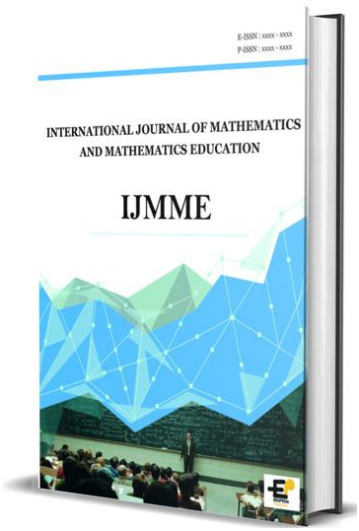

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Prospective Mathematics Teachers' van Hiele's Geometry Thinking and Habits of Mind: A Description of Hard Skill and Soft Skill by Gender

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Prospective Mathematics Teachers' van Hiele's Geometry Thinking and Habits of Mind: A Description of Hard Skill and Soft Skill by Gender

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Abstract

Geometric thinking level and habits of mind were important hard and soft skills required of prospective mathematics teachers. The purpose of this study is to describe the van Hiele geometric thinking level and habits of mind of prospective mathematics teachers. The descriptive quantitative research method was used. There were 31 female and 17 male prospective mathematics teachers in the sample. The research instrument for measuring geometric level was derived from Usikin's (1982) van Hiele geometric thinking test and a habits of mind questionnaire. According to the findings of this study, prospective mathematics teachers' ability to think geometrically has progressed to the stage of analysis and informal deduction. Furthermore, male prospective mathematics teachers achieved the highest level of geometric thinking, known as rigor. Furthermore, both as a whole and in terms of indicators, prospective mathematics teachers' habits of mind fall into the strong category. Male prospective mathematics teachers have more positive habits of mind than female prospective mathematics teachers. The study's findings can help lecturers, particularly those in the mathematics education study program, determine students' hard and soft skills at the end of the year. Prospective mathematics teachers can also be assigned by institutions based on their geometric thinking and habits of mind.

Introduction

In facing the challenges of industry 4.0, where students are required to live modern lives and create new technologies, Gleason (Gleason, 2018) explains that the industrial revolution 4.0 has fundamentally changed human life and work. Mathematics Education Students must receive learning and training so they can easily face these challenges in the future. In its development, mathematics education students need skills in carrying out life. Students are required to constantly think at the top level in doing tasks related to mathematics. Van hiele geometry thinking and habits of mind are needed by students in learning mathematical concepts. Geometry teaching entails teaching various skills, including the

development of reasoning skills, the ability to visualize concepts and relationships in geometric figures, problem-solving in everyday life, and knowledge of other subfields of mathematics (Battista & Clements, 1996; González & Herbst, 2006). (Chew & Lim, 2013) emphasized the importance of learning geometry as a prerequisite for learning other mathematics topics such as fractions, decimals, percentages, functions, and calculus. The benefits of learning geometry are not only in the lecture environment but also in everyday life, such as in several fields of the aircraft manufacturing industry, interior design, etc.

One of the geometric abilities is van hiele geometric thinking. Van hiele geometry thinking theory invented by Pierre and Dina van Hiele in 1954. Pierre and Dina van Hiele (Welle, 2001) suggest that a person will go through five hierarchical levels in learning geometry. The five levels are level 1 (visualization), level 2 (analysis), level 3 (informal deduction), level 4 (deduction), and level 5 (rigour). Level 1 Visualization, this level is also mentioned as the recognition phase. Students recognize a geometric building based on visual considerations at this stage. They are not yet aware of the properties of the geometric shape. Level 2: Analysis, at this level, students already understand the properties of concepts or geometric shapes based on informal analysis of the parts and their component attributes. Level 3: Informal Deduction. This level is often called ordering or abstraction. At this stage, students logically sort the properties of the concept, form an abstract definition and can distinguish the properties of sets necessary and sufficient conditions in determining a concept. Level 4: Deduction. Students' deductive thinking has developed at this level, but not optimally.

Able to understand the importance of deductive reasoning. Geometry is a deductive science. Therefore, drawing conclusions, proving theorems, and others must be done deductively. Students already understand this level's importance of undefined elements, axioms, definitions and theorems. However, students do not understand why this is used as an axiom or theorem. Level 5: Rigor, at this level, students can already understand the importance of excellence from basic things. This level is a level of thought that is similar in depth to that of a mathematician (Crowley, 1987; Nopriana, 2014; Nopriana et al., 2021). Each level describes students' thinking processes in the context of geometry. The level describes how students think and what geometrical ideas students think about, rather than how much knowledge they have. Students supported by the right teaching experience will pass through these five levels, where students cannot reach one level of thought without passing the previous level. Each level shows a person's thinking skills in learning geometric concepts.

Several studies report that van Hiele's geometric thinking is important to improve, especially for prospective teacher students (Armah et al., 2017, 2018; Armah & Kissi, 2019; ERDOGAN, 2020; Salifu et al., 2018; Yılmaz & Koparan, 2015). Research reported how to improve van hiele's geometric thinking without paying attention to aspects of soft skills. One of the important soft skills that prospective teachers should have is habit of mind.

Students tend to rely on previously learned habits in order to solve problems. Choosing what will work from their pool of habits and applying the selected habit appropriately are critical in overcoming any

problem. These habits, also known as "habits of mind" in the literature, are modes of thinking that come into play when it is unknown how to solve a problem; they provide an individual with a range of potential options (Bülbül, 2021; Johnson et al., 2005). Habits of Mind are mathematical, logical, and attitudinal modes of thought that are required for science, mathematics, technology, and engineering students to become effective problem solvers capable of transferring such modes to new contexts (Yellamraju et al., 2019). The theory of habits of mind is an important variable related to learners' academic performance at various educational stages, particularly at the university level (Abdellatif, & Zaki, 2020). Logically, habits of mind fuel thinking, as students with high habits of mind combine essential and creative thinking to solve problems. Furthermore, habits of mind are associated with adaptability, openness, independence, mental justice, and the ability to criticize and seek solutions to many dilemmas that individuals face.

The theory of habits of mind is an important variable related to the academic performance of learners at various educational stages in general, particularly at the university level (Abdellatif, & Zaki, 2020). Several studies stated the connection habits of mind of university students with some mathematical ability, for instance, problem-solving skills (Abdellatif, & Zaki, 2020), engagement with engineers (Hanson et al., 2022), informal reasoning (Kalin & Namdar, 2022), cognitive style (Nufus & Ariawan, 2019), hemispheric dominance status (TURAN & KURTULUŞ, 2021). These studies focus on finding the relationship between habits of mind and several abilities. Meanwhile, researchers believe assessing prospective teachers' habits of mind is critical, particularly prospective mathematics teachers.

Based on the previous discussion, which stated the importance of van while geometry thinking and habits of mind that could train prospective mathematics teachers' high-level thinking, none of the studies describe these hard and soft skills with empirical evidence. Therefore, this study aims to investigate prospective mathematics teachers' van while geometry thinking and habits of mind.

Method

This research is a qualitative descriptive study, in this study it describes the van hiele geometric thinking abilities and habits of mind of Grade III students of Mathematics Education as prospective mathematics teachers at a private university in Cirebon City. The sample in this study were 48 prospective mathematics teachers’ who were given the van Hiele geometry test and the habits of mind questionnaire.

The study's instruments were divided into tests and non-tests. The instruments used were a geometric thinking test and a mathematical habits of mind questionnaire. The following section explains the instruments and data analysis used.

Van Hiele Geometry Test (VHGT)

The test used to measure students' geometric thinking skills is the van Hiele Geometry Test (VHGT) which The Cognitive Development and Achievement developed in Secondary School Geometry Project (CDASSG) (Usiskin, 1982). The VHGT is a multiple-choice test with 25 questions organized into 5 levels of geometric thinking presented by van Hiele. Each level has five questions in Usiskin's test instrument that measures geometric thinking level. The following criteria are given based on the correct answer (Nopriana, 2014; Nopriana et al., 2021).

1. If students can answer 3-5 questions correctly at level 1, then these students reach the first level of geometric thinking.
2. If students can answer 3-5 questions correctly at level 2, then the student reaches the second level of geometric thinking, and so on.
3. If the student does not answer correctly 3 or more questions at levels 3, 4, and 5, then the student reaches the second level of geometric thinking.

Habits of Mind

The Habits of Mind questionnaire used in this study consisted of 10 statements with 4 Likert model scale categories, namely Strongly Agree (SS), Agree (S), Disagree (TS) and Strongly Disagree (STS), without a neutral choice. This is intended to avoid the attitude of doubt in students. The habits of mind questionnaire comprise two types of statements, namely positive and negative.

The aspects assessed are students' abilities in (1) exploring mathematics, (2) identifying problem-solving strategies, (3) asking themselves about activities that have been carried out (4) formulating questions (Hendriana et al., 2017). Student responses were assessed by calculating and comparing them to the maximum total scores from the habits of mind questionnaire. The percentage score is then classified using the criteria in Table 1.

Table 1 - Criteria for Student Habits of Mind

Percentages (%)	Criteria
81-100	Very Strong
61-80	Strong
41-60	Adequate
21-40	Weak
0-20	Very Weak

Results and Discussion

Analysis of Van Hiele Geometry Thinking

Table 2 describes van Hiele's Geometry Thinking Level of prospective mathematics teachers overall and by gender.

Table 2 – Prospective mathematics teachers' geometric d

Level	Overall		F		M	
	Q	%	Q	%	Q	%
1	5	10.4	4	12.9	1	5.9
2	19	39.6	11	35.5	8	47
3	18	37.5	13	41.9	5	29.4
4	5	10.4	3	9.7	2	11.8
5	1	2.1	0	0	1	5.9
Quantity	48	100	31	100	17	100

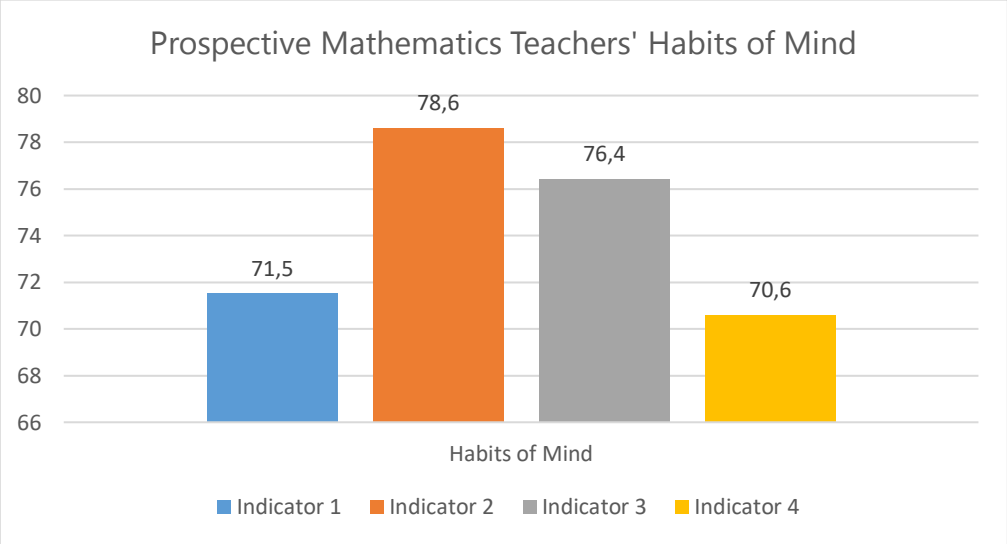
Based on Table 2, it can be concluded that only one student reached the level of rigor, and five students reached the level of deduction. Students' deductive thinking has developed at this level, but not optimally. Able to understand the importance of deductive reasoning. Geometry is a deductive science. Therefore, drawing conclusions, proving theorems, and others must be done deductively. Students already understand this level's importance of undefined elements, axioms, definitions and theorems. However, students do not understand why this is used as an axiom or theorem. At the rigor level, students can already understand the importance of excellence from basic things. This result exceeded previous research, which discovered that the highest geometric thinking level of prospective mathematics teachers was an informal deduction (Nopriana et al., 2021).

Nevertheless, overall, most sampled students still had a geometric thinking stage at the analysis stage and informal deduction. The higher the students' geometric thinking level, the better the geometric learning outcomes (Nopriana et al., 2021). According to Musa (2018), only students with strong geometrical abilities reach the informal deduction stage, while others only reach the analysis stage (Musa, 2018). This study result showed that most prospective mathematics teachers reached analysis and informal deduction levels of van Hiele's geometric thinking. These results are consistent with those of previous studies. It was stated in the literature that geometric thinking levels of prospective mathematics teachers were below level 3, informal deduction (ERDOGAN, 2020). However, it differs from Rafianti (2016) findings, who studied prospective elementary school teachers; the findings revealed that 50% of students only arrived at the stage of thinking about introduction or visualization (Rafianti, 2016). Geometric thinking levels of prospective mathematics education were lower than expected in level 4 (formal deduction) and level 5 (rigor) (ERDOGAN, 2020).

Prospective mathematics teachers are mostly women. Overall, most female prospective mathematics teachers reach level 3, the informal deduction level. Meanwhile, most of the male prospective mathematics teachers only reach level 2 of thinking geometry, namely the level of analysis. However, the highest level of geometric thinking, namely rigor, is achieved by male prospective mathematics teachers. College students with exceptional abilities were shown to be capable of reaching levels of visualization, level of analysis, level of informal deduction, and level of formal deduction. However, college students with moderate abilities were able to reach 3 levels of Van Hiele geometric thinking. However, collage students with low abilities turned out to be able to reached (Wulandari et al., 2021).

Analysis of Habits of Mind

According to the findings of the analysis of the habits of mind questionnaire, the habits of mind of prospective mathematics teachers have an average percentage of 74.5%. Based on the category, this percentage falls into the strong category. As a result, prospective mathematics teachers have strong habits of mind on average. Following that, Diagram 1 depicts the habits of mind of prospective mathematics teachers as seen through each indicator.



Explanation:

Indicator 1: Exploring mathematics.

Indicator 2: Identifying problem-solving strategies.

Indicator 3: Asking themselves about activities that have been carried out.

Indicator 4: Formulating questions.

Diagram 1. Prospective Mathematics Teachers' Habits of Mind

According to the findings, as many as 48 prospective mathematics teachers have strong habits of mind on each indicator, and the differences are not statistically significant. Previously, we discovered that there were 31 female prospective mathematics teachers and 17 male prospective mathematics teachers among the 48 students. Female prospective mathematics teachers had a habit of mind percentage of 73.4%, while male prospective mathematics teachers had a habit of mind percentage of 78.9%. Despite having very different habits of mind, they both fall into the same category, namely strong habits of mind. Overall, prospective mathematics teachers are in a strong category (Nopriana et al., 2021). Habits of Mind are required for effective thinking for those individuals who have the previously mentioned habits of not only thinking deeply but also solving problems when needed using their mental abilities. Habits of mind also reflect a pattern of intelligent performance, which may lead students to productive action. These actions are typically formed as a result of an individual's response to specific types of problems and issues, provided that solutions to such problems necessitate thinking, research, and reflection, as solving problems necessitates mental strategies, deep insight, perseverance, and creativity (Abdellatif, & Zaki, 2020). Furthermore, there was a significant positive relationship between academic

achievement and prospective mathematics teachers' habits of mind (Bülbül, 2021).

The identifying problem-solving strategy indicator is the highest indicator obtained by all prospective mathematics teachers. This shows that prospective mathematics teachers are used to identifying problem-solving strategies in lectures. So that these indicators develop better than other indicators. Developing a student's problem-solving strategies requires careful instruction because problem solving requires students formulating specific mathematical problems and acquiring various skills in representing the problem through numerical, symbolic, verbal, or graphical representation (Barham, 2020). Prospective mathematics teachers prefer new inventions and apply them to mathematical concepts in order to strengthen and expand their habits of mind. This can result in an increase in habits of mind for solving problems encountered in lectures and even in everyday life. Identifying problems-solving strategies is important, prospective mathematics teachers are already accustomed to identifying the problem solving strategies since first year of lectures (Nopriana et al., 2021).

Conclusion

Based on the results of the study, overall prospective mathematics teachers have a good level of van Hiele geometric thinking and strong thinking habits. There was a male math teacher who attained the highest levels of geometric thinking. That is, he could already understand the importance of excellence over basic things. The geometric thinking stage of prospective mathematics teachers is mostly in the informal analysis and deduction stage. This stage is also achieved equally by male and female prospective mathematics teachers. The thinking habits of prospective mathematics teachers reach the strong category, also seen from each indicator. This means that the habits of mind of prospective mathematics teachers have developed well in each indicator.

Recommendations

The findings of this study can assist lecturers, particularly those in the mathematics education study program, in determining the hard and soft skills of students at the end of the year. Before becoming a mathematics teacher, it is necessary to understand the hard and soft skills of prospective students' mathematics teachers. Institutions can also assign prospective mathematics teachers based on their geometric thinking and habits of mind

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