ANALYSIS OF THE NEEDED CONTENT OF MATHEMATICAL TEACHING KNOWLEDGE FOR PRIMARY SCHOOL TEACHERS IN MONGOLIA

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Abstract

Our aim was to identify needed content of mathematics teaching knowledge for primary school teachers in Mongolian contexts. The needed content was developed in two steps. The first step was content (item) generation, conducted by interviewing and administering an open-ended questionnaire. As a result, we obtained 36 items into six domains. In the second step, we presented validity evidence based on test content through experts' judgment. Two quantitative approaches to content validity, Content Validity Ratio (CVR) and index Aiken (V), were used to analyze 36 items. At the end content validity, 12 items were considered invalid, and the remaining 24 items valid. Structure of contents of 24 items with six dimensions was obtained: Common Content Knowledge (4 items), Horizon Content Knowledge (3 items), Specialized Content Knowledge (4 items), Knowledge of Content and Students (5 items), Knowledge of Content and Teaching (4 items), and Knowledge of Contents and Curriculum (4 items).

Keywords: content generation; content validity; mathematical knowledge for teaching; Mongolia; primary school teacher

1. Introduction

From 2014, the primary education core (new) curricula were developed by the Ministry of Education, Culture, and Science (MECS) of Mongolia and implemented in Mongolia. The curricula reform intended to shift from a subject-centered to learner-centered while switching the pedagogies from behaviorist to constructivist teaching (MESC, 2014).

One of the curricula was the primary school mathematics curriculum. In this regard, various studies have been conducted to improve the contents and development of mathematics education for primary school teachers in Mongolia (Magsar, 2016; Enkhtsetseg et al., 2016; Luvsandorj, 2016; Luvsandorj at al., 2017). However, the primary school teachers' perceptions and voices have not received enough attention in the research field.

The views held by teachers play an essential role in developing teacher education. Specifically, the views are important to form a coherent picture of the current status of teacher education and construct an extensive basis for the development work (Koponen et al., 2016).

The contents of mathematics education are related to teachers' knowledge, while teachers' knowledge is related to their students' achievements (Koponen et al., 2017). According to Schmidt et al. (2011), the inconsistent relationship between mathematics education contents and teachers' knowledge is because only crude indicators have been used as measures of opportunity to learn in teacher preparation programs. Darling-Hammond (2006) recommended a new approach that teachers' perceptions of the contents or learning are indicators of the development needs in the contents of teacher education. She used a survey tool to assess the content of the teacher program. The surveys investigating teachers' perceptions of what they think they learned during their teacher education can be an important indicator of teachers' general preparedness and self-efficacy (Koponen et al., 2017). The survey results help to develop the contents of teacher education (Darling-Hammond, 2006).

According to Guerriero (2017), the first critical study on teachers' knowledge was by Shulman (1987), who identified seven pedagogical content knowledge categories. This model played an essential role in education at that time by defining the scope of teacher knowledge. After that, many models have been created based on this model Tamir, 1988; Grossman, 1990; Fennema & Franke, 1992; An et al., 2004; Van der Sandt, 2007; Ball et al., 2008; Voss et al., 2011; Beswick, 2012; Döhrmann et al., 2012, etc.). Ball et al.'s (2008) mathematical knowledge for teaching (MKT) has been used in many primary education studies from these models. MKT has been defined as 'mathematical knowledge needed to perform the recurrent tasks of teaching mathematics to students'. Hill et al. (2005) found that a teacher's MKT is significantly related to primary students' mathematics achievement. MKT has been adapted and used for research in many countries and different contexts in primary education, for example, the United States (Ball et al., 2008; Santagata & Lee, 2021), Ireland (Delaney et al., 2008), South Korea (Kwon et al., 2012; Mitchel et al., 2014), Ghana (Cole, 2012), Indonesia (Ng, 2012), Norway (Fauskanger et al., 2012), Malawi (Jakobsen et al., 2016), Malaysia (Veloo & Puteh, 2017) and Turkey (Güven et al., 2018).

The survey was developed based on MKT to explore primary school teachers' perceptions of needed content of mathematical teaching knowledge in greater detail. In particular, "greater detail" refers to the investigation of teacher knowledge within the framework of six domains, as developed in the MKT. The two research questions were the following:

1. What MKT do primary school teachers of Mongolia want that they learn?
2. What kind of content would primary school teachers make for improving MKT in Mongolian contexts?

2. Theoretical Framework

Ball et al. (2008) refined Shulman's idea and developed the MKT framework as a construct to conceptualize mathematical knowledge specific to the discipline of teaching. The MKT model is divided into subject matter knowledge and pedagogical content knowledge, and each part consists of three domains (see Figure 1).

Proctor (2019) conducted the following research related to MKT: a review of the broader problem; the complexity of teacher knowledge; MKT related to teaching practice and student achievement; MKT, facilitating discussions, and eliciting student thinking; MKT and student engagement; call for a blended approach to MKT development; the impact of coursework on MKT development; and need for additional research on MKT development.

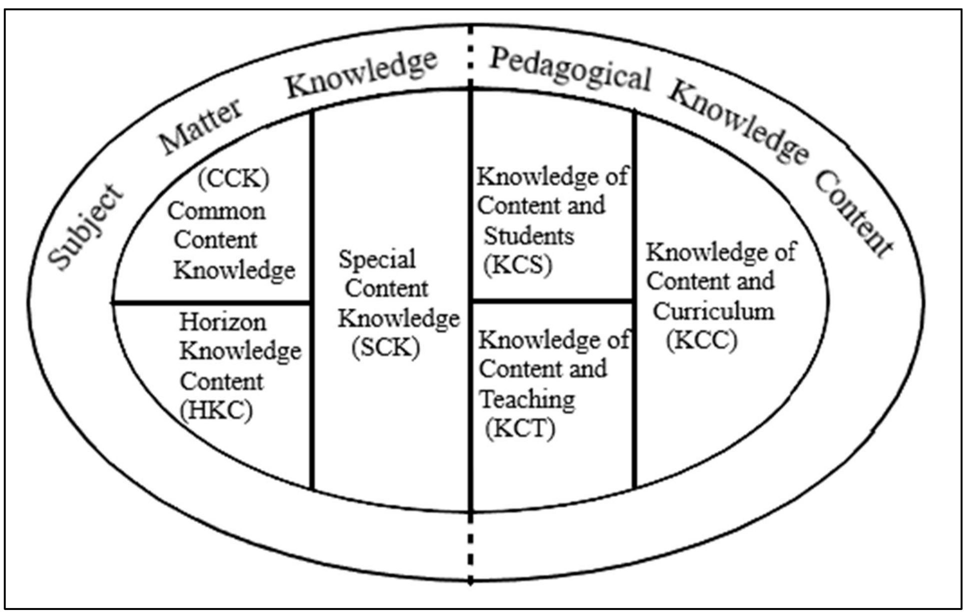

Fig. 1. Structure of the MKT Model (Ball et al., 2008)

2.1 Subject matter knowledge

Ball et al. (2008) named common content knowledge (CCK) and defined it as the mathematical knowledge and skill used in settings other than teaching. Also, CCK can be seen as mathematical knowledge that is not unique to teaching, and hence it is also useful in other professions Hill, Ball, & Schilling, 2008).

Ball et al. (2008) identified specialized content knowledge (SCK) as the mathematical knowledge and skill unique to teaching. SCK included evaluating tasks, designing mathematical problems, and marking exams (Koponen et al., 2017). Hill et al. (2005, pp. 377-378) defined SCK as a competence that “allows teachers to engage in particular teaching tasks, including how to accurately represent mathematical ideas, provide mathematical explanations for common rules and procedures, and examine and understand unusual solution methods to problems.”

Ball et al. (2008, p.403) recognized horizon content knowledge (HKC) as "an awareness of how mathematical topics are related over the span of mathematics included in the curriculum". Horizon knowledge helps teachers understand the mathematical foundation they are setting with their students and what pedagogical approaches may help students build upon their knowledge in future learning experiences (Proctor, 2019, p. 9).

2.2 Pedagogical content knowledge

The pedagogical content knowledge represents a teacher's knowledge to blend their knowledge of mathematics and instruction to advance students' understanding of mathematics (Proctor, 2019, p. 9).

Ball et al. (2008, p.401) defined knowledge of content and students (KCS) as "knowledge that combines knowing about students and knowing about mathematics". KCS is more like knowledge of how students learn mathematics: A teacher must anticipate students' difficulties and misconceptions, hear and respond to students' thinking, and choose suitable examples while teaching (Koponen, 2017. Knowledge of students (teachers' knowledge of student learning) is conceptions, learning difficulties, styles, misconceptions, and errors (Ball & Bass, 2000).

Ball et al. (2008, p. 401) described the knowledge of content and teaching (KCT) as the combination of "knowing about teaching and knowing about mathematics". Many of the mathematical tasks of teaching require a mathematical knowledge of the design of instruction. Teachers sequence certain content for instruction. KCT is the knowledge teachers use to design instruction with a focus on the impact of student learning. KCT is required in both planning and teaching, and it is something that teacher education should prepare students for (Koponen et al., 2017).

Knowing the content of curricula is referred to as Knowledge of Contents and Curriculum (KCC) for teachers. A wider perception of KCC also includes knowledge of teaching materials (such as textbooks, other materials, etc.), teaching instruments (blackboards, overhead projectors, etc.), and technology (computers, smartboards, calculators, software, etc.) (Koponen et al., 2017). Curricular knowledge is knowledge of texts and scheme used to teach mathematics, their contents and ways to use them; school produced curriculum materials; other teaching resources and teaching apparatus; examinations; tests and syllabi (Turner-Bisset, 2001). Curriculum knowledge is explicitly added to the model as knowledge of the subject content (concepts, procedures) and knowledge of different ways of presenting the content (pedagogical knowledge). However, it does not guarantee knowledge of different and effective teaching and assessment resources such as computer software (Van der Sandt, 2007).

3. Method

It was developed in two stages to identify the needed content of mathematics teaching knowledge for primary school teachers.

The first step was a content (item) generation, conducted by interviewing and administering an open-ended questionnaire in primary school teachers, specialists, researchers, and professors in primary education. The second step was a content validity of the new items testing by experts.

3.1 Item Generation (Step 1)

3.1.1. Participants

An in-depth interview was conducted with 25 participants, including three professors, two researchers, four methodologists, and 16 primary school teachers. An open-ended questionnaire was conducted 154 participants (16 males and 138 females, 11 specialists of primary education, 23 managers of primary school, 120 primary school teachers; 8 participants with a diploma's degree, 114 participants with a bachelor's degree, 32 participants with a master's degree). An expert panel was recruited to assess the face validity of generated items. The expert panel consisted of four persons (i.e., two experts with doctoral degrees and two experts with master's degrees).

3.1.2. Measures

Based on the MKT model, related literature and an in-depth interview outline were formed. The following questions were asked for each of the six domains:

(1) Please talk about your understanding of the domain;

(2) What do you think is the content for this domain?

(3) What do you think are the questions or items of assessment for this domain?

(4) What do you think are the exercise or problems of evaluation for this domain?

We then administered an open-ended questionnaire that included similar questions to the in-depth interview. The open-ended questionnaire used a matrix item format (Miyejav, 2007).

3.1.3. Procedure

Each of the 25 interviewees was invited by email to schedule a face-to-face interview that lasted 90 minutes. The authors conducted in-depth interviews. The first author interviewed 15 participants and the second author - 10 participants. The procedure of open-ended questionnaires was carried out.

(1) According to the questionnaires' results, representative phrases and words were extracted for the domain, and the response items were summarized.

(2) Then, items were further abstracted. The questionnaire was administered to 154 participants, and 142 valid questionnaires were collected for preliminary item construction. In doing so, we avoided evaluating the knowledge and skills that participants gained after graduation and during work experience.

3.1.4. Data analysis

The items with high cumulative frequency were selected as the measurement variables or indicators based on the interview results and open questionnaire.

3.2 Content validity (Step 2)

The first step was a content (item) generation, conducted by interviewing and administering an open The aim of step 2 was two quantitative approaches, Content Validity Ratio (CVR) (Lawshe, 1975) and V (Aiken, 1985), to content validity testing by experts was used in the analysis of 36 items.

3.2.1. Participants

Eight experts' judgment determined the content validity in this study. The experts were four university professors who teach mathematics didactics of primary and secondary education, one primary education researcher in a research institute, two specialists of primary education in a professional institute, and one primary school teacher.

3.2.2. Measures

The survey instrument consists of 2 sections. The first section contains a column of essentiality statements (with three options, i.e., essential, useful but not essential, and not useful). The second has a score in four scales (1 = Unusable, 2 = Can be used with many improvements, 3 = Can be used with little improvement, and 4 = Can be used without repair) for each item accompanied by a column for giving advice.

3.2.3. Procedure

Two quantitative approaches to content validity, CVR (Lawshe, 1975) and V (Aiken, 1985), were used to analyze 36 items. The survey, which consists of two sections, used Google form online. The experts of the related items that are being developed fill out each section.

3.2.4. Data analysis

The statement essentiality and score for each item are used to analyze the validity of the contents quantitatively using the formula Lawshe's CVR (the data from essentiality where the essential items are getting one score) and Aiken's V (from the score of items).

4. Results

4.1 Result of Item Generation (Step 1)

A total of 344 items were collected through literature analyses, in-depth interviews, and open-ended questionnaires.

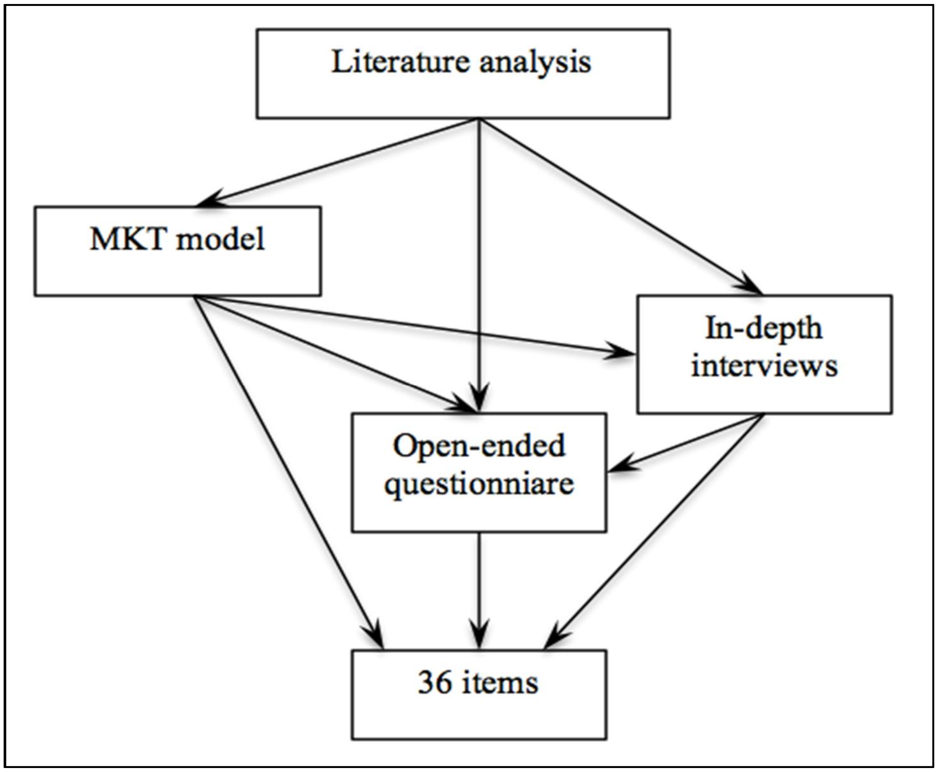

Fig. 2. The process of generating items

These items were further refined: (1) deleting inappropriate items: ambiguous items and items with high face validity were removed; (2) categorizing: items with similar content was classified as a category. A total of 83 different items were summarized under the MKT.

A total of 83 different items were summarized under the MKT, which consists of six domains. We obtained a total of 36 items of MKT, which consists of 6 items of each domain, and these items were chosen with high cumulative frequency. The process of generating items was presented in Figure 2.

4.2 Result of Content Validity (Step 2)

Based on the experts' judgment, then do calculations using formula Lawshe (CVR), and Aiken (V) index gained validity in Table 1. The minimum CVR for each item to be considered acceptable was .75 for a one-tailed test at the 95% confidence level if eight judges were used for the study (Lawshe, 1975). The value of validity coefficient V (Aiken, 1985) was found from the table for eight experts, with four rating categories. These significant values were V= .75, p = .40 for eight raters.

Table 1. *The results of the content validity analysis with Lawshe's CVR and Aiken's V formula*

Domain	Number item	Lawshe's CVR		Aiken's V		Decision
		CVR	Category	V	Category	
CCK	1.	1.00	Valid	0.83	Valid	Remained
	2.	**-0.25**	**Invalid**	**0.58**	**Invalid**	**Removed**
	3.	0.75	Valid	0.83	Valid	Remained
	4.	0.75	Valid	0.75	Valid	Remained
	5.	0.75	Valid	0.83	Valid	Remained
	6.	**-0.25**	**Invalid**	**0.5**	**Invalid**	**Removed**
HCK	7.	0.75	Valid	0.79	Valid	Remained
	8.	1.00	Valid	0.83	Valid	Remained
	9.	**0.25**	**Invalid**	0.79	Valid	**Removed**
	10.	**0.50**	**Invalid**	**0.67**	**Invalid**	**Removed**
	11.	**0.50**	**Invalid**	0.92	Valid	**Removed**
	12.	0.75	Valid	0.88	Valid	Remained
SCK	13.	0.75	Valid	0.75	Valid	Remained
	14.	0.75	Valid	0.79	Valid	Remained
	15.	1.00	Valid	0.79	Valid	Remained
	16.	0.75	Valid	0.79	Valid	Remained
	17.	**-0.75**	**Invalid**	**0.58**	**Invalid**	**Removed**
	18.	**-0.5**	**Invalid**	**0.5**	**Invalid**	**Removed**
KCS	19.	0.75	Valid	0.83	Valid	Remained
	20.	1.00	Valid	0.75	Valid	Remained
	21.	0.75	Valid	0.75	Valid	Remained
	22.	0.75	Valid	**0.71**	**Invalid**	**Removed**
	23.	0.75	Valid	0.79	Valid	Remained
	24.	1.00	Valid	0.75	Valid	Remained
KCT	25.	0.75	Valid	0.75	Valid	Approved
	26.	0.75	Valid	**0.71**	**Invalid**	**Removed**
	27.	1.00	Valid	0.83	Valid	Remained
	28.	0.75	Valid	0.79	Valid	Remained
	29.	**0.50**	**Invalid**	**0.58**	**Invalid**	**Removed**
	30.	0.75	Valid	0.83	Valid	Remained
KCC	31.	1.00	Valid	0.92	Valid	Remained
	32.	1.00	Valid	0.75	Valid	Remained
	33.	0.75	Valid	0.75	Valid	Remained
	34.	1.00	Valid	0.86	Valid	Remained
	35.	0.75	Valid	**0.25**	**Invalid**	**Removed**
	36.	**0.50**	**Invalid**	**0.63**	**Invalid**	**Removed**

From the results of the CVR analysis, it appears that nine items that stated invalid (item 2, 6, 9, 10, 11, 17, 18, 29. 36) and CVR index on these items also showed below of 0.74. Next, on the analysis according to Aiken's formula, in addition to the item 2, 6, 10, 17, 18, 26, 29, 36, there are three other items entered an invalid category, i.e., item 22, 26 and 35.

Table 2. *Listing of MTKS items and sources*

Domain	Item	Item content	Sources
CCK	cck_1	Mathematical concepts	Koponen et al., 2017
	cck_2	Using mathematical knowledge and skills in problem-solving	From interview
	cck_3	Using figures, diagrams, and models to developing own mathematical thinking	Koponen et al., 2017
	cck_4	Using mathematical notation and language	Nyamjav, 2010
HCK	hck_1	Structure of mathematical concepts (e.g., axioms, definitions, lemmas, propositions)	Hill et al., 2005
	hck_2	Relationship between mathematical topics	From interview
	hck_3	Connecting a topic being taught to topics from prior or future	Ball et al., 2008
SCK	sck_1	Presenting mathematical ideas	Ball et al., 2008
	sck_2	Explaining mathematical concepts, laws, and rules	From open-ended questionnaire
	sck_3	Mathematical representations (concrete, pictorial, and abstract)	Hoong et al., 2015
	sck_4	Mathematical application in everyday life, science, social and technology	Hill et al., 2005
KCS	kcs_1	Recognition of learning difficulties in mathematics	Koponen et al., 2017
	kcs_2	Recognition of students' errors in mathematical learning	Koponen et al., 2017
	kcs_3	Recognition of students' misconceptions in mathematics	Koponen et al., 2017
	kcs_4	Developing a student's mathematical thinking	Koponen et al., 2017
	kcs_5	Motivating students to learn mathematics	From open-ended questionnaire
KCT	kct_1	Responding to students' "why" questions	Ball et al., 2008
	kct_2	Applying to learning theories in the teaching	Koponen et al., 2017
	kct_3	Planning a mathematics lesson	Baldulmaa and Munkhjargal, 2010
	kct_4	Finding an example to make a specific mathematical point	Ball et al., 2008

KCC	kcc_1	National mathematical curriculum	Koponen et al., 2017
	kcc_2	Assessment in the classroom	From interview
	kcc_3	Using technology in teaching mathematics	Koponen et al., 2017
	kcc_4	Using tools in teaching mathematics	Enkhtsetseg et al., 2017

Out of the 36 items, 12 items were considered invalid, and the remaining 24 items are valid. Consequently, the final proposed content generation contained 24-items. To reflect the significance of content generation, the authors presented each item's literature source (Table 2).

5. Discussion

The needed content of mathematical teaching knowledge for primary school teacher was developed in two steps: content (item) generation and content validity.

When creating the item generation, we have benefited from the items in the literature based on MKT (Ball et al., 2008), the opinions of professors, researchers, methodologists, and primary school teachers. An item pool was collected, a total of 344 items. As the result of deleting inappropriate and categorizing, 83 different items were summarized. After calculating the high cumulative frequency, the number of items has been reduced to 36 from 83 items. Thus, as a result, Step 1 (an Item Generation) produced 36 items, which consists of 6 items of each domain, grouped into the six domains (CCK, HCK, SCK, KCS, KCT, and KCC), and a draft content has been created.

The draft content was determined by eight experts' judgments and two quantitative approaches, CVR (Lawshe, 1975) and V (Aiken, 1985), to content validity. At the end content validity analysis (Step 2) of the draft content, 12 items were considered invalid, and the remaining 24 items valid. Structure of contents of 24 items with six dimensions was obtained: CCK (4 items), HCK (3 items), SCK (4 items), KCS (5 items), KCT (4 items), and KCC (4 items).

6. Conclusion

This study aimed to identify needed content of mathematics teaching knowledge for primary school teachers in Mongolian contexts. Based on the MKT model (Ball et al., 2008), we elaborated a needed content consisting of six factors (CCK, HCK, SCK, KCS, KCT, and KCC) and 24 items, which presented evidence of reliability as well as validity based on item generation and test content. The validity test used in this study has adequate face and content validity and thus, can be further used for the next research. For future research, this study be conducted a psychometric analysis.

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