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Scaffolding Based On Learning Style As An Effort To Increase Mathematical Creative Thinking Skill

Wahyudi Wahyudi[1]
St. Budi Waluya[2]
Rochmad Rochmad[3]

Abstract

This article describes the ability of mathematical creative thinking and scaffolding process of pre-service teachers according to the learning styles. The research design used qualitative triangulation. The subject was 50 first year students of Elementary School Pre-service Teacher in Satya Wacana Christian University who were taking Basic Mathematics Concept course. Research data was taken through tests and interviews. The result of this study indicates that the subjects have different creative thinking abilities which were seen from their learning styles. Two aspects of them that were still low were flexibility and originality. The lack of love of mathematics was one of the reasons why mathematical creative thinking ability was still low. Scaffolding according to the subject's learning styles could improve the ability of mathematical creative thinking. The technique and duration of the scaffolding process depend on the learning styles and the subject's ability to follow the scaffolding process. The scaffolding process should be done according to the subject's response and needs according to their learning styles. Although they have different learning styles, scaffolding process can be done successfully with the use of media, either in the form of props and simulation drawings.

Keywords: Creative thinking, scaffolding, mathematic, pre-service teacher.

[1] Assist Professor, Universitas Kristen Satya Wacana, Indonesia, Faculty Of Teacher Training And Education. yudhi@staff.uksw.edu

[2] Prof. Dr., Universitas Negeri Semarang, Mathematics Education, Postgraduate Program. s.b.waluya@mail.unnes.ac.id

[3] Assoc. Prof. Dr., Universitas Negeri Semarang, Mathematics Education, Postgraduate Program. rochmad@mail.unnes.ac.id

Introduction

One of the aims of Indonesian education is to develop the potential of learners to become creative human beings. In fact this is one of the reasons for the change of the Indonesian national curriculum from KTSP (Kurikulum Tingkat Satuan Pendidikan) into the 2013 curriculum that is to form creative learners. Creative is also one of the major components in 21st century education (Mann, 2005). Therefore, the contemporary curriculum emphasizes the development of creative thinking skills for learners (Vale & Barbosa, 2015; Sternberg, 2006). The ability to think creatively leads to the acquisition of new insights, new approaches, new perspectives, or new ways of understanding issues that include aspects of fluency, flexibility, and originality, and elaboration.

The ability to think creatively grows from the creativity of learners. Therefore, creativity becomes something that needs to be developed in education. This is similar to the results of research by Dyers et al. (2011) said that 2/3 of a person's creativity ability is obtained through education, the remaining 1/3 comes from one's genetics. In contrast to the ability of intelligence holds that 1/3 the ability of intelligence is obtained from education, 2/3 of the rest comes from one's genetic. That means we cannot do much to improve one's intelligence but we have many opportunities to improve his creativity. Creativity is applicable to all areas of learning including in the field of mathematics, especially the ability to think creatively. Thus the ability to think creatively in the field of mathematics needs to be developed so that learners have high creativity in solving mathematics problems. In addition, this ability becomes a benchmark of the success of learners in learning (Mairing & Jackson, 2016).

The problem that arises is that not all mathematics learning provides opportunities for learners to improve their creative thinking ability. Often, learning is oriented on the amount of material given. It was seen from the rank of Indonesia for mathematics subjects in Programme Internationale for Student Assessment (PISA) in recent years Indonesia is still lower than other countries. Indonesia is ranked 64 out of 72 countries. The rank has improved, but still needs to be improved again.

In addition to the rank in PISA, Indonesia's education rank still lags behind other countries, which is at the 57th rank of a total of 65 countries (World Education Ranking) published by the Organization for Economic Co-operation and Development (OECD).

This condition needs to be taken seriously by educators in this country. A change is necessary in aspect of learning mathematics for learners. Not just active learning, but also provides opportunities for learners to think more with contextual conditions. Several studies have shown that the application of innovative learning has not provided an opportunity for learners to develop their creative thinking skills in the field of mathematics (Sriwongchai at al., 2015). Therefore, it is required packing appropriate learning model.

To get the appropriate learning model, it is required a preliminary study to describe the ability to have mathematical creative thinking and how the process helps learners who still have difficulty in achieving such competence in the process of scaffolding. Scaffolding in the learning environment is a process of interaction involving the provision of assistance or guidance to learners by a teacher or friend to understand the knowledge or skills that cannot be achieved without any help (Anne at al., 2004; Jelfs at al., 2004). Scaffolding is a strategy that teachers can use in teaching and fostering the ability of learners (Bikmaz, 2010). In mathematics learning, scaffolding is an aid to solve problems, as well as help build concrete mathematical concepts and improve students' self-confidence (Akhtar, 2014). This support or assistance is tailored to the characteristics and changes in learners' abilities (Lajoie, 2005). Teachers should pay attention to the problems of each individual before providing scaffolding.

The success of learners in learning is influenced by several factors; both internal and external. One of the factors is learning styles. Learning styles will determine how teachers teach and decide which media to use (Nindiasari, 2016; Bire, 2014). This should be taken as a consideration when doing scaffolding. The scaffolding process can be done in groups (McNeill at al., 2006) and can be done with media tools (Lajoie, 2005; McNeill at al., 2006). There is limited use of media in the scaffolding process (Holton & Clarke, 2006), so it needs to be well prepared according to the learning style that the learners have. With these considerations, it is required a good cooperation between learners and teachers in determining the media in scaffolding process (Holton & Clarke, 2006).

This study will provide an overview of the descriptions of the ability of mathematical creative thinking and description of the scaffolding process for prospective students according to their learning style. Scaffolding process is intended for students whose the ability to have mathematical creative thinking is still low according to learning style.

Methods

Participants

The subjects were 50 first year students of Elementary School Pre-service Teacher from Faculty of Teacher Training and Education of Satya Wacana Christian University. In the meantime, the subjects were taking a Basic Mathematics Concept course. The educational backgrounds of the subject were from Senior High School and Senior Vocational School. The data on learning styles were taken through a questionnaire.

Design of the Study

This research was a qualitative research. The research design used triangular qualitative research. The scope of this research included the descriptions of the ability of mathematical creative thinking and scaffolding process according to the ability of mathematical creative thinking and learning styles.

Instrumentation

The ability of mathematical creative thinking was taken with test and interview techniques which include four aspects of fluency, flexibility, originality, and elaboration. Scaffolding process was done directly according to the problems of each student, observation of answers and interviews according to student answers until students understand the concept correctly.

The learning style indicators used was adopted a style questionnaire developed by De Porter that included visual, auditory and kinesthetic learning styles. The indicator of creative thinking ability is described in four aspects: fluency, flexibility, originality, and elaboration. The four aspects are described in the ability that must be owned by students as in Table 1 below.

Table 1. The Description of Mathematical Creative Thinking Aspects

No	Mathematical Creative Thinking Aspects	Description
1	Fluency	The ability of students to produce various answers correctly within a short of time.
2	Flexibility	The ability of students to generate various ideas and approaches to solve problems for each answers.
3	Originality	The ability of students to use a new, unique, or unusual strategy to solve problems correctly
4	Elaboration	The ability of the students to explain sequentially in detail and coherently based on certain mathematical procedures, answers, or mathematical situations.

Data analysis

The data was analysed using triangulation method, which is data analysis process by comparing information or data obtained through test result and interview, and scaffolding process for student with low creative thinking ability. The steps used in this study were presented as follows: 1) provide a learning styles questionnaire; 2) to provide students with a test of mathematical creative thinking ability; 3) analyse the obtained test results; 4) interviewing some students with low mathematical creative thinking ability; 5) analysing test results and interviews; 6) scaffolding process.

Results And Discussion

The subjects of this study were 50 pre-service teachers. Based on the result of the questionnaire, there were 8 students (16%) having visual learning style, 32 students (64%) had auditory learning style, and 10 students (20%) had kinesthetic learning style. Table 2, below, presented the detail of learning styles of research subjects. In detail can be presented in Table 2 below.

Table 2. The Learning Styles of Research Subjects

Learning Styles	Frequency	Percentage
Visual	8	16
Auditory	32	64
Kinesthetic	10	20
Total	50	100

Result of educational background and learning styles from 50 student which become the subject of this research, it was obtained that their learning styles were different even though their education background was the same, 32 students (64%) had an auditory learning style. Details of the data can be seen in Table 3 below:

Table 3. Summary of Learning Styles Based on Their Education Background

Education	Visual	Auditory	Kinesthetic	Total
Senior High School	8	20	9	37
Vocational High School	0	12	1	13
Total	8	32	10	50

After students filled out the learning style questionnaires and their educational background form, they work on the test questions about geometry plane This test was used to review the subjects' mathematical creative ability. The result of of students' mathematical creative thinking ability can be seen in Table 4 below.

Table 4. Summary of Students' Mathematical Creative Thinking Ability

Interval	Categories	Frequency	Percentage
≥ 20,3	Very High	0	0
16,2 – 20,2	High	9	18
12,1 – 16,1	Medium	18	36
8 - 12	Low	23	46
Total		50	100

Test results showed that 9 students (18%) were in the high category, 18 students (36%) were in medium category, and 23 students (46%) were in low category. For students with high mathematical creative thinking, originality was the aspect that has not been mastered. They still use the same solving method.

Students in the medium category had also performed four aspects of mathematical creative thinking. Fluency and originality were two aspects that had not mastered yet. Students in the medium category have not shown the originality of the answer and only provide one or two solving strategies. Students with low categories have not been able to apply the four aspects of mathematical creative thinking and or provide an incorrect solution. Based on educational background, students' mathematical creative thinking ability from senior high school is better than student from vocational high school. The highest score was achieved by students from high school (there are 2 people) with auditory and kinesthetic learning styles. However not all students from high school have the mathematical creative thinking ability in high category, their ability is very diverse. This shows that pre-service teachers' mathematical creative thinking ability based on educational background is very varied.

Based on these results, the elementary school pre-service teacher has low mathematical creative thinking ability. The complete data of the 4 aspects of creative thinking is illustrated from Table 5 below.

Table 5. Summary of Mathematical Creative Thinking Results Based on the Aspects

No	Mathematical Creative Thinking Aspects	Average	Categories
1	Fluency	1,8	High
2	Flexibility	1,2	Low
3	Originality	1,2	Low
4	Elaboration	1,8	Medium

Judging from the learning style and educational background, it shows that the subject of this elementary school pre-service teachers have a variety of mathematical creative thinking. This data is used as a consideration to determine the subject chosen for the next stage in the process of scaffolding for subjects who still have low mathematical creative thinking based on learning styles (visual, auditory and kinesthetic). There are 6 subjects selected at the beginning stage, 2 subjects for each learning style.

The results of in-depth interviews of the 6 selected subjects indicate that all subjects do not like mathematics. Five of them say that the dislike happens because the teaching process is not interesting and only work on the book questions. Educators did not motivate the learners in an interesting way. This happened since they were in junior high school. One of the reasons they are majoring in elementary school teacher is to reduce the burden in learning mathematics. They assume that with this department the burden in learning mathematics will be less. Turns out, it was different in classes, not just material but how to teach the material in a way that is good and correct. This is what makes them encountering troubles in learning mathematics so that their mathematical creative thinking ability is still in the low category.

The interview results also provide information that the mathematical creative thinking was low because of the lack of ideas in providing alternative solutions to problem solving. The problem solving strategy is not diverse (similar to other students), and the completion stage is incomplete and unfinished. This result is in line with the opinion of Best & Thomas (2007); Torrance (1969) and McGregor (2007) who stated that to produce something creative as a result of creative thinking (in this case mathematics) it is required a process that produces something new with a new idea, original idea, to solve problems that exist both well and respectively. If one is unable to think of a solution or not even understanding the given problem then one will not be able to create a solution to the problem let alone be guided by many new ways. Even to get creative thinking especially in mathematics, Vale & Barbosa (2015) requires a high curiosity

with the process of exploration and observation, and imagination and original thinking thing. If someone does not like what is being learned then the thinking process will be hampered, they cannot be demanded to think creatively.

This data is used as a material to start the scaffolding process. The indirect scaffolding process helps them understand and work on mathematics problems but focuses on building their commitment to becoming a teacher. This becomes important because their mood will affect their learning process. After this process is adequate to give understanding and build their commitment then the process of scaffolding done. Deep scaffolding process is only done on 3 selected subjects, 1 subject for each learning style. Three other subjects considered to have been able to resolve the questions well after being guided and be reminded of the formula used, because they have forgotten the formula is the only problem.

Scaffolding process for the subjects with visual learning

Scaffolding Stages	**Activities**
Stage 1	*Motivating and discussing with the subject about the encountered problems while working on the question* Discussion process includes the subjects' answers and problems they encountered while working on the problem. Based on the encountered problems, researchers prepare the media needed for the scaffolding process. At the time of motivation building process, the subject tells the problem they faced when they were working on it. The problem faced is the difficulty of identifying the elements of the geometry plane in the problem, which is determining the base and height of the plane in question. The subject said that the plane that needs to be determined is a parallelogram. This happens because the plane position is not upright like the usual subject view. This data is used as a consideration to make props to facilitate the subject to understand the problem of a parallelogram like the subject had understood.
Stage 2	*Explaining and Constructing the Correct Concept and Working on Problem 1* a. Make a simulation using props according to the plane in the question. Subjects are guided to identify that the plane is a parallelogram with the help of props. The second step is to position the props precisely at the image position in the problem so that the subject is able to imagine and identify the parallelogram elements in the problem. b. Ask the subject to use props to write the height and base of the parallelogram in the picture in question. c. Guide the subject to determine how to solve the subject after using props. d. Ask the subject to solve the problem according to the chosen way on the provided worksheet. e. Help the subject to think of the alternative answers with the help of props. f. Guide the subject to solve the problem in a new way according to the alternative answers generated by the subject on the provided worksheet. g. Guide the subject to choose another strategy in solving the problem with the same answer and writing answers on the provided worksheet. h. Guide subjects to determine the alternative answers which rarely used by other subjects to generate a new way in solving the problem and wrote answers on the provided worksheet.
Stage 3	*Explaining and Constructing the Correct Concept and Working on Problem 2* Scaffolding process was be done as follow: a. Create props from the problem picture along with the subject. b. Request the subject to use props that have been generated to make it easier to understand the problem.

c. Guide the subject to determine how to solve the subject after using props.
d. Asking the subject to solve the problem according to the chosen way.
e. Help the subject to think of alternative answers with the help of props on the provided worksheet.
f. Guide the subject to solve the problem in a new way according to the alternative answers generated by the subject and writing answers on the provided worksheet.
g. Guide the subject to choose another strategy in solving the problem with the same answer.
h. Guide subjects to determine the alternative answers which rarely used by other subjects to generate a new way in solving the problem and wrote answers on the provided worksheet.

The interesting event of the scaffolding process is that the subject is quicker to understand the contents of the problem with the props they made together. Subjects have been able to identify any plane that forms the polygon in the problem. The subject is able to separate some parts of the plane and write down the elements and determine the area of each plane and determine the total area of the polygon in the problem.

Scaffolding for subjects with Auditory learning

Scaffolding Stages	**Activities**
Stage 1	*Motivating and discussing with the subject about the encountered problems while working on the question.* Discussion process includes subjects' answers and problems encountered while working on the problem. Giving motivation and discussion begins with the discussion of the subjects' answers and the encountered problems while working on the question. Based on the problems encountered, the researcher explained about the given problem, gave an idea of the problem and how to solve the problem so the subject does not see the problem as something difficult to do.
Stage 2	Help the subject solve the problem by constructing the concept correctly. Scaffolding process was done as follow: a. Guide subjects to reread the questions b. Guide the subject to look at the image of the problem and try again to solve the problem c. Ask the subject whether there is any problem.
Stage 3	Guide the subjects to get alternative answers. Scaffolding process was done as follow: a. Make props according to drawing images together with subject. This step is done because the subject has difficulty in getting alternative answers. b. Give an explanation to the subject using props that have been made to make it easier to understand the problem. c. Guide the subject to determine how to solve the subject after using props. d. Ask the subject to solve the problem according to the chosen way. e. Help the subject to think of alternative answers with the help of props on the provided worksheet. f. Guide the subject to solve the problem in a new way according to the alternative answers generated by the subject and writing answers on the provided worksheet. g. Guide the subject to choose another strategy in solving the problem with the

Scaffolding Stages	Activities
	same answer. h. Guide subjects to determine the alternative answers which rarely used by other subjects to generate a new way in solving the problem and wrote answers on the provided worksheet.
Stage 4	*Explaining and Constructing the Correct Concept and Working on Problem 2 without props* This process is done because the subject has shown excellent progress in thinking. Subjects are able to understand the problem well and able to provide several different problems solving. While working on the problem, the subject heard several explanations related to the problem so that the subject is able to solve problem 2 with alternative answers are diverse.

Scaffolding process for subjects with kinesthetic learning style

Scaffolding stages	Activities
Stage1	*Motivating and discussing with the subject about the encountered problems while working on the question* Giving motivation and discussion begins with the discussion of the subjects' answers and the encountered problems while working on the question. Based on the problems encountered, the researcher asks the subject to explain the contents of the problem according to the subject's understanding.
Stage 2	*Explaining and Constructing the Correct Concept and Working on Problem 1* Scaffolding process was done as follow: a. Ask the subjects to reread the question b. Ask the subject to solve the problem according to the chosen way. c. Help the subject to think of alternative answers with the help of props on the provided worksheet. d. Guide the subject to solve the problem in a new way according to the alternative answers generated by the subject and writing answers on the provided worksheet. e. Guide the subject to choose another strategy in solving the problem with the same answer. f. Guide subjects to determine the alternative answers which rarely used by other subjects to generate a new way in solving the problem and wrote answers on the provided worksheet. The problem that arises from this stage is subject's difficulty to find the alternative answers. By cutting and pairing a few pieces of plane to other parts, the subject can finally get some alternative answers.
Stage 3	*Explaining and Constructing the Correct Concept and Working on Problem 2* Scaffolding process was done as follow: a. Help the subject understand problem 2 by simulating the problem image with the ballpoint. The process can be seen in the following picture. b. Ask the subject to look back at problem 2 on its own way. c. Guide the subject to determine how to solve the subject after using props. d. Ask the subject to solve the problem according to the chosen way. e. Help the subject to think of alternative answers with the help of props on the provided worksheet. f. Guide the subject to solve the problem in a new way according to the alternative answers generated by the subject and writing answers on the provided

Scaffolding stages	Activities
	worksheet. g. Guide the subject to choose another strategy in solving the problem with the same answer. h. Guide subjects to determine the alternative answers which rarely used by other subjects to generate a new way in solving the problem and wrote answers on the provided worksheet.

The first step in scaffolding is to build the motivation of the subject. The goal is to motivate the subject to have a learning commitment to the topic to be resolved. The subject needs to be motivated and directed about the importance of the topic being studied and the benefits in their later work as pre-service teachers. This is in line with Dennen's (2004) thinking, that scaffolding gives cognitive and emotional influences, not only affecting skills and knowledge, but also motivation and builds the confidence of learners in doing the task. The results of interviews from 6 selected subjects, they have less good experience of mathematics even at the level of junior high school. So, there should be a change in the subject's understanding of mathematics and learning. Thus the subject will have a positive attitude towards mathematics so that the scaffolding process runs smoothly and helps the subject solve the given mathematical problem.

The second step is to explain and construct the correct concept and work on the problem. The goal is to provide reinforcement that the information in the matter is not unfamiliar and they can work on it. With this concept, the subject will be able to think from what they have understood, so that they are able to solve problems within their range of ability (Zone of Proximal Development (ZPD)) (Vygotsky, 1978). In the end the three subjects are able to solve the problem with the help given. If this process succeeds then the learning process on the more complex will be successful too (Vygotsky, 1978).

These results indicate that scaffolding helps the subject in solving the problems they face even though each subject takes a different time. The interview results support this result, in which the subject is more likely to understand the content of the question, and be able to think how the solution of the problem in given question. Subjects also said that the provided assistance gave them direction to get a solution they had not previously had. In addition, the explanation and props are used to provide simulation of the problems that exist in the matter so that the subject is able to think of the solution.

The scaffolding process of each subject takes different times according to the subject's ability to receive the help and also depend on their learning styles. The results show that subjects with visual and kinesthetic learning styles are more quickly to understand and solve the problems. Subjects with auditory learning style require a longer scaffolding process. Subjects with auditory learning style require a detailed explanation, the need for media to guide problem solving. This indicates that the scaffolding needs of each subject are different and this must be considered by the scaffolding giver to provide assistance according to the needs of the subject. This is in line with the opinion Vygotsky (1978) that the provision of assistance through scaffolding must be tailored to the needs of the subject. If subjects are able to solve their own problems; then they should be given an independent work to solve so that scaffolding will form an independent person (Williams, 2008) and self-confidence subject (Akhtar, 2014). So the subject that failed or cannot solve the problem in the matter can be helped by scaffolding (Lange, 2002).

The assistance are given to the subject through scaffolding, used in explaining, reviewing and reconstructing subjects' concepts about something so that subjects have a better understanding on the concept and be able to build the concept properly and be able to utilize in everyday life (Ormond, 2016). The technique and duration of the scaffolding process depend on the learning

styles and the subject's ability to follow the scaffolding process. A teacher in doing scaffolding must be able to provide correct instructions and carefully according to the needs of the subject (Bikmaz, 2010). If this instruction is correct then it will build and develop the subject's knowledge.

The scaffolding process should be done according to the subject's response and the subject's needs according to their learning styles. Subjects with visual learning style require visual aids to make it easier to understand and solve problems. Subjects with auditory learning style require detailed explanations and props to understand and solve problems. Subjects with kinesthetic learning style require image simulation to provide help in understanding and solving problems. Although they have different learning styles, scaffolding process will be successful when used along with the media, either in the form of props and simulation images.

Conclusion

The first result of this study indicates that the subjects have different creative thinking abilities seen from his learning style. Most of the subjects have medium creative thinking ability (18 students, 36%) and low (23 students, 46%). The lack of the subjects' mathematical creative thinking abilities is due to the lack of love of mathematics. Flexibility and originality are the aspects of creative thinking that are still low. Subjects still use the same methods and problem solving strategies.

The second result of this study shows that scaffolding according to the subject's learning style can help to improve the ability of mathematical creative thinking. The scaffolding process begins with the provision of motivation, explaining, constructing the correct concept and working on the problem. The technique and duration of the scaffolding process depend on the learning style and the subject's ability to follow the scaffolding process. Scaffolding process should be done according to the response and needs of the subject and their learning styles. The speed of the subject in receiving assistance through scaffolding takes different times. The results show that subjects with visual and kinesthetic learning style are more quickly to understand and solve the problems. Subjects with auditory learning style require a detailed explanation; they need media to guide problem solving. Subjects with visual learning style require visual aids to make it easier to understand and solve the problems. Subjects with auditory learning style require detailed explanations and props to understand and solve problems. Subjects with kinesthetic learning style require image simulation to provide help in understanding and solving the problems. Although they have different learning styles, scaffolding process will be successful when used along with the media, either in the form of props and simulation drawings.

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