SYNTHESIS OF TEACHING AND LEARNING RESEARCH FOR CONSTRUCTING FRAMEWORK TO DEVELOP STUDENTS' REASONING SKILLS IN LEARNING MATHEMATICS

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Abstract - The objectives of this study were (1) to synthesis teaching and learning research related to reasoning skills, and (2) to construct framework for developing teaching and learning high school mathematics based on mathematical reasoning skills from synthesis research. The samples of research were the mathematics education research focused on mathematical processes and skills related toreasoning skills and published in 2001 – 2018. There were three categories of research synthesis: (1) roles of teachers and learners in developing reasoning skills, (2) active learning activities to develop reasoning skills, and (3) learning environment. The researchers focused on two topics of each category: 'Research Objectives/Research Questions' and 'Research Results'. The analysis of results were determined by using 'Percentage of Research Objectives/ Research Questions' and 'Content Analysis of Research Results' before constructing the framework to develop classroom action research for students' reasoning skills in learning mathematics. The results from18 prior research studies showed that there were 15 studies (83.33%) applied active learning approach, and the other 3 studies (16.67%) applied passive learning approach. The popular learning activity was 'Questioning' with the percentage of 38.89%. For learning environment, the result showed that 'Participation' was high percentage of usage with 55.56%. In addition, the framework to develop mathematical reasoning skillswas meta-cognitive reasoning through interaction and real-life context which combined basic reasoning, critical reasoning, and creative reasoning. For further study, the researchers may categorize in different subdivisions for synthesis research such as effective teaching for mathematical reasoning not only focus on types of reasoning or factors to support teaching and learning mathematical reasoning.

Index terms - Synthesis of research, Reasoning skills, Active learning

I. INTRODUCTION

In Thailand, mathematics is one of eight learning areas in Basic Education Core Curriculum B.E.2551 (A.D.2008). It comprises bodies of knowledge, skills or learning processes and desired characteristics. For mathematics area, the components of bodies of knowledge, significant skills and characteristics are required for all basic education learners as follows: application of knowledge, skills and scientific process for problem solving, way of life and further education, reasonableness, favorable attitude toward mathematics, and development systematic and constructive thinking[1, pp. 10]. Mathematics area is divided into 6 strands: Strand 1 Number and operation, Strand 2 Measurement, Strand 3 Geometry, Strand 4 Algebra, Strand 5 Data Analysis and Probability, and Strand 6 Mathematical Skills and Process.

The standard for Strand 6 Mathematical Skills and Process is aimed to educate students' ability in problem solving through diverse methods, reasoning, communication, presentation of mathematical concept, linking various bodies of mathematical knowledge, and linking mathematics with other disciplines, and attaining ability for creative thinking [1, pp. 14].

Cooper and Hedges [2]designed research synthesis conceptualized as research process in six stages as follows: Stage 1 Problem Formulation, Stage 2 Literature Search, Stage 3 Data Evaluation, Stage 4 Data Analysis, Stage 5 Interpretation of Results, and Stage 6 Public Presentation. Each stage has three characteristics to be considered, i.e., 'Research Question', 'Primary Function', and 'Procedural Variation'. KaewsaihaandOhama[3]synthesized the mathematics education research focused on mathematical processes and skills related to the 21st century skills and published in 2007 – 2018 by conceptualized framework using four categories of research synthesis: (1) critical thinking and problem solving, (2) creativity and technology, (3) communication, and (4) collaboration. Each category had two characteristics to be reviewed, i.e., 'Research Objectives/Research Questions' and 'Research Results'.

This study focused on 'developing mathematical reasoning skills' in three factors: (1) roles of teachers and learners, (2) active learning activities, and (3) learning environment. They were included 'Basic Reasoning', 'Critical Reasoning', and 'Creative Reasoning' for designing action research framework.

II. THEORETICAL FRAMEWORK AND LITERATURE REVIEW

The researchers were interested in 'The Role of Reasoning Skills in Mathematics Problem Solving',

influencing on students' achievement in learning mathematics. There were two theories applying in this study: 'Theories for Mathematics Learning' and 'Mathematical Reasoning for Problem Solving'.

THEORIESFOR MATHEMATICS LEARNING

Learning is a mental activity. In mathematics classroom, each learner's brain receives information about mathematics knowledge and mathematics process and skills, interprets information, stores it, transforms it, associates it other information to create new information and allows information to be recalled. The brain also only develops and retains the faculties which it is called upon to use [4].

There are many of the teaching and learning approaches applied in classroom. This section will explore two basic types of learning theory: 'Behaviourism' and 'Constructivism'. Teachers will need to find out what works and what doesn't work with the learners in mathematics classroom. Behaviourism focuses on the change in learner's behaviour through positive or negative reinforcement. Skinner (1974, as cited in [5]) believed that behaviour is a function of its consequences, i.e. learners will repeat the desired behaviour if positive reinforcement is given. Constructivism is about learning being 'constructed', 'active', 'reflective', 'collaborative', 'inquiry-based', and 'evolving'.

MATHEMATICAL REASONINGFOR PROBLEM SOLVING

The national curriculum requires that all basic education learners are taught to solve problems through diverse methods. The problem activities should allow learners to work at different levels with a variety of routine and non-routine problems. In helping learners to succeed in problem solving and do not get 'stuck', the teacher should provide learning activities and learning environment to aid their thinking skills [6]:

- Information processing: for example, identifying relevant information, sorting, classifying and sequencing, analyzing results and relationships
- Reasoning: for example, giving reasons for their opinions, making deductions, using precise language to explain what they think, and making judgements and decisions informed by reasons and evidence
- Enquiry: for example, asking relevant questions, planning what to do, predicting outcomes
- Creativity: for example, generating and extending ideas, applying imagination, looking for alternative outcomes
- Evaluation: for example, evaluating information, judging the value of what they hear, read and do

The four components of thinking skills that include reasoning are shown in Figure 1 [7]:

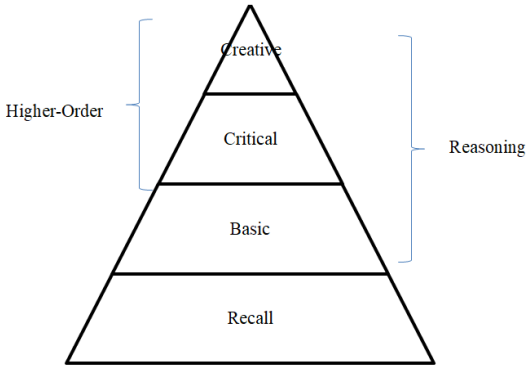

Figure 1: Hierarchy of Thinking

In this study, the researchers focused on the research related to constructivism theory describing three factors: (1) roles of teachers and learners, (2) active learning activities, and (3) learning environment. In addition, mathematical reasoning for problem solving was designed in framework for development students' mathematical reasoning on three components (basic reasoning, critical reasoning, and creative reasoning).

Krulik and Rudnick [7]explained the three components of reasoning in the following:

Basic reasoning includes the understanding of mathematical concepts.

Critical reasoning is reasoning skill that examines relates, and evaluates an aspect of the situation or problem.

Creative reasoning is reasoning skill that is original, effective, and produces a complex product.

III. RESEARCH METHODOLOGY

SAMPLES

The samples of research were the mathematics education research focused on mathematical processes and skills related to reasoning skills and published in 2001 – 2018.

RESEARCH INSTRUMENTS

A synthesis matrix form for analyzing and synthesizing prior research

RESEARCH PROCEDURE

The main concepts of synthesis research were described as follows:

(1) Research involves incorporating many sources to understand a research question;

(2) Sources support subtopics to prove the research statement and/or answer research question;

(3) Synthesis integrates information from two or more sources to demonstrate how the researches work together.

The researchers designed five steps for research synthesis based on Cooper and Hedges [2] and Kaewsaiha and Ohama [3]in the following:

Stage 1 Problem Formulation,
Stage 2 Literature Search,
Stage 3 Data Evaluation,
Stage 4 Data Analysis, and
Stage 5 Interpretations of Results.

This study focused on 'developing mathematical reasoning skills' in three factors: (1) roles of teachers and learners, (2) active learning activities, and (3) learning environment. They were included 'Basic Reasoning', 'Critical Reasoning', and 'Creative Reasoning' for designing action research framework.

DATA COLLECTION

There were two objectives of this study: (1) to synthesis teaching and learning research related to reasoning skills, and (2) to construct framework for developing teaching and learning high school mathematics based on mathematics teaching and learning research. The researchers collected quantitative data and qualitative data as follows:

1. Quantitative Data: To synthesis teaching and learning research related to reasoning skills,
2. Qualitative Data: To construct framework for developing teaching and learning high school mathematics based on mathematical reasoning skills from synthesis research.

DATA ANALYSIS

Researchers analyzed quantitative data for Objective 1 and qualitative data for Objective 2 as the following details:

Objective 1: The researchers applied descriptive statistics by calculating the percentage of prior research related to mathematical reasoning skills (basic reasoning, critical reasoning, and creative reasoning) in three factors: (1) roles of teachers and learners (RTL), (2) learning activities (LA), and (3) learning environment (LE).

Objective 2: The researchers designed framework for developing teaching and learning high school mathematics based on mathematical reasoning skills from synthesis research. This framework was evaluated for content validity from ten lecturers in Mathematics Education Program and Practicum Schools.

IV. RESEARCH FINDINGS

OBJECTIVE 1:

Overall, 18 prior research related to teaching and learning for development students' mathematical reasoning skills were synthesized. The results of the percentage of studies applied three types of reasoning (basic, critical, and creative) and three factors influencing on mathematical reasoning skills were shown in Table 1.

Table 1
Distribution of Number of Studies for Types of Reasoning and Factors. (N=18)

Types of Reasoning (number of studies)	RTL		LA (number of studies: N=18)	LE (number of studies: N=18)
	Active	Passive		
Basic (n_1=6)	4	2	Game (4)	Activity Sheet (1)
Critical (n_2=6)	5	1	Questioning (7)	Participation (10)
Creative (n_3=6)	6	-	Task Situation (3)	Real-life Context (1)
			Practice and Test (2)	Textbook-Based (1)
			Software (2)	Technology-Based (5)
Total	15	3	18	18

The results in Table 1 showed the mode of prior research published in 2001- 2018. There were 15 studies (83.33%) applied active learning approach, and the other 3 studies (16.67%) applied passive learning approach. The popular learning activity was 'Questioning' with the percentage of 38.89%. For learning environment, the result showed that 'Participation' was high percentage of usage with 55.56%.

OBJECTIVE 2:

The researchers designed the framework according to the results for Objective 1 in Figure 2.

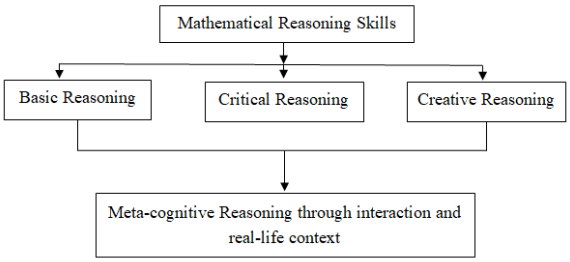

Figure 2: Framework for Developing Mathematical Reasoning Skills

DISCUSSION

The results showed that the researchers of prior research preferred to apply the active learning approach in developing students' mathematical reasoning to solve the problems. Synthesis of prior

research shows the benefit of active learning can have upon students' learning outcome which is consistent with Freeman et al. [8] and Prince [9].

LIMITATIONS

In this study, the researchers found a few research related to teaching and learning mathematical reasoning in problem solving for high school classroom setting. Some research emphasize on pre-service and in-service training and some research focus on teaching undergraduate students in learning mathematics and the same discipline subjects.

RECOMMENDATION

For further study, the researchers may divide the topic in different categories, not only types of reasoning or factors to support teaching and learning mathematical reasoning.

CONCLUSION

Based on the results of this study, the researchers conclude that mathematics teachers should make decision to select diverse methods in fostering or developing mathematical reasoning by applying active learning and real-life situation to engage students.

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