The creativity of pre-service mathematics teachers in designing GeoGebra-assisted mathematical task

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Abstract. The aim research is to obtain a description of designing of the GeoGebra-assisted mathematical task created by pre-service mathematics teachers. This study uses a qualitative approach to observe the phenomenon of participants in making mathematical tasks. Participants are 26 pre-service mathematics teachers who will implement the program of teaching experience in mathematics teaching in high school in Ciamis. Participants work in the group (about 3-4 people) to make a GeoGebra-assisted mathematical task, the topic is the system of two linear equation. Creativity in the mathematical tasks designed is shown by a participant when they the integration of mathematical topics with GeoGebra for a specific task purpose. The results obtained in this study are mathematical assignments designed by utilizing the feedback generated by GeoGebra both geometrically and algebraically. The aimed of mathematical task design is at introducing new content, giving students the opportunity to apply procedures in new situations, and developing problem-solving, improving understanding skills, connections, and generalizations. These results indicate that pre-service mathematics teachers try to find creative mathematical tasks that integrate mathematics topics with GeoGebra.

1. Introduction

The interaction between teachers, students, and mathematics facilitated by a mathematical task in the learning process. A mathematical task is a form of social practice, which is done by teachers and students collectively [1]. The social interaction can provide mathematical and cognitive activity in the learning process [2]. The task of mathematics is an environment that can cultivate students' mathematical skills and competencies that have been targeted by teachers. The mathematical task is designed with regard to the relationship of teachers, students, and mathematics so as to form four vertices called the tetrahedron model [1-2]. Mathematical tasks are designed with attention to the purpose of assignment [1], learning objectives (adjusting to school curriculum & vision-mission), content domains and mathematical activity domains [3], as well as the type, nature and task variables mathematics [4]. The design of mathematics tasks in accordance with the purpose of its use to achieve an expected competence. The purpose of using mathematical tasks is to introduce new mathematical content, consolidate the taught procedures, allow students to apply procedures in new situations, assess students' understanding of concepts or procedures, create conditions in student placement, develop more common problem solving, or collaborative skills [1].

The design of mathematical tasks should be in line with the principles of learning in the 21-st century [5] in the most fundamental areas of knowledge (interdisciplinary approach, information literacy,
concepts-focused), competence (creativity and critical thinking), attitudes and values needed to solve complex problems. There is a mathematical task derived from mathematical problems. The situation becomes a problem for a person if there is a barrier to achieving the goal, whereas the knowledge, responses, and behaviors of the student are not enough to remove the barrier [4]. Mathematical tasks can come from routine and non-routine issues. Routine issues are needed to foster understanding of concepts [6] and procedural skills. On the other hand, non-routine issues are needed to foster students' creativity and originality [6]. Reasoning also has an important role in solving mathematical tasks. Therefore, task design should take into account the reasoning that will be performed by the students. Reasoning and problem solving are the core or heart of mathematics learning and use of technology [5].

Mathematical learning by utilizing computer technology has been done a lot nowadays. GeoGebra has a role in the achievement of various student competencies. GeoGebra can improve students' mathematical understanding [7]. Feedback generated by GeoGebra can provide assistance to students in the problem-solving process through reasoning [8]. GeoGebra can facilitate the process of abstraction from real-life situations (between geometric models and algebraic models [9]. GeoGebra-assisted task assignments can display the types of mathematical activities that encourage students to make generalizations [10].

Stimulus given appropriately to students using GeoGebra provides many benefits in mathematics education. Based on research in cognitive psychology and mathematics education that knowledge, understanding, and skills of a person are needed in learning. It will determine the mathematical skills consisting of conceptual understanding, fluency of procedure, strategic competence, adaptive reasoning, productive disposition [11]. Therefore, it takes the creativity of teachers to design mathematics tasks by integrating mathematical topics with GeoGebra so as to encourage students' mathematical abilities.

Creative characteristics have a different variety of view. Discovery, innovation, authenticity, insight, enlightenment, and imagination are creative characteristics [12]. Silver stated that the core quality of creativity is fluency, flexibility, and novelty [13]. In addition, Clinton and Hokanson [14], in creativity research regarding instructional designers put forward key concepts consisting of creativity and problem solving, stages of creativity, enhancing creativity, creativity and self-perception, creativity and social context, creativity within constraints. The limitation of creativity in this study was carried out on the purpose of using very diverse tasks [1] which were integration with feedback generated by GeoGebra. This diversity will open opportunities for teachers to design creative mathematical tasks.

Creativity in designing a math task through the integration of mathematical topics and computer technology will provide added value in the meaning of mathematics learning for students. Therefore, this study aims to obtain a description of the creativity of pre-service mathematics teachers in designing GeoGebra-assisted mathematics tasks.

2. Methods
This study uses a qualitative approach to observe the phenomena of pre-service mathematics teachers in making mathematical tasks. Participants are pre-service teachers who will carry out a program of experience in teaching mathematics practice at secondary schools in Ciamis. Participants were 26 women, working in groups (3-4 people), namely groups of K-1, K-2, K-3, K-4, K-5, K-6, and K-7. They work in a mathematical laboratory with computer facilities with GeoGebra software. The problem given was to design GeoGebra-assisted mathematical assignments on the subject of two-variable linear equation systems within 60 minutes. Participants had previously obtained a GeoGebra course and were accustomed to using it in lectures.

The research data has obtained the results of a mathematical task designed and interviews. Design of task analysis to see the creativity of integrating the topic of systems of linear equations with GeoGebra and looking at the purpose of user tasks. Interviews are intended to ask the purpose of using the tasks they expect later to occur to students.
3. Result and Discussion

3.1. Result

The design of mathematical tasks produced by K-1 utilizes feedback generated by GeoGebra, both geometry, and algebra. Tasks are used to introduce new content, develop problem-solving and make generalizations to define the terms of two lines parallel. Visualization of geometry is useful for viewing the alignment of two variable linear equations, while algebraic visualization is useful for determining the terms of two parallel lines. The design of mathematical tasks from group K-1 are:

1. the teacher tells the general form of the linear equation of two variables $ax + by = c$.
2. students make one equation with any value a, b, and c, then put it in GeoGebra.
3. students make another equation;
4. students pay attention to feedback generated by GeoGebra both graphics and algebra;
5. if the two lines are not parallel, then the student retries another equation to obtain two parallel lines;
6. after the students have obtained parallel lines, then make rules on the terms of two parallel lines.

The design of mathematical tasks generated by the K-2 group utilizes feedback GeoGebra, both geometrically and algebraically. The task is intended to introduce new content, develop problem-solving, and generalize. Students can identify two intersecting equations. Visualization of geometry is used to see the two linear equations generated by GeoGebra, while algebraic visualization is useful for determining the terms of two intersecting lines. The design of mathematical tasks from group K-2 are:

1. make a line equation that contains two variables;
2. make another line that intersects with the first line;
3. determine the rules regarding two intersecting lines;
4. analysis of the rules you have obtained, can they be applied to all equations?

The design of mathematical tasks produced by groups of K-3, K-4, and K-5 is almost the same. The goal is to provide an opportunity for students to apply the procedure in a new situation that is to know the intersection of the equations given by the graph method. The utilization of visual feedback generated by GeoGebra is used to provide an understanding of the solution of the two-variable linear equation system. The design of mathematical tasks from group K-3 are:

1. enter the following equations: $x + y = 5$, $3x + y = 9$, $3x + 2y = 12$, $2x + y = 7$;
2. notice the image produced by GeoGebra, the four lines will intersect at the same point;
3. find the coordinates of the intersection of the line.

The design of mathematical tasks from group K-4 are:

1. enter $x + 2y = 8$;
2. enter $2x - y = 6$;
3. select the toolbar point, select a point, and click on the intersection point of the two lines.

The design of mathematical tasks of the K-5 group are:

1. two equations $3x - 2y = 7$ and $2x + y = 14$;
2. look for the set of a settlement with the settlement method that you like;
3. find a solution using GeoGebra;
4. compare the results obtained from parts (2) and (3).

The design of mathematical tasks produced by the K-6 group utilizes GeoGebra feedback, both geometry, and algebra. The aim is to introduce new material content that is knowing the form of two variable linear equations. The design of the mathematical tasks of the K-6 group are:

1. for points A (0.5) and B (5.0);
2. connect points A and B to form a straight line;
3. note the graphs and equations produced by GeoGebra;
4. in the same way, make two other points until a two-variable linear equation is formed.

The completion of this task requires the ability of a mathematical connection to create a mathematical model.
This design integrates the word problem with a solution of a linear equation system whose solution from GeoGebra. The cut point produced by two line is the solution. The design of the mathematical tasks of the K-7 group:

Ani bought three pencils and one ballpoint worth Rp.5000,- and Rio bought four pencils and the same three pens in the same shop worth Rp.10000. What are the unit cost of a pencil and a ballpoint? Complete the following issues with the following steps:

1. make the equations of the problem;
2. enter these equations on GeoGebra;
3. select the toolbar point, click the point, click the intersection of the two lines.

3.2. Discussion
The results of the design of various mathematical tasks show creative work. They seem to be trying to get out of the design of routine tasks, although they tend to imitate routine tasks first and then integrate them with GeoGebra. The discovery of a design that integrates the GeoGebra and topic of systems of linear equations is evidence of the existence of creativity from simple to complex. In general, the results of the design of mathematical assignments utilize the feedback generated by GeoGebra both geometry and algebra. The task is intended to introduce new content, provide opportunities for students to apply procedures in new situations, develop problem-solving, and improve understanding skills, connections, and generalizations.

The feedback generated by GeoGebra in the form of geometry and algebraic visualization together is GeoGebra's superiority. Feedback in the form of graphics visualization and algebra can be used to construct a mathematical rule. Pre-service mathematics teachers take advantage of these advantages in designing mathematical assignments on the topic of systems of two variable linear equations in this study. For example, the design of K-1 and K-2 is intended so that students can make a pattern from the results of graphics and algebraic visualization produced by GeoGebra. Inductively, students can predict a rule into a knowledge that is more meaningful because it is the result of his own experience. Therefore, the power of graphics and algebra possessed by GeoGebra can be used by the teacher to make mathematical tasks that correspond to mathematical competencies so that students can construct their knowledge independently.

Introducing new content is one of the goals of designing tasks. In this study, many of the results of the design of mathematical tasks were to introduce systems for solving linear equations through graphs from GeoGebra. Determine the intersection of two lines. The graphical accuracy generated from GeoGebra feedback will produce an accurate solution compared to the graph in the picture using paper, pencil, and ruler.

The activity of completing a system of linear equations using GeoGebra will provide opportunities for students to apply procedures in new situations. Visualization and exploration of objects and mathematical concepts in the multimedia environment can foster students' understanding in new ways [15]. For example, the design of tasks produced by K-3, K-4, and K-5 can accelerate students' understanding of the completion of a two-variable linear equation system, especially for students who prefer visual learning methods. Students can compare the solutions produced by GeoGebra with algebra-based completion methods such as elimination and substitution methods. Students are able to represent mathematical situations in different ways and know the differences [11]. Students can understand the advantages and disadvantages of each method based on their own experience.

Word problem and GeoGebra can also be integrated. For example, in the design of the K-7. Students first need an analysis of the relationship between the real world and mathematical concepts. The relational paradigm can be a good theoretical tool for helping and building tasks [16]. The role of GeoGebra in this task is a tool for computing to solve the system of linear equations.

Another goal in the design of mathematical assignments is to increase generalization. For example, the design of mathematical tasks produced by groups K-1 and K-2 is in the form of problem-solving aimed at generalizing a rule. Completion of this task requires creative reasoning and high-level thinking from the feedback generated from GeoGebra. Students who can complete tasks are those who are able to describe feedback from GeoGebra [8]. The ability to interpret and predict feedback from GeoGebra
is very important for success in completing tasks. This mathematical task gives the possibility for students to formulate a guess that can be generalized.

Development of mathematical assignment designs must be carried out by prospective mathematics teachers. Development to provide a broader learning experience for students. For example, we can develop tasks K-3, K-4, and K-5 by adding a case of a system of two variable linear equations with non-single solutions. Development to train to reason and provide a comprehensive understanding from simple cases to complex cases. Designing tasks should start from a basic principle, then try to find a special case that generates generalizations [10].

The development of non-routine tasks with GeoGebra is expected to foster students' creative mathematical reasoning. GeoGebra has the potential to help complete non-routine tasks through transformation and representation quickly and precisely (Olsson, 2018). Reasoning from GeoGebra's feedback supports students solving mathematical problems. The reasoning is the driver of problem-solving. In each stage of problem-solving, reasoning is needed. Milieu, competence, and thought processes can influence students' reasoning sequences [13]. GeoGebra can act as an environment that will stimulate student reasoning. GeoGebra can train high-level thinking students. However, routine tasks must still be given to students. The combination of routine and non-routine tasks will make students more creative because routine problem-solving skills will support non-routine solving processes [6].

Finally, each teacher will be a creative person when finding a mathematical task design by integrating a mathematical topic with GeoGebra. Integration will bring a teacher out of the routine path in setting a task. A strategy that can be done by teachers in integrating mathematical tasks with GeoGebra: (1) if students are accustomed to using GeoGebra, students can be given assignments with open and challenging answers without being given procedures for using GeoGebra tools, and (2) if students do not know GeoGebra, students can be given assignments with closed answers (given procedures for using GeoGebra tools) to provide opportunities for students to carry out completion procedures in new situations.

4. Conclusion
Pre-service teachers design mathematical tasks in accordance with learning objectives. The creativity of pre-service teachers in designing mathematical tasks has an important role in achieving that goal. The habit of designing creative tasks needs to be initiated by pre-service teachers from a now. The design of tasks produced in this article shows that pre-service mathematics teachers try to find creative mathematical assignments that integrate mathematics topics with GeoGebra.

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