Development of learning tools: learning constructivist mathematics to improve creative thinking ability

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Abstract. The purpose of this study was to determine the implementation of learning constructivist mathematics through Guided Discovery Learning assisted with the Shapes Doll to improve Mathematical Ability of students Creative Thinking effective with valid and practical tools. This research is a development research that refers to the modified Plomp model. Learning tools developed consist of syllabus, lesson plan, worksheet, and Test of creative thinking ability. Test data is processed by one sample t test, z proportion test, comparative test, regression, and Gain test. The results of the development of learning tools: (1) learning tools that was developed valid according to the validator with an average syllabus validation value of 4.29, lesson plan 4.37, worksheet 4.27, and Test 4.02; (2) effective learning, by achieving: a) The experimental class mathematical creative thinking ability reaches class average completeness and classical completeness, b) attitude and activeness together have a positive effect on mathematical creative thinking ability, c) The ability to think creatively mathematically in the experimental class students with an average of 81.21 is better than the control class of 70.82, d) Increased ability of mathematical creative thinking in the device trial class by 61%.

1. Introduction
Education for each discipline besides helping students think, also helps students to be responsible for the way they think. Mathematical education deserves this responsibility because mathematics from elementary to higher education can be used to solve problems [1]. [2] said that the ability to think creatively is the ability to see various possible solutions to a problem. Whereas according to [3] the ability to think creatively can be developed through creative activities in mathematics learning. The components of creative thinking are fluency, flexibility, originality and elaboration. The existence of creativity in learning mathematics, students are expected to dare to solve problems or math problems using the method from their own ideas.

Based on observations and interviews of researchers and discussions with several math teachers at SMA Negeri 1 Rowosari in Kendal district, the preliminary study explained that "students' attitudes are lack of motivation to learn mathematics and tend to be lazy to learn mathematics in class" or quickly feel bored with the applied learning methods, so students' understanding is reduced, because learning does not work effectively. Students' creative thinking skills are needed especially in learning mathematics, because in creativity there is a process of creative thinking. In mathematical creative thinking there are many answers put forward to solve problems that arise and that thought pushes to be broader in finding problem solving. Understanding creativity in mathematics is the ability to think creatively in solving mathematical problems. With the creativity in learning mathematics, students are expected to be brave enough to solve math problems or problems using the method of their own ideas. The decrease was caused by the lack of activity of students towards ongoing learning. In addition, students tend to be individualistic but have good academic abilities, so students' learning attitudes toward learning are lacking. The decrease was due to the lack of active students in learning. In addition, students tend to be individualistic but have good academic abilities, so students' learning attitudes toward learning...
are lacking. Based on consideration of the results of the interview, the researchers wished to develop a tool for constructivist mathematics learning using guided discovery learning method with Shapes Doll assisted on trigonometry grade X in order to improve mathematical creative thinking skills and improve students’ learning attitudes.

Learning tools have been prepared, but only formalities to meet administrative demands, so that they do not lead to learning activities that can improve students' creative thinking skills. The existing syllabus and lesson plan were made by the team of teachers of mathematics subjects. worksheet used by students is developed and printed by the publisher which contains a summary of the material and practice questions and the teacher rarely uses the media in learning. Therefore, it is necessary to develop a learning tool.

One alternative that can be used is the use of constructivism mathematics learning with the guided discovery learning method assisted by Shapes doll. Learning constructivism emphasizes that knowledge is built by students themselves actively based on their knowledge. Furthermore, in the view of Guided discovery learning is a learning method that uses discovery techniques by giving directions or instructions from the teacher. Guided Discovery Learning can encourage students to learn and think independently. This is because discovery activities allow students to be able to solve problems and build their own knowledge actively through meaningful learning [4-5]. Guided Discovery is a learning method that involves students to learn the concept of discovery. Learning with discovery is an important component in the constructivism approach where students find new understanding of the experiences they experience and are associated with the understanding they have had before. [4] said that students try themselves to find problem solving and the accompanying knowledge will produce meaningful knowledge.

Guided Discovery is a learning method designed to teach concepts and relationships between concepts [6]. Meanwhile, according to Brunner, "...student receives problems, but the teacher also provides hints, direction, coaching, feedback, and / or modeling to keep the student on track in guided discovery methods...". That in guided discovery learning students are given a problem to solve and the teacher gives instructions, direction, feedback and examples to guide students in solving the problem. As stated in QS. Al-Maidah verse 2 which reads: "... and help you in doing good and piety, and do not help in committing sins and transgressions ...". Shapes Doll as one of the media in learning mathematics in this study, Shapes Doll is a mathematical formula doll, or a trigonometry clock doll which is expected to arouse students' attitudes to study material well and be able to capture concepts easily, which ultimately can stimulate students' mathematical creative thinking skills.

In the initial observation activity in SMA Negeri 1 Rowosari Kendal in the application of learning constructivist mathematics through Guided Discovery Learning assisted with shapes doll, various mathematical problems were identified in SMA N 1 Rowosari Kendal, as the students were not maximal in exploring mathematical creative thinking skills. Students still tend to focus only on conceptual understanding, and students are less active in asking questions or expressing their opinions. This is also due to the techniques and methods used by the teacher often not in accordance with the material presented. In addition, the lack of teacher closeness with students during on going learning also causes students to be less interested in learning mathematics. As a result, mathematics learning activities are still low so that the classroom atmosphere that is expected to be fun in learning mathematics is almost invisible.

The teachers stated that they had made an effort to overcome the existing problems. Some of them are by processing teaching strategies, in house training, “study banding” and others. But the character of children who cannot be patterned to learn is an obstacle in this matter. This problem occurs because the teachers do not have enough skills in preparing syllabus, lesson plan, not enough skills to vary worksheets, and in terms of compiling questions that measure mathematical creative thinking skills. Departing from that, the teachers of SMA Negeri 1 Rowosari Kendal need to be equipped with various enlightenments in the pursuit of function revitalization as an innovation in the development of learning tools.
This study aims to determine the implementation of learning constructivist mathematics through guided discovery learning assisted with Shapes doll to improve effective teaching and learning on effective grade X on trigonometry with valid and practical tools.

2. Review Literature
2.1. Constructivist Learning
Constructivist is one of the schools of philosophy that has the view that the knowledge that we have is the result of construction or the formation of ourselves [7]. The thoughts of various educational experts such as Piaget and Vigotsky are interwoven in the constructivism perspective which has various manifestations in the learning process. Piaget assumed that individual factors were more important than social factors while Vigotsky emphasized the importance of the role and construction of knowledge as a social process and togetherness. Furthermore, the creativity psychometric theory was introduced by Guilford who suggested that in one part of the intellectual structure, the operations section contained divergent thinking processes which included fluency, flexibility, authenticity and elaboration.

2.2. Guided Discovery Learning
2.2.1 Definition of Guided Discovery Learning
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Guided Discovery is a method of teaching that allows students to be able to develop their creativity so that they are given the maximum freedom. Nevertheless, discovery activities are not carried out individually but are carried out in groups. Through group activities will make it easier for students to solve problems faced. In guided discovery, the teacher functions as a facilitator. The teacher acts as a road guide and helps students to be able to issue ideas, concepts and skills in solving problems. Students are encouraged to think and analyze themselves so that they can find their own material or data provided by the teacher.

Guided discovery learning based on expert opinions can be concluded as a learning process or method in which students play an active role in finding information and obtaining their own knowledge. The teacher only gives direction or instructions to students so that students observe and discuss in order to get more meaningful learning.

2.2.2. Aspects in Guided Discovery Learning
Learning with guided discovery generally consists of planning, implementation and evaluation. It aims to avoid mistakes in the process and the success of learning goals. Furthermore assessment or evaluation of the guided discovery method according to [8] is defined as the process of delineating, obtaining, and providing useful information for judging decisions alternatives which means evaluation is the process of describing, obtaining, and presenting information that is useful for formulating an alternative decision.

Assessment in guided discovery learning can be done using tests or non-tests. Assessment can be used in the form of cognitive assessment, process, attitude, or assessment of student work. If the form of assessment is in the form of cognitive assessment, it can use a written test, but if the assessment uses
an assessment of the process, attitude, or assessment of student work, the assessment can be carried out with observations.

2.3. Mathematical Creative Thinking Ability
Creative thinking according to [9-11] is a process that is used by someone in synthesizing ideas, building new ideas and applying them to produce new products fluently and flexibly. According to [12] is a poses produce ideas or ideas, which emphasize the aspects of fluency, flexibility, originality and elaboration in thinking. Meanwhile, according to [13] creative thinking is thinking that leads to the acquisition of new insights, new approaches, new perspectives, or new ways of understanding something.

According to [14] creativity does not only occur in certain fields, such as art, literature or science, but is also found in various lives including mathematics. The importance of creativity in mathematics was put forward by Bishop, who stated that a person needs two mathematical skills, namely creative thinking which is often identified with intuition and analytical thinking skills that are identified with the ability to think logically. While Kiesswetter stated that flexible thinking ability which is one aspect of the ability to think creatively is an important ability that students must possess in solving mathematical problems. This opinion confirms the existence of mathematical creative thinking abilities.

Creative thinking makes it possible to produce and expand ideas and to find alternative outcomes. Creative thinking is one of the natural talents needed so that individual creativity can help solve various types of social problems, as stated by [15], creative thinking is a natural talent needed to be nurtured so that creative individuals can help society solve their problems are different. Whereas according to [16] creative thinking was initially believed to be a talent possessed by extraordinary individuals, and many studies carried out confirmed that these talents could be identified and maintained. Creative thinking will make students move to try different perceptions, concepts and points of entry. Students can use various methods including provocation to solve problems.

Creativity in mathematics can be interpreted as creative thinking in solving mathematical problems. According to Silver in [10-11] three key components assessed in students' creative thinking ability using TTCT (The Torance Test of Creative Thinking) are fluency, flexibility and novelty. Creative thinking is cross-field thinking, biosisitive thinking, lateral thinking, divergent thinking. Creative thinking is characterized by the characteristics of thinking that is fluency, flexibility, originality, elaboration, redifinition, novelty [17].

3. Method
This research is a development research, namely the development of constructivism mathematics learning tools with guided discovery learning method with Shapes doll assisted to improve students' mathematical creative thinking skills in class X trigonometry materials. The tools developed include syllabus, lesson plans, student worksheets and mathematical creative thinking skills (test of creative thinking ability).

The model for developing learning tools that refers to the general education development model of Plomp [19] which is modified. The development model proposed by Plomp consists of five stages, namely: initial investigation, design, realization / construction, testing, evaluation, and revision, and implementation. The implementation phase is not carried out explicitly but is integrated in the implementation of research, namely when conducting field trials of learning tools in the scope of the research subject. Because in this case, researchers made modifications in the application of the Plomp model.

The research instrument used to collect data consisted of creative thinking ability tests, student activity observation sheets, attitude questionnaires and student responses to mathematics and validation sheets. Data collection methods used in this study are test, observation and questionnaire methods.

Data analysis techniques used as follows learning tools are assessed by the validator, in accordance with the rubric made by the researcher. The data listed on the validation sheet which is the assessment of each validator against the learning device is analyzed based on the average device score. Practical learning tools need to be reviewed from student responses. Data from observations of students'
mathematical creative thinking skills during learning are analyzed by calculating how much percentage increase. The criteria for students' creative thinking skills are said to be effective if the percentage of students' creative thinking ability is relatively increased from one meeting to the next meeting. The effectiveness test is done by completeness test, comparative test, influence test, and improvement test. Test of completeness of mathematical creative thinking ability is used to determine the achievement of the completeness of the proportion and the average of the experimental class students. Regression analysis is used to determine the effect of students' attitudes and activeness on mathematical creative thinking skills. Test for improving students' creative thinking ability according to [21] based on Pretest and Posttest using the Normalized Gain formula \( \langle g \rangle \).

4. Result And Discussion

The results of the expert validation obtained can be seen in Table 1. The revised learning tools are in accordance with the validator's suggestions, then they are tested to obtain inputs to refine the learning device. Field trials were carried out in the last week of April and weeks 1 to 4 in May 2018 which consisted of 4 learning meetings and 1 meeting for the final creative thinking ability tests in the experimental class and control class. Selected class X6 as the control class and class X2 as the device test class for experimental class. As for the trial of creative thinking ability tests questions, class X5 is selected.

Table 1. Results of Validation of Learning Devices

| No. | Tools                        | Validators | average | Classification |
|-----|------------------------------|------------|---------|----------------|
| 1.  | Syllabus                     | 4.05 4.11 4.09 4.02 4.02 | 4.29    | Very good      |
| 2.  | lesson plan                  | 4.08 4.01 4.11 4.11 4.16 | 4.37    | Very good      |
| 3.  | worksheet                    | 4.05 4.10 4.08 4.02 3.02 | 4.27    | Very good      |
| 4.  | thinking ability tests       | 3.93 3.91 4.00 4.14 4.12 4.02 | Very good |

Before the device trial, normality and homogeneity analysis was carried out for the device and control class trial class. During the trial process, data collection included activeness observation data and student attitude questionnaire data. Then at the end of the trial process a creative thinking ability tests was conducted to measure mathematical creative thinking skills in the experimental class and control class.

Learning devices are said to be practical if after being tested in the experimental class obtains results: positive student responses, and the teacher responds well. Based on the results of filling in the student response questionnaire, then the percentage was obtained and it was found that 92.96% of students gave a positive response, in other words the students gave a positive response of more than 75% and the average results of the teacher response questionnaire on the learning device was 4.67.

Based on the process of data analysis about student activity after using constructivism mathematics learning with guided discovery learning method assisted by Shapes doll, the results shown are as follows.

1. Indicator of activity in home preparation is 4.12;
2. The indicator for participation in learning starts at 4.59;
3. The activeness indicator in the learning process is 4.28;

Thus, it can be concluded that student activity is good. This activity arose after learning through constructivism learning using the Guided Discovery Learning method assisted by Shapes Doll. Based on the process of data analysis regarding students' learning attitudes after using constructivism mathematics learning with guided discovery learning method assisted by Shapes doll, the results
obtained were the percentage of students' learning attitudes. The results of the research data are used to determine the level of success of the use of development tools. The level of effectiveness is measured through four statistical tests, namely (1) learning completeness test; (2) effect test; (3) difference test; and (4) Improvement test. The results of the data obtained by creative thinking ability tests students of the experimental class have exceeded the average and classical completeness of 75 as minimal completeness criteria and the proportion is 80%. Difference test was carried out to compare the creative thinking ability students of the experimental class with the control class. Based on the results of the calculation obtained the results of the average score of different completeness, with the average value in the experimental class 81.21 and the control class 70.82. The results obtained from the experimental class and control class as follows.

Based on the formula obtained:

\[ s = 9.44 \]

\[ t = \frac{\overline{x}_1 - \overline{x}_2}{s \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \]

\[ t = \frac{81.21 - 70.82}{9.44 \sqrt{\frac{1}{34} + \frac{1}{34}}} = 4.5387 \]

By using the real level \( \alpha = 5\% \) and \( dk = (n_1 + n_2 - 2) = 34 + 34 - 2 = 66 \), obtained the value of \( t_{\text{table}} = 1.67 \) because of \( t_{\text{count}} > t_{\text{table}} \), then Ho is rejected. Means that the experimental class has an average creative thinking ability value better than the control class.

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Analysis of the joint influence between student activity and attitude towards creative thinking ability by multiple regression test results that the equation model is linear. Then the results of the improvement test of mathematical creative thinking ability in the experimental class based on the initial test scores and the final test showed an increase in the medium category. This shows that learning is effective because it meets the indicators of learning effectiveness.

Some inputs from the validator in developing the syllabus include that the syllabus developed by researchers is expected to be able to answer questions about competencies that students must master, how to achieve them, and how to find out how to achieve them. The disadvantages found in the syllabus before being validated are the written rules of the mathematical formula all written with the math equation. Some things that need to be considered in the development of lesson plan are: the writing system, the creative thinking ability tests time allocation is adjusted to the number of items and the complexity of the questions; and assessment activities are included in the core / closing activities and need to increase the creative thinking ability assessment. creative thinking ability assessment needs to pay attention to the indicators that will be achieved. This is intended to be able to clearly and focus in measuring the expected mathematical creative thinking skills.

The developed worksheets need to pay attention to simple color selection and comfortable color combinations to read. Another thing that is suggested is about writing equations and mathematical formulas that should all be written in math equations, and discussion questions should be arranged towards Mathematical Creative Thinking Ability.

The completeness in this study is the proportion in completeness and the average mathematical creative thinking ability of the experimental class students. Based on the calculations that have been made, it was found that there were 32 students who completed learning from a total of 34 students, and in proportion the students who scored \( \geq 76 \) as minimal completeness criteria had exceeded the proportion
hypothesized by 80%. The results of supporting research, among others: [22] which states that the average value of mathematics learning outcomes of students who take mathematics learning guided discovery learning methods based on constructivism is higher than students who take lessons with conventional strategies and differ significantly. This can happen because students build their own knowledge so that understanding of the learning material is deeper and permanent. The same thing is also found in [23]'s research, that the average student learning outcomes in classes using Constructivism Mathematics Learning models are better than students’ learning outcomes with conventional models.

Learning constructivism mathematics with guided discovery learning method using Shapes Doll is an effective method of learning, because students are preferred to construct their own knowledge through assimilation and accommodation, while the teacher is only as a facilitator and can encourage students to learn and think independently. This is because the guided discovery learning method assisted by Shapes Doll allows students to solve problems and build their own knowledge actively through meaningful learning. This is in accordance with what was raised by [5].

5. Conclusion

Learning constructivist mathematics tools with Shapes doll through guided discovery learning on trigonometry in grade X developed in this study have been declared valid after getting validation from the expert team. The learning tools can also practically improve mathematical creative thinking skills based on students providing a positive response of 92.96%, and the teacher responds with an average of 4.27. The results of the analysis on the effectiveness of the learning have achieved effective indicators, namely: experimental class mathematical creative thinking abilities achieve completeness by exceeding 75 as minimal completeness criteria and the proportion of 80%; (2) the experimental class’s mathematical creative thinking ability is better than the control class; (3) the activeness and attitudes of experimental class students have a positive effect on their mathematical creative thinking abilities; and (4) there is a significant increase in students’ mathematical creative thinking ability, which is 61%.

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References

[1] Hudojo H 2005 Teaching and Learning Mathematics Strategies (Malang: IKIP Malang)
[2] Munandar U 1999 Develop School Talent and Creativity (Jakarta: Grasindo)
[3] Dwijanto 2007 The Effect of Learning Computer Assisted Problems on Achieving Students Mathematical Problem Solving and Creative Thinking Abilities (Bandung: UPI)
[4] Trianto 2007 Innovative Constructivist Oriented Learning models (Surabaya:Kencana)
[5] Trianto 2009 Designing a Progressive Innovative Learning Model (Surabaya:Kencana)
[6] Jacobsen & et al 2009 The five mediterranean-type climate regions are among the most biodiverse and may vary greatly among these communities
[7] Hadi R 2010 Development of Constructivist Mathematics Learning Tools with the Student Team Achievement Division Type Cooperative Learning Model in Building Materials in Class V (Semarang: PPs UNNES)
[8] Stufflebeam D L & et al 1971 Educational Evaluation and Decision – Making (Itasca Illinois: Peacock)
[9] Siswono T Y E 2006 Theory Implementation of the Level of Creative Thinking of Students in Mathematics Paper Seminar on National Mathematics XIII Conf. and Indonesian Mathematical Association Congress at the Mathematics Department of FMIPA Semarang State University July 24-27 2006
[10] Siswono T Y E 2007a Improving Students Creative Thinking Abilities Through Problem-Solving What’s Another Way Mathematics Education Journal 1 1
[11] Siswono T Y E 2007b Humanistic Mathematics Learning that Develops Student Creativity Paper National Seminar on Mathematics Education Humanizing Mathematical Learning for Humans in the Mathematics Education Study Program FKIP Sanata Dharma University Yogyakarta 29-30 August 2007

[12] Grieshober W E 2004 Continuing a Dictionary of Creativity Terms and Definitions (Buffalo Stage College: The International Center for Studies in Creativity)

[13] Mahmudi A 2010 Measuring Mathematical Creative Thinking Abilities UNIMA XV National Mathematics Conf. Manado 30 June-3 July 2010

[14] Pehkonen E 1997 Fostering of Mathematical Creativity ZDM International Reviews on Mathematical Education 29 63

[15] Awang H and Ramly I 2008 Creative Thinking Skill Approach Trogh problem-Based Learning: Pedagogy and Practice in Classroom International Journal of Human and Social Sciences 1 18

[16] Mokaram A K et al 2011 Enhancing Creative Thinking trough Designing Electronic Slides International Education Studies 4 39

[17] Guilford J P 1973 Fundamental statistic in psychology and education (New York: mc graw-hill book company)

[18] Guilford J P 1967 The nature of human intelligence (New York: mcgraw-hill)

[19] Plomp T J 1997 Educational Design: Introduction From Tjeerd Plomp (eds) Educational & Training System Design: Introduction Design of Education and Training (in Dutch) Utrecht (the Netherlands): Lemma Netherland Faculty of Educational Science and Technology University of Twente

[20] Plomp T J and Wolde J van den 1992 The General Model for Systematical Problem Solving From Tjeerd Plomp (Eds) Design of Educational and Training (in Dutch) Utrecht (the Netherlands): Lemma Netherland Faculty of Educational Science and Technology University of Twente Enschede the Netherlands

[21] Hake R R 1999 Analyzing Change/Gain Scores AREA-D American Education Research Association's Devison D Measurement

[22] Lasmin 2011 Development of Mathematical Learning Devices Guided discovery learning Method Constructivism grade X on Circle (Semarang: Program Pascasarjana Unnes)

[23] Sa’dijah C 2006 Development of Constructivism-Based Mathematics Learning Models for High School Students Journal Mathedu 1 111