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Developing the Mathematics Learning Management Model for Improving Creative Thinking in Thailand

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Abstract

The study purposes were: 1) To study current states and problems of relevant secondary students in developing mathematics learning management model for improving creative thinking, 2) To evaluate the effectiveness of model about: a) efficiency of learning process, b) comparisons of pretest and posttest on creative thinking and achievement of students, and c) comparison of creative thinking and achievement between experimental group and control group. The model was created and implemented with grade eight students of secondary schools, in Thailand, and compared with control group, provided in traditional approach.

The research results were:

Most of relevant teachers didn't concentrate in mathematics learning for improving creative thinking, and lacked using strategies to engage divergent thinking. The model was designed through methodology of R&D, which was composed of: 1) principles and theoretical concepts, 2) learning objectives, 3) learning process, 4) social system, 5) principles of response, 6) the support system. Whereas, the activities in learning process consisted of 1) engagement and understanding prior knowledge, 2) encountering problems with thoughtful thinking, 3) analyzing alternative and investigating solutions, 4) modifying of thinking patterns, 5) concluding and evaluating for creative thinking.

The findings indicated that effectiveness of model based on achievement score was 76.25%, and based on creative thinking was 61.67%. The average posttest in learning achievement and creative thinking abilities of the experimental group were higher than pretest, and experimental group showed higher creative thinking than control group at the .01 level of significance.

Keywords: mathematics learning management model, creative thinking

1. Introduction

1.1 Introduce the Problem

Mathematics is the science of thinking and it is an important tool for improving the thinking potential in learning process and understanding causes and effects. Most of mathematics teachers in secondary schools in Thailand, lacked abilities to provide and focus on the importance of mathematics learning management for improving creative thinking, and students were not encouraged most their creative thinking ability through a problem based learning strategies. Normally, mathematics learning activities for secondary students were quite inefficient in improving students' creative thinking. Nevertheless, more of mathematics teachers were not really encouraged and supported to find new efficient strategies for improving creative thinking. Creativity has been described in many ways but a common theme is that a personal activity intent on producing something new and unpredictable (Pehkonen, 1997). Craft (2006) has suggested that fostering creativity with wisdom could help to nurture the learner's moral development. On such occasions, a teacher needs to clear the notion of creativity in general and creativity and problem solving in particular subject. The conceptions of creativity in school subject may affect what they do, their classroom climate, and what they value and reward (Esquivel, 1995). Thus, teachers in the UK and in other countries are being urged to foster creativity in children across all curriculum subjects, including mathematics (Bolden, 2012). However, only providing learners with open-ended problem solving opportunities can develop their fluency, flexibility and originality in problem-solving (Silver, 1997). Thus the act of problem solving that lies at the heart of students creativity in mathematics classrooms, and problem solving is

the important thing of effective learning and teaching of mathematics creativity.

1.2 Exploring Importance of the Problem

According to the PISA report (Program of International Student Assessment), the findings indicate the weak point of Thai students creative thinking ability in comparison with both the international and Asian students. The Institute for the Promotion of Teaching Science and Technology (IPST), reported the research project assessment on "Trends in International Mathematics and Science Study (TIMSS) in 2011, and the results showed that the average mathematics achievement score of the 8th grade students throughout Thailand was 427 points, which was less than in 2007 (441 points). The international mathematics score of the 8th grade students was 500 points, and the scores of the students from fourteen countries around the world were higher than the international scores, whereas, the scores of the students from forty two countries including Thailand were lower than the international score. The three highest Mathematics scores of the students have been from South Korea, Singapore and Finland, those were 587, 583 and 570 points respectively. Office of the Basic Education Commission of Thailand (2013). The author was aware of the problems of thinking skills of Thai students, and then applied the concepts of Metacognition, constructivist theories, Gestalt learning psychology, problem solving strategies, and inquiry approach to improve thinking skills of students that focused on creative thinking ability. The recent study on creative thinking development has not been successful according to the second report of the quality assessment of the basic education. The Office of the Basic Education Commission of Thailand (2006-2010) reported 25,944 schools (82.41%) have been qualified whereas, 5,536 schools (17.59%) have not been qualified yet. The report also identified that most students from the unqualified schools have problems of critical thinking, analytical thinking, creative thinking skills, and the overall thinking abilities of the students throughout Thailand are at a moderate level (83.91%). Additionally, The Office of Secondary Educational Zone 30 (2011) reported the results of external education quality assurance of eighteen schools in Chaiyaphum province, showed that thirteen schools were qualified, while five schools were not qualified. One of the key indicators of the failure was creative thinking of students. Thus, the relevant students in secondary level should improve creativity in mathematical learning. Beyond, Oksuz (2009) supported that the ability in mathematical thinking skills were necessary for solving mathematic problems effectively, and Mann (2005) suggests that mathematics learning should be emphasized on problem solving for students to work on rich mathematical tasks that require divergent thinking, and keeping students interested and engaged in mathematics by recognizing and valuing their mathematical creativity. Whilst mathematical learning activities in secondary level were inefficient in improving the creative thinking of students. Most mathematics teachers were not really encouraged and supported to find new effective strategies for improving the student abilities in creative thinking.

1.3 Describe Relevant Scholarship

More relevant researches indicate that the poor performance of students learning mathematical problem solving effectively, are not due to lack of adequate content knowledge, but rather to students' inability to organize, implement, and monitor what they already know (Sarver. 2006). Mathematics provide learners with basic skills in identifying causes and effects, thinking for correct answers, analytical thinking for problem analysis, using rules and algorithms to assess computing ability of learners (Ministry of Education, 2009). (Arieti, S, 2011) described that the characteristics of students with creative thinking are the ones who have creative thinking ability in creating and finding new strategies and solutions for problems. Whereas, Sanders (1966) believed that the creative person has a "questioning mind- a sensitivity to problems" and Newell, Shaw & Simon (1962) claimed that creativity is a special kind of problem-solving behavior and problem-solving is a vital part of mathematics learning management. Including Amabile's (1983) belief that componential conceptualization of creativity were domain-relevant skills, creative working and thinking skills, and intrinsic motivation, and Guilford (1950) defined creative pattern as manifest in creative behavior, which includes such activities as inventing, designing, contriving, composing, and planning. However, Guilford (1959) proposed characterizing a creative personality includes an individual's sensitivity to problems, ideational fluency, flexibility of a set, ideational novelty, synthesizing ability, reorganizing or redefining ability as in the sense of Gestalt psychology, span of ideational structure such as complexity intricacy of an individual's conceptual structure, and evaluating ability. Beyond, Feldhusen (1995) presented the relevant factors in creativity model as follows: (1) Metacognitive processing are the set of strategies or metacognitive skills for processing new information and for using the knowledge base that one has acquired; (2) The knowledge base are large and fluent knowledge base and mastery of skills in the particular domain; (3) Personality variable are composed of a set of attitudes, dispositions, motivations which were acquired from concerned persons, and personal experiences that predispose and orient the individual learner to search for alternatives, new configurations, or uniquely appropriate solutions. Nevertheless, problem solving is a complex task involving many types of knowledge and skills. Those skills in

planning, monitoring and revising strategies are as important as having a large domain of knowledge. Problem solving requires many types of knowledge, including linguistic, factual, schematic, strategic and procedural knowledge (Mayer, 1987). Thus, the elements of those learning process could help problems solving successfully and obtain abilities of students thinking creatively.

Rationally, this research paper presented the results of developing learning management model to promote creative thinking ability in mathematics learning for the secondary level. That learning management model was created from integrating some important ideas and learning principles, to promote creative thinking through various activities supporting divergent thinking. Especially engagement of discussion on problem solving concepts and giving the possible alternative strategies in each applied situation for the learners (Savage & Armstrong, 2004; Goleman et al., 1992; cited in Wood et al., 2011). Encourage learners focused on divergent thinking skills in applying open-ended problems with incubations for flexibilities and novelties solutions. Whereas, Bolden and David (2012) claimed that problem solving strategy concerned an important role for improving creative thinking and social skills, self recognition, motivation and learning achievement of students. Craft (2008; Cited in Newton, 2012) described that problem solving activities were necessary for improving creative thinking ability and re-established problem solving by students. Whereas, the learners could be encouraged in designing and solving problems by themselves. Parke and Guavain (2004) supported that the inquiry approach provides learners to use their retrieval skills of knowledge and problem solutions, especially generalizations of meaningful knowledge.

There are critical ideas about framework of creativity in general concept, such as Torrance (1965) who has described that the components of creativity involved a number of abilities and were not a unitary factor, and Guilford (1963) agreed that there are a number of components of creativities, that are different for a scientist or a musician than a mathematician. Some of the most commonly listed creative traits are fluency, flexibility, originality, elaboration, and redefinition, as noted by Torrance (1965). Burt (1970) has listed the traits of creativity composed of fluency, divergent association, receptivity, and insight into a problem's solution. Whereas, Guilford (1970) defined the abilities of creativity that included fluency, flexibility and originality which come under the general heading of divergent thinking, and also Roger (1970) has remarked that creativity involves the emergence in action of a novel, relational product, which required a relationship to the surroundings, and the product grows out of the uniqueness of the individual and his surroundings.

The relevant study of creativity including exploration pre-service primary teachers' conceptions for creativity in mathematics and the results showed that the vast majority of teachers thought mathematics was not a creative subject and that most other subject domains offered more opportunities for creativity in the classroom. Whereas the discussion concerning Guildford (1967; cited in Bolden, 2012) distinction between convergent and divergent thinking suggests that learners should be encourage to develop their mathematical creativity by being offered activities that are open-ended and have multiple solutions. There was a developed program to encourage divergent thinking in primary level via open-ended problems and discovering that was indeed helpful in developing mathematical creativity, as measured by fluency, flexibility and originality (Kwon, Park & Park, 2006). Providing learners with opportunities for open-ended problem solving which can emphasize divergent thinking. However, only by providing learners with open-ended problem solving opportunities can we hope to develop student's fluency, flexibility and originality in problem solving and thus the ability to break free from established mind sets (Mann, 2005). Beyond, Oksuz (2009) supported that the ability in mathematical thinking skills were necessary for solving mathematic problems effectively.

The components of main ideas and knowledge were analyzed and provided to create a learning management model based on constructivist theory, metacognitive strategy, problem solving strategy, inquiry approach, and Gestalt psychology principles. The cognitive and social constructivist theory emphasizes various dimensions of thinking skills based on the potential and background of the students for new learning situations. Galotti (2011) concludes for the concepts of social constructivist theory of Vygotsky, and described that peers and teacher can help learners understand and improve cognitive structure based on their potential and background regarding the scaffolding and Zone of Proximal Development (ZPD). Those conclusions were congruent with Krutetskii (1976), who gives comments that the students display mathematical creativity of the independent formulation of uncomplicated mathematical problems, can finding ways and means of solving these problems, those are original methods of solving nonstandard problems, and may be included with the terms of independent, different or varied, inventive, and flexible activities. Those conditions are also congruent with constructivist idea. For the metacognitive strategy, Sternberg (1988) emphasizes on metacognitive skills as an aspect of creativity - relevant skills, because of metacognitive processing is a set of strategies for processing new information and for using the knowledge base that one has acquired. Most problem solving have required thinking that is directed towards

achieving the goals, and required metacognition , which is awareness and management of one's mental processes, to guide his goal – directed thinking (Sarver, 2006). While metacognition provided for problem solving has been characterized as the knowledge and belief about cognitive process, and the control and execution of cognitive actions. Conditions in supporting how students control and regulate their behaviors while working through mathematical tasks can have a powerful effect on performance. Metacognition has been characterized as (a) the knowledge and beliefs about cognitive processes and (b) the control and execution of cognitive actions (Garofalo & Lester, 1985). Whereas, problem solving approach is the means by which an individual uses previously acquired knowledge, skills, understanding to satisfy the demands of unfamiliar situation (Krulik & Rudnick, 1980). It's a complex task involving many types of knowledge and skills that begin with confrontation with the problems and ends when the answer has been obtained and check against the conditions of problems. The National Council of Teachers of Mathematics (2000) has defined how the problem solving to apply and to adapt various strategies for problem solving. To self – regulate and reflect on the problem solving process, the students should acquire the ways of thinking, habits of persistence and curiosity, and confidence in unfamiliar situations. Good problem solving task can have a powerful effect on performance and characterized control on planning activities prior to understanding the problem, monitoring activities during learning, and checking outcomes to evaluate outcomes of any strategic actions against criteria of efficiency and effectiveness (Brown et al., 1983).

Inquiry-based mathematics learning is one strategy emphasizing problem solving, student centeredness, and rich mathematical discussions. Newman et al. (1996) used the term disciplined inquiry to signify for authentic task that engage students in discussions and solutions of real world problems and uses their prior knowledge. Hiebert et al. (1997) advocated that the role of the teacher is shaped by the goal of facilitating conceptual understanding. The teacher now has the role of selecting and posing appropriate sequences of problems as opportunities for learning, sharing information when it is essential for tackling problems and facilitating the establishment of a classroom culture in which pupils work on novel problems individually and interactively, and discuss and reflect on their answers and methods. The teacher relies on the reflective and conversational problem solving activities of the students to drive their learning. Whereas, Newman & Associates (1996) stressed that student's authentic achievements (high-quality intellectual achievement or learning) must reflect the construction of knowledge, discipline inquiry, and achievements that have an impact beyond the school context. Disciplined inquiry consists of the use of prior knowledge, an in-depth understanding of subject matter, and elaborated communication. They claimed that having a knowledge base includes knowing and understanding facts, vocabularies, concepts, theories, algorithms, and conventions; but that "the ultimate point of discipline inquiry is to move beyond such knowledge through criticism, testing, and development of new paradigms. In-depth understanding is the creation of relationships among pieces of information such as facts and concepts. Cobb et al. (1992) suggested that when students communicate and discuss their mathematical ideas, certain activities are important, that can encourage students understand a concept.

Supporting a Gestalt psychology principles, Ackoff and Vergara (1981) identify process–oriented approach for creativity capacities, that focused on associationists of Gestalt psychologists, those who believe that thinking involves the exploration and evaluation of responses that are associated with the type of problematic situation at hand. There are three elements in this theory of thinking: the stimulus or a particular problem situation, the response to a particular problem – solving act, and the mental associations between them (Mednick, 1962). Gestalt psychologists focus on productive or novel ways of thinking about a problematic situation (Couger, 1990). Wertheimer (1959) believes in thinking proceeds neither by piecemeal logical operations nor by disconnected arbitrary associations, but by successively more determinate restructuring of the whole situation. Including the ideas of Gestalt learning psychologists who believed that learners can understand the components and conditions of problems and also the connections of the conditions and each of problem conditions, and that may be explained as the process of productive thinking. The Gestalt notion that the structure of the whole defined the functions and interrelations of its parts seemed particularly relevant to develop problem solving and generalized thinking skills (Resnick & Ford, 1981). Because of conditions in supporting how students control and regulate their behaviors while working through mathematical tasks can have a powerful effect on performance. Metacognition has been characterized as "(a) the knowledge and beliefs about cognitive processes and (b) the control and execution of cognitive actions" (Garofalo & Lester, 1985). Thus, most of learners could be encouraged in designing and solving problems independently or reciprocally with their friends through inquiry approach. Including stimulus the students associate elements of the problem situation for success in divergent or creative solving by themselves. In addition, integrating these ideas and principles for creating this learning management model can help and support creativity in mathematics learning of secondary students increasingly.

1.3 The Study Objectives

- To analyze the current states and problems of mathematics learning with relevant secondary students for developing learning management model in improving creative thinking.
- To assess the effectiveness of mathematics learning management model in improving creative thinking for the secondary students in the following perspectives:

(1) Studying for the efficiency of mathematics learning management process in improving creative thinking of secondary students.

(2) Comparison of the students' creative thinking and learning achievement between before and after learning based on the mathematics learning management model.

(3) Comparison of the students' creative thinking between those who learned in the experimental group and a control group.

1.4 Hypotheses

- The students who learned through the mathematics learning management model obtained creative thinking competencies and mathematics learning achievement higher than before taking learning management.
- The students who learned through the mathematics learning management model obtained creative thinking competency and mathematics learning achievement higher than the students in control group.

2. Method

2.1 Research Methodology

The research study was based on the methodology of Research and Development (R&D), those composed of three phases, the details in each phase were as follow:

Phase 1: Study of current state with conditions and problems about Mathematic learning management in the secondary schools

The research participants consisted of 6 mathematics teachers who taught in 9th grade level and 102 students in 9th grade level in the academic year of 2013, from four schools in Khonsawan District, Chaiyaphum Province, Thailand. They were selected by the cluster random sampling method for interviewing and observing about leaning management to support creative thinking in mathematics learning of the students in secondary level. The finding were found that normally, learning activities in mathematics rarely improve the students' creative thinking and are more concentrated in the traditional approach, especially using learning activities that provide content based learning. Most teachers present concepts for the students by explaining details for problem solving methods through rule or algorithm approaches, and not interested in encouraging the students to investigate and think about solutions diversely. Moreover, they lacked the fostering ability in creative thinking by using open-ended problem in learning situations. Therefore, the students in secondary level should be supported to use new approach to improve their creative thinking together with mathematics learning increasingly.

Phase 2: Design and development of the Mathematics learning management model

The purpose of this phase proceeded on activities to analyze and integrate the information from the first phase and knowledge concerned about conceptual framework of instructional model, learning theories, and some teaching approaches to design and create a learning management model for improving creative thinking in mathematics learning. Which were created based on ideas and knowledge, those composed of constructivist theory, metacognitive strategy, problem solving strategy, inquiry approach, and Gestalt psychology principles. The succeeding of learning management model for enhancing creative thinking of students in mathematics learning were composed of: 1) principle, and concerned theoretical concepts, 2) learning objectives, 3) learning process, 4) social system, 5) principles of reflection, and 6) a support system. The results of the learning process consisted of 5 steps, which were: 1) engagement and connection to prior knowledge, 2) encounter of problem and thoughtful incubation, 3) analyzing alternative and investigating solutions, 4) applying and modifying thinking pattern, and 5) concluding and evaluating creative thinking. Then proceeding to evaluate the learning management model by relevant experts and judging its quality and appropriate of model. Then continuing to take the prototype of the learning management model for trying – out with two groups of 9th grade students in two schools, the same student participants in the first phase, for an overall 30 hours of learning. The results in this phase could be adjust in some activities in learning process to be congruent with student abilities appropriately.

Phase 3: Implementation and evaluation of the Mathematics learning management model

The purpose of the third phase was to implement and assess the mathematics learning management model, to

explore and assert the effectiveness of learning management model in three aspects, that consisted of: 1) studying for the efficiency of mathematics learning management process in improving creative thinking of secondary students, 2) comparison of the students' creative thinking and learning achievement between before and after learning based on the mathematics learning management model, and 3) comparison of the students' creative thinking between those who learned in the experimental group and a control group. Whereas, the results of implementing were experimental effects with the 9th grade students in Khonsawan school, Thailand.

2.2 Research Variables

For the independent variable in this research provided as a mathematics learning management model, and for dependent variables consisted of: 1) creative thinking that is composed of elaborate thinking, flexibility thinking, fluency thinking, originality thinking, and 2) mathematics learning achievement. In addition, the mathematics contents used for the research were 9th grade Mathematics (Math 23102) of the core course of the National Basic Education Curriculum in 2008, Thailand, entitled "Probability and Statistics", which took thirty hours for learning activities.

2.3 Research Instruments

1) An interviewing form, and an observing form for collecting data about learning management to improve creative thinking in the first phase, 2) lesson plans for improving creative thinking in mathematics learning for overall of learning 30 hours, 3) assessing form to evaluate learning management model by relevant experts and judging its quality and its appropriateness of model, and note–taking form for recording incomplete data of trying–out learning management model, 4) a test of creative thinking ability that was constructed by using problem situations with rubric scoring for assessing , and 5) a mathematics learning achievement test.

2.4 Data Collecting

Phase 1: Gathering data about the current state and problems of mathematics learning management to improve creative thinking , by using interviews and observing forms for recording the searched information from the relevant teachers and students, and then taking them to design the prototype of the learning management model.

Phase 2: Gathering data for assessing the learning management model from relevant experts for judging the quality and appropriateness of the model with rating form, and also using note - taking form for recording problematic data that emerged while trying – out with student participants. Then taking those information to improve learning management model before implementing it with relevant students in experimental group.

Phase 3: Gathering data for assessing the learning management model with the research objectives to assess the efficiency of learning process in that model. That was done using creative thinking test and mathematics learning achievement test with both the students of experimental group and from the control group before and after using the learning management model.

2.5 Data Analysis

- The first phase of research was gathering qualitative data from participants and concerned knowledge for designing and constructing the prototype of learning management model, and continuously analyzing the results of expert assessing quality and appropriateness of that model, which were all identified by mean score. Whereas, in trying-out the model with the participants students, the researchers recorded related information for improving some incomplete activities and added qualitative narration, before implementing the learning management model with experimental group continuously.
- The t-test (Dependent sample) was used to determine the level of significance different between the pre-test scores and post-test scores of creative thinking and mathematic learning achievement of the experimental group. Also was used the t-test (Independent sample) for determining the level of significant difference in comparison of creative thinking between the experimental group and a control group.

3. Results

The research results are presented as follows:

- The findings showed that most of the teachers did not recognize the importance of mathematics learning management for improving creative thinking competencies, and most students did not improve their creative thinking competencies through problem based learning strategies. Additionally, mathematics activities were inefficient in improving the creative thinking of students. Nevertheless, most mathematics teachers were not really encouraged and supported to find new efficient strategies for improving creative thinking abilities. Thus the developing model was designed through the research methodology of Research and Development (R&D), the components of that learning management model consisted of: 1) principle,

and concerned theoretical concepts, 2) learning objectives, 3) learning process, 4) social system, 5) principles of reflection, and 6) a support system. Those components were based on constructivist theory, metacognitive strategy, problem solving strategy, inquiry approach, and Gestalt psychology principles. Whereas, the activities in learning process consisted of: 1) engagement and connection to prior knowledge, 2) encounter of problem and thoughtful incubation, 3) analyzing alternative and investigating solutions, 4) applying and modifying thinking pattern, and 5) concluding and evaluating creative thinking.

- The findings of study indicated that the efficient index of the mathematics learning management model based on the achievement score was 76.25%, and the efficient index of the learning management model based on the creative thinking score was 61.67%. The average posttest scores in learning achievement and creative thinking abilities of the experimental group students were higher than those of pretest scores at the .01 level of the statistical significance, as showed in Table 1.

Table 1. Comparison of learning achievement and creative thinking between before and after learning based on mathematics learning management model of experimental group

Achievement/Creativity	Condition	n	Full Score	Average	Standard deviation	Value of t	Mark level
Learning Achievement	Pre-test	30	40	10.43	4.25	33.73**	0.000
	Post-test	30	40	30.50	5.07		
Creativity	Pre-test	30	40	9.17	3.21	26.59**	0.000
	Post-test	30	40	24.66	4.29		

** level of significance at .01.

Additionally the group of experimental students showed higher creative thinking than the control group at the .01 level of statistical significance. The result of comparison of students' mathematical creativity between those two groups is shown in Table 2. (For the Levene's Test for Equality of Variances, F = 0.48, Sig = .827)

Table 2. Comparison of creative thinking between experimental group and control group after providing on learning management model

Condition	n	Full Score	Average	Standard deviation	Value of t	Mark level
Experimental group	30	40	24.67	4.29	7.951**	.000
Control group	32	40	15.91	4.38		

** level of significance at .01.

4. Discussion

In the First Phase, the research results showed that most teachers did not recognized the importance of learning management for improving creative thinking, and the teachers had not understood the course description, definition including the application of the mathematic learning management model for improving the creative thinking competency. The results may be caused by the low quality and inappropriateness of the application of problem-based learning strategies designed by the Institute for the Promotion of Science and Technology in Thailand. Most of mathematics teachers had not understood precisely open-ended problem solving, which can support the students learning with divergent thinking and can encourage them to improve their creative thinking abilities. Additionally, components of the creative thinking more complicated for the teachers in providing learning activities to enhance creativity with their students. Therefore, the quality in mathematics learning achievement in many schools of Thailand were at a low level and most students had difficulties in learning mathematics for a long time. In consequence, concerned teachers need to improve both creativity and achievement in mathematics learning with the appropriate approach. Many of knowledge and ideas can be applied for creating a learning management model effectively for secondary students. Smith (2001) described

that the concept of creativity is composed of magic, heredity, wish fulfillment, sublimation, unconscious thinking, gestalt, association, a cognitive style, divergence, a personality type, novel product, or process. Furthermore, Newton (2012) claims that creative thinking skills will provide an opportunity to improve the creative thinking skill based on the nature of subjects. Whereas, Newell, Shaw, and Simon (1962) claim that creativity is a special kind of problem-based behavior and problem-solving and are a vital part of Mathematic learning management. Torrance's (1968) work analyzed creative characteristics in his development of the Torrance Tests for Creative Thinking (TTCT), to identify creative students. The first evaluation that is referred as divergent thinking abilities that consisted of fluency, flexibility, originality, and elaboration. Furthermore, Wallas (1926; cited in Dickman, 2014) presented a four stage model of problem solving, that is composed of: preparation, incubation, illumination, and verification. The preparation involves background content-knowledge, which suggests learning specificity, as well as conscious work on the problem at hand. Incubation refers to an interstitial lull during which the solver spends time away from consciously working on the problem. Illumination, sometimes known as insight, refers to the solution's emergence into an individual's conscious thinking. Additionally, verification denotes the solver's checking, assessment, and implementation of a solution. That four-stage model is frequently incorporated or adapted in works on the creative thought process. A more complete framework for what is necessary to be a successful mathematical problem solver can be found in Schoenfeld's (1985) book Mathematical Problem Solving. Similarly heuristics, which is what Polya's work concerned itself, with framework also puts forth resources, beliefs and belief systems, and control and metacognition as integral features. So that, designing and constructing the learning management model to improve the students' creativity in mathematics learning effectively, that is a more complex procedure to be successful. The designer and participants should be concerned by contexts and situations of the students learning and develop understanding in integrating many ideas and knowledge to create learning management model thoughtfully.

The results in the Second Phase: the finding shows that the model was designed and then presented to the experts for assessing quality and appropriateness. That model was composed of six elements: 1) the principle, and theoretical concepts, 2) objectives, 3) learning process, 4) social system, 5) principles of reflection, 6) a support system. It is in accordance with ideas of Constructivism theory, Metacognitive strategy, problem solving strategy, inquiry approach, and Gestalt principle. Accordingly, the learning process is comprised of five stage as: 1) engagement and connection of prior knowledge, 2) encounter of problem and thoughtful incubation, 3) analyzing alternative and investigating solutions, 4) applying and modifying thinking pattern, and 5) concluding and evaluating creative thinking. Additionally, experts evaluating the model gave a highly appropriate judgment. Nevertheless, the model was adapted from the concepts of Joyce, Weil, and Calhoun (2011) that state the efficient learning model should consists of theories and research related to the efficient learning management process, reflection and adaptation of learners, strategies for learning competency management, practical application, learning condition and environment. Taylor (2008) asserts that the Constructivism-based activities provide learners with the understanding of the concepts and complex relation of the contents. Accordingly, Sarver (2006) also affirms that Metacognition strategy helps students improve their problem solving skills and critical and analytical skills more effectively. Craft (2006) claims that problem solving activities are a key factor for improving creative thinking of the students especially re-establishing a problem solving strategy which is used to assess the mathematic creative thinking skills of students. Whereas, Parke and Guavain (2004) state that a knowledge retrieval process is necessary to improve creative thinking, and the retrieval process is composed of valuing skills such as, describing, explaining, predicting and choosing. Lastly, Osksuz and Cumali (2009) state that the main mathematics knowledge is available by enhancing mathematics skills and creative thinking successfully.

The result in the Third Phase: The findings of the study indicated that the efficient index of the mathematics learning management model based on the achievement score was 76.25%, and the efficient index of model based on the creative thinking score was 61.67%. The average posttest scores in learning achievement and creative thinking abilities of the experimental group students were higher than those of pretest scores at the .01 level of the statistical significance. Additionally the group of experimental students showed higher creative thinking than control group at the .01 level of statistical significance. Those results may be caused by the systematic steps of the activities design and development, and the relevant approaches that were employed for improving effective learning with creativity in mathematics, especially by applying and encouraging open-ended problem solving with divergent thinking in various learning situations. Whereas, Cropley (1992) and Sriraman (2009) claim that divergent thinking is important for creative thinking skill and learners should understand and identify problems before solving the problems. Mann (2005) argues that learning achievement of students is related to mathematical creative thinking skills. Furthermore, Pham (2013) describes that main knowledge and divergent

thinking skills can predict the ability in creatively solving mathematics problems, and Parke and Guavain (2004) claim that investigating learning method will enhance learners to use their critical thinking skills when they are facing problems. Whereas, investigating method refers to using specific knowledge in understanding, identifying problems and making conclusion with a variety of solutions. Accordingly, Jensen (1973) agrees that searching for mathematics knowledge of students help them to improve creative thinking and divergent thinking skills in solving problems. Haylock (1987) supports that the ability in divergent thinking is used to assess the level of creative thinking skill of students, and the good points of divergent thinking are flexibility, fluency and originality. Moreover, Chambers and Timin (2013) affirm that the creative thinking skill should be improved by new concepts and flexible concepts and that the teacher should realize the relationship among the components of mathematics and be able to design problem-based learning activities. In additionally, Resnick and Ford (1981) suggest that the process of productive thinking through gestalt notion is that the structure of the whole defines the functions and interrelations of its parts and seems particularly relevant to the development of problem solving and generalized thinking skills for discovery in meaningful learning. So that, many of concerned principles and ideas above can confirm the influence with the progress of creative thinking in learning mathematics. When comparison creativity of students who learned using a traditional approach with the control group it was found that they obtained lower creative thinking abilities than the experimental group. That result could affirm the weak points and limitations of traditional approach. Normally, that traditional approach was designed on the principles of learning process, provided by The Institute for the Promotion of Teaching Science and Technology (2008), Thailand. It this composed of 6 steps of learning activities such as: 1) Reviewing of prior knowledge, 2) Investigating for new knowledge, 3) Conceptual conclusion, 4) Practicing new knowledge, 5) Application of knowledge, and 6) Evaluation on learning. The students learning in each step must only concentrate in their abilities to find out the correct answers of problems, and encourage the students thinking to discover solutions through open-ended problems or divergent thinking continuously. Together with this traditional approach in mathematics learning, it could not affect the nurturing of creative thinking with the students learning, as the results revealed in the research.

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