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Development of the D-Geometry Module Based on Discovery Learning

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Abstract
Teaching module is of immense importance for teachers to utilize during classroom instruction for helping students learning construction. The purpose of this study is to develop a geometry module (D-Geometry) based on the discovery learning theory. The ADDIE instructional model guided the need analysis, design, and development phases of the research. The first phase involves three aspects: synthesis of literature review, student analysis, and context analysis. The results of the need analysis showed ten levels of activities in the teaching and learning that molded the design of the D-Geometry module. The D-Geometry module focused on the lesson implementation plan, teacher book, student book, and activity sheets. It is hoped that the module can contribute to improving the mathematical curriculum in schools and student achievement. In producing quality mathematical learning, it is recommended that teachers utilize discovery learning when teaching mathematical topics. Future studies are needed to examine the effectiveness of the module on student mathematics learning outcomes.
Keywords: Discovery, Geometry, Module, Research, and Development

Introduction

Using traditional teaching of geometry topics yield as a failure in mathematics problem-solving techniques, when students experienced misconceptions of the mathematics concepts in classroom learning (Disbudak & Akyuz, 2019; Ibili et al., 2019; Rakes & Ronau, 2018; Tambychik & Meerah, 2010). The geometry is the most difficult topics by many students (Adolphus, 2011). Geometry is one of the topics that are hard to be understood deeply by students (Hua et al., 2019). The factors contributed to students' difficulty in understanding geometry topics were the conventional method of learning (student-cantered), and the topics learned are not related to students' daily lives. Furthermore, the heavy use of formulas and questions, and students are less trained with the creativity and understanding of geometry concepts made mathematical learning is complex (Fonna & Mursalin, 2019).

Geometry has a link with the skill of students' understanding because these two aspects are the basic ideas needed by students in completing various mathematical questions (NRC, 2001).

Achievements on this topic are in the low category among students based on the marking results obtained by each student. This case was found based on the results of independent studies that have been carried out by educators and reviewers. In general, Geometry is one of the most challenging topics to be understood by many students (Adolphus, 2011; Hua et al., 2019; Rohendi, Septian & Sutarno 2018) especially on the understanding the concepts, regions, and circumference (Damayanti, Krisdiana, & Setyansah, 2019). In overcoming the problems faced by a student, teachers need to realize learning methods that provide broadest opportunities for students to be actively involved in the T&L process, especially on Geometry topics (Damayanti, Krisdiana, & Setyansah, 2019; Rohendi, Septian, & Sutarno, 2018). The discovery method on the topic of Geometry in mathematics learning in schools is very encouraged to be applied for high school students. The development and using the D-Geometry module may help students to understand mathematical learning well. However, so far, there have been few studies using modules with the discovery approach on the topic of Geometry in Indonesia (Febriana, Haryono, & Yusri, 2017). Some of the results of the study only show the implementation of learning by discovery with different topics. Therefore, the researchers developed a module on geometry topic based on discovery learning to improve the teaching and learning of this topic at schools. The active learning principle is integrated into the D-Geometry module can help students to build their depth understanding of the topics learned (Nicol et al., 2018).

The Integration of Discovery Learning

Discovery learning is a process of acquiring scientific knowledge and skills based on constructivism learning theory. Students can freely share their ideas with partners (Cetin-Dindar, 2016; Treadwell et al., 2010). Therefore, students need to understand and be able to apply their knowledge, solve problems, find something by themselves (Slavin, 2018). During discovery learning, students explore and create their understanding through problem-solving or investigation process (Nichols, 2012; Sutman, Schmuckler & Woodfield, 2010). Students take over their learning process while building their new knowledge based on previous learning in problem-solving (Nichols, 2012; Seifori & Mostafaee, 2015). The discovery process involved the development of many skills in the form of critical skills, observation, reasoning, measurement, manipulation of numerical data, preparation of schedules, graphs, and data interpretation. Through this process, students can explain, identify the correct solution, and make conclusions (Sutman, Schmuckler & Woodfield, 2010). Also, the focus of discovery learning is to learn how to analyze and interpret data to be able to understand what is learned and not to memorize (Mostafaee, 2015). The goal of discovery learning is to gain profound knowledge and to provide more in-depth learning opportunities for students (Kukar et al., 2012; Mostafaee, 2015). In relation, the D-geometry module was developed based on the elements of discovery learning and other learning theories: behaviorism and cognitivism. The analysis, design, and development (ADD) phases were utilized to produce a useful quality learning module that suits the needs of the students and teachers. Additionally, the development of the D-Geometry module can overcome the problems faced during the teaching and learning of Geometry. McCaslins (2015) supported the use of cognitive-based and constructive-based elements in the D-Geometry module as the essential tools in improving students' quality of understanding and knowledge in areas of science and mathematics.

The Needs Analysis

The analysis is carried out following the description in Table 1. The first level carried out is to analyze the goal of mathematics education in secondary school (SMP). The curriculum outlines are eight objectives of mathematics education in Indonesia (Permendikbud, 2014). Firstly, the understanding of mathematical concepts which students should be able to explain the relationship between ideas and use them in a flexible, efficient, and accurate way of solving a problem. Secondly, using patterns as an allegation in problem-solving and generalization based on existing phenomena or data. Thirdly, ability to use reasoning, mathematical manipulation in simplification, analyzing existing components in problem-solving in mathematical contexts or outside of mathematics field (real life, science, and technology). The fourth objective of learning mathematics is to communicate ideas, reasoning, and able to arrange mathematical arguments by using complete sentences or equations, symbols, tables, diagrams or other media to clarify the situation or problem. The fifth and sixth objective to have an enthusiastic attitude of the use of mathematics in life, such as having curiosity, attentive, interest in learning math, diligence, consistency, and tolerance. Ability to perform activities in problem-solving with direct objects and knowledge (the seventh and eight).

Table 1. Phase 1 of the D-Geometry module development

Phase I		Items Analyzed	Criteria
1. Teacher Analysis		(a) The goal of mathematical learning according to the curriculum	The Primary Framework and First Secondary School Curriculum Structure/MTs
		(b) Teacher constraints and barriers	
		(c) Syllabus	The Primary and Secondary Education Process Standard
		(d) Geometry textbooks	
2. Student Analysis	A	(a) The goal of mathematical learning according to the curriculum	The Primary and Secondary Education Content Standards
		(b) Students' constraints and barriers	
		(c) Geometry textbooks	
		(d) Learning media	
		(e) Behavior	
		(f) Skills	
		(g) Student academic motivation	
	B	(h) Students knowledge of Geometry	
3. Context Analysis		(a) Classroom space arrangement	The Standards of Facilities and Infrastructure, Part D, Section 1 on classroom space and Learning Resources
		(b) Seating arrangements	
		(c) Learning media	

Teacher Analysis

Teacher analysis consists of four elements. The study conducted was administering five-point Likert scale questionnaires (Very Good = 5, Good = 4, Good enough = 3, Bad Good = 2 and Not Good = 1). This analysis involved five math teachers. Table 2 shows that the implementation of measurable learning goals according to the curriculum is in the "Good Enough" category. Meanwhile, the aspects of teacher constraints and obstacles, syllabus, and K-13 textbooks used are in the "Not Good" category.

Table 2. The teacher analysis

Teacher Code	Question Item No				Total	Interpretation
	a	b	c	d		
A-1	1	2	2	3	8	Not Good
M-2	1	1	1	1	4	Not Good
S-3	1	2	2	2	7	Not Good
U-4	1	1	1	1	4	Not Good
Y-5	3	2	2	2	9	Bad Good

Instructions: A-1=First teacher; a= The goal of mathematical learning according to the curriculum; b = Teachers' constraints and barriers; c = Syllabus; and d= Geometry Textbook

Student Analysis

Student analysis is divided into two parts. The first part consists of seven items and the second part about students' knowledge of geometry topics. Student analysis was conducted on ten students for the first part, and the second part of the need analysis involved 32 students. Based on Table 3, the analysis for the first part is under the "Not Good" category.

Table 3. The student analysis

Student Code	Question Item No							Total	Interpretation
	a	b	c	d	e	f	g		
P-1	4	3	2	3	4	2	4	22	Good Enough
P-2	2	2	2	2	1	1	1	11	Not Good
P-3	2	2	2	2	3	2	3	16	Not Good
P-4	2	2	2	3	2	2	3	16	Not Good
P-5	2	2	2	3	3	2	4	18	Bad Good
P-6	2	3	2	2	5	2	1	17	Not Good
P-7	3	3	3	2	3	2	2	18	Bad Good
P-8	2	2	2	3	5	4	4	22	Good Enough
P-9	1	3	2	2	3	2	3	16	Not Good
P-10	1	2	2	2	1	2	1	11	Not Good

Indicator: P-1=Student number 1; a = The goal of mathematical learning according to the curriculum; b = Students' constraints and barriers; c = Geometry textbooks; d = Learning media; e = Behaviour; f = Skills; g = Student academic motivation

Further, a questionnaire of the Geometry topic was distributed to 32 students. The results of the analysis were used to examine the students' knowledge of the topic. The study showed there were 26 students under "Unsuccessful", while only six were under the "Successful" categories. A total of 81.25% of the students were unsuccessful in learning the Geometry topic, and only 18.75% of the students were successful in solving the Geometry topics. Many students have not yet reached minimal completeness criteria (KKM) set by the school because students are having difficulties in understanding the geometry topic (Ulusoy & Argun, 2019).

Context Analysis

In the next stage, analysis of context has been carried out by administering questionnaires to 10 students. The following Table 4 is the result of the study of context analysis.

Table 4. The context analysis

Student Code	Question Item No			Total	Interpretation
	a	b	c		
P-1	2	1	1	4	Not Good
P-2	1	2	2	5	Not Good
P-3	3	4	3	10	Good Enough
P-4	1	1	1	3	Not Good
P-5	3	3	3	9	Good Enough
P-6	2	2	1	5	Not Good
P-7	3	3	1	7	Bad Good
P-8	1	3	1	5	Not Good
P-9	3	2	1	6	Bad Good
P-10	1	2	2	5	Not Good

Indicator: P-1 = Student number 1, a = Classroom space arrangement; b = Seating arrangements; c = Learning media

Table 4 shows the arrangement of classrooms, classrooms, and learning media implemented in the school. In general, the need analysis showed different outcome with the goals set by the Depdiknas because the students and teachers responses were a majority in the "Not Good" category. The classroom management situation, the setting of the seats was improper, and the learning medium used by the teachers was less encouraging for the students to be involved in the T&L process.

Design

The design of this study is based on the results of the needs analysis. Hence, the module developed integrates the discovery teaching method on the topic of geometry. There are ten stages of activities conducted during the T&L process, according to Banks and Barlex (2014); Cunningham and Carlsen (2013). The first stage is the preparation of prerequisite materials. Students are given the pre-requisite materials that aims to encourage students to think and help them in exploring related topics. Teachers can begin learning activities by asking students. The identification of problems is the second stage when the teacher allows students to identify issues

that are relevant to the topic being studied. Identifying problems facilitates students to answer and solve problems. The third is data collection. At this level of activity, students explore various sources related to the topics. According to Li (2014), three phases in the searching for data based on the discovery learning are defining, finding and reviewing, and problem-solving.

In the fourth stage, students analyze the data that they have obtained to support the existing data. During the analysis process, each group member contributes ideas to get an accurate data analysis. Then, at the processing stage (fifth stage), data that have been obtained by students through surveying, observing, and testing activities are processed to get further insights. During the sixth stage, the designing of a solution can be carried out in various ways to solve the problems they face from data processing. Then, the verification is crucial to ensure that the T&L process is carried out effectively (seventh stage). At this process, students have the opportunity to discover their knowledge and concepts for better understanding. The eighth phase is the assessment of the learning. At this stage, students will be corrected for any mistakes based on data processing. Then, the communication process by the student presenting about the findings that they have made in groups, it is the nine-stage. At this level, the teacher explains if the student is confused about the questions. The last stage is to make conclusions wherein each student received feedback from the teacher.

Discussion

The development of this module is based on the elements in Table 1. Transformation of the 2013 Curriculum (K-13) is a form of improvement from the education unit curriculum (KTSP). The objectives of K-13 are strongly influenced by the ability of teachers in implementing the K-13 components. Therefore, the researcher needs to carry out the analysis of the K-13 implementation in schools and determine the various constraints and obstacles faced by teachers and students. Based on the findings from Krisdiana, Apriandi, and Setiansyah (2014), there are some constraints and barriers in implementing the K-13. The study found that teachers were not competent in the mathematics classroom. The teachers and students argued the textbooks uses difficult language and content. Also, students claimed the classroom instruction rarely experiment for them to observe.

The syllabus is a reference in the development of the learning implementation plan. The curriculum covers the subject identity, school identity, and core competencies (attitude, knowledge, and skills), the themes, and topics (including facts, concepts, principles, relevant learning procedures, evaluation, duration, and appropriate learning resources). Further, mathematics textbook was analyzed to determine the suitability of the books used by the teachers in the T&L process.

Students' analysis is carried out to determine the condition of students in terms of behavior, skill, motivation, and student academic fulfillment. Students must be honest, disciplined, polite, confident, caring, and responsible. Meanwhile, the element of the students' skills includes creative, productive, critical, independent, collaborative, and communicative. Furthermore, the knowledge aspect includes capable of understanding and applying factual, conceptual,

procedural, and metacognitive knowledge. Also, the context analysis was conducted to determine the school environment, including the classroom space arrangement, student seating arrangements, and the availability of instructional media. The results of the context analysis examine the suitability of the Ministry of Education with the T&L process in schools.

According to Mehta (2019), the majority of students perceived mathematics as a scary and dull subject that creates confusions. Some students do believe that mathematics subject is too theoretical because of the abstract concepts. Therefore, students are less interested and tend to avoid, abstain, and hate mathematics in school. As a result, students become lazy and weary during the teaching and learning process can affect their learning outcomes. When students have positive attitudes towards mathematics subjects, they would be motivated and diligent in learning a further mathematical concept.

Table 4 shows the classroom space arrangement, students' seating arrangement, and the instructional media are under the "Not Good" category. The classroom space arrangement and the use of instructional media by teachers were factors for students to participate actively in the classroom. Wilson and Grigroan (2019) stated that conventional teaching methods could affect students' anxiety level, awareness, and attitudes towards mathematical subjects.
The goal of teaching in school is to bring positive change to the students. However, the traditional teaching methods merely focused on teacher-centered that not helping students to build their knowledge, memorization-oriented, and less practical (Tsai, 2012). The present-day learning is encouraged to apply student-centered teaching approaches, as this method inspires and motivates students to conduct research activities and train students to think critically (Hennessy, Ruthven, & Brindley, 2005). Teaching methods used by teachers in the T&L process has a strong relationship with the students' mathematical skills (Hall, Lindorff, & Sammons, 2016). Therefore, He pointed out that to make a change, teaching methods that fit the needs of students should be implemented to bring about the desired change (Hall, Lindorff, & Sammons, 2016). The objectives of teaching are achieved when the learning method is suitable. One of the ways of teaching today is by using modern technology that brings many changes in the area of learning (Muema, Mulwa, & Mailu, 2018). This method encourages students to be active in the learning process because the concepts used are more towards discovery. The effect that arises from this method is to raise the interest of learners to learn other mathematical subjects (Hightower, 2011). Based on the phase I analysis and the previous research analysis, students and teachers need a method of teaching that can help students become more active in learning. The D-Geometry module is one of type to help solve the various problems of the students and influence their results in studies, especially in mathematics (Bray, 2011).

Conclusion

The success of student achievement is very much in line with the ability of teachers to carry out the teaching and learning processes in schools because teachers carry the role as facilitators. The geometry module (D-Geometry) is based on the discovery learning theory can improve the quality of teaching and learning. Therefore, teachers must be knowledgeable in various approaches to support student-oriented learning. The elements of discovery learning utilized in

the D-Geometry module is one of the efforts for students' active involvements during the classroom instruction. It is hoped for teachers to apply discovery learning to all mathematical sub-topics in T&L.

Previous research has demonstrated the discovery learning can help teachers in the classroom. The present work shows the theoretical and contextual contribution of D-Geometry module. Theoretically, the integration of discovery learning has given some impact to the teaching and learning of geometry, wherein students were actively involved during classroom instruction in constructing their knowledge. The constructivism, cognitive, and behaviorism theories were also applied which based on the planned activities on geometry. Contextually, the meaningful two-way communication between teacher and students provided a positive environment to classroom instruction. As a sum, the D-Geometry module might be useful for facilitating teachers during the teaching and learning of geometry.

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