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Development of Ability in Construction of Mathematical Skill and Process Instruments for Students in the Faculty of Education

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Abstract

The measurement instruments are part of assessment the teacher uses in assessing the learner's learning process and outcomes. So, it is very necessary to prepare teacher students for their future as teachers. The objectives of this research were 1) to develop guidelines on construction of mathematical skill and process instruments, 2) to develop ability of construction of mathematical skill and process instruments of teacher students to meet the 70 percent criterion. The target group of the focus group discussion consisted of 4 experts in mathematics study. The experimental group consisted of 48 4th year students in the Faculty of Education, Mahasarakham University, obtained through cluster random sampling. The instruments used in the research were focus group issues, guidelines on construction of instruments, and an assessment form for ability of construction of mathematical skill and process instruments. The analysis of data employed content analysis and one sample t-test analysis. The research results were as follows: 1) The guidelines on construction of mathematical skill and process instruments emphasized enabling students to design instruments by themselves, by answering the following questions: "What is measured?" (What), "Why is it measured?" (Why), "When is it measured?" (When), "Who measures it?" (Who), and "How is it measured?" (How). The instruments constructed were various. 2) The ability of construction of mathematical skill and process instruments of the teacher students met the 70 percent criterion, with statistical significance at the .05 level (t=7.06, df=47). The research results, apart from being able to be used with teacher students, can also be used with in-service teachers.

Keywords: mathematical skill and process, assessment, instrument construction

1. Introduction

1.1 Introduce the Problem

Assessment is an important process in judging whether the learner's achievement meets the objectives that have been set or not because assessment is used to monitor learning progress, learning outcomes and to search for crucial things needed to be corrected in order to create sustainability in the learner (Muklis et al., 2018). Therefore, measurement instruments are part of assessment the teacher uses in assessing the learner's learning process and outcomes. So, it is very necessary to prepare teacher students for their future as teachers.

The Association of Mathematics Teacher Educators (AMTE) (2017) set standards of preparation for being a mathematics teacher that a mathematics teacher must have the knowledge of the content, in order to be able to choose the method and technique appropriate for the content. A well-prepared teacher with proper teacher qualifications can promote the learner's learning process efficiently. However, apart from having competency in the content, curriculum and teaching, it is also important for the teacher to have the competency in assessment process (Lisnawati, 2018; Sumaryanta et al., 2018). This is consistent with the components of the professional mathematics teacher, prescribed by the Teacher Education and Development Study in Mathematics (TEDS-M) as having 3 components: mathematical content knowledge, pedagogical content knowledge and general pedagogical knowledge. The learner assessment process is in the pedagogical content knowledge. Thus, developing teacher students for them to have the body of knowledge of assessment is the essential part that leads to being professional teachers (Tatto, 2013). The assessment principle focus on two main ideas: 1) assessment should enhance students learning, and 2) assessment is a valuable tool for making instructional decisions (The National Council of Teachers of Mathematics (NCTM), 2000). This is consistent with Brown (2008) who states that the teacher ought to know

how to construct instruments for classroom assessment, including how to use the outcomes of the assessment in improving the learners as well as the teacher's teaching.

Nevertheless, the problem of assessment concerning the teacher is very important because it is related to the quality of assessment tools which are directly chosen and constructed by the teacher. A study by Kanchanawasi (2000) on learning assessment in Thailand in both primary and secondary education reveals that learning assessment emphasized the cognitive domain (about 90%), assessment on the affective domain was not very important (about 10%), and there was a lack of assessment on the skill and process. This can be held that the assessment did not cover what was required by the National Education Act B.E. 2542. The results of using traditional assessment methods which have many weaknesses bring about failure in measuring complicated knowledge and understanding as well as practical ability. This makes the teacher turn to teaching that does not adhere to or emphasize the context but emphasizes memorization without learning and skills (Puwiphadawat, 2001). Traditional assessment often relies on standardized tests and exams that may not accurately reflect students' abilities or knowledge in real-world contexts. Traditional assessment may also be limited in its ability to measure non-cognitive skills such as creativity, problem-solving, and collaboration, which are increasingly valued in today's workforce (Darling-Hammond, 2010).

In the basic education curriculum of Thailand, the mathematics learning strand group sets the goals for the students to achieve upon their completion as follows: 1) having knowledge and understanding about concepts, principles and theories in essential mathematical substances; 2) having ability to solve problems, communicate, interpret, connect, reason on matters in mathematics, and having creative thinking; 3) having good attitude towards mathematics; 4) having ability to choose proper technological equipment and media and data sources (The Institute for the Promotion of Teaching Science and Technology (IPST), 2017). It is clear that beside knowledge, the aim of the curriculum is to enable the students to acquire skills and good attitude towards mathematics. Therefore, in order to know whether or not the students have achieved the objectives, it is necessary to have an assessment process that covers all of the aforementioned aspects.

This research attaches importance to problem solving, mathematical communication and interpretation, connection, reasoning and creative thinking, which are abilities called mathematical skills and process by the IPST; and they are similar to the process standards of the National Council of Teachers of Mathematics (NCTM) (2000) which are termed problem solving, reasoning and proof, communication, connections, and representation. These mathematical skills and process are very important for students, as seen in a cohort study by Parsons and Bynner (2006), using a big sample size in the UK and it was found that persons with defects in mathematics skills were more affected than persons with defects in literary skills, in terms of opportunity. Therefore, the teacher must find ways to develop these skills. Good designing of assessment is regarded as a process that can promote mathematical skills and process of students.

From the aforementioned state of problems and importance, the researcher became interested in developing ability of construction of mathematical skill and process instruments of the teacher students majoring in mathematics in the Faculty of Education, Mahasarakham University so that they gain knowledge and basic skills of construction of mathematical skill and process instruments which will benefit them in their own development towards being professional teachers in the future.

1.2 Research Objectives

- To develop guidelines on construction of mathematical skill and process instruments
- To develop ability of construction of mathematical skill and process instruments of teacher students to meet the 70 percent criterion

2. Method

This research was quasi-experimental research. The research phase was divided into 3 phases as follows:

Phase 1: Development of guidelines on construction of mathematical skill and process instruments

The researcher developed guidelines on construction of mathematical skill and process instruments by using focus group discussion of mathematics experts and synthesis of related research documents.

1) Target group: 4 mathematics experts
2) Instrument: questions for focus group discussion (How important are mathematical skills and processes? How to check each student's mathematical skills and processes? And What are the reasonable tools to measure mathematical skills and processes?)
3) Data analysis: content analysis

Phase 2: A tryout of the guidelines and assessment of ability of construction of mathematical skill and process instruments of teacher students

In this phase, the guidelines constructed in Phase 1 was tried out with the sample and followed by assessment of the ability of the sample.

Population: 71 4th year students from 3 groups of mathematics majors in the Faculty of Education, Mahasarakham University in the academic year 2020. The students' abilities in all of the 3 groups were not different.

Sample: 48 4th year students 12 male and 36 female from 2 groups, Group 1 and Group 3, of mathematics majors in the academic year 2020, obtained through cluster random sampling.

Instruments: an assessment form for ability of construction of instruments, which was a test for students' practical activity of designing mathematical skill and process instruments and their abilities were assessed on 3 aspects of a rubric: having a complete set of components, congruence of the instrument and the skill, and accuracy and appropriateness (see Appendix for detail).

Data analysis: Comparing the ability of construction of mathematical skill and process instruments with the 70 percent criterion, using one-sample t-test analysis. The normality assumption of the dataset of 48 students' scores was met, as indicated by the results of the Shapiro-Wilk test and the normal probability plot. Therefore, parametric tests can be used to analyze the data.

3. Results

Regarding the focus group discussion, the experts gave the following opinions: Before developing mathematical skill and process instruments, one should study the definition of the skill to be measured to understand it by studying concepts and theories and construct the instrument according to the theories that had been studied. Such instrument may be able to measure various skills, and that can stimulate the learner to gain skills of more coverage, and the teacher can measure various skills by not having to use 1 instrument for 1 skill. Moreover, an important property of the instrument is that it must pass instrument quality examination and it is practically convenient to be used. Regarding the guidelines on construction of mathematical skill and process instruments, the emphasis is on enabling the teacher students to design the instrument by themselves. Thus, guidelines were provided for the students to plan the instrument construction by presenting them the questions "What is measured?" (What), "Why is it measured?" (Why), "When is it measured?" (When), "Who measures it?" (Who), and "How is it measured?" (How). The instruments to be constructed would be various and consistent with the content and the skill aimed to be measured, with the checking method that is not separated from the teacher's normal practice. The guidelines on instrument construction are given in Table 1.

Table 1. Guidelines on construction of mathematical skill and process instruments

Steps of Planning	Details	Examples of Answers
What What is measured?	What is the skill wanted to be measured, and with which content is it related?	Mathematical skill and process - Problem solving - Mathematical communication and interpretation - Connection - Reasoning - Creative thinking Learning substance - Number and algebra - Measurement and geometry - Statistics and probability - Calculus
Why Why is it measured?	What are the goals of this assessment?	To be used in judging mathematics learning achievement To be used in correction or development of specific skills of students To be used as guidelines on development of activities appropriate for students' levels

When When is it measured?	The period of time suitable for skill and process measurement	The teacher should set the time of students' skill measurement such as every month, after finishing teaching of each topic or chapter, midterm assessment, final assessment The length of time for each assessment should be planned ahead of time. How will student's mistakes be corrected, and when?
Who Who measures it?	Who carries out measurement?	Teacher assesses students Fellow students carry out assessment Each student carries out self-assessment
How How is it measured?	How is the assessment process carried out?	Testing Interviewing Inquiring Observing Recording learning Using portfolios Doing math projects Problem solving in simulation Mathematical operation Oral presentation Exhibition

Regarding development of the ability of construction of mathematical skill and process instruments of teacher students to meet the 70 percent criterion, it was found that from the full score of 30 which 70% is 21, 48 teacher students had the mean of 24.17 which is higher than 21, with statistical significance at the 0.05 level (t=7.06, df=47). So, it can be stated that the ability of construction of mathematical skill and process instruments of the teacher students met the necessary 70 percent, as in Table 2.

Table 2. Comparison of the ability of construction of mathematical skill and process instruments with the 70 percent criterion

Variable	n	Full Score	70% Score	Mean	Std. Deviation	t	df	P-value
Ability of construction of mathematical skill and process instruments	48	30	21	24.17	3.108	7.06*	47	.000

*p<.05.

4. Discussion

The guidelines on construction of mathematical skill and process instruments emphasized enabling the teacher students to design the instruments by themselves. Therefore, guidelines were provided for the students to plan the instrument construction by presenting them the questions to be answered as follows: "What is measured?" (What), "Why is it measured?" (Why), "When is it measured?" (When), "Who measures it?" (Who), and "How is it measured?" (How). This is consistent with Ma Khanong (2016) who states that before assessing mathematical skill and process, the teacher should plan ahead of time by taking the following actions: 1) Specify the mathematical skill and process to be assessed; 2) Specify the method and instrument that will be used in the assessment; 3) Make a systematic assessment plan; 4) Specify what the assessment results will be used for. The instruments constructed are various. These are consistent with the concept of authentic assessment which is a process of observation, recording and collecting data from the accomplishment, method or performance of the student, to be used as the base of making decision on the student. Authentic assessment does not emphasize assessment of basic skills but emphasizes assessment of complicated thinking skills used in work, problem solving ability and actions from the performance in authentic condition by using various instruments suitable for competencies needed to be measured (Funchian, 2019; The Institute for the Promotion of Teaching Science and Technology (IPST), 2003; University of Florida, 2018).

Development of the ability of construction of mathematical skill and process instruments of teacher students met the 70 percent criterion. This was because the target group of teacher students really constructed the instruments and they understood the guidelines well. So, they were able to design the mathematical skill and process

instruments appropriately. This is consistent with Poonputta (2017) who studied about development of competency of learning assessment of student teachers: the case of Rajabhat Mahasarakham University, and found that the competency of learning assessment of the students after the development was higher than before the development; the increase was 31.60 percent. Also, Puangyod (2012) studied about development of teacher's potential in construction of mathematical skill and process instruments, by aiming to construct and verify the quality of a training set for developing teacher's potential in construction of mathematical skill and process instruments and aiming to develop teacher's potential in construction of mathematical skill and process instruments by using the training set. The results revealed that the development of teacher's potential was participated by 6 mathematics teachers who had majored in other fields rather than mathematics. Most (5) of them had the potential in construction of mathematical skill and process instruments in the very good level, and only 1 teacher had the potential in the fair level. Muklis et al. (2018) developed mathematical skill instruments basing on the concept of Bloom taxonomy by using project assessment which comprised student project, grid of assessment, assessment rubric and rubric of project scoring. The development was reflected by the users as being in the very good level.

However, some teacher students constructed their rubrics with inadequate details, or they were unreasonable scoring rubric. The problem might have been caused by lack of experience in scoring student's work and inability to set appropriate steps for scoring.

5. Recommendations

5.1 Recommendations for Utilization of the Research Results

To use the guidelines on construction of mathematical skill and process instruments, the user should have basic knowledge of the definition of mathematical skill and process as well as good understanding of the mathematics learning strand group of the basic education curriculum. The guidelines on construction of mathematical skill and process instruments, apart from being able to be used with teacher students, can also be used with in-service teachers.

5.2 Recommendations for Future Research

This research presents only guidelines on construction of mathematical skill and process instruments. Interested persons can develop mathematical skill and process instruments for each skill to facilitate readers who wish to use such instruments in real conditions. There should be studies on quality verifying processes that employ high measurement methods for mathematical skill and process instruments.

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Appendix

Rubric scoring for ability of construction of instruments

Criteria	Score
Complete set of components	
1. Planning, Tool Creation, Criteria Defined	3
2. Planning, Tool Creation, No Criteria	2
3. No Planning, No Criteria Defined	1
Congruence	
1. Tools and Criteria are Aligned with Planned Content	3
2. Some Misalignment between Content, Tools, Criteria	2
3. Tools Created Do Not Align with Content or Skills	1
Accuracy and appropriateness	
1. Accurate and Appropriate Tools, Effective Criteria	4
2. Accurate and Appropriate Tools, Ineffective Criteria	3
3. Accurate Tools, but Inappropriate for Content/Skills	2
4. Inaccurate and Inappropriate Tools	1
Total score	10

Explanation:

The purpose of this Rubric is to measure the ability in construction of mathematical skill and process instruments of teacher students in three main areas: number and algebra (10 points), measurement and geometry (10 points), and statistics and probability (10 points). The scoring details are as follows:

Complete set of components

A score of 3 would be awarded if the project had a well-defined plan, tools were created, and criteria for evaluation were established.

A score of 2 would be given if the project had a plan and tools were created, but no criteria for evaluation were established.

A score of 1 would be given if there was no planning, no criteria were defined, and there was no clear understanding of what, why, when, who, and how the project was to be executed.

Congruence

A score of 3 would be awarded if the tools and criteria were well-aligned with the planned content of the project, and all three components worked together cohesively.

A score of 2 would be given if there were some instances of misalignment between the content, tools, and criteria. While some areas were well-aligned, there were still areas that needed improvement.

A score of 1 would be given if the tools created did not align with the content or skills that were intended to be measured. This would indicate a lack of planning or a significant disconnect between the project's objectives and the resources created.

Accuracy and appropriateness

A score of 4 would be awarded if the tools designed were accurate and appropriate for the content and skills being assessed, and the criteria for scoring were well-constructed and effective.

A score of 3 would be given if the tools designed were accurate and appropriate, but the criteria for scoring were not effective in measuring the intended content or skills.

A score of 2 would be given if the tools designed were accurate but not appropriate for the content or skills being assessed. The criteria for scoring may be suitable, but the tools do not align with the content and skills being measured.

A score of 1 would be given if the tools designed were inaccurate and inappropriate for the content and skills being assessed, indicating significant flaws in the design and planning process.