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Abstract: We discuss the adaptation and piloting of the previously developed U.S.-specific measures of mathematical knowledge for teaching to the Malawi context. The purpose is to produce measures that can be used to evaluate changes in mathematical knowledge for teaching gained through primary teacher education, thus informing teacher educators on the most effective evidence-based practices. By interviewing 14 teachers, we first examine whether the 16 recurrent mathematical tasks of teaching tasks identified in the U.S. are applicable to the Malawi context. This is followed by the discussion of the adaptability of the U.S. developed number concept and operations LMT measures. Next, we report on the item psychometric properties estimated from a pilot study in which 351 preservice primary school teachers participated at the end of their coursework. Our findings suggest that all the 16 tasks of teaching mathematics are applicable to the Malawi context, albeit to varying degrees, and should be complemented by additional tasks suggested by the Malawi teachers. For the LMT measures, we found that the majority of the LMT items psychometrically function well in the Malawi context and that item difficulty estimated in Malawi was strongly correlated with that reported in the U.S. We thus argue that there is some generality to the mathematics teaching tasks across the two contexts, as well as some specificity to Malawi, and that the adapted LMT measures can be used in a Malawi context.

Keywords: Teacher knowledge, Mathematical knowledge for teaching, Primary teacher education, Malawi.

Introduction

Teacher knowledge is important for both teaching and learning. Since Shulman (1986) introduced the concept of pedagogical content knowledge, his ideas have triggered widespread interest among researchers and practitioners alike. In addition, different conceptualizations of teacher knowledge have emerged, such as Knowledge Quartet (Rowland, Huckstep, & Thwaites, 2005), Knowledge for Teaching (Davis & Simmt, 2006), and Mathematical Knowledge for Teaching (Ball, Thames, & Phelps, 2008). Despite different views on categorizations, researchers seem to agree that teacher knowledge plays a key role in student learning (e.g., An, Kulm, & Wu, 2004; Rowan, Correnti, & Miller, 2002; Wright, Horn, & Sanders, 1997), and much progress has been made in understanding the professional mathematical knowledge that teachers need in order to perform the recurrent tasks of teaching mathematics. There is also an extensive body of knowledge on how this knowledge is acquired, how it can be measured, and how it relates to teaching and student learning (e.g.,

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Ball et al., 2008; Hill, Rowan, & Ball, 2005; Rowland et al., 2005). Nonetheless, a greater understanding of how this knowledge might differ as context changes is necessary.

Different approaches to measuring teacher knowledge are presently in use, one of which is based on analyzing school mathematics curriculum and developing measures that would test knowledge and the teaching of that curriculum. The main drawback of this approach is that it requires many, often inaccurate, assumptions about outcomes of teaching that is aligned with the curriculum. Ball and colleagues (2008) developed an alternative practice-based approach in the United States. According to the authors, their aim was to "unearth the ways in which mathematics is involved in contending with the regular day-to-day, moment-to-moment demands of teaching" (p. 395). Using this approach enabled these researchers to define the theory of mathematical knowledge for teaching (MKT) (Ball & Bass, 2003). In particular, they identified a list of 16 mathematical teaching tasks that are part of the work teachers routinely do (Ball et al., 2008). In connection to this work, measures of mathematical knowledge for teaching were developed as a part of the Learning Mathematics for Teaching (LMT) project at the University of Michigan. The LMT project developed items in three content areas, namely (i) number concepts and operations (NCOP); (ii) geometry; and (iii) patterns, functions, and algebra (a sample of released items can be found in Ball and Hill (2008)).

The LMT measures[1] have been adapted for use in different contexts outside the U.S., for example, in Ireland (Delaney, 2012), Norway (Fauskanger, Jakobsen, Mosvold, & Bjuland, 2012), Indonesia (Ng, 2012), South Korea (Kwon, Thames, & Pang, 2012), and Ghana (Cole, 2012). In South African context, Adler and Patahuddin (2012) researched mathematical knowledge for teaching, reporting that the LMT items "have much potential in provoking teachers' talk and their mathematical reasoning in relation to practice-based scenarios; and exploring with teachers a range of connected knowledge related to the teaching of a particular concept or topic is most important resource for teachers" (p. 17).

It is important to note that the mathematical knowledge for teaching theory and the associated LMT measures were developed from classroom observation in the U.S. and were not intended for use in other cultures. Thus, we were interested in exploring whether the 16 tasks of teaching identified by Ball et al. (2008) also are applicable in a Malawi context. By applicable we mean if teachers in Malawi would do the same or similar tasks as part of their work of teaching mathematics in schools. Our interest in mathematical knowledge for teaching, with associated tasks of teaching and measures, developed from our work in teacher education in Malawi. With the overarching project goal of improving quality and capacity of mathematics teacher education in Malawi, we are interested to learn more about the development of preservice teachers' mathematical knowledge for teaching through their teacher education. Knowing what works and what does not in teacher education in Malawi is the first step in the process of improving the quality of teacher education. In our view, measures of mathematical knowledge for teaching can help answer these questions. In this larger study, we plan to measure preservice teacher mathematical knowledge for teaching before and after coursework, using a pre- and post-test. This can help us determine knowledge growth in preservice teachers, and consequently inform our practice. Since the LMT measures were developed from studying work and identifying tasks of teaching in the U.S. context, our first objective was to ascertain whether these tasks are applicable to the Malawi context.

[1] The measures (or instruments) developed as part of the Learning Mathematics for Teaching Project at the University of Michigan are also sometimes called LMT items, MKT items, or MKT measures. In this paper, will use the terms LMT measures/instruments.

These findings elucidated the suitability of adapting the LMT measures for use in Malawi. Our next goal was to outline the method of adaptation that the measures underwent. This paper is therefore guided by the following research questions:

1. Are the tasks of teaching mathematics identified in the U.S. applicable in Malawi?

2. What can we learn about the adaptability of LMT measures to the Malawi context from psychometric properties estimated in a pilot study?

Other researchers have raised similar questions when adapting the LMT measures to their contexts (for example, Cole, 2012; Delaney, 2012; Fauskanger et al., 2012; Ng, 2012). We focus specifically on the Malawi context, acknowledging the cultural differences between Malawi and other cultures. Furthermore, in their work, Hoover, Mosvold, and Fauskanger (2014) called for "increased efforts to identify professionally defensible mathematical tasks of teaching that can serve as a common foundation for conceptualizing and measuring mathematical knowledge for teaching internationally" (p. 7). Our study is an attempt to respond to the call. By adapting the measures and piloting a set of 88 items, our study will also make an argument for use of the LMT measures in a Malawi context.

Adapting LMT Measures to Different Cultural Contexts

Many researchers agree that teacher knowledge of mathematics is influential in shaping teaching practices that in turn affect student achievement (e.g., Hill, Ball, & Schilling, 2008). One of the reasons the work of Ball and colleagues has received extensive attention is that the authors based their findings on a thorough study of actual classroom teaching. Because their research was conducted in the U.S. context, it is debatable whether the findings are generalizable. For example, Andrew (2011) argued that "teacher's mathematical knowledge, as manifested in their observable behavior, is a cultural construction" (p. 100). While we raise similar questions about generalizing the theory of mathematical knowledge for teaching to the Malawi context, we also draw upon findings of similar studies in this filed. We agree with the view that the practice of teaching is a cultural activity, making teaching of mathematics culturally specific, even though the content is general (Delaney, 2012).

According to the results reported by Cole (2012), the LMT measures can be used in the Ghanaian context after careful adaptation. However, so far Ghana is the only African country where the LMT measures have been used. Moreover, Cole and other researchers have demonstrated that adaptation of LMT measures is not easy and requires a process that considers all differences between the contexts, including culture, language, and teaching practices (Delaney, 2012; Fauskanger et al., 2012). In our study, we observed that the differences were manageable and hence proceeded with the adaptation.

Malda et al. (2008) emphasized on fairness of adapted measures, noting that "it is unfair to assess intelligence of children from Africa with a test that has been validated in a Western culture . . . , with a population of children exposed to very different educational and material environments at home and school" (p. 452). Similarly, it could be argued that it is not fair to assess Malawian teachers' knowledge using measures developed for the vastly different U.S. context. As Hoover et al. (2014) pointed out, such an argument focuses on differences in the practice of teaching in different cultures. The authors further argued that, to evaluate such arguments, we need to consider "the underlying concept of *work of teaching* and *tasks of teaching* used in MKT assessment items and to ask whether, or to what extent, such concepts, as defined therein, are meaningful across cultural contexts" (p. 8) [emphasis in original]. In this study, we consider whether the items we adapted are meaningful in the Malawi context.

Malawi Context

Malawi, formerly known as Nyasaland, was a British protectorate that gained its independence from Britain in 1964. English remains the official language and is also the school language from fifth year of primary school onwards. Malawi's school system comprises of eight years of primary and four years of secondary school. Primary school education is free and easily accessible, neither of which is the case for secondary school education (Kazima & Mussa, 2011). Currently recommended age for enrollment into the first grade of primary school is six years. Thus, primary school students are aged 6 to 13 years old, whereas secondary school serves 14 to 17-year-olds. However, in reality, many classrooms are attended by children of various ages because some children commence education when they are older than six and some repeat classes. At the end of secondary school, students take Malawi Schools Certificate of Education (MSCE) national examinations, equivalent to the Ordinary level (General Certificate of Education). Tertiary education, including teacher education, requires passing the MSCE examinations. Teacher education for primary schools is offered by teacher education colleges, most of which are government owned, while some are private institutions. All teacher colleges follow one curriculum, referred to as the Initial Primary Teacher Education program. It is a two-year full time program, comprising of college coursework in the first year and teaching practice, which is the focus of the second year (Malawi Institute of Education, 2010). Students that successfully complete the program are awarded Primary Teacher's Certificate. There is no subject specialization for primary teachers; all preservice teachers learn all subject areas, including mathematics, and they are expected to teach all subjects in primary schools (Malawi Institute of Education, 2010). As a part of this study, we piloted the adaptability of LMT measures on preservice teachers at the end of their coursework, as a part of the first year of the teacher education program.

Methods

Mathematical Tasks of Teaching

In order to answer our first research question about the applicability of U.S.-specific tasks of teaching in the Malawi context, we asked 14 experienced teachers to respond to a questionnaire and followed this with a group discussion. All study participants were practicing teachers from various primary schools in Malawi and were drawn from an in-service upgrading course at the University of Malawi. The questionnaire consisted of two parts, whereby Part A listed all the 16 core tasks of teaching mathematics (Ball et al., 2008). The respondents were asked to indicate which ones were applicable to them as mathematics teachers and were required to elaborate on their responses. Verbal instructions were given to the teachers prior to completing the questionnaire. In particular, they were informed that they should draw from their experience and consider whether each of the tasks is something they do as a part of their work of teaching mathematics. In Part B of the questionnaire, the teachers were instructed to note tasks of teaching mathematics that they perform that are not included on the list. All study participants completed the questionnaire at the same time, in one room. Subsequently, eight teachers took part in a group discussion.

LMT Measures

We answered the second research question in two phases—Phase I, which was the actual adaptation of instruments, and Phase II, pilot testing of the adapted instrument.

Phase I: Adapting measures. Phase I was performed in three stages, the first of which consisted of selecting the most appropriate instruments from those available. We limited our study to measures of number concepts and operations (NCOP) content area. The

LMT project provided us with ten forms,[2] with items from the content area number concept and operations, and corresponding questions related to content knowledge (CK) and knowledge of content and students (KCS) (see, for example, Ball et al., 2008). Upon closer inspection, we noted some repetition and modification of stems and items from the 2001 to the 2004 version. After aligning items in each form to Malawi's mathematics curriculum for Initial Primary Teacher Education, we observed that Form A from the 2001 instrument (NCOP-CK_2001A) had the closest and the most comprehensive range of items covering the curriculum. Therefore, we selected this form and its corresponding Form B (NCOP-CK_2001B) as a starting point for adaption. There were six common items between the two forms and because we wanted to pilot as many items as possible, we replaced the common items in Form B with similar items from the remaining forms. We also added new stems to both forms to cover the concepts of division, multiples, and factors, which were not sufficiently covered by the original forms. These stems were also taken from some of the remaining forms. In total, our new Form A had 25 stems and 46 items, while Form B had 24 stems with 42 items, making a set of 88 items. The original 2001 Form A has 13 stems with 26 items, while Form B has 15 stems with 24 items. Having two forms at this stage allowed us to pilot as many items as possible. We considered the alternative of having all items in one form, but decided that it was not appropriate, since it would make the form too long. Another argument for having two forms at this stage was that the project would eventually need to group all items into two comparable forms that could be used in pre- and post-tests.

The second stage of adaptation involved contextualizing the U.S.-based instruments, both stems and items, to the Malawi context. This was done by changing some words, phrases, and names of places, people, and objects to what we think would be familiar in Malawi context, as shown in Table 1.

Table 1. *Examples of Changes Made from U.S. to Malawi Context.*

Category of change	**U.S.**	**Malawi**
General context: • Names of people (42 instances)	Ms. Jamison	Mrs. Banda
	Chad	Chisomo
• Names of objects (21 instances)	Pizza	Bread
	Field	Farm
School context: (11 instances)	Scoring/Reviewing	Marking
	Rules of thumb	Simple rules
	Student papers	Student notebooks
	State assessment	MANEB examinations
	Quiz	Test
	Mini-lessons for students focused on particular difficulties	Revision lessons
Item Numbering	Numbering not continuous	Continuous numbering

[2] These are three 2001 NCOP-CK forms (A, B, and C), three 2001 NCOP-KCS forms (A, B, and C), two 2002 NCOP-CK forms, and two 2004 NCOP-CK forms.

The third and final stage required checking and modifying the mathematical content of each stem and the corresponding items in order to ensure that they reflect the Malawi curriculum. The modifications made addressed "changes related to school cultural context" and "changes related to mathematical substance" (Delaney et al., 2008, p. 182). After initial changes were made to both forms, we sought input from four experienced primary school teachers via semi-structured individual interviews. Their feedback helped us modify the items further, thus ensuring relevance of the content, wording, representations, and notations (Kasoka, Kazima, & Jakobsen, 2016).

Phase II: Pilot testing. The two adapted (and extended) forms (Form A and B) were subjected to a pilot test by 351 preservice primary school teachers. The two forms were administrated to all preservice teachers at one Teacher Education College at the end of their first-year coursework. They were all informed of the objectives of the study and the instructions were carefully explained to them. The two forms were randomly distributed to the students, whereby 212 students answered Form A while 139 answered Form B. Ideally, we wanted the two groups to be equal in size, but due to incorrectly estimating the total number of students at the teacher college, this was not achieved. We had no control over the distribution of the two forms within the group because the forms were mixed in advance for randomness. While the preservice teachers were allowed as much time as they needed to complete the forms, the majority took 1–2 hours. After the test, fifteen randomly selected students were asked to comment on the test and the specific items. Their input allowed us to assess the suitability of the items for testing teacher knowledge in Malawi.

Results and Findings

Mathematical Tasks of Teaching

Table 2 shows the results of Part A of the questionnaire answered by the 14 teachers. The results reported pertain to the frequencies, the number of teachers that indicated that the task was applicable (yes), or not applicable (no), or did not respond to the question (non-response).

As can be seen from Table 2, there was no task that none of the teachers identified with, and all 16 tasks were considered applicable to Malawi school context by at least five of the teachers. In other words, the teachers viewed these tasks as something they do as a part of their work of teaching mathematics. This finding seems to suggest that U.S. and Malawi contexts share some similarities. However, there were variations in the frequencies, as some tasks were considered applicable by a greater number of teachers than others were. Thus, in subsequent analysis, we consider these tasks as most applicable to the Malawi context. We also identified three tasks that all teachers felt were applicable to Malawi, namely "presenting mathematical ideas," "finding an example to make a specific mathematical point," and "appraising and adapting the mathematical content of textbooks." All these tasks involve typical traditional classroom practices of mathematics teachers—explaining mathematics content or procedure, illustrating to students using examples and often from textbooks, and asking students to practice exercises from textbooks. Hence, it is not surprising that all the teachers identified these as aspects of the work they do when teaching mathematics, thus making these tasks most applicable to the Malawi school context.

Table 2. *Frequencies of Responses to Applicability of Tasks to the Malawi School Context.*

Task Description (from Ball et al., 2008)	Is task applicable to Malawi school context?		
	Yes (%)	No (%)	Non-response (%)
Presenting mathematical ideas	14 (100)	0 (0)	0 (0)
Finding an example to make a specific mathematical point	14 (100)	0 (0)	0 (0)
Appraising and adapting the mathematical content of textbooks	14 (100)	0 (0)	0 (0)
Connecting a topic being taught to topics from prior or future years	13 (93)	0 (0)	1 (7)
Recognizing what is involved in using a particular representation	12 (86)	1 (7)	1 (7)
Modifying tasks to be either easier or harder	12 (86)	1 (7)	1 (7)
Responding to students' "why" questions	11 (79)	3 (21)	0 (0)
Linking representations to underlying ideas and to other representations	11 (79)	2 (14)	1 (7)
Giving or evaluating mathematical explanations	10 (71)	2 (14)	2 (14)
Choosing and developing useable definitions	10 (71)	2 (14)	2 (14)
Asking productive mathematical questions	10 (71)	2 (14)	2 (14)
Selecting representations for particular purposes	10 (71)	2 (14)	2 (14)
Evaluating the plausibility of students' claims (often quickly)	9 (64)	2 (14)	3 (21)
Using mathematical notation and language and critiquing its use	8 (57)	3 (21)	3 (21)
Inspecting equivalences	6 (43)	5 (36)	3 (21)
Explaining mathematical goals and purposes to parents	5 (36)	8 (57)	1 (7)

In sum, 12 of the 16 tasks were identified as applicable by more than 70% of the teachers. Of the remaining four tasks with lower frequencies, only two—"inspecting equivalences" and "explaining mathematical goals and purposes to parents"—were identified as applicable to the Malawi context by less than half of the teachers. Those that deemed the task applicable explained that they discuss teaching mathematics (and other subjects) with parents during gatherings, such as Parents and Teachers Association meetings. During the subsequent group discussion, it was clear that some schools do indeed inform parents about the teaching of mathematics.

It is also important to note that not all teachers responded to all questions and some failed to elaborate on their responses. This issue was raised in the group discussion, where the participants revealed that, if they were unsure about some of the tasks, they felt that it was appropriate not to respond to the question.

Tasks Teachers Did Not Find Applicable

We also examined the tasks that some teachers did not view as something they do. Looking at Table 2, it is evident that, for 12 of the 16 tasks, at least one teacher responded that he/she does not see it as applicable to the Malawi context. We have presented some of these tasks in Table 3 in descending order of frequencies. We have also included examples of the reasons that teachers gave. It is important to note that, following the group discussion with eight teachers, no new information arose. Nevertheless, the discussion helped explain some of the written responses.

Table 3. *Examples of Teachers' Reasons for Tasks Not Being Applicable to Malawi Contexts.*

Mathematical task of teaching	**Freq. for not applicable**	**Reasons**
Explaining mathematical goals and purposes to parents	8 (57%)	Parents rarely know what their children learn in school. Majority of teachers do not have time to deal with parents. Parents are not involved in class work. Learners' guardians do not ask about mathematics. Teachers do not discuss mathematics with parents.
Inspecting equivalences	5 (36%)	Teachers' guide matches content to find links Associating concepts is not done by teachers. We do not do this in primary school.
Responding to students' "why" questions	3 (21%)	Teachers just give explanations. Learners ask how to solve problems. Teachers do not do this.
Using mathematical notation and language and critiquing its use	3 (21%)	Teachers do not critique teachers' guide. Notation given in textbooks. Guided by teachers' guide.
Choosing and developing useable definitions	2 (14%)	Definitions are given in textbooks. Teachers guide has definitions.
Selecting representations for particular purposes	2 (14%)	Teachers' guide has representations. Use text books.
Modifying tasks to be either easier or harder	1 (7%)	Textbook includes both easy and hard problems.

More than half of the teachers indicated that the task of "explaining mathematical goals and purposes to parents" is not applicable to the Malawi school context, as this is not something they do as a part of their work. The reasons given suggest that the teachers do not consider this as a mathematical task of teaching because, according to the teachers, parents are not involved in what goes on in the mathematics classroom; thus, teachers do not talk to parents about mathematics. During the group discussion, some teachers said that they have not seen this practice in any school they had worked in. They explained that they have meetings with parents where they discuss students' welfare, but do not address any academic issues. From our experience of the Malawi context, some schools would not involve parents into their students' academic progress due to the low literacy levels of parents and guardians, especially in rural areas. Another reason might be teachers' lack of subject matter knowledge or confidence in their own knowledge of mathematics. This was not mentioned by the teachers that took part in this study, but seems plausible that, if teachers are not confident of their knowledge or are aware of their limitations, they might not be willing to discuss their work with parents. Interestingly, one teacher stated, "learners' guardians do not ask about mathematics," which seems to suggest that, if the parents asked about goals and purposes of mathematics, the teacher would explain them. Another teacher noted, "majority of teachers do not have time to deal with parents," suggesting that lack of time is the only reason for this omission. Nevertheless, it is evident that some teachers do not perceive parent involvement as a task related to teaching mathematics in Malawi primary schools.

The mathematical task of "inspecting equivalences" was found not applicable by five teachers, two of whom did not give any reasons. The remaining three explained that this is done for the teachers but not by the teachers themselves. One teacher clearly stated that this is done by the teachers' guides, which are books for teachers that accompany textbooks for each grade.

Most of the reasons given pertain to teachers' guides and textbooks, which are perceived as sufficient, thus absolving the teachers from the responsibility for checking the equivalencies, as this is done by the authors of these curriculum materials. For example, the tasks of "using mathematical notation and language and critiquing its use," "choosing and developing useable definitions," and "selecting representations for particular purposes" were not perceived by the teachers as something they should do, as they are guided by what is written in textbooks and in teachers' guides. It appears that the teachers follow the textbook and teachers' guide diligently without questioning their applicability. This is common among Malawi teachers, who tend to take teachers' guide and textbooks as prescriptions of what and how to teach and not as suggestions. It might be important to note that the Malawi Institute of Education—a government institution—is the sole provider of textbooks and accompanying teachers' guides for primary schools in Malawi and these are made available to the teachers. Hence, for most of the teachers, these are the only resources they have and use. There are other possible reasons for not identifying with the tasks, although these are not mentioned by the teachers. For example, limited knowledge of the mathematical content by the teachers would compromise their ability to see equivalences, develop useable definitions, select representations, or critique use of mathematical notations. All these require deep understanding of the mathematics involved and might explain the heavy reliance on teachers' guides.

Similar to reasons for finding tasks applicable to the Malawi context, some teachers did not give the reason for selecting "no" as their response. It is likely that these teachers did not clearly understand the task or their own perception of it, and thus felt that it would not be appropriate to elaborate on their response.

Other Mathematical Teaching Tasks

Table 4 shows results pertaining to Part B of questionnaire, where teachers were asked to indicate tasks of teaching mathematics in Malawi schools that are not included in the original list of 16.

Table 4. *Frequencies of Responses to Other Mathematical Teaching Tasks in the Malawi Context.*

Other mathematical tasks of teaching mentioned	**Frequency (%)**
Making teaching and learning aids (TALULAR)	14 (100)
Assessing learners (preparing tests, marking scripts)	10 (71)
Using different teaching methods	8 (57)
Ordering content/sequencing topics	6 (43)
Relating mathematics to context and other subjects	4 (29)

As can be seen from the results presented in Table 4, five additional tasks of teaching were mentioned by at least four of the teachers. All participating teachers mentioned "making teaching and learning aids" and they referred to this as TALULAR, which stands for Teaching And Learning Using Locally Available Resources. TALULAR is a common concept in Malawi schools and is emphasized in teacher education. Thus, teachers take it as part of their job to make their own resources for teaching (Malawi Institute of Education, 2010). We acknowledge that use of teaching aids per se is not part of Ball et al.'s (2008) conceptualization of mathematical tasks of teaching. However, we contend that, in the Malawi context, where the teachers are expected to make the teaching aids from their local resources, this involves some mathematical reasoning and is hence integral part of their mathematical tasks of teaching.

The next common additional task was "assessing learners," most likely because assessment of learners is very important in Malawi schools, where learners take school tests at the end of each term, as well as during the term. Furthermore, learners' progression from one grade to the next is dependent on passing such tests. It is therefore not surprising that Malawi teachers consider "assessing learners" as one of distinct mathematical tasks of teaching. Indeed, the reasons teachers gave for explicitly noting this task was that it is their job to prepare tests, evaluate learners' work, and give feedback to their students. However, this is not a distinct task because the work involved in assessing students is reflected in some of the tasks in the original list of 16, such as "evaluating the plausibility of students' claims" and "asking productive mathematical questions."

More than half of the teachers mentioned "using different teaching methods" as another distinct mathematical task of teaching, as all respondents felt that it was linked to using learner-centered approaches in teaching. This reflects the current curriculum and initiatives in Malawi schools, which emphasize learner-centered teaching, as opposed to the traditional teacher-centered teaching methods (Malawi Institute of Education, 2014). We also acknowledge here that teaching methods do not fit with the conceptualization of mathematical tasks for teaching by Ball et al. (2008).

The last two suggested tasks "relating mathematics to context and other subjects" and "ordering content/sequencing topics" are partly covered by the task of "connecting a topic being taught to topics from prior or future years." While during the group discussion, teachers acknowledged this, they nonetheless felt that their suggestions extended beyond what is covered in the 16 tasks. For example, comparing "connecting a topic being taught to topics from prior or future years" with "relating mathematics to context and other subjects," one teacher said:

. . . that task is about scope and sequence, what we teach before and after . . . it is

> talking about scope and sequence . . . this we are saying linking to everyday life and other learning areas, science, agriculture . . . it is not same thing

The fact that the teachers were suggesting other tasks that are partly covered in the 16 tasks emphasizes our finding from Part A that, in general, the teachers find the tasks originally developed in the U.S. applicable to the Malawi context. The parts that are not covered seem to be additional tasks for Malawi and therefore worth paying attention to. We acknowledge that Ball et al. (2008) do not claim that the list of 16 is exhaustive, and our goal is not to show that the Malawi context has more tasks. Rather, our aim is to illustrate that there seems to be notable similarities between the two contexts, while acknowledging some specificities of the Malawi context.

Discussion on Mathematical Tasks of Teaching

These findings are drawn from teachers' responses to the questionnaire and the information gained during the group discussion, rather than from observations of actual teaching of mathematics in Malawi schools. Some might dispute this approach because it is based on teachers' views and not their practice. While we acknowledge the limitations of our approach, we argue that experienced teachers would be able to consider each of the tasks presented to them and draw from their experience to determine whether the task is something they do as part of their work of teaching mathematics. We emphasize that the goal of this work was to gain a better understanding of what teachers perceive as tasks of teaching in the Malawi context. On one hand, the fact that all 16 tasks were recognized by at least a third of the teachers informs us that the recurrent tasks of teaching are generally applicable to both the U.S. and the Malawi context. On the other hand, the fact that some tasks were not recognized by a relatively large number of teachers suggests that there is some specificity to the Malawi context. Thus, our findings help elucidate some differences between the two contexts, which support the claim that teaching is culturally specific (Delaney, 2012). The additional tasks of teaching described by teachers, especially the making of teaching aids (which was mentioned by all teachers), emphasize further the cultural specificity of teaching mathematics in the Malawi context. Thus, while we acknowledge that Ball et al. (2008) do not claim that the list of 16 is exhaustive, we also highlight the fact that some of the additional tasks the Malawi teachers suggested are covered in the original list of 16.

Piloting Adapted Measures

As explained earlier, the adapted forms were piloted on preservice teachers, whose responses were analyzed via the BILOG-MG software version 3.0 (Zimowski, Muraki, Islevy, & Bock, 2003) using the 2-parameter logistic (2PL) IRT model. As suggested by Hambleton, Swaminathan, and Rogers (1991), a model-data fit was investigated using multiple methodologies, starting from the assumptions of the IRT model, including unidimensionality. Since the two forms were answered by two equivalent groups (drawn from the same sample), we used equivalent groups equating with no overlapping items, placing the items on the two forms on the same scale. The 2PL IRT model produces two parameters for each item—parameter *a* that defines item discrimination, and parameter *b*, often referred to as item difficulty, as it shows the location where a respondent with ability of *b* will have a 50% chance of answering the item correctly (Edwards, 2009). Item characteristics on this scale typically range from -3 to +3, with items associated with higher values being more difficult than those with lower values. We used the values of these parameters to investigate problematic items in the Malawian context, and to identify items that are candidates for inclusion in the two forms that can be used for measuring teacher knowledge. We also studied point biserial correlation to identify problematic items (Fauskanger et al., 2012; Ng, 2012).

All the preservice teachers were also given an IRT score, placing them along the ability interval with 0 as the mean ability level and 1.0 as the standard deviation. It is, however, important to note that the preservice teachers' scores are not the focus of this paper, even though the psychometric properties of the items are.

The results yielded by the IRT analysis revealed an IRT reliability of 0.874, whereby maximum information was obtained at 1.25 standard deviation above the mean score. This indicated that this set of items is optimal for assessing more knowledgeable preservice teachers. BILOG flagged two items that had problematic point biserial (less than -0.15) and these were omitted from further calculation (Item 11b and 24d, both from Form B). In the next phase of data analysis, we examined the relative item difficulty distribution reported in the U.S. and estimated in the Malawi context. Even though the two scales are not directly comparable, one can expect—if the items function similarly in the Malawi as in the U.S. context—that there are some similarities among the relative ordering of item difficulties when looking at the full set of items (Fauskanger et al., 2012). More specifically, we posit that, if items are ordered from easy (low value of the *b* parameter/difficulty) to hard (more difficult, high value of the *b* parameter), one should expect—if the psychometrical properties of these items are similar across the two populations—that the order should be maintained (Fauskanger et al., 2012). The strong correlation pertaining to the relative item difficulty in the U.S. and Malawi context indicates that the relative order of the item difficulties is strongly maintained. This finding suggests that the items seem to function in a similar manner in the two populations.

For this set of items (Form A and Form B), the item difficulty found in the U.S. ranged from -4.281 to 3.961, with the average item difficulty of -0.535. In Malawi, the relative item difficulty ranged from -5.56 to 4.98, with the average difficulty of 1.119. A scatterplot of relative item difficulty found in the U.S. and in Malawi is depicted in Figure 1.

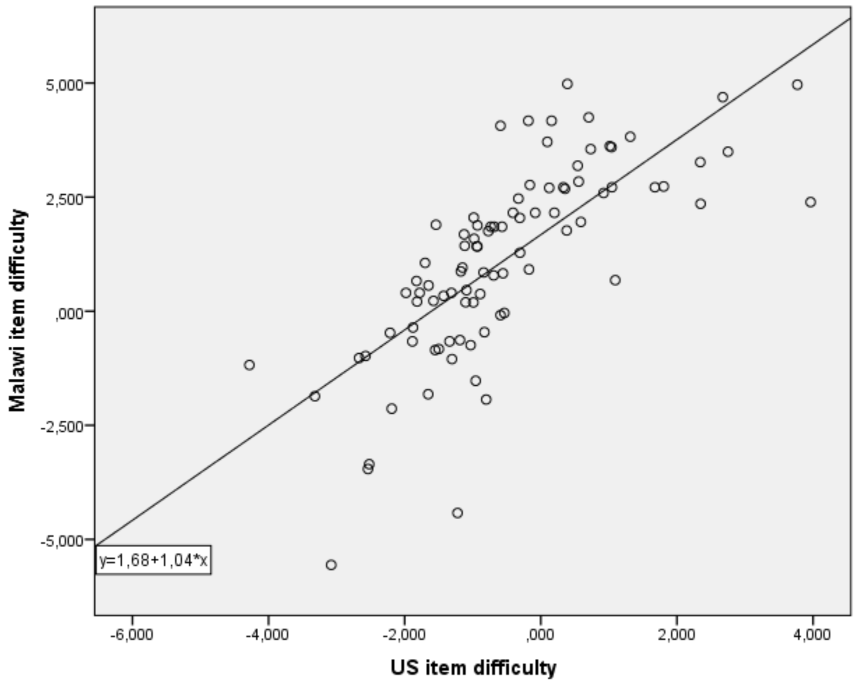

Figure 1. A scatterplot of the relative item difficulty found in the Malawi context, plotted against item difficulty found in the U.S.

We found a strong correlation between the item difficulty reported in the U.S. and that estimated in the Malawi context (Pearson correlation $r = .738$, $p < .0005$). The average item difficulty for this set of items was -0.535 for the U.S., while 1.119 was estimated in the Malawi context.

Discussion of the Psychometric Results

The primary purpose of the psychometric analysis was to ensure that the adapted items function well psychometrical in the Malawi context, and to finalize two forms with items—including anchoring items—that can be used for further studies in Malawi. For the set of items used in this pilot, it seems clear from the results that some of the more difficult items should be taken out of the set. Firstly, the point of maximum information (0.874) and the average item difficulty (1.119) indicated that the set of items was skewed in favor of the more knowledgeable respondents, implying that, overall, there were too many difficult items in the set. We were ideally seeking to compose two forms, both with approximately 30 items (including five repeating items as anchoring items) in a pre- and post-test study. Because of this aim, we decided to remove some items that appeared too difficult for Malawi preservice teachers. The main objective was to attain item distribution on each form with majority of items around mean ability of zero. As a result of these considerations, Item 2b, 3, 5b, 6, 7, 13, 18, 21e, and 24 from Form A, and Item 3, 8, 10, 11b, 14b, 16a, 17, 18, 20, 21, 22, and 24d from Form B were removed. We then added five items from our Form B to Form A, and one item from Form A to Form B. After this Form A had 38 items and Form B 35 items including six anchoring items on both forms. The resulting revised set of items had an average item difficulty of 0.854 in Malawi, versus -0.770 obtained in the U.S. The final item distribution of the new forms is given in Table 5 below, which also provides the average difficulty level when the items are distributed to the two forms.

Table 5. *Distribution of Item Difficulty for the Malawi Context.*

	Number of items		
Difficulty level	**Form A**	**Form B**	**Common items**
$b < -3$	2	1	
$-3 \leq b < -2$	-	1	
$-2 \leq b < -1$	4	4	1
$-1 \leq b < 0$	7	7	1
$0 < b \leq 1$	9	9	
$1 < b \leq 2$	10	8	3
$2 < b \leq 3$	5	4	1
$b > 3$	1	1	
Total items	**38**	**35**	**6**
Total stems	20	20	6
Average Malawi	**0.823**	**0.425**	
Average U.S.	**-0.83**	**-0.929**	

Conclusion

In conclusion, we revisit our research questions and briefly explain how we have answered them in this work based on the findings we obtained. With respect to the first question—*Are the tasks of teaching mathematics identified in the U.S. applicable in*

Malawi?—our findings show that the 16 tasks are applicable in the Malawi school context. However, some of the tasks are more commonly recognized by teachers as applicable to the Malawi context, while other tasks are found less relevant. The Malawi school context is very different from the U.S. context and it is interesting that the work of teaching seems generally similar. It is also intriguing to observe that, while there seems to be generality between the two contexts, there is also some specificity to the Malawi setting. In Malawi, making teaching aids from local resources is seen as integral part of teaching mathematics. It is important to note that this study does not draw any inferences about the way the tasks are carried out. It also does not extant to the assessment of their implementation by teachers in the Malawi classroom. Thus, while answering the call for efforts to identify mathematical tasks of teaching as a basis for conceptualizing MKT (Hoover et al., 2014), the study does not provide empirical evidence. However, it does offer a valuable foundation for further studies in this field, where empirical evidence can be gathered in order to contribute towards building a shared understanding of "common tasks of teaching mathematics" and consequently development of "internationally shared measures of MKT" (Hoover et al., 2014, p. 9).

For the second research question—*What can we learn about the adaptability of LMT measures to the Malawi context from psychometric properties estimated in a pilot study?*—we found, after piloting the set of 88 adapted items, that majority of items psychometrically function well in the Malawi context. The item difficulty reported in the U.S. was strongly correlated with that pertaining to the Malawi context. We also found that the set of items was slightly skewed towards the "difficult" side of the ability scale. Thus, by removing some of the more difficult items, we were able to group the set of items into two adapted forms—Form A and Form B—that can be used for further studies in the Malawi school context.

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