focusing on review of previously taught issues, presentation of new theories with corresponding examples, and a strong focus on solving textbook tasks (Alseth, Breiteig, & Brekke, 2003).

Indonesian students' performance in mathematics on national examinations is poor, with an average of below 5 on a 10-point scale, making it consistently the lowest-scoring subject of all those taught in school (Depdikbud, 1997). In international comparative studies like TIMSS and PISA, Indonesian students performed below most other participating countries. Norwegian students performed somewhat better than their Indonesian peers, but the Norwegian students were still below average (Gonzales et al., 2008).

In the area of curriculum development, there have been efforts to develop exemplary curriculum materials for teaching school mathematics in Indonesia (Armanto, 2002; Fauzan, 2002; Hadi, 2002; Sembiring, Hadi, & Dolk, 2008). However, unlike the United States,

where efforts to reform mathematics instruction have proceeded for a considerably long period of time, Indonesia is just beginning to initiate reform in mathematics education through a standard based curriculum introduced in the 2009/2010 academic year.

Both Indonesia and Norway adopted national curricula where mathematics is required at all grades at both the elementary and secondary levels. Unlike the United States, where there are five content strands (Number and Operation, Algebra, Geometry, Measurement, and Data Analysis and Probability) (NCTM, 2000), Indonesian elementary curriculum consists of only four strands (Algebra is not included at the elementary grades) (Departemen Pendidikan Nasional, 2003). Moreover, Geometry and Measurement are also treated as one strand, and Probability is excluded in the elementary grades. In Norway, students are supposed to work on the subject areas: Numbers (becomes Numbers and algebra in years 5-10), Geometry, Measuring, Statistics (becomes Statistics and probability in years 5-7, and then Statistics, probability and combinatorics in years 8-10), and Functions (only in years 8-10) (Utdanningsdirektoratet, 2008).

When compared with the content of the MKT items that are used in our studies, it is important to notice that algebra does not appear as a main content area in first grade through fourth grade. In the previous curriculum guideline, algebra only appeared in years 8-10. Functions only appear in years 8-10. For Indonesian students, algebra is not included at all in elementary school.

The most recent Norwegian curriculum (UFD, 2005) has increased the focus on achievement goals, and it does not include descriptions of processes or methods, or materials that could be used. The Indonesian curriculum is somewhat more similar to the previous Norwegian curriculum, in that it includes all these aspects. Both countries publish the national curriculum as an official publication. There are, however, differences when it comes to textbooks and teacher guides. In Norway, there are no longer mandated or recommended

textbooks for mathematics. According to Mullis and colleagues (2008), there are no official instructional or pedagogical guides, but this has been developed more recently. In Indonesia, there are both official guides and textbooks.

The language of instruction in Indonesia is Bahasa Indonesia, whereas Norwegian is the official language of instruction in Norway (Mullis et al., 2008). Although students in the two countries are taught English in school, neither of the countries have English as an official language. The MKT items therefore had to be translated into Norwegian and Indonesian respectively.

Method

The Indonesian and Norwegian projects in focus in this article were part of larger projects with different purposes. The purpose of the Indonesian project was to use the MKT instrument to examine factors that may contribute to Indonesian elementary teachers' mathematical knowledge for teaching geometry and to evaluate the effectiveness of a professional development program focusing on knowledge of geometry in the context of teaching elementary mathematics (Ng, 2011). Thus, only the geometry scales were used. On the other hand, a whole set of items were used in the Norwegian project since the main purpose was to ensure that the construct of MKT meant the same to Norwegian teachers as to U.S. teachers, and to address issues related to the format as well as the content of the items.

The two projects also differed in the translation procedure used. The Norwegian project used a double translation procedure (Adams, 2005), where the translation of the items took about half a year. Towards the end of this period, a working seminar was conducted where pairs (or sometimes three) of researchers translated all the items. Two groups of two researchers would work separately on the same set of items. In the Indonesian project, the researcher translated the items, and the results were examined by a team consisting of a mathematics educator, a TESOL professor, and two staffs from a professional development

provider.

Throughout the translation process, all changes that were made to the items were carefully documented according to a common framework. Both the Indonesian and the Norwegian projects used a modified version of Delaney and colleagues' (2008) categories of change as a framework for translating the MKT instrument for use in another cultural setting:

1. Changes related to the general cultural context
2. Changes related to the school cultural context
3. Changes related to mathematical substance
4. Changes related to the translation from American English into Norwegian and Indonesian

The translation of the MKT items were conducted by mathematics educators, rather than professional translators because we believe that there are many issues that need to be resolved other than making sure that the texts mean the same in both contexts, which is what will be discussed in this paper.

This article reports on a case study where two items were translated and adapted for use in Indonesia and Norway. The two items were selected for the particular purpose of illustrating the challenges that came up in the process of translating and adapting items in our separate projects. After selecting two items from the released items pool that would best exemplify the goal of this paper, these items were translated and adapted according to the same principles that were used in the main studies. All changes were categorized according to the above-mentioned framework from Delaney and colleagues (2008). For the purpose of discussions and analyses in this article, the changes were translated back to and explained in English. The challenges of translation and adaptation were then analyzed and discussed in relation to this common framework.

Results

Item 1

As mentioned earlier in the article, we are going to discuss two sample items in this article, in order to shed light on issues related to translation and adaptation. The first item asks teacher to evaluate which story problem could be used to illustrate division by a fraction.

7. Which of the following story problems could be used to illustrate $1\frac{1}{4}$ divided by $\frac{1}{2}$? (Mark YES, NO, or I'M NOT SURE for each possibility.)

	Yes	No	I'm not sure
a) You want to split $1\frac{1}{4}$ pies evenly between two families. How much should each family get?	1	2	3
b) You have $1.25 and may soon double your money. How much money would you end up with?	1	2	3
c) You are making some homemade taffy and the recipe calls for $1\frac{1}{4}$ cups of butter. How many sticks of butter (each stick = $\frac{1}{2}$ cup) will you need?	1	2	3

Figure 2. One item from the released items pool.

This item involves two story problems where food is a vital part of the context, and food is a culturally specific entity. Thus, any item that uses food as a context needs to be changed in order to be familiar to the audience. Some changes are straightforward because of the availability of the same food in the other culture, such as butter. Others, such as pies, are not common in Norway and Indonesia. In the Indonesian translation of alternative a), cake was used instead of pie. In the Norwegian translation, pies were replaced by pizzas, even though pies are sometimes used in Norwegian textbooks (Boye Pedersen, Andersson &

Johansson, 2005). The choice of pizzas over pies was made because pizzas are more widely used in Norwegian textbooks to illustrate fractions (for example in Alseth, Nordberg & Røsseland, 2006). Although this change seems to be rather trivial, such alteration brings out some interesting new issues into the item. Where pies have circular shapes, cakes might be squares and rectangles too, and homemade pizzas may also be rectangular in Norway. In Indonesian textbooks, if cakes were to be used as a context, a pictorial representation of a circular cake would always be provided to avoid confusion. Despite possible differences in the shape of the food, this variation does not change the intended mathematical substance of this problem. In this case, the amount of fractional pieces will be the same.

Alternative c) also involves food as a context, and this one is even more challenging. In the Norwegian context, it is uncommon to make homemade taffy, so this would have to be replaced with something else. Similarly, taffy is not commonly found in Indonesia. Also "cups of butter" and "sticks of butter" are not standard units of measurement in either the Norwegian or Indonesian contexts. Instead, weight measurements such as grams are used for recipes. Although it is possible to make a literal translation of this part of the item, the result would be something which teachers in these two countries would find quite unfamiliar, and this could potentially make the item more confusing and difficult to answer. If the context of homemade taffys was to be kept and the units of measure were changed into grams, the problem would change completely. Therefore, this particular alternative would have to be completely rewritten and the context changed.

The item also includes a change that relates to the school cultural context, but this alteration is a minor issue in this particular item. "Story problem" would in this connection be translated into the Norwegian word "regnefortelling" rather than the more direct translation. Although this change is minor, it is important in order to provide the teachers with the most sensible context, and it is an example of a challenge that demands knowledge of the school

cultural context (and also knowledge of teaching mathematics) that goes beyond knowledge of translation alone.

Alternative b) in this item involves an example of a type of change pertaining to the mathematical substance of the item, and this is relevant in both countries. Where a decimal point is used in the U.S. context, both the Norwegian and Indonesian context calls for a decimal comma here. Such a change is not problematic in this particular example. However, the difference of currency makes it more complicated, and this is related to the general cultural context of the countries. Indonesia and Norway both have different currencies, and neither use dollars. Quarters are commonly used in the U.S., and although Rp. 25 do exist in Indonesia, due to its extremely small nominal value (to date $1 is approximately Rp. 9000) and are therefore rarely used or even available in circulation anymore. The mathematical substance is also altered considerably in the translated version of the item because the whole is no longer one ($1) but one hundred (Rp. 100), which changes the original problem. In the context of Norway, no such thing as a quarter exists (although it did several years ago); 1,25 NOK (Norwegian crowns) would therefore not make sense in a daily context. An alternative might be to introduce the context of bank accounts, because 1,25 NOK might exist in a bank account, although no such coins exist in the Norwegian currency. Still, the context would provide little meaning, because most people do not really care if 1,25 NOK will double or not. If that were the amount of money they had in their bank account, it would imply that there were practically no money there. The context of money could therefore not be used to illustrate this kind of mathematical problem in a Norwegian context.

When it comes to other changes, there is one change that might be important in the Norwegian setting. The initial formulation of the question in the item stem was “Which of the following story problems could be used...” In many items similar formulations were used. When translating the word “which” into Norwegian, you have to make a choice between the

words “hvilke” and “hvilken”. The first alternative indicates that there is more than one solution, whereas the second indicates that there is only one solution. In this particular item there are no indications of whether or not only one solution is correct, and a minor difference like the choice of words in the Norwegian translation here could potentially help the teacher. An alternative would be to translate it with “hvilke(n)”, indicating that there might be one or more solutions, and this was often done when such items were translated into Norwegian. The challenge is that the original set of items was not made with the purpose of being translated into other languages, and it is unlikely to know if the creator of the item intended to provide an indication of the number of correct solutions or not. The worst scenario would be if the intention of the item is that only one solution is correct, and the translation of the item confuses the teacher into thinking that several correct answers exist, or the other way round.

Item 2

The second item is interesting in many respects, and it contains examples of changes that relate to all the four categories. This item is also a geometry item, and the Indonesian study (Ng, 2009) made use of the geometry items in particular whereas the Norwegian study (Mosvold & Fauskanger, 2009) used a complete form including numbers, geometry and algebra items.

27. Mrs. Davies' class has learned how to tessellate the plane with any triangle. She knows that students often have a hard time seeing that any quadrilateral can tessellate the plane as well. She wants to plan a lesson that will help her students develop intuitions for how to tessellate the plane with any quadrilateral.

Which of the following activities would best serve her purpose? (Circle ONE answer.)

a) Have students cut along the diagonal of various quadrilaterals to show that each can be broken into two triangles, which students know will tessellate.

b) Provide students with multiple copies of a non-convex kite and have them explore which transformations lead to a tessellation of the plane.

c) Provide students with pattern blocks so that they can explore which of the pattern block shapes tessellate the plane.

d) These activities would serve her purpose equally well.

Figure 3. A second item from the released items pool.

In this item, and many similar items, teachers (and sometimes students) are referred to with their names. When translating these items into a different language, a change of names was often necessary in order to preserve the familiarity of the context. Mrs. Davies would therefore be translated into Ibu Dariah in the Indonesian version, where Dariah is a more familiar Indonesian name and Ibu is the title used to address a female adult. Similarly, Mr. Davies would have been translated into Bapak Dariah. In the Norwegian context, however, the change of name is not so trivial in this particular context. In Norwegian classrooms, particularly in elementary schools, teachers are almost exclusively addressed by their first name rather than by their family name and a title. Mrs. Davies would therefore be translated with Dorthe, or a similar first name, which is more common in the Norwegian context. Such a change is a little less trivial, for several reasons. First, it might sometimes make it harder to distinguish between the teacher and the students in items like these, and a misunderstanding of parts of the context is possible. In some items, we had to include some kind of explanation or clarification of who is the teacher. In this item, a Norwegian translation would read something like "Dorthe's class", with the possibility of confusing Dorthe with a student. The context of the item eventually makes it clear that Dorthe is the teacher in this case, but there is still the possibility of producing a slightly more confusing text. The use of Mrs. Davies or Ibu Dariah leaves no doubt as to who is the teacher in this class.

Another issue with this item, which is related to the school cultural context, is that the direct translation of the word "students" would not be used in the Norwegian context, although it exists. In the Norwegian school system students are referred to as pupils (or "elever" in Norwegian) in school, and the term student is only used when they enter university or college. This is a trivial change, but if it had not been made, it would result in a

somewhat more unfamiliar context for a Norwegian teacher.

The word "tessellation" is also challenging in the translation of this item. In Indonesian, there is no equivalent word for tessellation, and instead a more general term like "tiling" ("pengubinan" in Indonesian) would be used. The word tessellation does exist in Norwegian, however, but it is considered a more technical term and seldom used by teachers or students in an elementary school classroom. A term like tiling might also be used in a Norwegian setting, but then again the terms tiling and tessellation are not precisely equal terms. One solution in the translation of this item might be to use the word tessellation and include a short explanation of the term to avoid confusion, but this would probably make the item easier for teachers in Indonesia and Norway than it was intended.

The original formulation in alternative a) that quadrilaterals can be "broken into" two triangles had to be rewritten in both countries. In both Indonesian and Norwegian, the translation "divided into" makes more sense because "broken" refers to many pieces.

Alternative b) was problematic in both the Norwegian and the Indonesian context. The text refers to "non-convex" kites, and this is a technical term that would not be used in Indonesian or Norwegian elementary classrooms. The text would therefore have to be translated into a somewhat more everyday language. The problem here is that we do not really know if the term was supposed to be technical, and possibly even teachers in the U.S. might experience this as a technical term. If a decision is made to rewrite the term into a more everyday language, the result might be that the item becomes easier than it was intended. If, on the other hand, one decides to keep the technical term in a more direct translation, there is a possibility that teachers in a certain culture are more familiar with this term than teachers in another culture, and the difficulty of the item might vary across cultures.

"Pattern blocks" are referred to in alternative c), and this is an example of concrete materials or representational tools that might vary across cultures. A direct translation would

therefore not be good enough in neither the Norwegian nor the Indonesian context. One possibility might be to include a picture or an explanation, but that would imply a rather substantial change of the item. Furthermore, in the context of Indonesia, physical manipulatives such as pattern blocks are not widely available commercially, and a majority of the teachers will be unfamiliar with these concrete materials.

There are also examples of phrases that are hard to translate for other reasons, which are partly language related and partly culturally related, like the sentence in alternative d). The phrase "would serve her purpose equally well" would not be used in Indonesian or Norwegian, and it would have to be rewritten to make sense. Although this should be a minor issue, care needs to be taken to avoid adding unnecessary clutter to the item.

Discussion

The two items presented in this article were selected because they represent many of the issues that came up when translating the MKT items into Norwegian and Indonesian. Not all items were this complicated to translate, but most items included some of the elements that are discussed in this article. Our discussion here is not meant to be exhaustive in nature. However, our idea was to use these items as examples in order to explain the kinds of difficulties that might occur, and these are difficulties or challenges that researchers (or translators) need to be aware of when they work with similar kinds of projects. Some of the themes we found during the process of translating these two items include a) cultural differences that present minor challenges but do not affect the mathematical substance of the items; b) differences in the use of technical language in schools; c) incommensurable contexts across countries; and d) differences in instructional practice specifically in the use of mathematical models. Different countries might have somewhat different challenges, but we believe that several of these types of challenges are as relevant for many countries or languages as they were for the Norwegian and Indonesian translation.

Some cultural aspects such as language and food present challenges when translating the MKT items. The use of food in mathematical problems serves as a familiar context for the audience. However, when adapting to a different country, the food in context may not be common for the audience in that setting. The challenge becomes finding similar food without changing the mathematical substance of the problem. In our case, exchanging pies with pizza or cake, although they pose a problem because these substitutes exist in other shapes such as square or rectangular, did not change the representation of the fraction.

The difference in languages may result in minor issues as evidenced in the Norwegian context. Such issue does not necessarily change the validity and difficulty of the items, but because additional explanations need to be provided so as to avoid confusion, which may make the descriptions of the item wordy and cluttered.

The way teachers are addressed may differ across cultures. Although this issue seems to be trivial, it poses problem in the Norwegian culture where teachers are normally addressed by their first names. Also, the way that students are organized in classes or groups, and how these are referred to, might differ between countries. Quite recently, there was an official convention in Norway that "class" should not be used when referring to groups of students (cf. Mosvold et al., 2009; Mosvold & Fauskanger, 2009). This was related to a government initiative to change the more formal organization of schools. Lately, however, this initiative is about to be reversed, and this would apparently not be a problem in the future. Still, the use of the concept of class might be confusing in cultures where students are organized in other types of group structures.

Mathematical language may be considered universal in terms of the symbolic expressions used. However, when it is related to definitions or terminologies, variations may exist across cultures. As exemplified in both the Indonesian and Norwegian context, although the more technical terms such as "non-convex" and "tessellation" exist in both countries, they

are not used in the grade schools. Instead, a more general term such as "tiling" is used. Such change may undermine the integrity of the item in measuring teachers' mathematical knowledge for teaching, and would instead measure teachers' familiarity of certain technical vocabulary. In other instances, the more familiar terminology may be more descriptive than the technical term. For example, Ng (2009) found that the term "polygon" needed to be translated into a more familiar term to Indonesian teachers, "bangun datar segi-banyak," which literally means "multi-sided flat shape". This more descriptive term thus may compromise the difficulty of the item when assessing teachers' knowledge of the definition of polygon. This difference in mathematical language might also imply distinction in the school cultures of our countries when compared with the U.S., but this is difficult to conclude because we do not have any data on how teachers in the U.S. conceive these issues.

While adapting the MKT measures in Ireland did not face major problems in terms of context (Delaney et al., 2008), in the case of Indonesia and Norway, we found instances where the context of the problem could not be translated without majorly change the mathematical substance of the items. The use of measurement units, such as "cups" and "sticks" of butter, is not standard in the two countries. Changes to grams or similar units are possible, but then the context of the problem differs significantly because the whole in the fraction needs to be changed. So is the case with the context where money is involved. The currencies in Norway and Indonesia, although different from each other, differ enough from the U.S. currency to provide a serious problem. Using equivalent values of money does not make sense mathematically to represent the intended fraction. These two contexts would be almost impossible to translate into either of our languages without changing the entire context. This issue of incommensurable context introduces a serious threat to the instrument equivalence.

Teaching practices vary greatly across cultures (Stigler & Hiebert, 1999), especially

the use of concrete materials as tools or models for representing mathematical ideas. Unlike the U.S., many developing countries may not have commercially available physical manipulatives. Any mention of these objects, for example in our case "Pattern Blocks," needs to be clarified either by providing an explanation or a picture, or both. Such an attempt, however, may make the item easier because of the availability of multiple modality of representations.

Conclusion

The purpose of this article is to shed light on some of the challenges that might arise when translating test items from one language into another and adapting them to be used in a different setting than they were intended. Both the projects that are described and discussed in this paper have made use of the MKT items, and it might be argued that these items are special in that they were written particularly to be used among teachers in the United States. Researchers have argued that there are cultural variations in teaching practice (cf. Stigler & Hiebert, 1999), and it can therefore be argued that items that are developed based on the teaching practice in one culture are not necessarily applicable in another. Still, the MKT items were created in order to describe and measure issues related to the tasks of teaching rather than teaching practice, and the tasks of teaching are considered to be of a more universal nature per se (cf. Ball, Thames, & Phelps, 2008). The discussions in this article indicate, however, that although the construct might be of a more universal nature, actual items that are developed for use in measures of this kind of construct would necessarily have to be dependent on some kind of representations, tools, or other kinds of artifacts that by nature will be more culturally specific. We do not, however, attempt to dismiss the MKT items (or any similar types of measures for that matter) or the use of such measures in other countries altogether, but we want to direct attention to some of the issues and challenges that are necessarily going to be part of the process.

As Delaney and colleagues (2008) and others have done, we would also like to call for an inclusion of these types of discussions whenever research of this kind is reported. We would also like to suggest a closer investigation of how cultural issues actually might influence the results in measures like these. Since the MKT measures are now being used by researchers in other countries, and this appears to be a growing tendency, we suggest a common effort to create a framework where these issues can be investigated in a more scientific way. Such investigations might even result in a further development of the theoretical construct of MKT and possible cultural differences in relation to this construct as well.

References

Alseth, B., Brekke, G., & Breiteig, T. (2003). *Endring og utvikling ved R97 som bakgrunn for videre planlegging og justering: matematikkfaget som kasus*. Notodden: Telemarksforsking-Notodden.

Alseth, B., Nordberg, G. & Røsseland, M. (2006). *Multi 6b*. Grunnbok. Oslo: Gyldendal undervisning.

Adams, R. (2005). *PISA 2003 Technical Report*. Organization for Economic Co-operation and Development.

An, S., Kulm, G., & Wu, Z. (2004). The pedagogical content knowledge of middle school, mathematics teachers in China and the U.S. *Journal of Mathematics Teacher Education*, *7*(2), 145-172.

Armanto, D. (2002). Teaching multiplication and division realistically in Indonesian primary schools: A prototype of local instructional theory. Enschede: Doctoral dissertation, University of Twente.

Ball, D. L. (1990). The mathematical understandings that prospective teachers bring to teacher education. *The Elementary School Journal*, *90*(4), 449-466.

Ball, D. L., Hill, H. C., & Bass, H. (2005). Knowing Mathematics for Teaching. Who Knows Mathematics Well Enough To Teach third Grade, and How Can We Decide? *American Educator* (*Fall 2005*), 14-17+20-22+43-46.

Ball, D. L., Lubienski, S., & Mewborn, D. S. (2001). Research on teaching mathematics: The unsolved problem of teachers' mathematical knowledge. In V. Richardson (Ed.), *Handbook of research on teaching* (4th ed., pp. 433-456). Washington, DC: American Educational Research Association.

Ball, D. L., Thames, M.H., & Phelps, G. (2008). Content knowledge for teaching: What

makes it special? *Journal of Teacher Education*, *59*(5), 389-407.

Boye Pedersen, B., Andersson, K. & Johansson, E. (2005). *ABAKUS. Matematikk for barnetrinnet*. *Grunnbok 4B*. Oslo: Aschehoug Forlag.

Bradburn, M. B., & Gilford, D. M. (1990). *A framework and principles for international comparative studies in education*. Washington, DC: National Academy Press.

Cai, J. (2005). U.S. and Chinese teachers' constructing, knowing, and evaluating representations to teach mathematics. *Mathematical Thinking and Learning*, *7*(2), 135-169.

Cole, Y. (2009). Mathematical Knowledge for Teaching: Transferability and Use in the Ghanaian Context, a Pilot Study. Paper presented at the AERA 2009 Annual Meeting.

Delaney, S. (2008). Adapting and using U.S. measures to study Irish teachers' mathematical knowledge for teaching. Unpublished PhD-Thesis.

Delaney, S., Ball, D., Hill, H., Schilling, S., & Zopf, D. (2008). "Mathematical knowledge for teaching": adapting U.S. measures for use in Ireland. *Journal of Mathematics Teacher Education*, *11*(3), 171-197.

Departemen Pendidikan Nasional. (2003). *Kurikulum 2004: Standar kompetensi mata pelajaran matematika sekolah dasar dan madrasah*. Jakarta: Depdiknas.

Depdikbud. (1997). *Statistik persekolahan 1995/1996*. Jakarta: Depdikbud.

Emenogu, B. C., & Childs, R. A. (2005). Curriculum, translation, and differential functioning of measurement and geometry items. *Canadian Journal of Education*, *28*(1-2), 128-146.

Fauzan, A. (2002). Applying realistic mathematics education in teaching geometry in Indonesian primary schools. Enschede: Doctoral dissertation, University of Twente.

Geisinger, K. F. (1994). Cross-Cultural Normative Assessment: Translation and Adaptation

Issues Influencing the Normative Interpretation of Assessment Instruments. *Psychological Assessment*, *6*(4), 304-312.

Gonzales, P., Williams, T., Jocelyn, L., Roey, S., Kastberg, D., & Brenwald, S. (2008). *Highlights from TIMSS 2007: Mathematics and science achievement of U.S. fourth- and eight-grade students in an international context*. Chestnut Hill, MA: TIMSS International Study Center, Boston College.

Hadi, S. (2002). Effective teacher professional development for the implementation of realistic mathematics education in Indonesia. Enschede: Doctoral dissertation, University of Twente.

Hill, H.C., Ball, D.L., & Schilling, S.G. (2008). Unpacking "Pedagogical Content Knowledge". *Journal for Research in Mathematics Education*, *39*(4), 372-400.

Hill, H.C., Blunk, M.L., Charalambous, C.Y., Lewis, J.M., Phelps, G.C., Sleep, L., & Ball, D.L. (2008). Mathematical knowledge for teaching and the mathematical quality of instruction: An exploratory study. *Cognition and Instruction*, *26*(4), 430-511.

Hill, H.C., Rowan, B., & Ball, D.L. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Education Research Journal*, *42*(2), 371-406.

KUF (1996). *Læreplanverket for den 10-årige grunnskolen*. Oslo: Kirke- og undervisningsdepartementet.

Kwon, M. (2009). Validating the Adapted Mathematical Knowledge for Teaching (MKT) Measures in Korea. Paper presented at the AERA 2009 Annual Meeting.

Lefevere, A. & Bassnett, S. (1998) Where are we in translation studies? In S. Bassnett, & A. Lefevere (Eds.), *Constructing cultures: Essays on literary translation* (pp. 1-24). Multilingual Matters Ltd.

Ma, L. (1999). *Knowing and teaching elementary mathematics: Teachers' understanding of*

fundamental mathematics in China and the United States. Hillsdale, NJ: Lawrence Erlbaum Associates, Inc.

Mosvold, R. & Fauskanger, J. (2009). Challenges of translating and adapting the MKT measures for Norway. Paper presented at the AERA 2009 Annual Meeting.

Mosvold, R., Fauskanger, J., Jakobsen, A., & Melhus, K. (2009). Translating test items into Norwegian - without getting lost in translation? *Nordic Studies in Mathematics Education*, *14*(4), 101-123.

Mullis, I.V.S., Martin, M.O., Olson, J.F., Berger, D.R., Milne, D., & Stanco, G.M. (Eds.) (2008). *TIMSS 2007 Encyclopedia: A Guide to Mathematics and Science Education Around the World, Volumes 1 and 2.* Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: Author.

Ng, D. (2011). Indonesian Primary Teachers' Mathematical Knowledge for Teaching Geometry: Implica-tions for Educational Policy and Teacher Preparation Programs. *Asia-Pacific Journal of Teacher Education, 39*(2), 151-164.

Ng, D. (2009). Examining Indonesian elementary teachers' mathematical knowledge for teaching geometry: An exploratory study. Unpublished doctoral dissertation, Boston University, Boston, MA.

Sembiring, R. K., Hadi, S., & Dolk, M. (2008). Reforming mathematics learning in Indonesian classrooms through RME. *ZDM*, *40*(6), 927-939.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Singh, J. (1995). Measurement issues in cross-national research. *Journal of International Business Studies*, *26*(3), 597-619.

Stiegler, J. W., & Hiebert, J. (1999). *The Teaching Gap. Best ideas from the world's teachers for improving education in the classroom*. New York: The Free Press.

UFD (2005). *Kunnskapsløftet*. Oslo: Utdannings- og forskningsdepartementet.

Utdanningsdirektoratet (2008). Mathematics subject curriculum. Retrieved March 4, 2009, from http://www.utdanningsdirektoratet.no/upload/larerplaner/Fastsatte_lareplaner_for_Kunnskapsloeftet/english/Mathematics_subject_curriculum.rtf

Zhou, Z., Peverly, S. T., & Xin, T. (2006). Knowing and teaching fractions: A cross-cultural study of American and Chinese mathematics teachers. *Contemporary Educational Psychology*, *31*(4), 438-57.

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