Development of Mathematical Learning Model Using Activity-Based Learning

Assoc.Prof.Dr,Yupadee Panarach

Faculty of Education, Kamphaeng Phet Rajabhat University, Thailand.
E-mail: yupadee.kpru@gmail.com

Abstract: The purposes of this research were to 1) develop the mathematical learning model using activity-based learning, 2) study learning outcomes after using mathematical learning model using activity-based learning. The samples were 28 pre-service teachers in mathematics program who participated in creating and developing the model, and 29 seventh grade who learned mathematics with the mathematical learning model using activity-based learning. The research instruments were the process of action research, the mathematics achievement test, the work commitment questionnaire, and the attitude toward mathematics questionnaire. The data were analyzed by mean, standard deviation, t-test dependent ($p<.05$), and content analysis. The results found that: 1) the mathematical learning model using activity-based learning was a process of learning management focusing on allowing students to practice individually and in groups in order to be able to create ones' own knowledge from the practice. Competition activities between groups were organized to encourage joyfulness which everyone had an opportunity to present knowledge. Students were also given compliments and encouragement which helped boost their self-esteem. The five steps of the mathematical learning model using activity-based learning included preparation, learning, group activities, competition, and summarization and compliment; 2) the seventh graders' mathematics achievement after receiving the mathematical learning model using activity-based learning was higher than the criteria of 60 percent at .05 level of significance. Overall, their level of work commitment and attitudes toward mathematics were considered high. Moreover, it was found that the pre-service teachers had abilities to manage learning in terms of designing learning management, developing lesson plans, developing materials and equipment, constructing a learning behavior questionnaire for learners, and learning the role of teachers from teaching practice and observing classroom teaching

Index Terms: mathematical learning using activity-based learning, mathematics achievement, attitudes toward mathematics, work commitment, action research

1. Introduction

Mathematics plays a key role in the success of 21st century learning as it empowers humans to be creative, be able to think logically and systematically, be able to analyze problems or situations carefully and thoroughly, be able to predict and make a decision when solving problems appropriately, and be able to apply knowledge in real life effectively. In addition, it is also a tool for studying science, technology, as well as other sciences which lays foundations for the quality human resource development of the nation [4]. In order to initiate learner development in learning mathematics as planned, teacher quality in terms of knowledge and ability in learning management should correspondingly be developed [1]. Accordingly, these are to support students to learn and develop to reach their full potential. The guidelines for developing teachers to be able to provide various quality learning management includes Teachers and Educational Personnel Enhancement Based on Mission and Functional Areas as Majors (TEPE Online), Professional Learning Community (PLC) and Active Learning [2]. The cooperation focuses on the process of planning (Plan), practice (Act), observation of results from practice (Observe) and reflection (Reflect) [12] which emphasizes on improving work performance that relies on the participation of researchers and coresearchers to put the process into practice [6].

From the aforementioned reasons, the development of learning management model deriving from cooperation in learning design, implementation, observation and reflection for further improvement leads to learning management methods that allow learner development toward the expected learning behaviors. Reflection enables teachers to understand the learning management process and be able to adjust to suit learners accordingly.

2. Research Objectives

1. To construct the mathematical learning model using activity-based learning.

2. To study learning outcomes after implementing mathematical learning model using activity-based learning.

3. To develop the mathematical learning model using activity-based learning.

3. Research Methods

A. Populations and Samples

The population is divided into 2groups were:

1. Pre-service teachers in mathematics program, Faculty of Education, Kamphaeng Phet Rajabhat University from the first to fourth year who participated in constructing and developing the learning model using activity-based learning and being studied on the ability to manage learning after developing the learning model using activity-based learning. The sample was 28 third-year students in the second semester of the academic year 2018 who were selected by purposive sampling from students who enrolled in Teaching and Learning Algebra in School course. The course was instructed by integrating teaching and learning with research and academic service.

2. The seventh graders from three classrooms of Chakungrao Wittaya School who received the learning model using activity-based learning. The sample was 29 of them selected by cluster random sampling.

B. Research Instruments

The research instruments included:

1. The action research process used to construct and develop the learning model using activity-based learning with four steps as follows:

Step 1: Planning (Plan: P) which was finding the mathematical learning model using activity-based learning with four steps as follows:

1.1 Planning (Plan: P) which was designing the mathematical learning model using activity-based learning, determining its suitability, developing lesson plans and developing materials and equipment.

1.2 Practice (Act: A) and observation (Observe: O) which was the application of the learning model in a simulated situation with the sample group of university students by dividing the students' roles as teachers, students and observers.

1.3 Reflection (Reflect: R) which was proceeded after teaching and learning with the simulation of each lesson plan.

Step 2: Practice (Act: A) which was an implementation of the mathematical learning model by using activity-based learning to arrange teaching and learning activities for seventh graders who were the sample group, conducted five times, each time with 3 steps as follows:

2.1 Planning (Plan: P) which included preparing lesson plans and materials and equipment for students, and assigning instructors and observers of each class.

2.2 Practice (Act: A) and observation (Observe: O) which included implementing the mathematical learning model by using activity-based learning with seventh graders, each class with one teacher and three observers.

2.3 Reflection (Reflect: R) which proceeded after the teaching and learning of each lesson plan by students as instructors assessed their teaching and students as observers assessed the teaching, following by the improvement of the lesson plans.

Step 3: Observation (Observe: O) which was proceeded after implementing every lesson plan including the distribution of mathematics learning achievement test, work commitment questionnaire, and attitude towards mathematics questionnaire.

Step 4: Reflection (Reflect: R) which was the analysis of results from Step 3 to determine students' learning and reflect strengths and weaknesses of the mathematical learning model by using activity-based learning.

2. The instruments for studying the learning outcomes after the implementation of the mathematical learning model by using activity-based learning including:

2.1 The mathematics achievement test which was validity analyzed by index of item – objective congruence (IOC) between 0.67 to 1.00, reliability analyzed by Kuder-Richardson 20 (KR-20) was 0.67, difficulty value (p) between 0.30 to 0.73, and discrimination value (r) between 0.20 to 0.60.

2.2 The work commitment questionnaire which was validity analyzed by index of item – objective congruence (IOC) between 0.67 to 1.00, and reliability analyzed by Conbach's Alpha was 0.85.

2.3 The attitude toward mathematics questionnaire which was validity analyzed by index of item – objective congruence (IOC) between 0.67 to 1.00, and reliability analyzed by Conbach's Alpha was 0.81.

3. The ability in conducting learning activities which was a questionnaire about learning management, development of lesson plans, development of materials and equipment, development of learners' behavior evaluation instruments, and classroom learning management which was evaluated of the validity and reliability by experts and adjusted accordingly, also piloted with pre-service teachers in mathematics program which shown to

have clarity.

C. Data collection

The data collection applied the action research practice as follows:

Step 1: Planning (Plan: P), finding a mathematical learning model using activity-based learning by:

1.1 Planning (Plan: P) included organizing a meeting to find an activity-based learning model, evaluating and improving the model, constructing lesson plans, and developing materials and equipment as follows:

1) Organize a workshop for researchers and pre-service teachers in mathematics program to find a mathematical learning model using activity-based learning.

2) Have the mathematical learning model using activity-based learning evaluated by three experts of teaching mathematics.

3) Improve the activity-based learning model as suggested by experts.

4) Develop lesson plans based on the activity-based learning model and prepare materials and equipment for each lesson.

1.2 Practice (Act: A) and observation (Observe: O) included providing teaching and learning activities according to the activity-based learning model by using simulations, each lesson was with one instructor, three observers and 15 students.

1.3 Reflection (Reflect: R) included organizing a workshop after each lesson for the lesson to be evaluate by the instructor, observers and students, following by improving the learning management model, lesson plans and materials and equipment.

Step 2: Practice (Act: A) was the implementation of the mathematical learning model using activity-based learning on the sample group, the seventh graders, for five times, each time with the following procedures.

2.1 Planning (Plan: P) included organizing a meeting to check understanding among the pre-service teachers who was instructor and observers of each lesson, rechecking and preparing lesson plans, materials and equipment for learners, and making an appointment to travel to the school.

2.2 Practice (Act: A) and observation (Observe: O) included conducting teaching and learning activities according to the mathematical learning model using activity-based learning on seventh graders with one instructor and three observers for each lesson.

2.3 Reflection (Reflect: R) was conducted after each session of the implementation as a meeting to exchange knowledge by having the pre-service teacher as instructor reflecting themselves and the pre-service teachers as observers reflecting the teaching. Thereafter, the lesson plans were being revised.

Step 3: Observation (Observe: O) after implementing every lesson plan, the mathematics achievement test, the work commitment questionnaire and the attitude towards mathematics questionnaire were distributed to students.

Step 4: Reflection (Reflect: R) a workshop was arranged to analyze the learning outcomes and reflect strengths and weaknesses of the mathematical learning model using activity-based learning. Then the pre-service teachers did the questionnaire about the ability in conducting learning activities.

D. Data

1. The mathematical learning model using activity-based learning and the ability in conducting learning activities were analyzed by using content analysis.

2. The learning outcomes were analyzed as follows:

2.1 The results of mathematics learning achievement test were analyzed by comparing the average score with the criteria of 60 percent by using t-test one sample.

2.2 The results of attitude towards mathematics questionnaire and work commitment questionnaire were analyzed by using mean and standard deviation.

4. Result

1. The steps of the mathematical learning model using activity-based learning construction were as follow:

1.1 Planning (P): The activity-based learning model composed of features of mathematics instruction by using activity-based learning. Learners constructed their knowledge from practicing throughout the learning process from

individual and group activities. The competition between groups created joyful learning atmosphere. The steps of mathematical learning model using activity-based learning composed of five steps: preparation, learning, group activities, competition and summarization and compliment. The approval of the experts, it was found that the mathematical learning model using activity-based learning was appropriate for further application. Suggestions for writing lesson plans and preparation before teaching were as follows:

1) There should be a variety of warm-up activities in each. The activities should be emphasized on having fun in order to encourage students to be interested in and be ready for the lesson.

2) Teaching and learning materials in the learning step should be big enough for everyone, or every student should get to practice. It is suggested that questions should be used to encourage students and every student should have a chance to answer. When posing a question, it is suggested that teachers should wait for answers from learners before providing answers. If it is found that students misunderstand, the teachers should provide further instruction until they clearly understand the content.

3) When dividing learners into groups, it is suggested that they should be divided to be mixed in terms of gender and ability.

4) During group activities, teachers should design learning activities that involve every student in each group and encourage participation from everyone in the group.

5) During competition session, teachers should allow students' work to be displayed around the classroom, not just on the board so students are able to visit the work as they prefer. The board is recommended to be used for writing additional explanation.

6) Mind maps which present a summary of each group and each kind of content should have a display spot in the classroom or be collected in a portfolio in order for students to be able to revisit the content of their group and other groups.

1.2 Act (A) and Observe (O): The results of the employing five lessons of instructional activities using activity-based learning and stimulations with one instructor, three observers, and 15 students were being reviewed after each lesson.

1.3 Reflect: Meetings were arranged to review and improve instructional activities in each step as follows:

1) Preparation: In this step, learners were prepared by doing mindful activities following by reviewing background knowledge. They also participated in presenting how to find the answers.

2) Learning: Learners learned content accompanying by materials, questions and activities to develop knowledge which they took part in presenting how to find the answers.

3) Group activities: Learners were divided into a group of 3-4 by mixed genders and ability. Each group participated in finding answers which was the way to implement knowledge in new situations. Instructors prepared materials and equipment for every group and encouraged learners in each group to participate in finding answers.

4) Competition: Instructors prepared questions equal to the number of group members. Then, each member was responsible for each item and cooperated to find the answers within the time limit. After that, they displayed their work in the allocated area. The first group then explained the answers and other groups with different methods shared their answers.

5) Summarization and compliment: Learners summarized the content learned and presented through mind maps by displaying in the allocated area. Instructors gave compliments to the group with highest score and encouraged groups with lower scores.

2. Results of using the mathematical learning model using activity-based learning were as follows:

2.1 The seventh graders' mathematics learning achievement after receiving the instruction of the mathematical learning model using activity-based learning was significantly higher than the criteria of 60 percent at the significance level of .05. The results were presented in Table I.

2.2 The seventh graders, overall, had highly positive attitudes towards mathematics. When investigated by items, it was found that students viewed that "mathematics can be used in everyday life" highest, following by "mathematics is a useful subject". The results were presented in Table II.

2.3 The seventh graders had high work commitment. When investigated by items, it was found that "students pay attention to their assignments" and "students are proud of their work" had the highest average score, following by "students are determined to work on their assignments", "students try to solve problems in order to complete

tasks", "students study and try to understand the content before starting working" and "students try to improve and develop their work by themselves" respectively. The results were presented in Table III.

Additionally, it was found that the pre-service teacher had ability in designing instructional activities, developing lesson plans, developing materials and equipment, constructing learner's learning behavior evaluation form, and they more understand teacher role.

Table I Results of mathematics learning achievement of seventh graders after implementing the mathematical learning model using activity-based learning

	μ	$\bar{X}$	S.D.	t	Sig.
Mathematics Learning Achievement	15.00	16.41	2.83	2.69	.01

Table II Mean ($\bar{X}$) and standard deviation (S.D.) of seventh graders' attitudes towards mathematics after providing instruction by using the mathematical learning model using activity-based learning.

Attitudes towards Mathematics	$\bar{X}$	S.D.	Meaning
1. Mathematics is a useful subject.	3.83	0.80	highly positive
2. Students love to solve problems related to mathematics.	3.59	0.68	highly positive
3. Students do mathematics exercises by themselves.	3.52	0.63	highly positive
4. Students can explain the content or mathematics exercises to their friends.	3.66	0.61	highly positive
5. Mathematics is a subject that helps us to be reasonable.	3.69	0.76	highly positive
6. Students feel that learning mathematics is fun.	3.66	0.72	highly positive
7. Students check the correctness of mathematics exercises.	3.59	0.68	highly positive
8. Students answer teacher's questions during mathematics class.	3.66	0.61	highly positive
9. Mathematics is a subject that helps us to think systematically.	3.66	0.77	highly positive
10. Students love to study mathematics.	3.79	0.68	highly positive
11. Students learn more about mathematics.	3.66	0.72	highly positive
12. Students participate in mathematics-related activities.	3.72	0.70	highly positive
13. Mathematics can be used in everyday life.	3.86	0.83	highly positive
total	3.65	0.72	highly positive

Table III Mean ($\bar{X}$) and standard deviation (S.D.) of seventh graders' work commitment after providing instruction by using the mathematical learning model using activity-based learning.

Work Commitment	$\bar{X}$	S.D.	Meaning

1. Students pay attention to their assignments.	4.41	0.50	high
2. Students are determined to work on their assignments.	3.72	0.59	high
3. Students are responsible for their work.	3.59	0.68	high
4. Students study and try to understand the content before starting working.	3.69	0.66	high
5. Students try to complete the task in time.	3.55	0.63	high
6. Students are dedicated to doing their assignments.	3.52	0.63	high
7. Students are patient and do not give up on any problems.	3.55	0.63	high
8. Students try to solve problems in order to complete tasks.	3.72	0.65	high
9. Students try to improve and develop their work by themselves.	3.69	0.76	high
10. Students are proud of their work.	4.41	0.50	high
total	3.79	0.70	high

3. Development of the mathematical learning model using activity-based learning consisted of processes as shown in Figure 1.
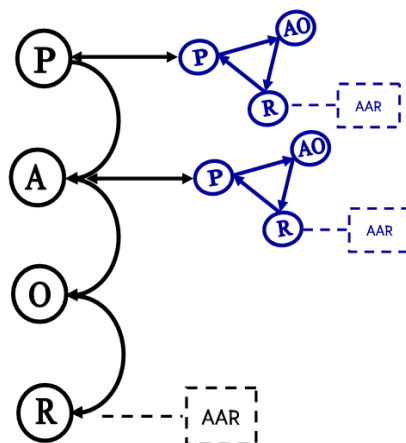
Figure 1 Process of development of mathematical learning model using activity-based learning

The mathematical learning model using activity-based learning was resulted from action research process. In step 4 Reflect (R), it was found that:

1. The mathematical learning model using activity-based learning was resulted from action research process. In step 4 Reflect (R), it was found that: The mathematical learning model using activity-based learning was an instructional process which emphasized on allowing learners to practice individually and in groups in order to develop the knowledge. The competition between groups created joyfulness. Everybody had an opportunity to present their knowledge. Compliments from the instructors encouraged them to be proud of themselves. The five steps of the instructional activities included:

Preparation stage: In this step, learners were prepared by doing activities with movements which emphasized on mindfulness following by reviewing background knowledge. They also participated in presenting how to find the answers. It was suggested that instructors should prepare different kinds of activities for each lesson.

Learning stage: In this step, learners learned new content individually. The explanation was presented with materials, questions and activities to present the method and answer. Learners were able to develop knowledge by themselves. It was suggested that instructors should check whether every learner understood the content.

Group activities stage: Learners were divided into a group of 3-4 by mixed genders and ability. Each group participated in learning and finding answers which was the way to implement the knowledge in new situations.

Instructors prepared materials and equipment for every group and encouraged learners in each group to participate in presenting methods and finding answers.

Competition stage: Members of each group shared responsibility in presenting methods and finding answers within the time limit. Then, the responsible person displayed the work as specified by the instructor. The answer of the first group that finished was explained by the responsible person. Other groups with different methods also shared the answers. It was suggested that the instructor clearly state the score for the group that finished first and other following groups. Additionally, exercise should be prepared enough for the members of each group.

Summarization and compliment stage: Learners summarized the content learned and presented the concept of the group through mind maps and displayed in the allocated spot. The instructor then concluded scores and provided compliments to the group with highest score and encouraged groups with lower scores.

2. Teachers' roles.

2.1 Prepare activities that focus on practicing mindfulness for Preparation stage.

2.2 Prepare media for learning management.

2.3 Prepare tests for competing activities.

2.4 Encourage students to participate in group activities.

2.5 Advice and explain further for the learners to complete learning.

2.6 Examine the students' concepts while they present and teacher should pay attention to every concept in order to find the answer.

2.7 Appreciate and encourage learners who do well and who have not.

3. Students' roles.

3.1 Punctual of attend class in order to continue doing activities.

3.2 Responsible for the assigned work.

3.3 Cooperate and help each other in the group.

3.4 Present a way of thinking in finding answer.

3.5 Summarize knowledge creatively and present it with a mind map.

4. Advantages.

4.1 Promote punctuality because the activity prepares students to study by allowing the students to move their bodies, express their gestures by using the music or rhythm. The learners feel fun and want to participate and complete activities.

4.2 Learners' understanding can be checked by the competition. Everyone was responsible for taking the test and helped each other in the group complete the test with in the time limit. They want their group to get the highest score possible.

4.3 Promote responsibility for learners because they have to complete the tasks assigned to them.

4.4 Promote teamwork because everyone has to help each other complete activities on time.

4.5 Promote mathematical communication skills because everyone has to explain their assignments.

4.6 Encourage an enthusiasm for learning because the score is different points for the correct answer but it takes the same time. The learners will be willing to work.

4.8 Summarizing of group concepts using mind map helps learner better understand the process of creating knowledge.

4.9 The work in each group which is shown at different area in the classroom. Learners are able to review as often as they like.

5. Restrictions.

The activities used in the preparation stage that emphasize on mindfulness must be unique. Because it will not stimulate the interest of learner.

6. Suggestions.

6.1 Teachers should control the time of learning activities in each stage. Because each learning stage may take a lot of time especially in the competition stage.

6.2 Setting points in competition stage should be clear and informed the learner beforehand, which may different scores for each item by consider the difficulty of the content in the item test.

6.3 Rules should be established so that everyone in the group can represent equally easy and difficult items test.

5. Discussion

1. The construction and development of the mathematical learning model using activity-based learning by applying the action research process was a continual process composed of planning, practice, observation and data collection, and reflection. As action researchers are educators who involved with continual research problems, there is a need for them to construct more knowledge. Action research as the lessons learned are used to develop new questions for better practice. Therefore, action researchers are involved in practice, data collection, reflection and implementation to increase or improve the practice [3]. Educationally, action research objectives are to develop teaching and learning and finding solutions to the problem. Research methodology involves the process of searching for knowledge with reflection of the results. It also allows stakeholders to comment the practice and results. The process is being run in cycle and becomes part of the practice. The results then lead to the improvement of the practice [10]. When applied to education, the focus has become increasing the academic results and improving learners' learning behaviors [7].

2. The results after the implementation of the mathematical learning model using activity-based learning found that the seventh graders had mathematics achievement higher than the criteria of 60 percent at the significance level of .05. Their overall work commitment and attitudes towards learning mathematics was high. The results were considered deriving from steps of research-based instruction starting from preparing learners, reviewing content, allowing individual learning, leading group learning, allowing students to present and compete, to letting learners summarize learned concept using mind maps. These considered greatly enhance learners' understanding of mathematics content. When each learner was responsible for their work and collaborated with group members to achieve the tasks as fast as possible in order to gain highest score enhanced learners' work commitment and attitudes towards mathematics. The results were consistent with characteristics of activity-based learning. To illustrate, learners were active and enthusiastic in developing their cognitive domain which they were encouraged to develop their own knowledge rather than relying on their teachers [11]. As in [9] found that after implementing flipped classroom by using activity-based learning, students' posttest score was significantly higher than their pretest score at the significance level of .01. Their determination was considered high. As in [8], also found that bachelor's students academic results after implementing activity-based instruction was significantly higher at the level of .01 comparing to before the implementation by using the 60 percent criteria. In terms of attitudes and satisfaction, students were satisfied and eager to learn. The learning enhanced their skills and provided practical knowledge. They also had opportunities to exchange knowledge with their classmates. Moreover, As in [5] found that students' attitudes towards mathematics, achievement motivation and mathematics learning behaviors after the implementation of activity-based instruction was significantly higher than before the implementation. The scores were also higher than students who received regular instruction at the significance level of .05.

Additionally, it was found that the teacher students were able to provide instruction in terms of designing instructional activities, developing lesson plans, developing materials and equipment, constructing learner's learning behaviors evaluation form, learning teacher roles from teaching practice and observation in classrooms. As the students had had full participation in the development of the instruction, from constructing and validating the instructional practice to developing the lesson plans which were piloted using simulations and were reflected before the implementation. Throughout the process, students learned from practice and observation in authentic situations allowing them to understand teacher's roles and classroom situations which can be applied to their future career.

6. Recommendations

A.   Recommendations for Practices

1. For mindful activities during the introduction of the lesson, instructors should practice to become skillful. The pace of the activity should start from slower to faster in order for learners to be focused on the activity.

2. Materials accompanying the lessons should be prepared as worksheet in order for learners to review later.

3. Quizzes given to each group should be printed in different colors and the presentation of the answers should be identified clearly, for example, arranging from top to bottom or left to right according to the order of completion.

4. Provide scores to everyone who are able to present the correct methods, but with different weight, to motivate students to work together as a group.

5. Mind maps of the summary of each group should be posted up in different sections of the classrooms for a certain period of time so students are able to learn and review accordingly.

B.   Recommendations for Further Research

From the advantages of this learning model, interested person should study the mathematical skills and processes and other desirable attributes such as responsibility, team work, or self-esteem by apply mathematical learning model using activity-based learning.

7. Conclusion

The mathematical learning model using activity-based learning is the learning model which encourages the learner enthusiastic, fun, and ready to help each other. This learning model provides learning process, teachers' roles, students' roles, advantages, restrictions, and suggestions which are support learning management to the most benefit with the learner.

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