The Open-Ended Problem Solving in Mathematics Class of Grade 6 Students

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ABSTRACT

The objective of this research was to study the result of open-ended problem solving methods in mathematics class instruction of Grade-6 students. Three open-ended problem solving activities had been implemented, including those activities related to geometry, arithmetic and problem solving skills, with 61 grade-6 students of Wat Chang Lek and Ras Padung Pol schools. The data collecting tools included evaluation and scoring criteria form, learning efficiency evaluation form and mathematic learning attitude evaluation form. The statistics tools included average value, standard errors, data presentation (table and descriptive). In learning efficiency comparison, the statistics term "*t*" was employed to compare learning efficiency of two groups of students. The result indicated that there was no difference in learning efficiency between two methods while the attitude in mathematics learning, with open-ended problem solving method, of the students in the experimental group was in "*strongly agree*" level. The thinking behavior, in problem solving by each aspect, of students in the same experimental group (in both small sub groups and individual) was in "good" level.

Key Words : open-ended

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1 Introduction

In the past two decades, educational mathematicians seriously concentrated on the role of problem solving techniques, in mathematics curriculums, for students' problem solving skill development. Siriporn Thipkong [1] and Wilson, etal[2] stated that problem solving is one of instructing methods that is able to be implemented as activities for encouraging students to learn the facts about and mathematical processes. Those activities are established through problem solving lessons. The problems are established as center for students to explore and discover. The most appropriate type of problems is open-ended type, which has wide varieties of answer and ideas in determining for the answer. The open-ended instruction has potential in expediting students into the essence of learning process. This would result in mathematical learning process from real world practicing. The epen-ended problems would encourage students to describe their own ideas in problem solving process (A Pearson Education Company, 2001[3]) and should lower the clearance between actual instructing and curriculum perspective. The problem solving is also defined as the essence of mathematic curriculum and as fundamental objective of mathematic learning and instructing by the fundamental education curriculum, announced in 2001. The learners are encouraged for diverse ideas by instructors. The defined problems or scenarios should be open-ended problems, which are able to induce diverse opinions and reasons. This could develop skills / five processes of learning (IPST., 2002 [4]). From those reasons stated previously, researchers were interested in experimenting the supplement open-ended problem solving activity in instructing grade-6 mathematic classes. The objectives are to evaluate the learning related thinking behaviors and to determine efficiency and attitude toward learning, under open-ended problem solving circumstance, of grade-6 students.

2 Material and Methods

This research is an experimental studies performed with 63 of grade-6 students in 2nd semester of 2003 academic year. Of these 63 students, 37 students are from Wat Chang Lek school and 26 students are from Ras Padung Pol school.Both schools are under superintendence of City of Bangkok School District, Ministry of Education. All 63 students was sorted based on the same range of average mathematic classes score from the first semester.

Research tools are established from the literature revision of researches those related to variables of this research including open-ended problems for elementary education, problem solving thinking behaviors, observations, problem solving strategies, implemented fundamental mathematical knowledge, flexible

ideas, creative ideas, ideas communication in learning efficiency problem solving, and attitude toward learning and instructing mathematics with open-ended problem solving activities.

Research tools consist of two parts. First, the experimental tools those include instructing materials with supplement open-ended problem solving activities for grade-6 students. The instructing material content consists of three research topics including geometry, arithmetic skills and problem solving with 50-minute period in each topic. The content was issued and consequently audited by two specialists for appropriateness and content accuracy, for further improvement. Second, data collecting tools, included evaluation forms and scoring criteria for problem solving thinking behavior which consisted of record form for thinking behaviors analysis. Those analyzed thinking behaviors included problem observation, problem solving strategy implementation, implementation of fundamental mathematics knowledge, flexible ideas, creative thinking and ideas communication in problem solving. The analysis was analyzed from activities performed followed by activity sheet and consequently presented verbally during in-class problem solving activities. The overview of scoring levels are 0 for "need improvement", 1 for "fair", 2 for "good" and 3 for "very good" (Preecha Nowayenpol : 2001)[5].

The objective of learning efficiency evaluation form is to evaluate skill and learning ability in geometry, arithmetic skills and problem solving skills after class period. The form consists of 16 of multiple choice questions and 4 of descriptive questions with 20 points in total score (one point for each question) and have 0.68 in easiness average value, 0.246 discriminant index average value and 0.84 accuracy coefficient. The mathematics learning attitude questionnaire consists of two parts. The first part is the learner status questionnaire, which consists of :

1. Closed-end check-list form and only one acceptable answer for each question (as learner's actual status) is permitted, used for observing each learner about gender, age and grade at the first semester of 2003 academic year.

2. Opened-end form with three uestions.

The second part is mathematic learning method, with opened-end problem solving activities, observation form. This form is designed as questionnaire for observing satisfactory in learning method with opened-end problem solving activities that consists of 10 questions and is rating-scale questionnaire with five(5) scales (5 for "strongly agree", 4 for "agree", 3 for "not sure", 2 for "not agree" and 1 for "strongly not agree"). In research tools testing and analysis, the observed questionnaires were evaluated for Cronbach's alpha confident value, which were at 0.89 and were considered as good and acceptable. In data collecting,

researcher needed to perform data collecting as following process :

2.1 Evaluate midterm score of 6-grade students, of the first semester of academic year 2003, for fundamental mathematic knowledge with independent t-test. The data was analyzed for equality among sampling groups, which were 37 students from Wat Chang Lek School and 26 students from Wat Ras Padung Pol School. Both schools are under superintendence of City of Bangkok School District, Ministry of Education and students from both schools are grade-6 students.

2.2 Perform simple sampling from all 63 and categorized into two groups. The first group was instructed with only conventional method and the second group was instructed with supplement opened-end problem solving activities.

2.3 Experiment by assigning supplement opened-end problem solving activities for the first group and assigning three(3) 50-minute learning period of conventional instructing method. The first group, with assigned supplement opened-end problem solving activities, was decentralized into small sub groups for brainstorming as following procedures:

a. Arranging all students in this group by learning efficiency score level of the first semester of 2003 academic year, start from the highest to the lowest.

b. Grouping all students into 4-6students in each group by arranged learning efficiency score level. Student with highest score was in the first sub group and student with second highest score was in the second sub group, consecutively until the last sub group, then arranged the remaining students, as previous process, reversely from the latest sub group back to the first subgroup until all students were sub grouped.

2.4 During learning period, observed and evaluated students' problem solving thinking behaviors of students in the first group by employing problem solving thinking behavior evaluation form.

2.5 Performed post learning test for students in the first group after one experimental week by employing mathematic learning efficiency evaluation form.

2.6 Observed learning attitude of students in the first group by employing learning attitude evaluation form.

2.7 Analyzed and discussed data obtained from all employed research tools. Data Analysis

2.7.1 Data obtained from problem solving thinking behaviors observation form, in term of exploration, problem solving strategies implementation, fundamental mathematical knowledge, flexible thinking, creative thinking and problem solving ideas communication, were analyzed for average

score, of each experimental group, for each aspect of problem solving thinking behavior. Scoring scales, as referred to the suggestion of Boonchom Srisa-ard [6], are 0.00-0.49 for "need improvement", 0.50-1.49 for "fair", 1.50-2.49 for "good" and 2.50-3.00 for "very good".

2.7.2 Data from the evaluation of learning attitude toward mathematic courses was categorized for frequency, means, standard deviations. Scoring scales, as referred to the suggestion of Boonchom Srisa-ard, are 1.00-1.49 for "strongly disagree", 1.50-2.49 for "disagree", 2.50-3.49 for "not sure", 3.50-4.00 for "agree", and 4.50-5.00 for "strongly agree". Any students in experimental group with scoring scale from 3.50 or higher would be considered "good" level.

3 Results and Discussion

From the research in implementing supplement open-ended problem solving activities in mathematic classes of grade-6 students, data and results is presented in three(3) parts as the following:

3.1 Data from open-ended problem solving thinking behaviors observation form is analyzed by average value, standard deviation, frequency and percentage. In open-ended problem solving thinking ability evaluation, the result is presented separately in two parts : Actual condition evaluation of open-ended problem solving thinking ability, from experimental activity 1-3 (subgrouping) and actual condition evaluation of open-ended problem solving thinking ability, from experimental activity 1-3 (individual).

3.1.1 Actual condition evaluation of open-ended problem solving thinking ability, from experimental activity 1-3 (subgrouping) : The results are as following Open-ended problem solving thinking behavior in activity 1 : Overall result is in "good " level (1.788). As consider by individual terms, the open-ended problem solving in "very good" level is creative thinking (2.67), in "good" level are exploration and problem solving strategy implementation (1.56), and in "fair" level are fundamental mathematic knowledge and °exible ideas. Open-ended problem solving thinking behavior in activity 2 : Overall result is in "good " level (1.788). As consider by individual terms, the open-ended problem solving in "very good" level is problem solving ideas communication (2.67) follow by problem solving strategy implementation (2.56), in "good" level are fundamental mathematic knowledge and creative thinking (2.44), exploration (2.22) and flexible ideas (1.89) respectively. Open-ended problem solving thinking behavior in activity 3 : Overall result is in "good " level (2.183). As consider by individual terms, every terms are in "good" level include problem solving strategy implementation and fundamental mathematic knowledge (2.44), followed by flexible thinking (2.22), creative thinking (2.11), exploration (2.00) and problem solving ideas communication (1.89)

respectively. Open-ended problem solving thinking behavior in all activities from 1 to 3 : Overall result is in "good " level (2.113). As consider by each individual term, all terms are in "good" level include creative thinking (2.41), problem solving strategy implementation and problem solving ideas communication (2.19), exploration (1.93) and flexible thinking (1.85) respectively.

3.1.2 Actual condition evaluation of open-ended problem solving thinking ability, from experimental activity 1-3 (individual) : The results are as following Open-ended problem solving thinking behavior in activity 1 : Overall result is in "good " level (2.08). As consider by individual terms, all terms are in "good" level include exploration and problem solving idea communication (2.15), follow by problem solving strategy implementation (2.10), fundamental mathematic knowledge (2.08), flexible thinking (2.05) and creative thinking (1.95) respectively. Open-ended problem solving thinking behavior in activity 2 : Overall result is in "good " level (2.072). As consider by individual terms, all terms are in "good" level include problem solving ideas communication (2.20), follow by exploration (2.17), problem solving strategy implementation (2.10), fundamental mathematic knowledge (2.08), flexible thinking (1.95) and creative thinking (1.93) respectively. Open-ended problem solving thinking behavior in activity 3 : Overall result is in "good " level (2.23). As consider by individual terms, all terms are in "good" level include fundamental mathematic knowledge and problem solving ideas communication (2.35), follow by creative thinking (2.23), problem solving strategy implementation (2.15) and flexible thinking (2.07) respectively. Open-ended problem solving thinking behavior in all activities from 1 to 3 : Overall result is in "good " level (2.128). As consider by each individual term, all terms are in "good" level include problem solving ideas communication (2.223), follow by exploration (2.192), fundamental mathematic knowledge (2.167), problem solving strategy implementation (2.117), creative thinking (2.003) and flexible thinking (2.025) respectively.

3.2 The Learning Efficiency Analysis : The students' learning efficiency score, from both groups, indicate that the students in the first group, in which are instructed with supplement open-ended problem solving activities, has 10.83 in mean value, 3.382 in standard deviation. The learning efficiency score of students in second group, in which instructed with conventional instructing method, has 9.42 in mean value, 3.113 in standard deviation. The testing result at the 0.05 and 0.01 *** , between conventional instructing method and with supplement open-ended problem solving activities, indicated that the is 0.102, which is greater than 0.05 and 0.01, means the learning efficiency scores from both instructing

methods are not different from each other.

3.3 Mathematic learning attitude valuation of students in experimental group

3.3.1 Student status analysis : students are 19 female students (51.35%) and male 18 male students (48.65%). Among 37 students, 28 students are over 11 years old (75.68%), follow by 7 students who are 10 years old (18.92%) and only 2 students who are 12 years old (5.40%). In term of students' mathematic grade point (4-level grade), 10 students are in 1-grade level (27.03%), 7 students are in 3-grade level (18.92), 2 students are in 2-grade level (5.40%) and only one student is in 0-grade level (2.70%).

3.3.2 Learning attitude toward mathematic learning with supplement open-ended problem solving activities : The overview of students' opinions are averagely in "strongly agree" level. From informal students' interviewing, students want instructing method with supplement open-ended problem solving activities again. From the study, students' opinions are also averagely in "strongly agree" level. As consider by each individual aspects, which are in "strongly agree" level, instructing methods with supplement open-ended problem solving activities promoted learning enjoyment (4.86), follow by less boring atmosphere (4.76), creative thinking (4.65), less stress (4.62), better lessons' understanding (4.54), and initiation of students' problem solving thinking (4.51). The aspects which are in "agree level" are less confusion (4.32), better logical thinking (4.27), and better interesting in practicing (4.22) respectively.

4 Conclusion

The research result indicated that

1. The problem solving thinking behaviors evaluation of experimented students, regarding to exploration, problem solving strategy implementation, fundamental mathematic knowledge, flexible thinking, creative thinking and problem solving ideas communication, are all in "good" level in both in subgroup and individual.

2. Students, from both experimental group and non-experimental group, yielded no difference in learning effective score.

3. Students in experimental group possessed learning attitude toward mathematic learning with supplement open-ended problem solving activities in "strongly agree" level.

The study result indicated that the instructing method with supplement open-ended problem solving activities yield better learning atmosphere due to the open-ended thinking and solution format. Some problems may have more than one correct solution. Students learned more diversified solutions from each group presentation. Students exposed to the most appropriate solutions to those problems. Some existed mistake in each solution was assumed to be self learning, as the studies of Preecha

Nowyenpol [5] which indicated that the presentation of diversified solutions (with diversified ideas and solving methods) from each subgroup would encouraged students to learn new solutions from each other and implement for further other problem solving in the future. The instructor assistance, in term of ideas diversifying, fundamental mathematic knowledge reviewing, and problem solving process supplementing, were gradually and meaning fully conducted because those solutions, presented by students, could be the perfect examples. Class presentation promoted students to think and communicate their ideas systematically, as the study of Holms [7] which indicated that promoting students to implement their own thinking concept (which may different from those of adult) may feel improper, inappropriate, and inefficient for adults' point of view but may be the suitable method for students in term of better lessons understanding, explainable reasons, acceptable by instructor and able to communicate to others. The group thinking encouraged ideas exchanging and interpersonal assisting which resulted in better attitude and confidence in mathematic learning due to students' participation and group-acceptable proposed ideas. The study of Holms [7] also indicated that group problem solving activities in mathematic learning not only promoted students' problem solving skill and ability but also develop supportive attitude for problem solving as well. The individual assignment promoted students in terms of creative and independent thinking which resulted in learning and discovering the new experiences. These aspects are the essential components to indicate the students' efficiency in mathematical problem solving, and satisfy elementary (grade1-6) mathematic curriculum's objectives (2001). The conclusion that open-ended mathematical problem solving activities are probably applicable to grade-6 students in order to achieve mathematic learning and problem solving objective, is compatible to the studies of many other mathematicians. The important issue is no interference to learning effectiveness. However, instructors still have an important role in stimulating students to express their own ideas, especially weak students. The suggestion of Boondow[8] and Bell[9] stated that weak students need longer learning time but still able to success in friendly atmosphere from instructors and friends. The self learning activity participation, by actual practicing, expressing their own ideas, and their ideas are being acceptable would promote self confidence and appreciation to their own ability.

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