JPPI (Jurnal Penelitian Pendidikan Indonesia)
Volume 11, Number 3 2025

Improving geometry transformation thinking skills using student activity sheets based on discovery-contextual learning based on Van Hiele's theory

Author Name(s): Nofyta Arlianti, Kamid Kamid, Jefri Marzal, Muhammad Haris Effendi Hasibuan

Publication details, including author guidelines
URL: https://jurnal.iicet.org/index.php/jppi/about/submissions#authorGuidelines
Editor: Zadrian Ardi

Article History
Received: 24 Nov 2025
Revised: 5 Sept 2025
Accepted: 6 Sept 2025

How to cite this article (APA)
Arlianti, N., Kamid, K., Marzal, J., Hasibuan, M. H. E. (2025). Improving geometry transformation thinking skills using student activity sheets based on discovery-contextual learning based on Van Hiele's theory. Jurnal Penelitian Pendidikan Indonesia.11(3), 151-162. https://doi.org/10.29210/020254836

The readers can link to article via https://doi.org/10.29210/020254836

JPPI (Jurnal Penelitian Pendidikan Indonesia)
ISSN: 2502-8103 (Print) ISSN: 2477-8524 (Electronic)

Vol. 11, No. 3, 2025, pp. 151-162
DOI: https://doi.org/10.29210/020254836

Improving geometry transformation thinking skills using student activity sheets based on discovery-contextual learning based on Van Hiele's theory

Nofyta Arlianti*), Kamid Kamid, Jefri Marzal, Muhammad Haris Effendi Hasibuan
Doctoral Study Program in Mathematics and Science Education, Universitas Jambi, Indonesia

Article Info

Article history:

Received Nov 24th, 2024
Revised Sept 5th, 2025
Accepted Sept 6th, 2025

Keywords:

Geometric thinking ability
Student activity sheet
Discovery-contextual
Learning Van Hiele theory

ABSTRACT

Geometry thinking ability is the ability of students in terms of observing objects, building definitions based on the characteristics inherent in the object, recognizing the relationship between one object with other objects, and applying it in solving geometry problems. However, the ability to think geometry students are still low. This is because students are still dependent on lecturers in receiving information and learning that occurs in the classroom has not facilitated the ability to think geometry, especially geometry transformation. For this reason, a student activity sheet based on *Discovery- Contextual Learning based* on van hiele theory was developed which is effective in improving the geometry thinking ability of mathematics education students of STKIP Muhammadiyah Sungai Penuh. The subjects of this study were 5th semester students of mathematics education. The development model used is adapted from the Plomp model. There are three stages in this model, namely *preliminary research, prototype phase, and assessment.* This study focused on seeing the effectiveness of the product at the *assessment* stage. The assessment phase was carried out on a *field test* consisting of 13 students for 9 meetings. The syntax of this learning model includes: 1) Stimulation, 2) Constructivism, 3) *Problem Statement*, 4) *Data Collection*, 5) *Learning Community*, 6) *Modeling*, 7) *Data Processing*, 8) *Verification*, 9) Reflection, and 10) *Authentic* Assessment.

Corresponding Author:

Nofyta Arlianti,
Universitas Jambi
Email: nofytaarlianti@stkipmsungaipenuh.ac.id

Introduction

From a psychological point of view, geometry is a presentation of abstractions from visual and spatial experiences, such as planes, patterns, measurements and mapping. While from a mathematical point of view, geometry provides approaches to problem solving, for example images, diagrams, vectors and transformations. Transformation geometry is a rule that moves a geometric figure from one position to another without changing the shape of the figure. Transformation geometry is also a part of geometry that discusses changes (location, shape, presentation) based on images and matrices. Transformation in the field consists of 4 kinds (Hanipah et al., 2022): (1) Translation. A translation is a transformation that moves all points in a given plane the same distance and direction; (2) Reflection. Reflection is a transformation that moves a point on a geometric figure by using the properties of the object and its image on a flat mirror; (3) Rotation. Rotation is a transformation that moves a point in geometry by rotating the point about its center; (4) Dilation. Dilation is a transformation that moves a point on a geometric figure depending on the center point of the dilation and the dilation scale factor.

In the fifth semester, the course on transformational geometry is taught. Its content includes several topics, such as: (1) prerequisites in the form of functions, (2) transformation, (3) composition of transformations, (4) isometry, (5) reflection, (6) half-turn, (7) translation, (8) rotation, (9) glide reflection, and (10) (Berta Dinata, 2019). A study conducted by Mentaruk revealed that students experience difficulties in understanding the topic of transformational geometry. They face challenges in identifying crucial information needed to test concepts as well as in selecting appropriate strategies to prove the material (Mentaruk & Tentena, 2015).Furthermore, according to Hanafi's research, the use of mathematics applications in the form of visualization is necessary to support the learning of transformational geometry (M. Hanafi, K.N. Wulandari, 2017).

Transformation Geometry is one of the branches of Geometry from Mathematics that considers how the properties of objects when mapped (Fanny, 2022). Transformation Geometry course is one of the compulsory courses that must be takenby students of mathematics education study program (Subekti & Kusuma, 2015). Transformation geometry in education is a course in the Mathematics Education Study Program which contains material on functions, geometric transformations, isometry, andtypes of geometric transformations.

This course is an advanced course from basic and analytical geometry courses, where students are required to have a fairly high ability to reason visually geometry and analytics (Maifa, 2019). In the transformation geometry course, the accuracy of the size and accuracy of the drawing field is very important. Size differences can be a major problem, this usually occurs if the utilization of learning media is not appropriate orhow to use the media that is less thorough, causing inaccuracies in the measurement data generated (Ridha et al., 2020). Therefore, due to the abstract nature of geometric material, understanding geometric material requires relatively high visualization and analysis skills. In learning geometry, it can be considered a mathematical process that introduces abstract concepts, but the initial steps use real objects that match the level of understanding of students. The study of geometry is very important in terms of material, application, and the development of thinking skills that can result from learning it.

However, this is not in line with the reality that occurs in the field. There are still many students whose geometric thinking skills are far from expectations. Supported by the results of observations at STKIP Muhammadiyah Sungai Penuh there is still a lack of understanding of students related to the concept of geometry transformation. Students tend to be given information by lecturers about formulas related to the field of geometry transformation studied rather than constructing their own knowledge. In addition, there is often a misunderstanding of what is delivered by lecturers and received by students. This is due to differences in the level of thinking between students and lecturers. As a result, students have difficulty understanding the learning trnasformation geometry and difficulty working on problems that contain the ability to think geometry.

Based on research results show that progress in learning geometry is currently limited (Maarif, 2013). One of the reasons behind this is students' difficulty in creating precise and accurate physical structures, as well as the belief that creating geometry drawings requires precision measurements and takes a considerable amount of time. In addition, students often have difficulty in proving the concepts taught (Sundawan et al., 2018). Compared to other areas of mathematics, geometry is often considered one of the most difficult areas to understand (Susilawati, 2022). Transformation geometry is part of the Mathematics Education curriculum that focuses on functions, geometric transformations, isometries, and various types of geometric transformations. It is a subject that requires deep understanding after learning basic and analytic geometry. Students are expected to have high visual and analytical thinking skills in this subject (Maifa, 2019). The application of transformation geometry can include things such as determining the slope of a staircase or determining the topological structure in a computer network (Nur'aini et al., 2017). However, learning transformation geometry in the classroom has not reached the optimal level because many students have difficulty in understanding concepts and solving problems (Sholihah et al., 2018). In addition, learning also has not linked the concept with real- life situations (Albab & Hartono, 2014).

Reaffirming the previous argument by referring to the perspective from the lecturer's point of view, (Susilawati, 2022) said "in the campus students consider that mathematics is a difficult subject matter to learn. Especially in solving the material kesebangunan of space and flat buildings in geometry ". Lecturers explain geometry concepts directly on the blackboard or using props, while active participation of students in the learning process is still lacking. In addition, in learning geometry, there are still many students who face difficulties in compiling arguments, which results in the development of their geometric thinking skills are limited (Prahmana, 2017).

According to Anisyah, (2023) "students have differences in many ways such as different abilities, talents, interests they have, different in the sharpness of seeing and hearing and different backgrounds of life. Therefore, lecturers should not generalize or assume that all children have the same ability and learning speed, so that in the same time all students are considered to be able to complete the same lesson content ". Research subjects often make mistakes in understanding concepts (Sholihah et al., 2018). To assess the extent to which students have developed geometry thinking skills, must meet the level of geometry thinking that has been determined. The learning theory that can overcome students' difficulties in geometry is Van Hiele Theory (Fitriyani, Widodo, & Hendroanto, 2018). Van Hiele's theory emphasizes that the teaching of mathematics, especially geometry, must be adapted to the developmental stage of students' geometry thinking ability. Several studies have shown the beneficial benefits of applying van Hiele's theory in geometry learning, which focuses on the concept of geometry (Fona Fitry Burais, 2014). Van Hiele's theory states that the quality of students' understanding depends not only on how much knowledge they have, but more on how they think and process information (Mason, 2021). In effective geometry teaching, it is important to pay attention to the level of geometry thinking at each level of students' mathematical ability and choose the appropriate learning method according to that level.

Many studies have been conducted in an effort to find out about the level of geometry thinking of students in college. Subekti (2015) in his research stated that students have difficulty in expressing ideas about the transformation of a function. This part requires students to formulate their thoughts visually and analytically to find the right solution. To be considered a transformation, a mapping must qualify as a bijective function. However, in reality, students still face difficulties in proving that a function is bijective (Subekti & Kusuma, 2015). From the results of the two studies, there have been no efforts and solutions given to be able to increase the level of thinking of students from one stage to the next, so further studies are needed to overcome the problems that already exist in the learning process in higher education.

One way to improve students' geometry thinking skills is through the development of learning tools that link concepts with real situations. This can help students in releasing ideas when solving existing problems (Fauziyah et al., 2016). Training yourself in solving geometry problems will improve skills and develop creativity in understanding space and shape.

Based on interviews with lecturers concerned STKIP Muhammadiyah Sungai Penuh revealed the available learning tools are not adequate to develop students' geometry thinking skills. Lecturers recognize that using LKM can help train students' thinking skills in the learning process. But the lecturer also admitted that it is not easy to make such learning tools so that only used textbooks in the learning process. Student worksheets that can be abbreviated as LKM are teaching materials that are often developed for the learning process (Taqwa, 2020). Research results (Martahayu & Yuanita, 2022) showed that by using student worksheets (LKM) which have met the criteria of valid, practical and effective in advanced calculus courses can foster student learning motivation.

From the content of existing teaching materials, it can be concluded that the learning design used does not fully support the development of geometry thinking skills of STKIP Muhammadiyah Sungai Penuh students. This condition potentially affects the development of student thinking at the level of analysis. The analysis process expected in the next stage is also not well structured in the delivery of material, thus affecting the achievement of the abstraction stage. Students may have difficulty in understanding the source of the concepts taught. The ability to think critically is very important for a person in facing various challenges, both in social and personal life (Nuryanti et al., 2018).

Seeing the problems presented above, a geometry learning tool was developed in the form of Student Activity Sheet (LKM) based on discovery-contextual learning based on Van Hiele's theory which is expected to help students in learning geometry and improve geometry thinking skills. For each stage on the LKM adapted to the stages of learning discovery-contextual learning model. The syntax of this learning model includes: 1) Stimulation, 2) Constructivism, 3) Problem Statement, 4) Data Collection, 5) Learning Community, 6) Modeling, 7) Data Processing, 8) Verification, 9) Reflection, and 10) Authentic Assessment. In some combinations of models and approaches and syntax, there are links to indicators from van Hiele's theory. The indicator serves as a marker of van Hiele's thinking ability that includes five levels of development in understanding geometry. The five stages include level 0 (visualization), level 1 (analysis), level 2 (informal deduction), level 3 (deduction), and level 4 (rigor).

Method

This research is a development with the Plomp model. There are three stages in the Plomp model, namely preliminary research, prototyping stage, and assessment stage (Gravemeijer et al., 2013). There are 5 formative evaluations in this Plomp model, namely (1) self-evaluation; (2) expert review; (3) one-to-one evaluation; (4) small group evaluation; (4) field test.

The selection of experts involved in design and development research, according to (Rusdi., 2018), is an essential step that must be carried out. The characteristics, level of expertise, and habits of the experts determine the quality and character of the resulting product.

The focus of this article is the effectiveness of the discovery-contextual learning-based LKM based on Van Hiele's theory developed during the field test. The field test was carried out on a limited basis for 5th semester students of STKIP Muhammadiyah Sungai Penuh. The data from the test results will be used as the basis for revising the product, so that the resulting product is suitable for use. The field test was conducted by STKIP Muhammadiyah Sungai Penuh mathematics lecturers to see the practicality and effectiveness of the product. Before the field test, the LKM was first validated by 3 validators. The subjects of this study were mathematics education lecturers and 5th semester student participants of STKIP Muhammadiyah Sungai Penuh. Students involved in the one to one evaluation were 3 people, during the small group evaluation were 3 people, and during the field test 13 people.

To assess the effectiveness of the developed LKM seen from the improvement of the exam results of cycle I, cycle II and cycle 3 students for 9 meetings, the average percentage value of students silkus I 78.4%, cycle II 88% and cycle III 92.8%. The instrument used is a test of geometry thinking ability of students based on the level of van hiele theory of geometry transformation material. The type of test used is an essay test. Data collection techniques by means of documentation, analysis of the results of observations of the implementation of learning, and analysis of the value of geometry thinking skills test.

Results and Discussions

Activities carried out at the preliminary research stage are needs analysis, identification and review of the mathematics curriculum, analysis of student conditions and concept analysis. After the analysis at the preliminary research stage, then developed a geometry LKM based on discovery-contextual learning based on Van Hiele's theory is one of the efforts to meet the teaching materials in college. This LKM is expected to train students' geometry thinking process, students can be directly involved in learning and develop one of the abilities needed in the 21st century is the ability to think critically. After the LKM was declared valid by the validator and declared practical by one to one evaluation and small group evaluation respondents, then the practicality and effectiveness test was carried out in the field test (Nasution & Yerizon, 2019).

The effectiveness of the LKM is reviewed from the test results of geometry thinking ability of 5th semester mathematics education students STKIP Muhammadiyah Sungai Penuh after participating in learning activities using geometry LKM based on discovery-contextual learning based on Van Hiele theory developed. Assessment is not only done at the end of competence, but also seen during the learning process in the classroom. Quiz results in each cycle showed an increase in the ability to think geometry and student skills in solving problems in the LKM.

Figure 1 is the results of students' work in working on student activity sheets (LKM) in cycle 1. In cycle 1 there were 2 face-to-face learning activities and 1 cycle 1 test. However, what is displayed in the journal is only the students' answers to the LKM at the first meeting.

The answers from several groups to this problem have different ways but the same goal.In solving the problems in the first meeting activity, most students have understood the content of the problem and are able to solve it.

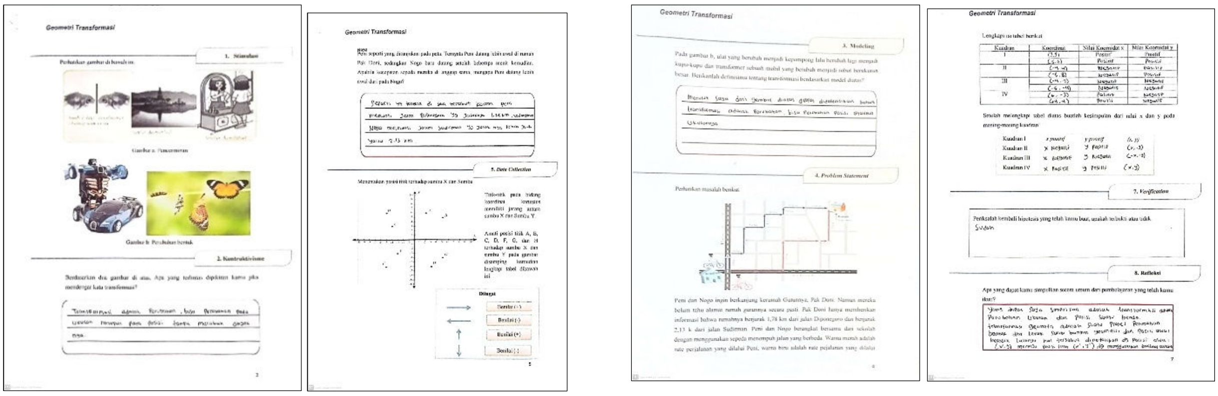
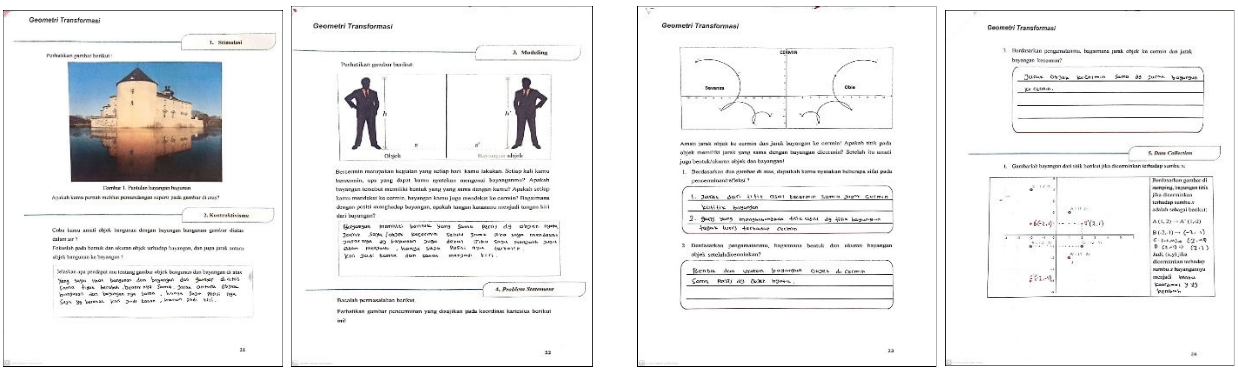


Figure 1. Students' answers on the first meeting LKM cycle 1

Figure 2 is the work of students in working on student activity sheets (LKM) in cycle II. In cycle II there were 2 face-to-face learning activities and 1 cycle II test. However, what is displayed in the journal is only students' answers to the LKM at the fifth meeting.



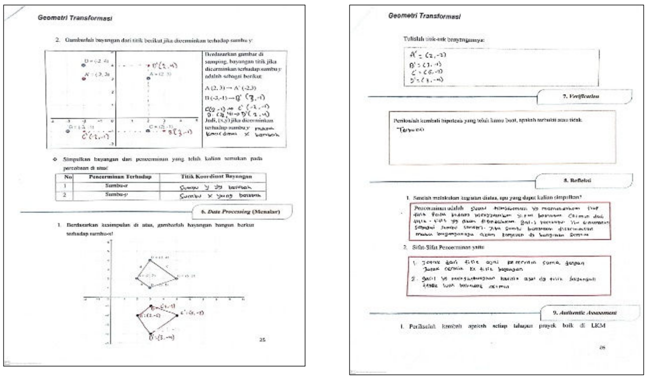


Figure 2 Student Answers on the Fifth Meeting LKM

In solving the problems at the fifth meeting, most students had understood the content of the problems and were able to solve them in their own way. Each group can work and solve the problems contained in the MFI in their own way.

Figure 3 is the work of students in working on student activity sheets (LKM) in cycle II. In cycle III there were 2 face-to-face learning activities and 1 cycle III test. However, what is displayed in the journal is only students' answers to the LKM at the seventh meeting.

So it can be concluded that there is an increase in the ability to think geometry transformation of mathematics education students. In addition, it is also noted the work of students solving problems on the LKM. In Figure 1, Figure 2 and 3 it can be seen that the answers of low and medium ability students on the *free orientation* stage LKM do not occur significant differences. It can be interpreted that students of diverse abilities can use *discovery-contextual learning-based* LKM based on van hiele theory developed this. Assessment of the ability to think geometry transformation is done by giving the final test/cycle after learning using *discovery-contextual learning-based* MFI based on van hiele theory.

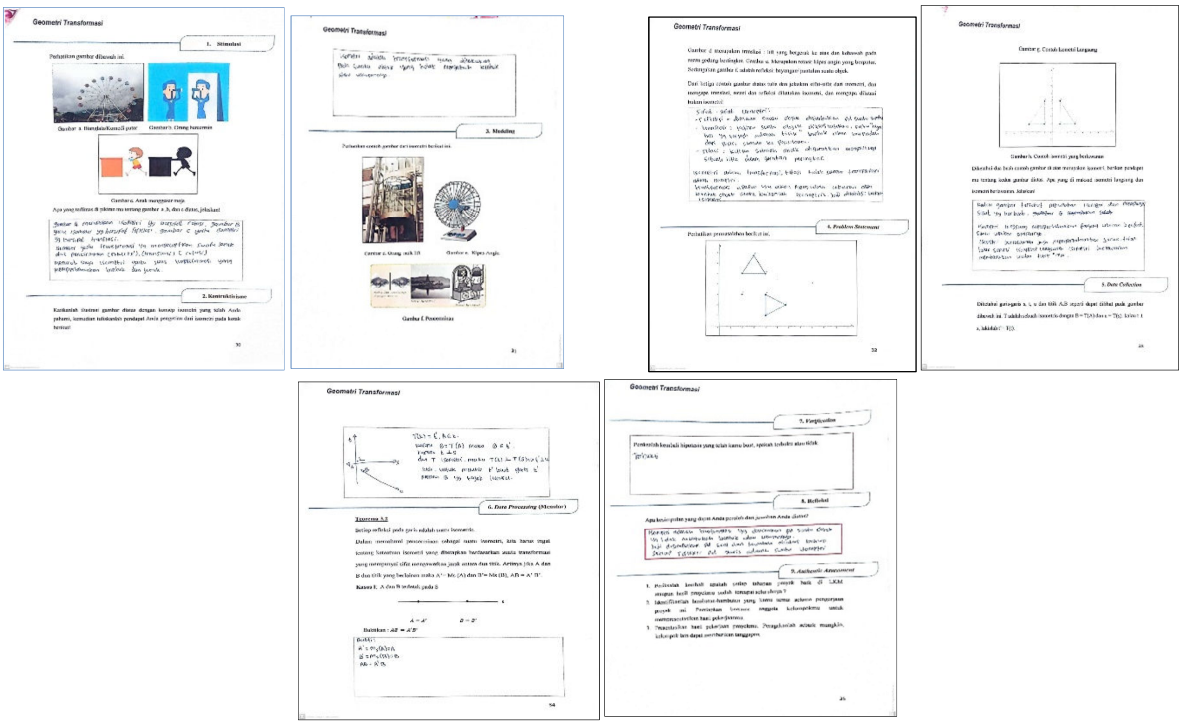


Figure 3 Student answers on the seventh meeting of the LKM in cycle III

Based on data analysis of geometry thinking ability of mathematics education students in cycle I, II and III using LKM based on *discovery-contextual learning* based on Van Hiele's theory. Improved geometry thinking ability of students can be seen in the following table.

Table 1. Improvement of Students' Geometric Thinking Ability Based on vanHiele Theory Level of Transformation Geometry Material

Cycle	Average Percentage	Category	Geometric thinking ability based on indicators according to the level of Van Hiele Theory				
			1	2	3	4	5
Cycle I	78, 4	Good	41	45	38	44	28
Cycle II	88	Very good	45	46	42	45	42
Cycle III	92,8	Very good	49	47	45	45	46

From table 1 above, it can be seen that the ability to think geometry mathematics education students STKIP Muhammadiyah Full River has increased from cycle I, Cycle II and Cycle III. According to researchers, the increase in students' geometry thinking ability is due to the use of *discovery-contextual learning-based* LKM based on Van Hiele's theory. By using LKM based on *discovery-contextual learning based* on Van Hiele's theory can attract students' attention and provide a real experience so that what is delivered by the lecturercan be received well. This is in accordance with the expected researchers because the ability to think geometry students have experienced a very good increase. Hereis presented the development of quiz results for each cycle in Figure 4.

If seen from figure 1 above, each cycle has increased, it can be said that overall students have been able to write the relationship between the material studied in the LKM question step by step by making shapes, constructing shapes and identifying shapes based on their appearance (visualization), describe a shape according to its properties and compare shapes based on the characteristics of its properties (analysis), recognize the relationship between one geometric shape with other geometric shapes (abstraction), deductive inference, namely drawing conclusions from things that are specific (deduction), and using images as a means to think and start looking for generalizations or examples of contracts (rigor / accuracy).

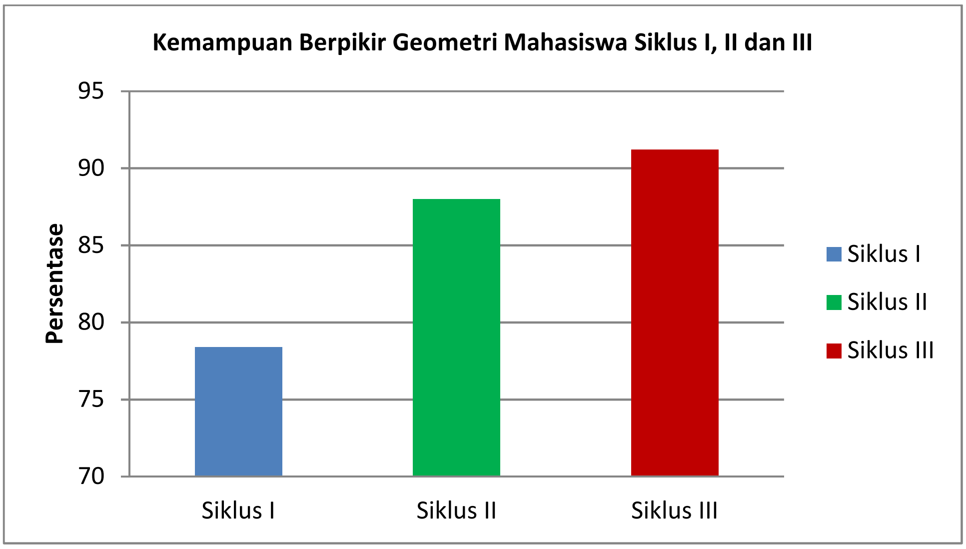


Figure 4 Improvement of geometry thinking ability of mathematics education students Cycle I, II and III

Based on the figure above, the evaluation results from the three implemented cycles show a significant improvement in the average student learning outcomes. In Cycle I, the average achievement was 77.9, which falls into the "Good" category. It then increased to 82.6 in Cycle II, categorized as "Very Good," and continued to rise in Cycle III, reaching 91.46, still within the "Very

Good" category. This improvement indicates that the applied strategy or learning model is effective in enhancing the quality of learning and students' understanding.

According to Utomo, "The CAR (Classroom Action Research) cycle will end once improvements have been successfully implemented. It should be noted that one CAR cycle may consist of at least three meetings. The success criteria of CAR serve as the benchmark or reference to determine whether the research conducted has achieved its objectives or not. Generally, the success criteria of CAR are related to the indicators of students' learning achievement (both the learning process and learning outcomes). The learning process is considered successful if it is implemented at 75%–100% in each cycle, while learning outcomes are deemed successful if the average mastery level reaches 75% with achievement scores above 70." (Utomo et al., 2024).

In Cycle I, students' geometric thinking ability based on the Van Hiele theory indicators showed an improvement from lower to higher levels. At the visualization level, only a few students were able to achieve it (15.4%). At the abstraction level, the percentage varied depending on the question, with the highest achievement being 46.2%. The deduction level showed an achievement of up to 53.8%, while at the rigor level, the highest achievement was 53.8%. Overall, there was an improvement in students' geometric thinking ability across all Van Hiele levels.

In Cycle II, students' geometric thinking ability showed a significant improvement based on the Van Hiele levels. At the abstraction level, the number of students reaching the indicators was still low (a maximum of 15.4%). However, at the deduction level, the achievement increased sharply to 76.9%. The rigor level also showed improvement, with the highest achievement at 61.5%. Overall, a positive development was observed in students' geometric thinking ability across various levels.

In Cycle III, students' geometric thinking ability based on the Van Hiele test demonstrated significant progress, particularly at the deduction and rigor levels. Although the achievement at the abstraction level remained low (7.8%), the deduction level increased to 53.8%, and the rigor level reached 76.9%. This indicates that most students had attained a higher stage of geometric thinking.

The geometric thinking ability of Mathematics Education students at STKIP Muhammadiyah Sungai Penuh experienced a significant improvement from Cycle I to Cycle III based on the Van Hiele theory. Each thinking level, from Visualization to Rigor, showed gradual progress, with the most notable increase occurring at the Rigor level (from 53.8% to 76.9%). This improvement reflects the effectiveness of the Discovery-Contextual Learning model based on Hypothetical Learning Trajectory in enhancing conceptual understanding, active engagement, and students' overall geometric reasoning.

Based on the observations, students' activities improved in every meeting, such as writing down the connections between the material learned in the LKM (Student Worksheet) step by step; investigating, reading, analyzing, and finding solutions in the LKM; as well as finding the correct answers. They also asked their peers or the lecturer when they did not fully understand the problem, worked on group assignments individually and then compared answers with group members accurately, and completed individual exercises optimally. Furthermore, overall, students demonstrated seriousness in carrying out these learning activities.

Implementation of learning using Student Activity Sheet (LKM) based on *discovery-contextual learning* based on van hiele's theory has a positive impact on improving the geometry thinking ability of mathematics education students STKIP Muhammadiyah Sungai Penuh. Based on the results of the test scores of the ability to think geometry transformation of students as a whole the average percentage of the ability to think geometry students cycle I reached 78.4% classified as good, for the second cycle the ability to think geometry students increased by 88% classified as very good, and in the third cycle the ability to think geometry students also increased by 92.8% classified as very good. From the data obtained, it can be seen that the ability to think geometry students have increased from cycle I, II and III, as well as the activity of mathematics education students also increased and has reached the success indicators. That way, geometry LKM based on *discovery-contextual learning based* on van hiele theory can already be said to be effective. This is in accordance with research conducted by previous researchers Primasatya, Nurita and Jatmiko (Primasatya, 2018) which states that the application of Van Hiele theory-based learning can improve students' critical thinking skills.

In addition, Van Hiele theory-based learning also has a positive impact on the level of geometric thinking of students (Hiele-geldof & Hiele, 1987; Ramlah & Jantan, 2014).

Critical thinking skills are developed through the stages of *discovery-contextual learning* based on van hiele theory in the LKM. In the learning process of the information stage, students are trained to identify geometric shapes from images of objects that are easily recognized and connect the properties between geometric shapes. This stage also trains students' visualization level, analysis level, informal deduction andrigor thinking level.

Learning Design is designed for transformation geometry material based on van Hiele Theory and discovery contextual learning model with hypothetical learning trajectory approach. Development 1 researchers construct the theoretical basis of constructivism, cognitivism and others to be implemented in the design of existing procedural solutions to be further realized into products solutive to learning problems such as Student Activity Sheets (LKM).

The characteristics of the learning tools produced have been adjusted to the principles of discovery contextual learning, namely 1) Stimulation, 2) Constructivism, 3) Problem Statement, 4) Data Collection, 5) Learning Community, 6) Modeling, 7) Data Processing, 8) Verification, 9) Reflection, and 10) Authentic Assessment, as well as levels of geometric thinking according to van Hiele's Theory of visualization, analysis, abstraction, deduction and sequencing. To make it easier for students to understand the geometry of transformation, researchers provide problems in the context of life in accordance with the stages of experience already owned. To emphasize the real picture then added a picture to describe the real form to students.

Based on the results of the study has also been produced learning design that meets the criteria of practical with the characteristics of attractiveness, process, use, ease of use, adequacy, time allocation and equivalence to be used in learning mathematical geometry transformation in college. Other characteristics such as the provision of illustrations / images in the lecturer's handbook and student handbook that can facilitate students to understand the problems presented, so as to improve the ability to think geometry according to van Hiele Theory.

This research resulted in a learning design based on van Hiele Theory and discovery contextual learning model with hypothetical learning trajectory approach implemented into lecturer handbook and student handbook that meets valid and practical criteria. Valid criteria with characteristics such as student-centered learning activities, use of models, interactive, real problems in each activity are suitable for achieving learning objectives, activities facilitate students to carry out vertical and horizontal mathematical processes, accuracy of activities in finding concepts and reflecting on discovery contextual learning. In the process of learning transformation geometry based on van Hiele Theory and discovery contextual learning, students will go through the ability of visualization, analysis, abstraction, deduction, and rigor. By using the real context and the use of images visible to what extent the visualization ability of students Continued with still using the real context, the use of images as well as the use of learning outcomes and interaction in the learning process will be visible analysis ability of students in learning geometry transformation. For abstraction skills, students will be seen if they can use intertwining with other mathematical materials. For deduction ability will be seen when students draw conclusions from things that are specific to the student activity sheet (LKM) (deduction), and use images as a means to think and start looking for generalizations from the material that has been studied (rigor/accuracy). Practical criteria with learning design characteristics can run at all levels of students, help students in finding concepts, develop students' geometry thinking skills and the time provided is sufficient to achieve learning objectives.

Implementation of geometry learning design based on van Hiele Theory and discovery-contextual learning can be seen in every activity that shows the ability of visualization, analysis, abstraction, deduction and rigor of students. Visualization ability by using the real context and the use of the model will be visible visualization ability of students in each activity. Analysis ability can be seen with the use of learning outcomes and interaction in the learning process, students can explore the definition of transformation in everyday life and visualization skills that have been obtained previously. For abstraction ability, students can use intertwining with other mathematical materials, students can utilize previous visualization and analysis skills to continue to the abstraction ability to find solutions at the problem statement stage. Deduction ability can be seen with the use of learning outcomes and interaction activities in the learning process, students already understand the role of notions, definitions, axioms and theorems on the geometry of transformation. At this level students have begun to be able to formally organize proofs. Rigor ability can be seen by the use of learning outcomes and interactions in the learning process, students have begun to understand the importance of the accuracy of the basic principles in a proof of transformation geometry.

Similar to the study by 1) Renanda in 2023, an analysis was conducted on the improvement of students' geometric thinking levels using the Van Hiele theory with a constructivist approach. The study was carried out with first-semester undergraduate students of the Mathematics Department, Faculty of Mathematics and Natural Sciences, State University of Malang. It reported that *"Before learning with the constructivist approach, students' geometric thinking ability was at levels 1 to 3, with the average at the informal deduction stage. After the learning process, their ability increased to levels 2 to 4, with the average at the formal deduction stage"(Renanda et al., 2023). Furthermore, 2) in 2017, Nurhidayah conducted research on the development of students' geometric thinking ability using the Van Hiele theory in the context of quadrilaterals through a discovery learning approach. The findings showed that each stage in the Discovery Learning model successfully improved students' geometric thinking ability (Nurhidayah, 2017). Then, the study by 3) Yuni Rochmawati (2022), entitled *"The development of a Discovery Learning model to improve mathematics learning outcomes,"* found that the development of the Discovery Learning model was proven to improve students' mathematics learning outcomes(Rochmawati, 2022). Additionally, the research by 4) M. Ikhsan (2012), entitled *"The development of a learning model based on the Van Hiele theory to improve junior high school students' geometry skills in Banda Aceh City,"* concluded that the developed Van Hiele-based learning model met the criteria of validity, practicality, and effectiveness(Ikhsan, 2012).

Thus, a learning model based on the Van Hiele theory and the Discovery-Contextual Learning approach can be concluded as a high-quality learning model because it is able to facilitate the gradual and systematic development of students' geometric thinking. This model not only encourages students to actively explore geometric concepts through direct and contextual experiences but also helps them reach higher levels of thinking according to the Van Hiele stages, ranging from visualization to rigor. The effectiveness of this model is reflected in the significant improvement in students' learning outcomes, their active engagement in the learning process, and their ability to solve geometric problems logically and in depth. Therefore, this model is feasible to be used and recommended as an innovative learning strategy in mathematics education at the university level.

Conclusions

The conclusions of this study are: 1) LKM based on *discovery-contextual learning based* on van hiele theory has been produced which is valid, practical, and effective, 2) the ability to think geometry students tend to increase each cycle. The results of the test scores of geometry thinking ability of student transformation showed the average percentage of geometry thinking ability of students in cycle I reached 78.4%classified as good, for cycle II geometry thinking ability of students increased by 88% classified as very good, and in cycle III geometry thinking ability of students also increased by 92.8% classified as very good. From the data obtained, it can be seen that the ability to think geometry students have increased from cycle I, II and III, as well as the activity of mathematics education students also increased and has reached the success indicators.

References

Anisyah, S. (2023). Upaya meningkatkan kreativitas transformasi geometri melalui metode penemuan (discovery) di kelas XI MIA 1 SMA Negeri 2 Sibolga. Jurnal Edu Talenta, 2(1), 1–14. https://doi.org/10.56129/jet.v2i1.38

Berta Dinata, K. (2019). Problematika Membangun Pemahaman Konsep Geometri Transformasi Mahasiswa Pendidikan Matematika di Universitas Muhammadiyah Kotabumi Tahun Akademik 2019/2020. *Eksponen*, *9*(2), 01–09. https://doi.org/10.47637/eksponen.v9i2.54

Fanny, A. (2022). Analisis kesalahan mahasiswa dalam memecahkan masalah geometri transformasi. Widyaloka, 9(2), 194–204. http://jurnal.ikipwidyadarmasurabaya.ac.id/index.php/widyaloka/article/view/94

Fauziyah, F., Zulkardi, Z., & Putri, R. I. I. (2016). Desain pembelajaran materi belah ketupat menggunakan kain jumputan Palembang untuk siswa kelas VII. Kreano, Jurnal Matematika Kreatif-Inovatif, 7(1), 31–40. https://doi.org/10.15294/kreano.v7i1.4829

Fitriyani, H., Widodo, S. A., & Hendroanto, A. (2018). Students′ geometric thinking based on Van Hiele′s theory. Infinity, 7(1), 55–60. https://doi.org/10.22460/infinity.v7i1.p55-60

Fona Fitry Burais, H. (2014). Peningkatan kemampuan pemecahan masalah geometri dan tingkat berpikir siswa melalui pembelajaran kooperatif berbasis teori Van Hiele. Tesis, VI(2), 52–57.

Gravemeijer, K., Fauzan, A., & Plomp, T. (2013). The development of an rme-based geometry course for Indonesian primary schools. *Educational Design Research – Part B: Illustrative Cases*, *2013*, 159–178. https://research.tue.nl/files/3900348/23590380570408.pdf

Hanipah, N., Farahita, R., & Fadhillah, R. (2022). Penggunaan alat peraga papan transformasi geometri untuk meningkatkan pemahaman konsep matematis siswa. Jurnal Pendidikan Matematika, 1, 14–22.

Hiele-Geldof, D. Van, & Hiele, P. M. Van. (1987). The Van Hiele model of the development of geometric thought. 1–16.

Ikhsan, M. (2012). *Pengembangan model pembelajaran berbasis teori van hiele untuk meningkatkan kemampuan geometri siswa SMP di kota Banda Aceh*.

Maarif, S. (2013). Aplikasi software Cabri Geometri (pp. 261–271).

Maifa, T. S. (2019). Analisis kesalahan mahasiswa dalam pembuktian transformasi geometri. Jurnal, 3(1), 8–14.

Martahayu, V., & Yuanita. (2022). Pengembangan lembar kerja mahasiswa berbasis problem based learning berbantuan e-learning pada materi manajemen peserta didik. Jurnal Cakrawala Pendas, 8(1), 29–39. https://doi.org/10.31949/jcp.v8i1.1913

Mason, M. (2021). The Van Hiele levels of geometric understanding. Professional Handbook for Teachers, 4, 4–8.

M. Hanafi, K.N. Wulandari, R. W. (2017). Transformasi geometri rotasi berbantuan software geogebra. *FIBIONACCI*, *3*(2), 93–102.

Mentaruk, N., & Tentena, U. K. (2015). Quality improvement on transformation geometry course through the implementation reciprocal teaching model at mathematics education study program in christian university of tentena. *JURNAL DAYA MATEMATIS*, *3*(2), 179–191. https://pdfs.semanticscholar.org/a91d/e4436229d28376cddfb8608747cd0a32155a.pdf

Nasution, D. H., & Yerizon. (2019). Development of student worksheets based on discovery learning to improve student mathematical problem solving ability in class X senior high school. International Journal of Scientific and Technology Research, 8(6).

Nurhidayah, V. L. (2017). *Perkembangan Kemampuan Berpikir Geometri Peserta Didik Berdasarkan Teori Van Hiele Pada Materi Segiempat Melalui Model Pembelajaran Discovery Learning*. 39–42.

Primasatya, N. (2018). Implementation of geometry multimedia based on Van Hiele′s thinking theory for enhancing critical thinking ability for grade V students. International Journal of Technology in Mathematics Education Research, 1(2), 56–59. https://doi.org/10.33122/ijtmer.v1i2.40

Ramlah, H., & Jantan, B. (2014). Relationship between students′ cognitive style (field-dependent and field–independent cognitive styles) with their mathematic achievement in primary school. International Journal, 1(10), 88–93.

Renanda, A., Qohar, A., Chandra, T. D., Matematika, P., Malang, U. N., & Malang, J. S. (2023). *Analisis Peningkatan Level Berpikir Geometri Mahasiswa Berdasarkan Teori Van Hiele dengan Pendekatan Konstruktivisme*. *6*(1), 101–114.

Ridha, M. R., Gumilar, A. C., & Dwipriyoko, E. (2020). Peningkatan kemampuan penalaran matematis pada mata kuliah geometri transformasi berbantuan software Geogebra. Jurnal Tiarsie, 17(3), 1–6. https://jurnalunla.web.id/tiarsie/index.php/tiarsie/article/view/87

Rochmawati, Y. (2022). Pengembangan Model Pembelajaran Discovery Learning Untuk Meningkatkan Hasil Belajar Matematika. *Jurnal Riset Pendidikan Indonesia (JRPI)*, *2*(April), 630–635.

Rusdi. (2018). Penelitian Desain dan Pengembangan Kependidikan.Rajawali Perss. Depok.

Sholihah, S. Z., Ekasatya, D., & Afriansyah, A. (2018). Analisis kesulitan siswa dalam proses pemecahan masalah geometri berdasarkan tahapan berpikir Van Hiele. Jurnal Mosharafa, 6(2), 287–298. http://e-mosharafa.org/

Subekti, F. E., & Kusuma, A. B. (2015). Efektivitas problem based learning berbantuan software Geogebra pada geometri transformasi. Prosiding, 1143–1148.

Sundawan, M. D., Liliana, I., Dewi, K., Noto, M. S., & Djati, G. (2018). Kajian kesulitan belajar mahasiswa dalam kemampuan pembuktian matematis ditinjau dari aspek epistemologi pada mata kuliah geometri transformasi. Jurnal, 4.

Susilawati, E. (2022). Efektivitas penggunaan model guided discovery learning terhadap kemampuan pemecahan masalah geometri dengan memanfaatkan software Geogebra pada mahasiswa STKIP Budidaya Binjai. Jurnal Serunai Matematika, 14(1), 6–9. https://doi.org/10.37755/jsm.v14i1.556

Syah, D. (2009). Strategi belajar mengajar. Jakarta: Diadit Media.

Taqwa, M. (2020). Pengembangan lembar kerja mahasiswa (LKM) untuk menumbuhkan motivasi belajar pada matakuliah kalkulus lanjut di masa pandemi Covid-19. 263–275.Berta Dinata, K. (2019). Problematika Membangun Pemahaman Konsep Geometri Transformasi Mahasiswa Pendidikan Matematika di Universitas Muhammadiyah Kotabumi Tahun Akademik 2019/2020. *Eksponen*, *9*(2), 01–09. https://doi.org/10.47637/eksponen.v9i2.54

Utomo, P., Asvio, N., & Prayogi, F. (2024). Metode Penelitian Tindakan Kelas (PTK): Panduan Praktis untuk Guru dan Mahasiswa di Institusi Pendidikan. *Pubmedia Jurnal Penelitian Tindakan Kelas Indonesia*, *1*(4), 19. https://doi.org/10.47134/ptk.v1i4.821