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E-Module Using Van Hiele Phases of Learning to Improve Student's Mathematical Creative Thinking Skills

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Abstract

The aim of this study is to (1) develop a web-based e-module based on the Van Hiele Learning Phases and (2) assess the validity, practicability, and effectiveness of an e-module based on the Van Hiele Phases of Learning to enhance creative thinking skills. The research method was R&D by using ADDIE (analysis, design, development, implementation, evaluation) model. The students in this study have been from SMP Negeri 21 Semarang's VII grade. The Discovery Learning approach is used to implement e-modules in learning. And, according to the evaluation of the implementation of this e-module, the value of improving students' creative thinking capacity reveals that the average percentage improvement in the experimental class is 47% greater than the control class, which is 39%. The results of the classical completion test revealed that the average creative thinking capacity of students who took the Van Hiele e-module was greater than 75. (KKM) The comparison test results showed that the average gain in students' creative thinking skills in the experimental class was greater compared to the control class with a sig 0.037<0.005, indicating that the implementation of the e-module with the Van Hiele phase satisfies the effectiveness requirements. This study suggests that teaching materials be improved with more complete material, questions focused on higher order thinking abilities, and other mathematical skills.

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INTRODUCTION

Geometry has always been an important part of the mathematics curriculum in schools. It was extremely important in people's life because of their desire to quantify, count, measure, and chart land and earth (Armah et al., 2018). Geometry is related to many other branches of mathematics, including measurement, algebra, calculus, and trigonometry, and is widely utilized by architects, engineers, physicists, instructors, and others. Geometry develops logic, deductive reasoning, analytical reasoning, and problem-solving thinking skills (Russell D, 2014). However, some pupils struggle to understand geometry content when studying mathematics(Nirawati et al., 2022). Learning geometry is difficult owing to lack of verbal understanding, poor visualization abilities, and inefficient learning(Idris, 2009).

Piere Marie van Hiele and Dina van Hiele-Geldof discuss how to organize geometry instruction in the classroom (Machromah et al., 2018). Students will go through five levels of geometry learning: recognition, analysis, order, deduction, and rigor, beginning with identifying geometry objects such as shapes and ending with formal deductive geometry understanding. This geometry learning with Van Hiele theory has been shown to be effective for school geometry learning(Abu & Zainal Abidin, 2013).

According to van Hiele's geometric thinking level theories, can be improved by instruction. The instruction is based on the five phases of geometry learning the level of geometry thinking. This stage of learning is designed to help teachers create teaching and learning activities that will facilitate students to think(Argaswari, 2018). To acquire each van hiele level of geometric reasoning, pupils must complete all five phases. To put this into context, students must go through the information, guided orientation, explicitation, free orientation, and integration phases in order to proceed from one level to the next (Abdullah & Zakaria, 2013).

In educational settings developed in accordance with the Van Hiele model, it also fosters the development of geometric concepts and the relationships between these concepts, as well as high-level thinking abilities including implication, association, communication, problem-solving, spatial thinking, and creative thinking(Erdoğan & Durmuş, 2009). One of the high-level thinking skills is creative thinking(Erdoğan & Durmuş, 2009). Creativity is a unique way of thinking, behaving, or creating anything. It is a synthesis of numerous abilities, skills, motives, and attitudes (Siew & Chong, 2014).

In math class, students merely imitate how the teacher solves problems, thus they learn mathematical principles by rote without thorough understanding (Setiyani et al., 2022).

According to the conclusions of teacher interviews at SMP Negeri 21 Semarang, the teacher conducts learning with the goal of reaching basic completeness and has not explored students' creative skills. This is also demonstrated by the questions that promote to the ability to think creatively yet do not have a place in classroom instruction. It is well known that the instructional material properties are in the form of printed books and summarized in slides, which are not ideal and consistent in the use.

Giving instructions can help pupils enhance their creative thinking skills in the subject of geometry. This teaching is organized around Van Hiele's phase of learning geometry learning approach. According to learning studies, Van Hiele can enhance mathematical communication abilities (Nuraini et al., 2021), increase conceptual comprehension (Meng, 2009), boost geometric thinking(Argaswari, 2018), and promote creative thinking(Erdoğan & Durmuş, 2009).

In the digital era, one of the use technology is the creation of modules that students may access online. The usage of the internet as a learning tool can broaden the range of issues that students can answer (Thomas & Edson, 2019).

A learning model is required in its application while learning to increase the ability to think creatively and test the items generated. The learning model has several variations in its evolution, one of which is the Discovery Learning model. This learning model attempts to build active learning processes through self-discovery and self-investigation, so that the findings acquired endure a long time in memory and are not readily forgotten by students (Kristin, 2016).

Based on the given description, the researcher will create an e-module in discovery learning using the van hiele learning phase to boost students'

creative thinking skills. It focuses on junior high school geometry content on the subject of quadrilaterals.

METHOD

This study was classified as research and development. E-modules are developed by using ADDIE model (analysis, design, development, implementation, and evaluation). The ADDIE methodology was chosen for this study because it is sequential and systematic, with each outcome reviewed so that the end result of one stage becomes an upgrade for the next (Ganesan, 2015).

The first step is to analyze. Field surveys and literature studies are among the activity conducted out at this stage. At the field survey stage, activities include examining teaching materials utilized in schools, as well as geometric material and students' creative thinking skills. The Van Hiele Phase of Learning was investigated by the researcher prior to examining teaching materials.

The next stage is design. Based on the outcomes of the preceding stage's analysis, an outline or design of the e-module is developed with the van hiele phase.

At the development stage, the e-module design that was created during the initial stage is detailed and complete. Following the completion of the module's preparation, experts validate it. Validation is determined based on the 5 validator's assessment. The validation results were analyzed by calculating the average of each aspect.

Table 1 Criteria for Validation Assessment

Average score	**Criteria**
1,00 ≤ V_a ≤ 1,80	Poor
1,80 ≤ V_a ≤ 2,60	Not good
2,60 ≤ V_a ≤ 3,40	Pretty good
3,40 ≤ V_a ≤ 4,20	Good
4,20 ≤ V_a ≤ 5,00	Very good
V_a= average validation score	

The fourth stage is implementation, which includes implementing the products created in class into action through a quasi-experimental design with a non-equivalent (pretest-posttest) control group design(Cresswell J, 2009). The experimental class (learning uses e-modules with the van hiele phases in the discovery learning learning model) and the control class are chosen (learning uses the discovery learning learning model). The creative thinking test was given to both classes as a pre- and post-test. Meanwhile, after the learning process, the experimental class students were requested to complete a student response questionnaire. The practicality of the e-module is determined by the students' responses to the questionnaire, which are then qualitatively analyzed and the average is determined.

Table 2. Practicality Assessment Creteria

Percentage Score	**Criteria**
86% ≤ R ≤ 100%	Very good
71% ≤ R ≤ 85%	Good
56% ≤ R ≤ 70 %	Pretty Good
40 % ≤ R ≤ 55%	Not Good
0 % ≤ R ≤ 40%	Poor

The last stage is evaluation. This step is used to evaluate the accomplishments of the system built with the developed e-learning module, as well as its conformity with expectations (Hamzah, 2019). The evaluation was conducted in order to assess the effectiveness of the e-module on students' creative thinking skills. To investigate this hypothesis, a statistical test was run utilizing data from the creative

thinking skills test performed to both the experimental and control groups.

The average completeness test is used to examine whether or not the average score of the experimental class's creative thinking skills is greater than the minimal completion level of 75. The average completeness was determined using a one-sample t-test on spss with a real level of 5%. In the test for the difference between the two means, the t-test is used to determine whether there is a difference in the mean of students in the experimental and control groups(Sudjana, 2010). The average difference test could use the independent t-test with a real level of 5% with the aid of SPSS 19 (Sukestiyarno YL, 2013).

Then, an analysis of the results of the problem-solving ability improvement is performed using the n-gain test, which refers to the normalized gain (n-gain) with the formula given.

$$gain\ score = \frac{posttest\ score - pretest\ score}{absolute\ highest\ score - pretest\ score}$$

And the gain-test cretiria is as follows:

Table 3. Gain Score Criteria

Interval	Criteria
$g > 0,7$	High
$0,3 \leq g \leq 0,7$	Medium
$g < 0,3$	Low

RESULTS AND DISCUSSIONS

By changing the processes in the Van Hiele phase, the development product in this study is aan e-module with an address at https://www.sinaumatematika.com/.This module was created using WordPress and the learnpress plugin, which permits display in the Learning Management System (LMS).

The first step is to do an analysis. Curriculum analysis reveals that the class VII curriculum is an merdeka curriculum. Based on the findings of the questionnaire replies, it is possible to assume that students are still having difficulties with mathematics. Teachers use learning media in class, but some students have not been assisted in understanding mathematical concepts. Students need learning resources that can help students construct their knowledge through sequential learning steps. Presentation of digital learning resources that can show material in the form of text, images, and interactive media is fun in learning.

The design stage begins with determining learning materials, the learning materials chosen are class VII quadrilaterals. The quadrilateral material will be divided into 2 learning activities, namely 1) the properties of the quadrilateral and 2) the perimeter and area of the quadrilateral. This e-module is website based with wordpres. To support the appearance of e-module, the wordpress web installs and activates the learnpress plug-in.

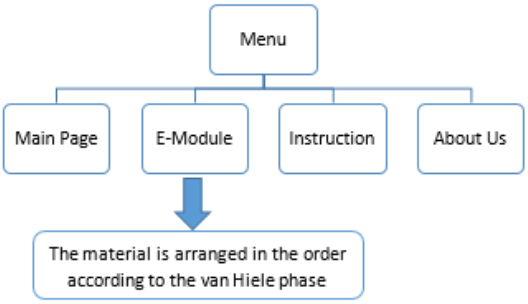

Figure 1. E-module menu

Van Hiele's learning phase is written as learning activities in this e-module. The learning framework is designed as follows:

Table 4. Activity Details on E-module with Van Hiele Phase

Learning objectives

1. Understand the definition and identify the properties of a quadrilateral.
2. Determine the formula for the perimeter and area of a quadrilateral and solve problems related to real life.

Van Phase	Learning Activities 1	Learning Activity 2
Learning objectives	Understand the definition and identify the properties of a quadrilateral	Determine the perimeter and area of a quadrilateral
Inquiry Phase	Get to know quadrilaterals in everyday life	Knowing the implementation of perimeter and area of a quadrilateral in

		daily life
Direct Orientation	Classify quadrilaterals into six types of quadrilaterals	Explore the perimeter and area of a quadrilateral
Explanation	Identify the properties of a quadrilateral	Identify how to derive the perimeter and area formulas
Free Orientation	Doing Practice Questions	Doing Practice Questions
Integration	Conclusion of the definition of a quadrilateral and its properties.	Summarize the formulas for the perimeter and area of a quadrilateral

The content of creative thinking skills is provided implicitly in the learning module through sample questions and practice questions in the form of open inquiries.

Development Stage

This process includes writing content for the website, creating drawings, and creating media. In developing material, many programs were used, including wordwall, Canva, and iSpring Suite. After that, the material is placed on the web page in accordance with the page.

Figure 2. Main page appereance

Student learning activities arranged in e-modules are developed according to the learning sequence of the Van Hiele Phase. Which includes the Inquiry Phase, Direct Orientation, Explanation, Free Orientation Phase and Integration

Inquiry Phase

At the inquiry or information stage contains an explanation. At this stage, the concept is introduced through linking knowledge with concrete objects and contextual problems relating to the content.

Directed Orientation

The core activities are related to constructing concepts, students discovering the properties of quadrilaterals, or related to problem solving algorithms. The activities are created so that students gradually discover the features of geometric concepts. Furthermore, activities in this phase revolve around investigating items to discover geometric properties.

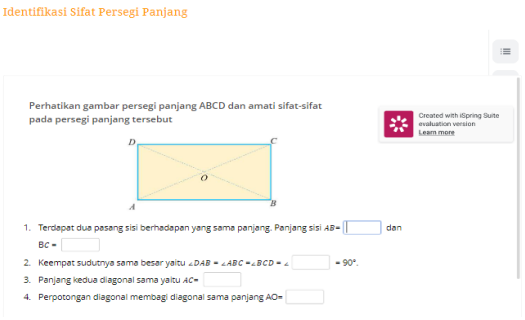

Figure 3. Directed Orientation

Explanation

In this phase, students explain formulas explicitly and describe the content in depth as part of the process of finding concepts. Students can discuss their understanding from the previous step in this stage.

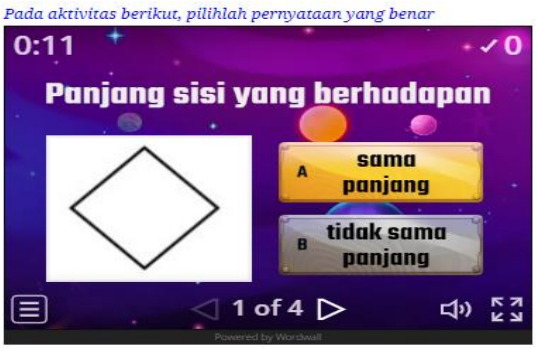

Figure 4. Explanation Phase

Free Orientation

Students can now develop their own methods for constructing conceptual linkages, like they did in the previous phase. Activities at this stage include applying concepts to a specific situation or conducting additional research based on preliminary findings.

Integration

Students create summaries in this phase, which are activities aimed to help students summarize or interpret the topic as a whole, or to combine it with other concepts.

Validation

The results of the e-module validation assessment with the Van Hiele Phase by the validator obtained an average score of 4.025 with a percentage of 81%.

Table 5. Average validation score

Aspects	Average	Percentage	Criteria
Content Quality	3.8	76%	Good
Self Instructional	4.2	84%	Good
Self Contained	4	80%	Good
Alignment with Learning Objectives	4.2	84%	Good
Stand Alone	3.8	76%	Good
Presentation Design	4	80%	Good
Reuse	4.2	84%	Good
Usage Interaction	4	80%	Good
Average	4.025	81%	Good

This shows that the average quality of the e-module with the Van Hiele Phase is in the good category. So it can be concluded that the e-module with the Van Hiele Phase is feasible for field trials with revisions according to the suggestions of the validator.

Suggestions for material validation in general for e-modules need to be revised in terms of the use of terms and their consistency, clarity of language use in instructions and delivery of material, as well as cross-checking quadrilateral concepts. In media validation, in general the module needs to be revised in terms of the use of more varied illustrations and the module cover design on the main page.

Furthermore, in the implementation phase, the use of learning modules with the van hiele phase is carried out by providing e-modules to students before learning. The Implementation of this module uses the discovery learning. learning was carried out in 4 meetings in class VII F at SMP Negeri 21 Semarang.

Practicality

The practicality value is based on the findings of the practicality questionnaire assessed by the students in experiment class. The results are presented in the following table.

Table 6. Average Questionnaire Results

Aspect	*Percentage of Response*	*Category*
Content Quality	84%	Good
Presentation Design	85%	Good
Feedback	82%	Good
Motivation	87%	Very Good
Usage Interaction	84%	Good
Stand Alone	82%	Good
Average	84%	Good

The practicality aspect of the e-module with the Van hiele phase showed a very good category in the motivational aspect and a good category in other aspects. And the average for all aspects of the response questionnaire is 84% in the good category. So that the product in the form of an e-module with the van hiele phase can be said to be practical.

Effectiveness

The effectiveness in this study is the effectiveness in improving the thinking skills of students who are in the learning process using e-modules with this Van Hiele phase. The data analysis start with the Kolmogorov-Smirnov test 0,200>5% showed that data was normally distributed and Levene's test = 0,299>5% showed that the test score was homogeneous.

The average completeness test results were acquired as the output of the test results with the one sample t test that the significant value of the final data was 0.000. Because sig = 0.000 < 0.05 and t_count = 9.179 with dk=n-1=12-1=11, we get t_table = 0.685. Because 9.179 > 0.685, the experimental class students' average value of creative thinking ability is more than the KKM (minimum passing limit) which is 75.

From the analysis on the independent-t test with SPSS showed sig. (2-tailed) = 0.037 <0.005, with an average interpretation of the creative thinking skills of students in the experimental class who complete the e-module with the Van Hiele phase in discovery learning being greater than the creative thinking abilities of students in the control class.

Improvement creative thinking skills before and after the implementation can be analyzed by the value of n gain. From the results of the gain calculation, the average n-gain score in the control class is 39% and in the experimental class is 47% and both are in the medium category. These results show a higher average increase in classes using e-modules with the Van Hiele Phase in the Discovery Learning learning model compared to the control class.

Discussion

The development of this product produces e-modules with the Van Hiele Phase to improve creative thinking skills that are suitable for use in learning mathematics. Implementation of the Van Hiele Phase in e-modules can encourage student creativity. This is similar (Erdoğan & Durmuş, 2009; Siew & Chong, 2014)that learning geometry can improve students' thinking skills using image visualization; besides that the ability to think creatively can be developed through problem solving (Kashani-Vahid et al., 2017). The material in this e-module is organized according to the Van Hiele Phases, which include inquiry, direct orientation, explanation, free orientation, and integration. The implementation of the geometry module based on Van Hiele's theory can serve as a bridge for students to develop geometric notions. Furthermore, it motivates students to be more engaged in learning mathematics, and students are encouraged to learn independently and attain ideal results with this module.

These findings are consistent with research indicating that the van Hiele phase of learning can boost students' creative thinking skills(Erdoğan & Durmuş, 2009; Indriani R & Darminto, 2021; Siew & Chong, 2014). Research on the development of e-modules can improve students' creative thinking skills(Maryam M, 2019).

Based on an analysis of the results of students' creative thinking ability tests, it was discovered that implementing e-modules with the Van Hiele Phase in the Discovery Learning learning model in effective learning to develop creative thinking skills.

The increase in students' abilities occurs because of assistance such as the sequence of instructions according to the stages in the Van Hiele Phase learning(Argaswari, 2018). Cognitive development in geometry can be accelerated by giving instructions in the learning process. Instructions given using Van Hiele's 5 learning phases can help students learn step by step so they can reach a higher level at the level of geometric thinking(Safrina et al., 2014).

The instructions given in the study were in the form of instructions in modules through questions and a series of activities. The series of module activities are organized based on The Five Phases of Learning Geometry which in Van Hiele's theory is stated as giving instructions in an effort to improve students' creative thinking abilities. As a result, it is reasonable to say that the improvement in students' thinking skills occurs as a result of the usage of instructions in the form of e-modules that comprise the Van Hiele learning phase in an endeavour to progress to a higher level. This conclusion is supported by the results (Erdoğan & Durmuş, 2009) in his findings showing that instruction based on the Van Hiele phase is effective in increasing the level of students' creative thinking.

CONCLUSION

E-module with The Van Hiele Phase in Discovery Learning was designed to produce products in the form of web-based learning modules

that students can access via cellphones or computers/laptops using the ADDIE development model. Following completion of the stages in accordance with the development procedures, the conclusions are summarized as follows. By the average score of validation, the e-module is in the category "valid with little revision", an average score of 4.03, and a percentage of 81%. Following revision, the e-module with the Van Hiele Phase meets the validity requirement. The analysis of the practicality questionnaire completed by students after learning using the e-model with the Van Hiele phase shows that motivation receives a very good predicate, while the aspects of content quality, presentation design, feedback, use interaction, and stand-alone receive a good predicate. In the good category, the average percentage of all parts of the response questionnaire was 84%. As a result, the e-module with the Van Hiele phase in the Discovery Learning learning paradigm meets the practical requirement. The average percentage gain in the experimental class was 47% more than the 39% increase in the control class, according to a review of the effects of increasing students' creative thinking skills. The classical completeness test findings revealed that the average creative thinking skills of students who were provided e-modules with the Van Hiele Phase in Discovery Learning was greater than 75 (KKM) with sig. 0.000<0.05. The comparative test outcomes showed that the experimental class's average gain in creative thinking skills was greater than the control cclass by a sig. 0.037<0.005. Thus, the use of e-modules with the Van Hiele phase in the Discovery Learning to enhance students' creative thinking skills meets the effectiveness criteria.

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