The Analysis of Student's Needs to Optimize Geometric Thinking Abilities

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Abstract. Students' geometric thinking abilities in geometry lectures are in the low category. The cause of aim of this research is to determine students' needs in learning geometry to improve the geometry learning process so that they can improve geometric thinking abilities. This research is qualitative, with the research subjects being students of the Mathematics Education Study Program at one of the Universities in Semarang. Data collection techniques at this stage are observation, questionnaires, and interviews. Needs analysis is carried out based on aspects of the learning process: objectives, materials, methods and strategies, textbooks, learning media, and learning evaluation. Observations were made during the geometry learning process. Questionnaires were given to students to obtain data regarding needs in geometry courses. To learn more deeply about students' needs in geometry courses, in-depth interviews were conducted with several students randomly. The research results show that harmony between objectives, implementation of the material presented, learning strategies, media, textbooks, and learning evaluation must be harmonious. Based on these results, improving the learning process to optimize students' geometric thinking abilities is necessary.

Keywords: Student Needs, Geometric Thinking, Learning Process, Media, Teaching Materials.

1. Introduction

Geometry is a mandatory subject in the Mathematics Education study program. The geometry studied at the university level is different from school education units. Geometry at the school education unit level contains material on basic concepts and their application in everyday life [1][2][3]. Still, at the tertiary level, students learn to construct their thoughts so that the concepts in geometry can be proven true [4][5]. Apart from that, geometry in higher education is implemented in everyday life and is also used as a basis for discovering concepts in other fields of mathematical study [6]. Geometry is a field of mathematics that studies the properties and relationships of space, shape, size, and properties related to geometric objects. Geometric objects are abstract, namely points, lines, angles, planes,

E. Yuliyanto et al. (eds.), *Proceedings of the 2nd Lawang Sewu International Symposium on Humanities and Social Sciences 2023 (LEWIS HUSO 2023)*, Advances in Social Science, Education and Humanities Research 850,
https://doi.org/10.2991/978-2-38476-267-5_8

distance, and other conditions [7][8][9]. However, in proving a concept/theorem in geometry, it is necessary to identify information and visualise it as a first step in establishing a theorem or solving a problem, followed by constructing the solution [10]. Students' ability to prove and solve geometric problems is called geometric thinking ability [11].

Geometric thinking ability refers to a person's ability to understand, analyse, and solve problems involving geometric concepts [12] [13][14]. It consists of visualising objects in space, understanding geometric relationships, and using geometric reasoning to solve problems involving shape, size, angles, and other geometric properties [15]. Students have good geometric thinking skills if: 1) visualise geometric objects, 2) analyse and recognise geometric patterns, 3) use deductive reasoning, 4) use geometric coordinates and calculations, and 5) solve geometric problems [16][17]. Van Hiele's geometric thinking abilities are categorised into 5, namely recognition, analysis, abstraction, deduction, and rigor [18][19][20][9][21].

The first thinking ability is visualisation. This ability is where students can describe geometric objects or identify geometric objects visually in various positions [22]. The second ability is analysing and recognising geometric patterns. This ability is the student's ability to understand the characteristics and identify geometric shapes based on their properties [23]. The third ability is the ability to abstract. Abstraction ability in geometry refers to a person's ability to understand, recognise patterns, and make generalisations about geometric objects without paying attention to the object's size, shape, or specific properties [24][25]. Deductive abilities in geometry refer to using logic and known information to reach conclusions or solve geometric problems [26]. Rigor ability in geometry refers to thoroughness, accuracy, and clarity in mathematical thinking and reasoning. In geometry, rigor involves using precise definitions, correct axioms, proven theorems, and valid reasoning steps to produce accurate and convincing mathematical proofs [27].

Mathematics education students must, of course, have all these geometric thinking abilities. The research results [21] show that the average student's geometric thinking ability is still at the level of abstraction ability. Other research shows that most students only have deductive geometric thinking abilities [28]. The conclusion obtained is that students' geometric thinking abilities are not optimal. Thinking geometrically is optimal if students can prove a theorem or the truth of a statement and implement the theorem in solving geometric problems.

These problems mean there is a need to improve the geometry learning process. Determining models, methods, strategies, approaches, and learning media in geometry learning must be studied deeply. Abstract geometric objects certainly require technological assistance to visualise them [29]. However, to determine the form of change in the learning process, it is essential to analyse students' needs in optimising geometric thinking abilities. Supporting factors for the learning process include learning objectives, methods, models, strategies, approaches, learning media, atmosphere, learning assessment, facilities, and infrastructure. These factors are, of course, also adjusted to students' needs to have geometric thinking skills. Based on the background of these problems, this research aims to describe the results of an analysis of student needs in geometry courses as an effort to improve learning and optimise geometric thinking abilities.

2. Methods

This qualitative research method describes an analysis of student needs in geometry courses as an effort to optimise geometric thinking abilities. The research sample of third-semester students from a mathematics education study program at a private university in Semarang who had received a spatial geometry course. Data collection using data triangulation, namely observation, questionnaires, and in-depth interviews. The following are the indicators for each instrument used in the research.

Table 1. Indicators for observing the geometry lecture process

No	Indicators	Observation Items
1	Students' ability to master geometric thinking	1,2
2	Students' spatial skills in solving geometric problems	3,4
3	Student skills in analysing	5,6
4	Availability of reference books that support students' geometric thinking abilities	7,8

Table 2. Questionnaire indicators for student needs in geometry lectures

No	Indicators	Statement Items
1	Learning objectives	1 – 5
2	Learning materials	6 – 15
3	Learning methods/strategies	16 – 20
4	Textbooks	21 - 25
5	Instructional Media	26 – 30
6	Learning evaluation	31 – 35

Experts have validated observation instruments and questionnaires. The validation results show that the observation instruments and questionnaires are valid and reliable. This instrument is then used to collect data regarding student needs in learning geometry. The first stage of data collection is observing the geometry learning process. The second stage of data collection is giving questionnaires to students. The data obtained was then subjected to data analysis consisting of data reduction, presentation, and verification. Data reduction was carried out by coding observation transcripts and questionnaires. Other data collection is in-depth interviews to obtain more information about students' needs in learning geometry. The final stage is data triangulation to reach conclusions [30].

3. Results and Discussions

The research results obtained data regarding material needs and student problems regarding geometric thinking abilities. The research was conducted on students of the Mathematics Education undergraduate study program in Semarang who had taken the Geometry course. Data collection techniques at this stage are observation, questionnaires, and interviews. Needs analysis is carried out based on aspects of the learning process, namely objectives, materials, methods and strategies, textbooks, learning media, and learning evaluation. Observations were made during the geometry learning process. Questionnaires were given to students to obtain data regarding needs in geometry courses. Interviews were conducted with several students randomly to determine students' needs in geometry courses. The following are the data results obtained by three data collection techniques.

Needs Analysis Based on Observation Techniques

The observation method used in this research is the participatory observation method. This method was chosen because the researcher was among the participants who were being observed. The observation results show that:

1. Students' ability to master geometric thinking is still lacking. This is shown by the fact that many students are still confused about solving questions regarding proof and geometric problems.
2. some students have spatial skills that are not optimal. This is indicated by students having difficulty visualising statements in the form of images.
3. Students' ability to identify and carry out formal deduction analysis is also not optimal.
4. Students need teaching materials that they can study

Needs Analysis Based on Questionnaire Techniques

The questionnaire was created based on essential aspects of the learning process, namely objectives, materials, methods and strategies, textbooks, media, and learning evaluation. The following is an analysis of the data obtained for each aspect.

1. Aspects of Learning Objectives

The results of data analysis on the learning objective components can be seen in the following diagram.

Fig 1. Student Needs for Learning Objective Components

Figure 1 shows that 100% of students need geometry material related to everyday life, links with other fields of study, and clarity on the objectives of geometry lectures at each meeting. The percentage of students who want lecturers to convey lecture objectives is 91.18%. The percentage of students who said the lecturer realised the lecture objectives was 94.12%. The conclusions from the results of this analysis are: (1) geometric concepts can be implemented in everyday life. They can be used to develop knowledge or study other sciences. (2) It is essential to know the objectives of the lecture at each meeting so that students at the beginning of the lecture begin to focus their thinking according to the objectives of the geometry lecture.

2. Learning Material Aspects

The results of data analysis on learning material components can be seen in the following diagram.

Fig 2. Student needs for learning material components

Information:

A = Students experience difficulties when studying geometry
B = Students can visualise geometry problems in the form of images
C = Students understand the lecturer's explanation of Geometry
D = Students can easily prove geometric theorems
E = Students have difficulty in questions regarding geometric proofs
F = Students prefer to work on geometric calculation problems
G = Students can identify components that are known and asked about in contextual or calculation questions
H = Students can identify known elements and ask questions in proving theorems or proof questions
I = Students have their way of solving geometry problems
J = It is easier for students to understand the material independently

Based on Figure 2, it is found that students' needs in mastering geometric concepts include: (1) students have difficulty understanding lecturers' explanations in delivering material with a percentage of 76.47%, (2) students do not have creative and critical thinking skills in solving problems with a percentage 38.24%, (3) identifying known components and being asked to prove them in proof or theorem problems with a percentage of 55.88%, and (4) students have difficulty solving geometry problems if done independently with a percentage of 70.59%.

3. Aspects of Learning Methods/Strategies

The results of data analysis on the Learning Method/Strategy component can be seen in the following diagram.

Fig 3. Student Needs for Learning Method/Strategy Components

Figure 3 shows that the percentage of students who will understand better if the lecturer explains the material is 79.41%. The percentage of students who prefer geometry lectures in the form of group discussions and group presentations is 73.53%. In the discussion method, students need confirmation or reinforcement by the lecturer from the explanations made by friends during the presentation.

4. Textbook Aspects

The results of data analysis on the Textbook component can be seen in the following diagram.

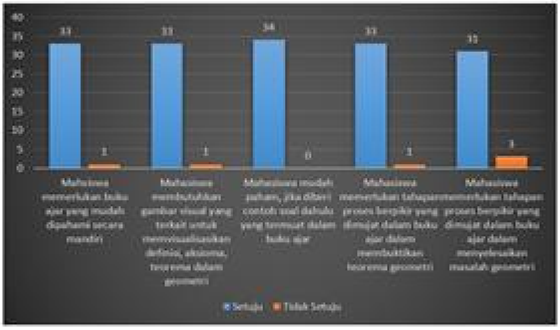

Fig 4. Student Needs for Textbook Components

Figure 4 shows that students need reference books that support geometry lectures and optimise students' geometric thinking abilities. 96.47% of students need textbooks that are easy to understand independently. Students also want the books used in geometry lectures to be given visual images that match the material and examples of problems or stages of geometric thinking in solving theorem proofs or geometric problems.

5. Aspects of Learning Media

The results of data analysis on the Learning Media component can be seen in the following diagram.

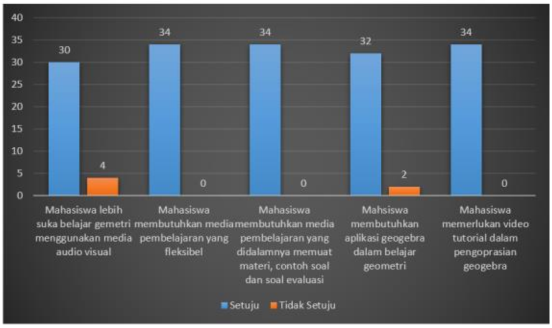

Fig 5. Student Needs for Learning Media Components

Based on Figure 5, it shows that all students need learning media. The learning required media in geometry lectures is, of course, technology-based. The technology needed is technology that can visualise geometric objects so that student abstractions are formed. One of these technologies is geometry.

6. Learning Evaluation

The results of data analysis on the Learning Evaluation component can be seen in the following diagram.

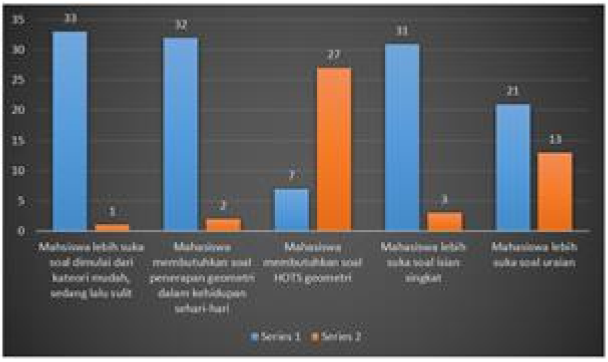

Fig 6. Student Needs for Learning Evaluation Components

Figure 6 shows that 79.41% of students do not want HOTS questions in geometry courses. 86.-3% of students want evaluation questions starting from easy, medium, and challenging questions. Additionally, they require the implementation of geometry in contextual problems.

Needs Analysis Based on Interviews

Interviews were conducted with research subjects selected randomly. Interviews were conducted to obtain in-depth information regarding student needs in geometry courses. The results of the interview were:

1. Students have difficulty proving several theorems in geometry. This is because students are not confident in their abilities and knowledge.
2. Students need initial assistance from the lecturer in proving theorems, and then students will practice their abilities in geometric thinking.
3. some students still have difficulty visualising geometric shapes.
4. There needs to be a long process for students' understanding of concepts. They need time to understand the idea of geometry. Especially if they are dealing with applying several geometric concepts in solving one problem, they are confused about the idea to use.

The results of data analysis obtained in this research are efforts to optimise students' geometric thinking abilities, starting from the geometry learning process in class. The learning process consists of learning aspects, namely aspects of learning objectives, learning methods, media, and textbooks, as well as learning evaluation [31][32]. To support students' geometric thinking abilities, clarifying and improving each of these aspects is necessary. Regarding learning objectives, students need to know the learning objectives. The concept of geometry can be implemented in everyday life[33]. It can be used as a basis for developing knowledge or studying other sciences, so it is essential to know the purpose of the lecture at each meeting. With clarity of learning objectives, students at the beginning of the class begin to focus their thinking according to the goals of the geometry lecture. Concentrating on studying material will make it easier for students to accept the concepts they have learned [34].

Student needs in the material aspect of geometry learning are that students need the material to match the learning objectives. Geometry is one of the basic concepts in the field of mathematics that can be used in the study of other sciences, so if your mastery of the geometry material is good, then the material's implementation will also be exemplary [35]. The delivery of geometry material needs to be linked to contextual problems so students can better understand, interpret and implement geometric concepts. In geometry's definition and axioms material, students need visualisation of geometric concept statements. The existence of visualisation can construct students' geometric thinking in describing geometric abstract objects [36][37]. Apart from the material, examples and practice questions are also crucial for students to learn. It is hoped that the standards and practice questions provided will contain stages of completion that can improve geometric thinking skills [38].

The aspect of determining the methods, models and learning strategies used in learning geometry has a significant influence on students' geometric thinking abilities. Students need learning that is fun and can motivate them in learning. If education is carried out using discussion, the role of the lecturer is expected to continue to accompany students in constructing their thoughts to solve problems. Each stage in geometric thinking skills needs to be conveyed in learning so that students can get used to it and improve their geometric thinking skills [39].

Aspect of textbooks and learning media, students need to optimise their geometric thinking abilities is textbooks. The textbooks required are textbooks that not only contain material but also include example questions and practice questions with stages of completion according to the level of geometric thinking [32]. These stages start from introduction, analysis, abstraction, deduction, and rigor. Apart from that, the textbooks used are flexible. What is meant by flexibility is that textbooks can be used anywhere and at any time, so textbooks are electronic textbooks [40]. It is hoped that this textbook can also guide students to learn independently in constructing their thoughts so that they can optimise their geometric thinking abilities. The learning media used is expected to utilise technology, one of which is geometry. Geogebra is an application that helps students visualise geometric abstract objects, thereby training visual-spatial abilities [41]. The final aspect is learning evaluation. The learning evaluation required is an evaluation that is by the learning objectives and accordance with the level of geometric thinking [42].

4. Conclusions

The conclusions in this research regarding student needs in learning geometry as an effort to optimise geometric thinking abilities include: (1) there is harmony between learning objectives and the material presented by the lecturer, (2) the implementation of the material presented is linked to everyday life, (3) there need to be models, methods, learning strategies and learning approaches that improve students' geometric thinking abilities, (4) technology-based media and textbooks used are adjusted to the objectives and can improve geometric thinking abilities, and (5) learning evaluations are also adjusted to goals and can improve geometric thinking skills.

Authors' Contributions

Contributions Made By The Research Team Include 1) Analysing Problems In Geometry Lectures, 2) Designing Qualitative Research, 3) Compiling Research Instruments, 3) Determining Research Subjects, 4) Collecting And Grouping Data, 5) Analysing And Presenting Data, And 6) Concluding. The Entire Research Team Carried Out The Above Stages.

Acknowledgments

The research team would like to thank the Universitas Muhammadiyah Semarang for supporting research funding through the Primary Lecturer Research Internal Grant in 2023. We would also like to thank the Universitas Negeri Semarang for their collaboration in this research.

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