e-ISSN: 3025-7638
p-ISSN: 3025-1842

IJRME International Journal of Research in Mathematics Education

Vol. 3 No. 2, December 2025

UIN Prof. K.H. Saifuddin Zuhri Purwokerto
Fakultas Tarbiyah dan Ilmu Keguruan

IJRME
International Journal of Research in Mathematics Education
Vol. 3 No. 2, December 2025
Universitas Islam Negeri Prof. K.H. Saifuddin Zuhri Purwokerto
e-ISSN: 3025-7638, p-ISSN: 3025-1842

Editorial Team

IJRME
International Journal of Research in Mathematics Education
Vol. 3 No. 2, December 2025
Universitas Islam Negeri Prof. K.H. Saifuddin Zuhri Purwokerto
e-ISSN: 3025-7638, p-ISSN: 3025-1842

Tabel of Contents

International Journal of Research in Mathematics Education
Vol. 3 No. 2, December 2025, 119-132
Universitas Islam Negeri Prof. K.H. Saifuddin Zuhri Purwokerto
e-ISSN: 3025-7638, p-ISSN: 3025-1842

Exploration of Ethnomathematics at the Batu Tulis Site in Cipaku Village Purbalingga as a Mathematics Learning Resource

Akbar Fuadin[1]✉; Abdelillah Jamous[2]

[1]Universitas Islam Negeri Profesor Kiai Haji Saifuddin Zuhri Purwokerto, Indonesia
[2]Universtity of Bourmerdas, Algeria

✉ *Corresponding email:* *fuadinakbar00@gmail.com*

Received April 2, 2025
Accepted November 17, 2025
Published December 31, 2025

https://doi.org/10.24090/ijrme.v3i2.13498

Abstract: This research aimed to explore mathematical concepts embedded in historical artifacts at the Batu Tulis Site in Cipaku Village, Purbalingga, and to examine their potential as resources for mathematics learning through an ethnomathematics approach. This study employed a qualitative method with an ethnographic approach. Data were collected through observation, interviews, and documentation. Observations were conducted by the researcher. Interviews were conducted with two informantsincluding the manager of the Batu Tulis Site in Cipaku Village, who also serves as a cultural expert. Documentation was carried out during the observation process. The results indicated that the Batu Tulis Site contains numerous cultural elements, as evidenced by the many historical artifacts, each possessing philosophical significance. In addition to cultural elements, mathematical concepts were also identified, such as geometric shapes found in the iron fence (rectangle), tiles (square), and wooden wheels (circle). The concept of angles is present in the statue of Dewa Wisnu (acute angle), houses (obtuse angle), and pillars (right angle). The concept of three-dimensional shapes is found in the watu kenong (sphere), genthong (cylinder), and stone inscriptions (irregular shapes). Geometric transformation concepts are evident in the statue of Dewi Welas Asih (translation), wooden wheels (rotation), floral motifs (reflection), and gamelan instruments (dilation). The concept of sets is reflected in the design of gamelan instruments. The concept of lines is present in the inscriptions on the stone. The concept of similarity is found in the entrance gate. In addition to cultural elements and mathematical concepts, ethnomathematical activities were also identified at the Batu Tulis Site in Cipaku Village, including play activities, design and construction activities, measuring activities, and location-determining activities. These ethnomathematical activities at the Batu Tulis Site can be utilized as contextual resources for mathematics teaching and learning.

Keywords: ethnomathematics; batu tulis site in Cipaku village; mathematics learning resource

A. Introduction

Education encompasses all knowledge and learning experienced throughout life that positively contributes to individual development (Dwi Annisa, 2022). . Education, as the process of teaching and learning, aims to develop knowledge, skills, values, and attitudes that enable individuals to function effectively in society. Education is future-oriented for students, and its curriculum is structured within an educational process (Syamsul Hidayat, 2023). One of the subjects included in the curriculum is mathematics education.

. Mathematics is among the most structured and precise branches of knowledge. Although 'exact' does not imply absolute certainty, mathematics is often considered more precise than many social sciences and some physical sciences. . Mathematics is a compulsory subject in many curricula, equipping learners with skills applicable in everyday life (Erik Santoso, 2021). Mathematics studies patterns, structure, space, and quantity. This involves the development of concepts, proof of theorems, and their application in various contexts, ranging from natural sciences to technology and economics. Mathematics is a universal language used worldwide, meaning every country plays a role in its development and application. Countries with strong educational systems make significant contributions to mathematics, both in research and in producing renowned mathematicians. Mathematics has a broad influence on various aspects of human life, including technology, science, economics, engineering, healthcare, and education itself. Beyond that, its impact extends to culture, art, and even philosophy, shaping how we understand and solve complex challenges. . The evolution and expanding influence of mathematics across eras have prompted the diversification of instructional resources. One promising approach is the integration of mathematics with local culture, known as ethnomathematics.

The term "Ethnomathematics" was first introduced by D'Ambrosio in 1977 (Ani Cahyadi, 2018). The word "ethnomathematics" comes from three roots: "ethno," "mathema," and "tics." "Ethno" refers to something within a cultural context, including language, symbols, and jargon. "Mathema" means explaining and engaging in activities such as measuring, inferring, and coding. Meanwhile, "tics" has a meaning similar to "techniques." In essence, ethnomathematics is the application of mathematics in the realm of culture, encompassing ethnic groups, social classes, communities, and more (Sri Rahmawati Fitriatien, 2016).

Ethnomathematics offers educators an approach to address challenges such as students' low interest in mathematics. Students' interest in mathematics is influenced by their perception that math is boring and intimidating (Cicik Pramesti, 2021). Additionally, other issues such as technology, limited class time, inadequate facilities, weak motivation, and an unsupportive learning environment can also affect students' interest in learning mathematics (Sri Ayu, 2021). This lack of interest can hinder their readiness and ability to grasp mathematical concepts taught by educators. Therefore, implementing ethnomathematics-based mathematics learning serves as an alternative solution to overcome these challenges. Ethnomathematics helps students understand abstract mathematical concepts through exploratory activities rooted in their own culture (Haris Hidayat Ismail, 2022).

As a culturally rich nation, Indonesia has diverse heritage sites that serve as regional icons, particularly in Purbalingga. The author is interested in exploring one of the cultural artifacts and historical relics of the Purbalingga community, specifically the Batu Tulis Site in Cipaku Village. The collection of artifacts there serves as an asset that can be developed into a contextual learning resource to enhance students' interest in mathematics.

B. Methods

This study employed a qualitative method, using observation, interviews, and documentation to collect data. Combining these approaches enabled the researcher to gain in-depth understanding for more nuanced analysis.

Qualitative research—often naturalistic or ethnographic—is commonly used in cultural anthropology because it examines phenomena in their natural contexts. Unlike quantitative research, which describes the surface of reality, qualitative research aims to gain an understanding of human and social issues. In other words, this type of research focuses on exploring deep insights into social, cultural, and human behavioral phenomena. . Therefore, an ethnographic approach was deemed suitable for exploring the ethnomathematical aspects of the Batu Tulis Site in Cipaku Village.

C. Results and Discussion

1. Analysis of Mathematical Activities at the Batu Tulis Site in Cipaku Village

After conducting observations and interviews, the researchers identified several ethnomathematical activities at the Batu Tulis Site in Cipaku Village. The data analysis is presented in Table 1.

Table 1. Analysis of Mathematical Activities at the Batu Tulis Site in Cipaku Village

Artifact	Math Activities
Gamelan	Playing
Dewa Wisnu Statue, Watu Kenong, Ornamental Iron Fence with Flower Patterns, Wooden Wheel, Archway	Designing/Building
Iron Fence, Dewi Welas Asih Statue, Support Pole, Gallery, Genthong	Measuring
Location of the Batu Tulis Site, Batu Tulips Inscription	Locating

The playing activity in this research involves playing the gamelan instruments at the Batu Tulis Site in Cipaku Village. The aim is to enhance understanding of patterns and sequences, as well as to improve comprehension of geometric shapes and transformation concepts. Playing the gamelan requires an understanding of rhythmic patterns, as each instrument has different beat timings to produce harmonious sounds. Therefore, the gamelan has a complex yet structured rhythm that reflects mathematical patterns, such as time division and repetition. The rhythmic patterns form regular cycles, meaning they repeat in an orderly manner, reinforcing the concept of repetition in mathematics.

Designing activities can be observed in various objects and architectural techniques at the Batu Tulis Site in Cipaku Village. Each object has its own philosophical meaning, and the buildings and supporting facilities there also feature specific motifs and designs. Besides creating sturdy and functional structures, these activities also foster a sense of admiration for the ancestors who crafted them with such detail and deep meaning. One example is the statue of Dewa Wisnu. Upon observation, Dewa Wisnu is depicted with four arms, two of which hold a chakra (discus) and a torch. The stone statue was meticulously carved with precise calculations, allowing it to stand firmly while maintaining clear details of the chakra and torch despite its age. The four arms also carry a profound symbolic meaning, representing human nature's constant desire for more and numerous wishes. Another object showcasing design is the Watu Kenong. Watu is Javanese for "stone," while kenong refers to a gamelan instrument. The Watu Kenong consists of two geometric shapes, a sphere and a cylinder, symbolizing fertility, life, and balance. The ancient carvers demonstrated remarkable skill, as the spherical and cylindrical carvings closely resemble the actual bronze kenong used in gamelan. The sphere was shaped with precise calculations, resulting in a perfect and aesthetically pleasing form.

The iron fence at the Batu Tulis Site also reflects design. This fence, which protects the inscriptions, features intricate floral motifs. The floral patterns were carefully duplicated with precise measurements, creating a clear reflective effect. The motifs are symmetrically positioned at the top and bottom, arranged neatly and accurately. Another example is the wooden wheel, shaped as a perfect circle with eight spokes representing the cardinal directions. Its construction required precise calculations to ensure symmetry and proper alignment with the compass points. The archway of the Batu Tulips Site also exhibits design and construction. Its distinctive features include various carved motifs and a tapered shape that widens at the bottom and narrows at the top. The gate is tiered like a staircase and painted in two colors, gold and dark blue.

Measuring activities can be seen in the iron fence surrounding some statues and inscriptions. The fence features a rectangular structure with two columns, constructed with precise calculations and measurements. Rectangular patterns must have equal length and width, and precise engineering ensures stability and optimal functionality. Another measuring activity is found in the statue of Dewi Welas Asih (Goddess of Compassion), particularly in its lotus flower motifs. Dewi Welas Asih (also known as Kuan Im) symbolizes human compassion. While often associated with worship, the statue is merely a representation of human virtues, not an object of deification. The lotus motifs at the base of the statue follow identical patterns in spacing and shape, indicating meticulous measurement during its creation. The supporting pole of the structures at the site also demonstrates measuring activities. These pillars, which hold up the roof above certain statues, required precise height and width measurements to ensure stability and safety. Accurate right-angle calculations were necessary to prevent collapse. The gallery of the inscription storage building at the site also involves measuring. The roof forms an isosceles triangle (without a base), requiring equal side lengths to function properly. The genthong at the site also required measurement during its making. Traditionally used for storing water or food supplies, its height and width had to be calculated to hold a specific watercapacity.

The Batu Tulis Site is located in Cipaku Village, Mrebet District, Purbalingga Regency. Situated away from urban crowds and accessible via a slightly steep path, the site offers a peaceful natural atmosphere, ideal for learning or relaxation. Nearby, there is SD Negeri 4 Cipaku (Cipaku State Elementary School 4) and several residential houses. The site’s remote location helps preserve its main artifact, the massive Batu Tulips inscription, which is too large to be moved to a museum. As seen in images, the site is surrounded by rice fields, hills, and small pathways. It is close to the Cipaku Village Hall, SD Negeri 4 Cipaku, and borders Metenggeng Village. Due to its proximity to farmland, some inscriptions and statues have been discovered in farmers' fields. Every Batu Tulis inscription is flanked by two water springs, and this holds true in Cipaku Village. In fact, across Java, such inscriptions are always found near two water sources, a traditional marker left by ancestors to indicate the presence of freshwater.

2. Analysis of Mathematical Concepts at the Batu Tulis Site in Cipaku Village

Researchers identified 7 sub-themes, namely: (1) plane figures, (2) angles, (3) solid figures, (4) geometric transformations, (5) sets, (6) lines, and (7) congruence. These sub-themes are further divided into several concepts, as shown in Table 2.

Table 2. Analysis of Mathematical Concepts at the Batu Tulis Site in Cipaku Village

Math Concepts	Artifact
Square	Tile
Circle	Stone Epigraph, Wooden Wheel
Trapezoid	Stand
Rectangle	Iron Fence, Signpost
Acute Angle	Dewa Wisnu Statue
Right Angle	Support Pole, Stone Step
Obtuse Angle	Gallery, Barrier
Set	Gamelan
Sphere	Watu Kenong, Street Lamp
Cylinder	Genthong, Alu, Cylinder Inscription
Cube	Stand
Rectangular Prism	Stone Step
Irregular Shape	Batu Tulis Inscription, Ganesha Statue, Telur Inscription, Stone Inscription, Lumpang
Translation	Iron Fence, Dewi Welas Asih Statue
Rotation	Wooden Wheel
Reflection	Ornamental Iron Fence with Flower Patterns
Dilation	Kenong, Gong, Saron
Line	Stone Epigraph
Congruence	Archway

a. Concept of Square, Circle, and Trapezoid

A rectangle is a two-dimensional quadrilateral with opposite sides equal and each interior angle equal to 90°. Based on this definition, each interior angle of a rectangle measures 90°

because opposite angles add up to 180° (Dimas Danar Septiadi, 2021). Upon closer observation, the iron fence and the signpost exhibit the characteristics of a rectangle, confirming that the iron fence has a rectangular shape. A square is a quadrilateral with all sides equal in length and one 90° angle. The tiles share these same features, so they can be identified as squares. A circle is defined as a two-dimensional shape consisting of a set of points equidistant from a central point. The concept of a circle appears in stone engraving and wooden wheel. Upon examination, the stand has two parallel sides. This aligns with the properties of a trapezoid, which has one pair of parallel sides but unequal lengths.

Figure 1. The rectangle concept in iron fence

Figure 2. Rectangle concept in signpost

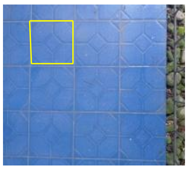


Figure 3. Square concept in tile

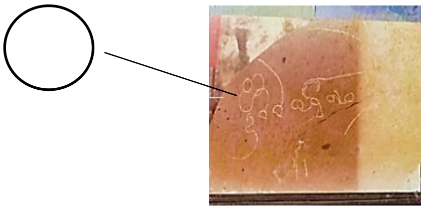


Figure 4. Circle concept in stone epygraph

Figure 5. Circle concept in a wooden wheel

Figure 6. Trapezoid concept in stand

b. Concept of Acute Angle, Right Angle, and Obtuse Angel

An angle is a figure formed by two rays with a common endpoint. These two rays form the sides of the angle, which lie on the plane containing the rays (Rosalina Tri Rahayu, 2023). An acute angle is an angle measuring between 0° and 90°, which can be written as $0° < \alpha < 90°$. This angle is formed when the hand of the Statue of Dewa Wisnu is raised upward. An obtuse angle, on the other hand, measures between 90° and 180°, expressed as $90° < \alpha < 180°$. This angle is formed when the hand of the Statue of Dewa Wisnu is slightly lowered. The application of obtuse angles can be seen in the roof design of the building housing ancient inscriptions (gallery) and a barrier. When viewed from the front, the roof resembles a triangle without a base, creating only one angle at the top. A similar concept applies to the edges of the stairs, which follow the direction of the steps, forming an obtuse angle. A right angle is an angle measuring exactly 90°. This angle is evident in the support pole and stone step.

Figure 7. Angles concept in the statue of Dewa Wisnu

Figure 8. Obtuse angle in the gallery

Figure 9. Obtuse angle in barrier

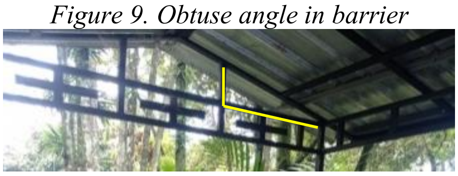


Figure 10. Right angle in the support pole

Figure 11. Right angle in stone step

c. Concept of Set

Gamelan is a traditional ensemble, particularly from Java, comprising a combination of various traditional Javanese musical instruments. The concept of sets in gamelan refers to the grouping of musical instruments that form a unified whole in a gamelan performance.

A gamelan ensemble consists of wind instruments such as the *suling* (bamboo flute), percussion instruments with knobbed gongs like *bonang, kethuk, kempul, gong,* and *kenong*, metallophones with metal bars such as *saron, peking,* and *demung*, as well as other instruments like the *kendang* (drum) and *rebab* (two-stringed fiddle).

The set concept in gamelan can be expressed as:
Set A = {gamelan}
n(A) = 8
A = {Suling, Bonang, Gong, Kenong, Saron, Peking, Demung, Kendang}

d. Concept of Sphere, Cylinder, Cube, Rectangular Prism, and Irregular Shape

A sphere is a three-dimensional curved surface object with a spherical shell-like side. Unlike other three-dimensional shapes, a sphere has no edges or corners. The concept of a sphere can be observed in watu kenong and street lamps. A cylinder is a three-dimensional shape bounded by two identical and parallel circular bases, surrounded by a rectangular surface. The concept of a cylinder is found in genthong, alu, and cylindrical inscriptions.

Figure 12. Sphere concept in watu kenong

Figure 13. Sphere concept in a street lamp

Figure 14. Cylinder concept in Gentong

Figure 15. Cylinder concept in alu

Figure 16. Cylinder concept in Cylinder Inscription

An irregular shape is a geometric form that lacks a defined pattern or symmetrical structure, unlike regular three-dimensional shapes. These shapes are difficult to define because they lack consistent sides, angles, or forms, unlike standard geometric solids. This concept applies to some inscriptions that have undergone deformation from their original shape.

Figure 17. Irregular shape concept in Batu Tulis inscription

Figure 18. Irregular shape concept in Lumpang

Figure 19. Irregular shape concept in stone inscription

Figure 20. Irregular shape concept in Telur inscription

Figure 21. Irregular shape concept in Ganesha statue

A cube is a three-dimensional shape with all edges of equal length, and all faces in the form of squares. The concept of a cube is evident in the stand. Meanwhile, the stone steps take the form of a rectangular prism, as they are three-dimensional with three pairs of square or rectangular faces, where at least one pair differs in size.

Figure 22. Cube concept in stand

Figure 23. Rectangular prism concept in stone step

e. Concept of Translation, Rotation, Reflection, and Dilation

The next concept found at the Batu Tulis Site in Cipaku Village is geometric transformation. Geometric transformation is the process of changing one geometric object into another according to specific rules (Meyta Dwi Kurniasih, 2017). There are several types of geometric transformations, including translation, rotation, reflection, and dilation.

The concept of translation is evident in the floral motifs on the iron fence and the lotus flower motifs on the statue of Dewi Welas Asih. If we observe the motifs on the fence, the golden flower and spiral patterns appear to repeat at equal intervals along the fence. Similarly, the lotus flower motifs on the statue of Dewi Welas Asih also show repetition at uniform distances. Both examples demonstrate that each motif is shifted through uniform translation.

The concept of rotation is evident in the wooden wheel, as illustrated by the movement of the wheel, where every point on the wheel rotates around its center, or the center of rotation. The concept of reflection is seen in the floral motifs on the iron fence. In this case, if there is a horizontal line in the middle of the fence, the position of the flowers and leaves above appears as a mirror image of those below, with identical shapes and sizes.

The concept of dilation is observed in several gamelan instruments, which involve resizing. There are two gongs of different sizes. The gong on the left is larger, while the one on the right appears smaller. The same applies to the kenong and saron, which come in various sizes.

Figure 24. Translation concept in an iron fence

Figure 25. Translation concept in Statue of Dewi Welas Asih

Figure 26. Rotation concept in a wooden wheel

Figure 27. Reflection concept in ornamental iron fence with flower patterns

Figure 28. Dilation concept in Kenong

Figure 29. Dilation concept in gong

Figure 30. Dilation concept in saron

f. Concept of Line

The concept of lines can be observed in the ancient inscriptions on the Batu Tulis (Stone Epygraph), specifically in the form of curved lines. Curved lines are lines that are not straight and instead form specific arcs or bends. This concept of curved lines is evident in the ancient Javanese script carved into the Batu Tulips prasasti (inscription).

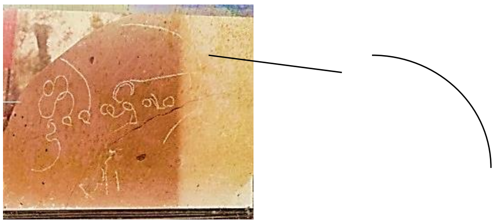


Figure 31. Line concept in stone epygraph

g. Concept of Congruence

The concept of congruence is evident in the archway, where the right archway and the left archway share identical shapes, sizes, and even matching motifs.

Figure 32. Congruence concept in archway

3. Discussion

The findings demonstrate that mathematical concepts historically taught in classrooms were also applied by various groups in ancient societies. By employing this ethnomathematical approach, students can recognize that mathematics is an integral part of their lives. This can help students appreciate their own cultural heritage and make learning mathematics more enjoyable. Overall, ethnomathematics offers a new perspective on learning mathematics. In addition to enriching the understanding of mathematics, it can also strengthen their cultural identity.

Mathematics learning resources can be obtained from various sources, such as the mathematical learning resources available at the Batu Tulis Site in Cipaku Village. Each collection item has unique characteristics, especially in terms of shape and philosophy. The diversity of these forms illustrates the implementation of specific mathematical concepts that can be used in the mathematics learning process. Mathematics is often known for its formulas and calculations, but ethnomathematics presents the logical, systematic, and creative ways of thinking used by ancient societies.

Upon closer examination, it becomes evident that the Batu Tulis Site in Cipaku Village features mathematical concepts and ethnomathematical activities. Several mathematical concepts are present, such as plane shapes, angles, sets, solid shapes, congruence, lines, and geometric transformations. There are also ethnomathematical activities, including playing, designing, measuring, and locating activities. This study indicates that mathematical practices are embedded within local culture and that these practices can be leveraged to enrich students' understanding of mathematics.

D. Conclusion

Based on the analysis conducted, researchers can conclude that the Batu Tulis Site in Cipaku Village is a cultural heritage site that contains historical artifacts rich in philosophical and historical value. In addition to cultural elements, mathematical concepts can also be observed, such as plane geometry concepts represented by the iron fence (rectangles), tiles (squares), the stone epigraph, and wooden wheels (circles). The concept of angles is present in the statue of Dewa Wisnu, the gallery, and the supporting pole. Meanwhile, the concept of solid geometry is found in the watu kenong (spheres), genthong (cylinders), stone inscriptions (irregular shapes), and stand (cubes). Other mathematical concepts, such as geometric transformations (the statue of Dewi Welas Asih, floral motifs, gamelan, wooden wheels), sets (gamelan), lines (stone inscriptions), and congruence (archway), can also be observed at the Batu Tulis Site in Cipaku Village.

In addition to its rich cultural elements and mathematical concepts, ethnomathematical activities can also be found at the Batu Tulis Site in Cipaku Village. Playing activities are often associated with the use of gamelan musical instruments. Design elements can be seen in the statue of Dewa Wisnu, the watu kenong, floral motifs on the iron fence, and wooden wheels. Measuring activities can be observed in the iron fence, the statue of Dewi Welas Asih, the supporting pole, the gallery, and the genthong. Locating activities can be found in the Batu Tulis inscription and the placement of the Batu Tulis Site in Cipaku Village on the map.

References

Annisa, Dwi. (2022). "Journal of Education and Counseling", Journal of Education and Counseling.

Ayu, Sri, Sekar Dwi Ardianti, & Savitri Wanabudiandari. (2021). "Analysis of Factors Causing Difficulties in Learning Mathematics", Muria Kudus University.

Cahyadi, Ani. (2019). *Development of Learning Media and Resources*. Serang: Laksita Indonesia.

Fitriatien, Sri Rahmawati. (2016). "Ethnomathematics Based Learning", Conference Paper.

Hidayat, Syamsul, et al. (2023). "The Development of Education in Indonesia", Tadbir Muwahhid.

Ismail, Haris Hidayat, Izwita Dewi, & Elmanani Simamora. (2022). "The Connection Between Philosophy of Mathematics and Culturally Based Learning Method", Journal Paradigm in Mathematics Education.

Kurniasih, Meyta Dwi & Isnaini Handayani. (2017). *Transformation Geometry Drill*. Depok: PT Raja Grafindo Persada.

Pramesti, Cicik & Ariesandi Prasetya. (2021). "Analysis of Students Difficulty Levels in Learning Mathematics When Applying Mathematical Principles", Edumatica: Journal of Mathematics Education.

Rahayu, Rosalina Tri, et al. (2024). "Mathematics Education Reog Ponorogo, and Geometry Concepts", Asimtot: Journal of Mathematics Education.

Santoso, Erik, et al. (2021). "Behavior Theory (E. Throndike) in Mathematics Learning", Prisma 4.

Septiadi, Dimas Danar. (2021). *Geometry for PGMI, Measurement and Plane Figures*. Malang: Madza Media.

This page has been intentionally left blank.

IJRME International Journal of Research in Mathematics Education
Vol. 3 No. 2, December 2025, 157-172
Universitas Islam Negeri Prof. K.H. Saifuddin Zuhri Purwokerto
e-ISSN: 3025-7638, p-ISSN: 3025-1842

Discovery in Student-Centered Learning: The Essential Role in Guiding Students' Mathematical Reasoning and Proof

Scristia[1]✉; Tatang Herman[1]

[1]*Universitas Pendidikan Indonesia, Indonesia*

✉ *Corresponding email:* scristia@upi.edu

Received April 26, 2025
Accepted November 19, 2025
Published December 31, 2025

https://doi.org/10.24090/ijrme.v3i2.13568

Abstract: This study explores how a teacher focuses students' mathematical reasoning to advance instruction through the implementation of five mathematically productive teaching streams: guidance to student reasoning and proof, student mathematical discussion, working with selected student mathematical arguments, working with worksheets on the proof process. The findings suggest that discovery teaching, especially guidance to students reasoning and proof resulted in the implementation of teaching discovery in student-centered learning. This teaching highlights whose mathematics is centered in the classroom and whether the focus is on correct answers and procedures or on students' mathematical thinking and justification.

Keywords: reasoning and proof; justification; discovery; student-centered learning

A. Introduction

According to the NCTM (The National Council of Teachers of Mathematics, 2000), reasoning and proof is one of the five main standards in the Principles and Standards for School Mathematics. These standards emphasize the importance of developing students' ability to think logically, reason, and be able to provide evidence for their mathematical arguments. In the context of NCTM, reasoning and proof includes several aspects, namely (1) mathematical reasoning, (2) proof, (3) respecting the reasoning and proof process, and (4) participating in mathematical discussions. This involves the ability to communicate effectively about mathematical concepts and arguments. By emphasizing reasoning and proof, NCTM seeks to ensure that students not only understand mathematical concepts, but can also think critically, develop essential mathematical logic skills, and construct strong mathematical arguments. (Conner et al., 2014) emphasize the importance of understanding, recognizing, and carrying out arguments in mathematics, argumentation is considered to be one of the themes that is at the core of mathematics education research and also mathematics research (Selden & Selden, 2013), This reflects the importance of providing a strong foundation for understanding deep mathematics.

Mathematics education researchers and the NCTM suggest that classroom interactions should be centered on student thinking as a means of advancing the learning process (Schoenfeld, 2010) and (Jacobs & Spangler, 2017). Student-centered learning has two actions that must be carried out by the teacher, namely: "the teacher pays attention to students and the teacher leads class discussions centered on student thinking, in terms of mathematical thinking." (Jacobs & Spangler, 2017).

In this study, using the term "student centered learning" to describe teaching where (a) proofs constructed by students on worksheets are presented in front of the class, (b) all students are involved in mathematical proofs in the form of discussion and collaboration between peers, (c) the teacher guides the flow of students' proofs, and (d) students carry out exploration, make accusations, test allegations, provide justification and write evidence. Rifdah builds her learning based on a series of student reasoning. We examined a set of five mathematically productive teaching activities designed to implement student-centered learning through stages of discovery, including Guidance for Understanding Student Reasoning and Proof, Organizing Student Mathematical Discussions, Working with Selected and Discussed Student Mathematical Arguments, and Working with Worksheets on Student Mathematical Proofs. The existence of such teaching as selected in this study in the practice of prospective mathematics teachers does not necessarily reflect student-centered learning. Therefore, we focus this exploration on how teaching implementations support or hinder student-centered learning during the discovery stage.

1. Students Centered Learning in the Mathematics Classroom

The ability to reason is crucial for anyone to comprehend a phenomenon, especially when it comes to understanding mathematics. With the initial reasoning skills capital that students bring to class, educators play a crucial role in helping students develop further in their mathematical reasoning. Mathematical reasoning is the process of thinking logically and analytically to understand mathematical concepts and solve problems effectively. As a final requirement of lectures, especially prospective mathematics teacher students, they must be able to understand and produce mathematical proof. With mathematical proof, students formally express their type of reasoning and provide justifications for a mathematical phenomenon.

When patterns or regularities are observed, students will question whether the pattern is a coincidence or if there is a logical reason behind it. Students are then encouraged to make conjectures, which are guesses or hypotheses about mathematical relationships or properties. This conjecture is then rigorously proven through a mathematical proof, which communicates the reasoning (Häsä et al., 2023) by providing a formal justification involving step-by-step logical arguments that demonstrate the truth of the mathematical statement. This process by (NCTM, 2000); (Ellis et al., 2012); and (G. J. Stylianides, 2007) are called reasoning and proof.

For all of that, the teaching and learning process in the classroom is needed as a learning community that forms collaboration and is student-centered, so that students are given the opportunity to reason and build their own mathematical understanding (NCTM, 2000), as done by previous researchers who involve more students as learners and teachers skillfully provide meaningful support in mathematics (Turner et al., 2013) and (Thanheiser & Melhuish, 2023). In addition, teachers must also have clear goals in teaching mathematics, be able to structure mathematical tasks that demand a high cognitive level, encourage students to explore non-single solutions, support students to argue, and form a supportive classroom community (Bandura, 1977); (Stein & Smith, 1998); (Conner et al., 2014), (Cohen et al., 1999).

Meanwhile, teachers have three tasks according to Richard R. Skemp, namely adapting mathematics material to the level of development of students' mathematical schemes; adapting the way of presentation to the way of thinking (intuitive only, concrete only, or intuitive and concrete reasoning, and also formal thinking) of what the student is capable of; and gradually increasing students' analytical abilities to a stage where they no longer depend on the teacher to digest the material. It is very important for prospective mathematics teachers to have the ability to construct proofs and teach proofs to facilitate students in school later in improving proof skills (Carrillo et al., 2018); (Buchbinder & McCrone, 2022); (NCTM 2000), and National Curriculum).

Taking into account the notion of mathematical discipline, enacting student-centered teaching that focuses on justification in the discovery process is complex, requiring deliberate and strategic practice (M. E. Staples et al., 2012) and (Stein et al., 2008). This practice requires extensive knowledge of student learning progression and how to make mathematical proofs appear proactive. In addition, these practices not only teach mathematical reasoning, but also involve social norms of mathematics in the classroom, such as sharing thoughts, asking questions, conducting exploration, analyzing fellow students' mistakes to find solutions, and understanding other students' arguments (M. Staples, 2007).

Due to the challenges of facilitating student-centered mathematics classes, many researchers have identified effective and structured approaches to make mathematics learning more student-centered (Thanheiser & Melhuish, 2023). This study, however, builds upon the steps taken by previous researchers. This study focuses on discussing five teaching routines by applying discovery during the process of proving mathematical problems, and continues with a discussion on student-centered learning.

2. Discovery in Teaching Student-Centered Learning

The implementation of student-centered mathematics teaching in this research has four components: (a) proofs constructed by students on worksheets are presented in front of the class, (b) all students are involved in mathematical proofs in the form of discussion and collaboration between peers, (c) the teacher guides the flow of student evidence, and (d) students explore, suspect, test allegations, provide justification and write proof. The first three components support the fourth component. Carrying out exploration, making conjectures, testing conjectures, and justification allows students to take responsibility for compiling evidence (Stephens et al., 2017) and (A. Stylianides & Stylianides, 2022).

Justification is a focus in curricula (NCTM, 2000). In this research, we develop the definition of proof from (G. J. Stylianides, 2007), which uses existing statements, uses known and valid forms of reasoning, and uses appropriate forms of communication to define justification as students make logical arguments that use mathematical structures and or provide counterexamples to invalidate claims to justify why mathematical solutions or statements are true or false. In order for teachers to know what students struggle, and how to support reasoning in classroom mathematics (Lo & McCrory, 2009). Also, teachers need to assess students' thinking so that they can build on early attempts at exploration, conjecture, and justification. Teacher attention to the process of conjecturing and justifying is complex (Melhuish et al., 2020), and then can increase their understanding of mathematics (M. E.

Staples et al., 2012), and as ways of doing mathematics. This study adds to the existing literature on the complexities of student-centered learning by: 1) discovering that can support student-centered learning; and 2) analyzing the application of this teaching in mathematics classrooms to better understand when and how the discovery stage can support student-centered learning.

Guidance for understanding student reasoning and proving is the core of student-centered learning because teachers need to assess students' mathematical reasoning so that students can carry out proofs. Other routines support this. Having students discuss and collaborate in conveying arguments among peers allows teachers to assess students' mathematical thinking while going around and listening to students' discussions about the arguments that make up the proof. In this way, students' mathematical reasoning becomes open to the teacher. It also allows students to engage with each other's mathematical reasoning in small groups. Working with Students' Mathematical Proofs Worksheets makes students' reasoning and proofs open to the whole class. Organize Mathematical Discussions while Working with Selected Students' Mathematical Arguments in a Whole-Class Setting. These four teachings, when combined, can lead to the formation of commonality in the classroom (Staples, 2007).

Ultimately, the goal is for students to write valid proof. This is different from using a teacher or textbook as a standard for determining valid proof. By using mathematical reasoning, students are positioned as decision makers and have the opportunity to compare and critique in ways that support better mathematical understanding (see Table 1).

Specifically, math-rich lessons center on specific math objectives. For example, identifying the core mathematics objectives of curriculum materials can support the development of mathematically productive classrooms (Remillard, 1996). By identifying the purpose of mathematics, a lesson can shift away from merely applying procedures to find answers in basic mathematics. Ideally, learning objectives should be specific, accessible, and challenging (Bandura, 1977)). To organize productive discussions, teachers must have clear learning objectives about what they want to achieve in the lesson and the topic (Cai, 2009).

In student-centered learning, we anticipate that students will engage in tasks with high cognitive demands (which must be aligned with learning objectives). Cognitive demands refer to the type of thinking required of students (Stein & Smith, 1998). Research shows that classrooms that support student engagement in higher-demand tasks promote greater success in measuring student reasoning and proof. Additionally, cognitively demanding tasks provide rich opportunities for students to engage in justification and proof (Stein et al., 2008).

This research follows (Thanheiser & Melhuish, 2023) categorization of low-level tasks that focus on memorization and procedures without connections, and higher-demand tasks that focus on procedures with connections and doing mathematics. Doing mathematics can include “exploring and understanding the nature of mathematical concepts” (Stein & Smith, 1998). Ultimately, we anticipate that discovery teaching in student-centered learning will feature student reasoning and discussion of tasks with high cognitive demands and in relation to overarching lesson objectives. In this research, the application of discovery in student-centered learning by prospective mathematics teachers aims to develop students' reasoning and proof skills.

B. Methods

This research was conducted at a junior high school in Indonesia. The majority of students at this school are from traditional Palembang backgrounds. There were 34 grade 9 students involved in Mrs. Rifdah's teaching. This research focuses on Rifdah's learning. This lesson is recorded on video. Teacher Rifdah was chosen because he maximized the opportunity to achieve the research objectives. Mrs. Rifdah's students appear to be engaged in a classroom that provides opportunities for learning. Mrs. Rifdah's teaching serves as the primary data source for this research. And Mrs. Rifdah reflected again regarding the writing of the results of implementing her teaching in class.

The purpose of the analysis is to qualitatively understand the implementation of discovery teaching in relation to how student-centered learning is (see Table 1). Apart from that, the learning objectives and integration of learning, as well as cognitive demands, are also examined. This research explores how teacher Rifdah's application of Discovery teaching is student-centered. This research also examined whether and how students' mathematical reasoning and proof served as the basis for implementing each discovery teaching approach (see Table 1).

We examine how applications on the surface (what and when discovery teaching takes place) and in the details (how students' reasoning and proof are supported in it) can explain the applications researchers observe in teaching. This analysis was carried out in several cycles, which involved watching video lessons and reading transcripts to create a narrative that reflected the implementation of discovery teaching.

C. Results and Discussion

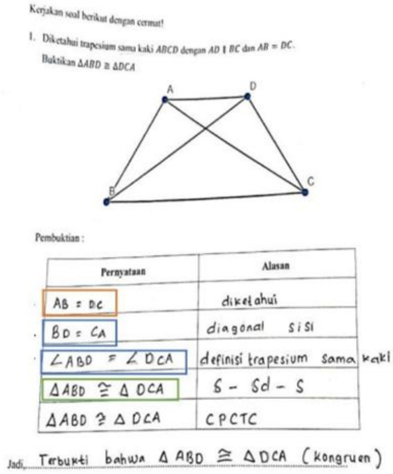
In this section, we start by explaining the learning carried out by teacher Rifdah. The learning was recorded at the end of the odd semester, and by applying the rules that apply in the class where the internship school has been determined. The learning duration is 120 minutes, equivalent to 3 hours of lessons in class 9, covering material on the congruence of triangles. The classroom (see Figure 1) was designed by teacher Rifdah in a way that facilitates collaboration among small groups to determine each other's evidence-based arguments (Bleiler-Baxter et al., 2023).

Table 1. Teaching Discovery in Student-centered Learning

Discovery in Student-centered Learning	Questions about teaching implementation:
The proof that students construct on the worksheet is presented in front of the class	• Have students write evidence arguments on worksheets and present them in front of the class, and how?
All students are involved in mathematical proof in the form discussion and collaboration between peers	• Are students asked to engage in each other's proofs, and how? • How do students discuss during the proof? • What arguments did students convey?
The teacher guides the flow of students' proof	• Are students guided throughout the proof flow, and how? • Are students given examples of valid proofs, and how? • Are students guided to reason in conveying arguments and logical reasons for proof, and how?
Students explore, make predictions, test their hypotheses, provide justification, and write evidence.	• Are students involved in the exploration process, and how? • Are students involved in making conjectures, and how? • Are students involved in testing conjectures, and how?

	• Are students involved in providing mathematical justification, and how?

Figure 1. Image of lesson



Kerjakan soal berikut dengan cermat!

1. Diketahui trapesium sama kaki ABCD dengan AD ∥ BC dan AB = DC.
Buktikan ΔABD ≅ ΔDCA

Pembuktian :

Pernyataan	Alasan
AB = DC	diketahui
BD = CA	diagonal sisi
∠ABD = ∠DCA	definisi trapesium sama kaki
ΔABD ≅ ΔDCA	S - Sd - S
ΔABD ≅ ΔDCA	CPCTC

Jadi, Terbukti bahwa Δ ABD ≅ ΔDCA (kongruen)

Figure2. Student Created Proof

Teacher Rifdah prepares a worksheet for each student containing the tasks to be discussed (two-column proof in Figure 2). Worksheets written by students about students' mathematical proofs and blank worksheets are displayed by the teacher in front of the class with the help of an LCD projector. Teacher Rifdah always refers to the worksheet throughout the proof process. Each argument given by the student is written in the left column, and the name of the student who states the proof argument is given. For each argument statement given by the student, Teacher Rifdah asks for the reason, which is then written in the right column. Thus, students' mathematical reasoning to produce evidence becomes the center of teacher Rifdah's teaching.

1. Teaching Implementation

Teacher Rifdah started by giving an apperception of the prerequisite material by asking for the definition of a triangle, with a classical discussion and questions, and students gave the answer. To ensure the correctness of the students' answers, teacher Rifdah displayed material on congruent triangles via an LCD projector, and explained the definition of a congruent triangle and explained the conditions for congruent triangles. Teacher Rifdah guides students to identify two congruent triangles based on the sides of the triangles by asking students which pair of triangles are congruent in the picture shown (See Figure 3).

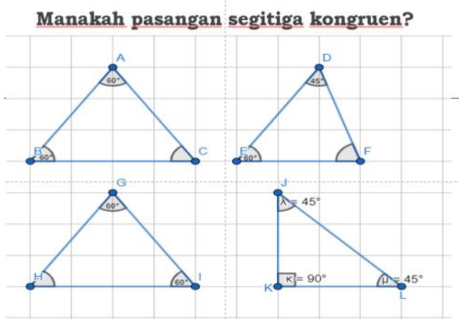


Figure 3. Triangle Identification

After observing the picture, students have no difficulty showing pairs of two congruent triangles based on the length of their corresponding sides; however, they are confused about showing two congruent triangles based on the size of their corresponding angles. Responding to the students' confusion, teacher Rifdah then asked a question that led the students to "how many angles are in a triangle?" Teacher Rifdah took turns confirming the students' thoughts until a student said 1800. Then, teacher Rifdah asked the students to read the proof of the number of proofs on the worksheet. Some students immediately understood how to determine the angle of an unknown triangle and show two congruent triangles based on the length of the side and the size of the angle.

However, some students still had difficulties, so teacher Rifdah provided guidance. Mrs. Rifdah ensured that her students were no longer confused and continued the discussion by explaining and discussing with the students the conditions for two congruent triangles, namely showing the condition (Side-Side-Side) by asking "which are the sides of the triangle?" Then students are asked to write forward and teacher Rifdah gives the student's name in the student's answer box. Mrs. Rifdah continued with the condition (Side-Corner-Side) and asked "name the sides that flank the corners of each triangle!" some students were able to name the sides that flank the corners of each triangle, but several other students were still confused so teacher Rifdah gave guidance again, and finally the condition (Angle-Side-Angle) teacher Rifdah also asked the question again "name the angles that flank every side of the triangle!", Rifdah's teacher did not directly guide her students, but asked peers to help them name them, and Rifdah's teacher asked for an explanation of the answer.

Between explanations, teacher Rifdah gave students the opportunity to ask questions if they did not understand any of the explanations. However, there were no questions from students. Then, teacher Rifdah asked the students to observe the worksheet (LK) that had been distributed. Teacher Rifdah gave directions and instructions for working on the worksheet, then asked students to read examples of proof on the worksheet. Next, Rifdah asked students to gradually work on Activity 1 first. Students work on Activity 1 individually, even though they sit in groups. After all students finished doing Activity 1, Rifdah asked one of the students to fill in the first question table (see Table 1).

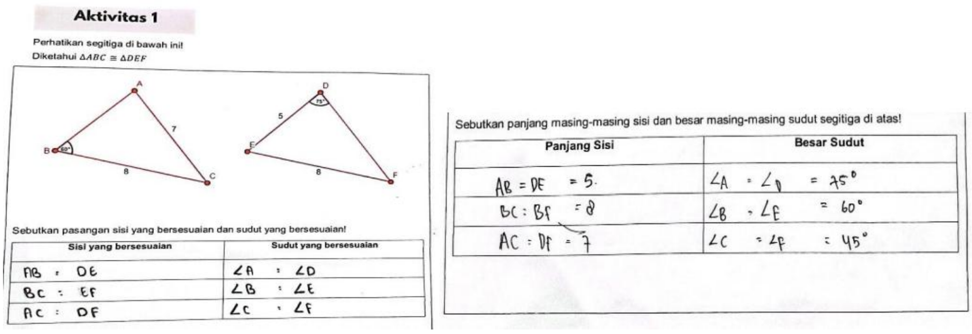


Figure 4. Student Answers to Activity 1

One of the students raises their hand to fill in the table for question one. Then, teacher Rifdah confirmed the student's answer to the other students. Rifdah made sure that her students were ready to prove the congruence of triangles, but She spent a day preparing them. Then Rifdah gave students time to review their work at home.

Rifdah applies the two-column proof strategy, combined with guidance, to understand students' proofs and reasoning during small-group work. Rifdah distributed the Activity 3 worksheet (see figure 5), where students were asked to prove congruence and explain the collaboration that students should carry out when discussing and interacting in groups:

When giving an argument for a statement in the left column, you must be prepared with the reasons why you are writing the argument. The reasons you think are written in the right column.

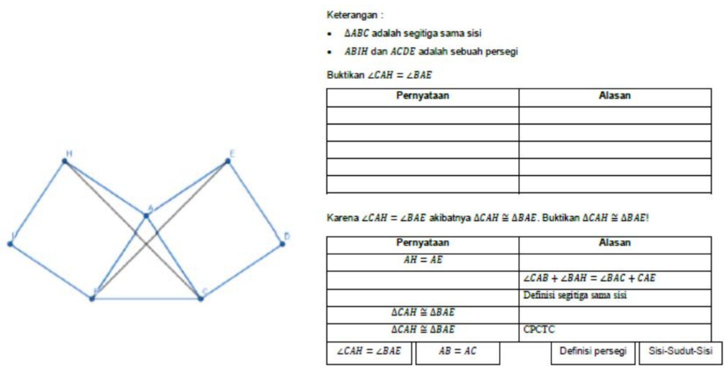


Figure 5. Activity 3

In this section, Rifdah found that her students had difficulty writing arguments in the statement column, Rifdah guided them to work on the proof $\angle CAH = \angle BAE$, Ridah repeated the explanation by giving several example questions. Proof $\Delta CAH \cong \Delta BAE$ Rifdah stimulates students' reasoning by completing the column of reasons and statements from the possible answers that are already available, students in groups express their arguments to each other, because the students must all be involved in the proof. Thus, explicitly student-centered teaching by encouraging students to engage with each other's evidence focuses on students' reasoning.

Next, Rifdah gave the students the opportunity to come forward to fill in the answers in Activity 3. One of the students came forward and wrote down the answer but after asking another friend's opinion, there were different answers so Rifdah asked the students to compare the two students' answers shown, which answer was the most appropriate . Below are pictures of the two students' answers.

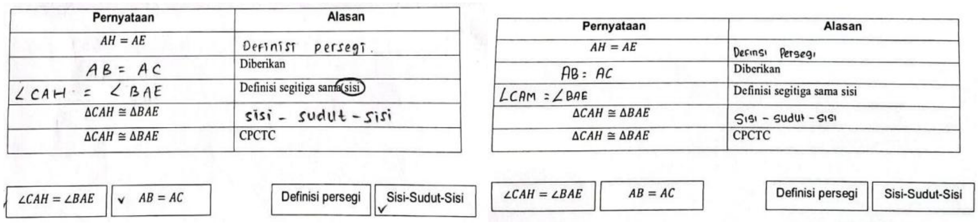


Figure 6. Student Answers in Activity 3

Student 2's After adding several explanations from the researcher, students can conclude that the most appropriate answer is the answer from the second student. In general, at this second meeting, students already knew the steps in carrying out proof. Teaching: students write arguments on the worksheet and publish them in class, and students are also guided as the proof flow is carried out. The lesson continued by providing examples of proof questions and then discussing them together. Teacher Rifdah is conducting the teaching, which demonstrates the teacher's guidance in the proof process.

Next, Rifdah gave Activity 4, which asked students to carry out a proof. The difference with Activity 3 is that in Activity 4, all the proof columns are still empty, whereas in Activity 3, there are several columns that have been filled in, and also for other columns, you just have to match the choices given by the researcher. In activity 4, Rifdah's students experienced difficulty again in determining the reasons for the statements written in the column.

Rifdah explained that he selected certain students to share "specific strategies for specific problems." This indicates that he not only pays attention to right/wrong, but also looks for specific strategies. He instructed the students:

> *The purpose of asking students to share their strategies and proofs this time is so that we can understand students' reasoning, and fellow students can ask each other why students choose that argument and why they use it. So, if someone has difficulty, ask the group lots of questions to help you understand the chain of reasoning.*

Rifdah involves students in each other's thinking and transfers responsibility for exploring, conjecturing, testing conjectures, and justifying to the students. Each student (chosen by Rifdah) shared how they proved it by presenting their work in front of the class. Apart from that, Rifdah recorded the students' thoughts on the whiteboard that had been prepared, so they could still be seen after the students had sat back and returned to their seats in the group.

Alvaro is a student who has written an argument to prove it completely but some of the arguments written are not all correct. Figure 7 shows that Alvaro has written $AB = DC$, which is the "data" argument component in TAP, correctly and with the right notation. Alvaro has also written the Warrant correctly in the form of a mathematical statement, $AC = DB$, based on the properties of an isosceles trapezoid. Furthermore, the mathematical statement $CA = AC$ is also true, and the reasons given are also correct, but Alvaro wrote the angle notation incorrectly. Based on the data and warrants that Alvaro uses in carrying out the proof, the claim written is (Side-Corner-Side), while in the proof, Alvaro attempts to prove congruence by demonstrating conditions that are in accordance with the postulate (Side-Side-Side). Finally, Alvaro has also written the conclusion to the proof that was carried out correctly. It can be seen in the picture below that Anin's first argument is a wrong statement, and she wrote down the wrong reasons too. Anin tried to show the condition of two equal angles, but what was written was the condition of two unequal angles.

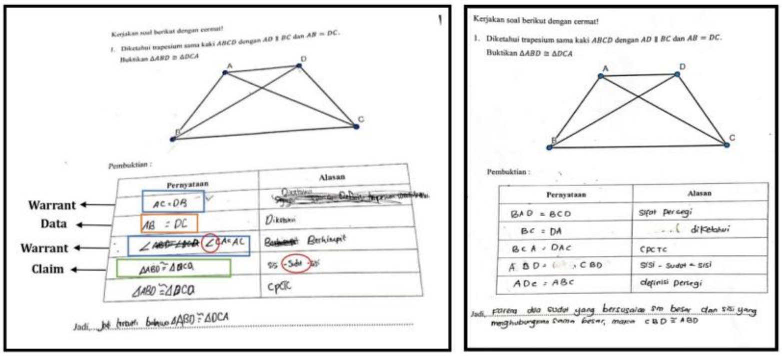


Figure 7. Answers of student Alvaro (a), Student Anin (b)

Overall, Mrs. Rifdah's students who can prove correctly are those who understand the steps of proof based on using a two-column proof strategy and are able to read the information provided well to process it into an argument when carrying out proof. This statement is in accordance with research conducted by Scristia et al. (2022), which indicates that students in the very good category who use the two-column proof strategy are those who build arguments by starting from an understanding of the facts or information given in the question. Students who are able to process information understand it well, so they know the concepts/rules/principles that can support them in making appropriate arguments. So that the match between the data and warrants used by students in carrying out proof can also give rise to the right claim. The Data argumentation component is the frequently. In this case, students understand that data is information provided by teacher Rifdah as support for the argument that will be written.

On average, students are able to write data well and with correct notation. This is because teacher Rifdah has provided clear and easy-to-understand information on the questions. During the learning process, students understand , and then how to use it as data. Teacher Rifdah's explanation is well-regarded regarding the information in the questions, and how to use it as data to prove it.

The Claim argumentation component is a component that always appears in the process of proving the congruence of triangles, but in this case, there are still some students who make mistakes in their determination. A claim is a conclusion obtained based on corresponding data and warrants. In this case, students tend to provide correct data and warrants, but their claim is incorrect.

In connection with student-centered mathematics teaching with the discovery stage, (a) proofs constructed by students on worksheets are presented in front of the class, (b) all students are involved in mathematical proofs in the form of discussion and collaboration between peers, (c) the teacher guides flow of student evidence, and (d) students explore, suspect, test allegations, provide justification and write evidence. Rifdah builds her learning based on a series of student reasoning.

2. Cognitive Demands and Lesson Integration

Most of the lessons are focused on proof, and students understand the chain of reasoning on the triangle congruence postulate. Additionally, students are asked to justify the reasons they provide when writing their arguments. Thus, this lesson is categorized as a lesson with high cognitive demands. In this lesson, the learning target is stated openly in front of the class and referred to several times during the lesson. The entire lesson is focused on reasoning and proving the congruence of triangles using the two-column proof strategy.

Rifdah's instruction reflects the four components of student-centered mathematics teaching with the discovery stage, which involves students in the process of exploring, guessing, testing conjectures and justifying. In connection with the implementation of learning, Rifdah works with selected students' mathematical arguments and uses worksheets to guide students through their mathematical proofs. Rifdah chose students who then shared the results of their work in front of the class. Apart from that, Rifdah also teaches Managing Mathematical Discussions and Collaboration.

Students actively collaborated several times by the end of the lesson, and this initial structuring likely contributed to the overall productivity of the small group. In addition, from the beginning of the discussion, the ideas generated during small group work are immediately shared publicly with all students in the class.

Mathematics Student Discussions, as well as between different strategies, to enable teachers to apply Guidance to Understand Student Reasoning and Evidence. This back and forth between small groups and the whole class allows the entire class time to be student-centered.

Interaction and collaboration in small groups allow students to engage in assignments and discussions with each other. This discussion is structured in such a way that students are involved in focusing on why they chose an argument like that, rather than getting the right or wrong answer. It also enables teachers to listen to and guide students, allowing them to utilize students' reasoning during class discussions. Alternating between small group discussions and class discussions allows more student voices to be heard in small groups, and teachers can engage in student reasoning during class discussions. Students can then engage with the arguments generated during group work in class discussions.

Teacher Rifdah's teaching approach involves providing guidance to help students understand their reasoning and proof, allowing teachers to assess students' mathematical reasoning. This learning is crucial in focusing the class on students' mathematical reasoning. A general description of Rifdah's teaching can be seen in Table 6. Rifdah is not only more actively involved in teaching and learning, but she also focuses more on students' proofs and reasoning, as well as their involvement with each other's proofs. Teaching with Guidance to Understand Reasoning and Proof. Students play an important role in the subsequent learning process.

Teacher Rifdah's learning focuses on understanding reasoning and proof of each other, and asking questions with a clear learning objective to understand the proof of congruence of triangles. Primary teaching, specifically teaching with Guidance for Understanding Student Reasoning and Evidence, serves to link structured discussions and small-group work with selected arguments, and is discussed throughout the class.

At the beginning of this article, the definition of student-centered learning with the discovery stage is a classroom in which (a) proofs constructed by students on worksheets are presented in front of the class, (b) all students are involved in mathematical proofs in the form of discussion and collaboration between peers, (c) the teacher guides the flow of students' proof, and (d) students explore, make assumptions, test allegations, provide justification and write evidence. Returning to this definition, we note that teacher Rifdah includes all four aspects (see Table 1).

In response to this research question, "How can teaching implementations support or hinder student-centered teaching with discovery stages?", it can be said that the inclusion of guidance from teachers to Understand Students' Reasoning and Proof combined with an explicit focus on students' mathematical reasoning and proof sequences mathematics rather than just procedures and right and wrong answers, produces learning that meets the four criteria for student-centered mathematics teaching.

Lastly, from this research on the cognitive demands of the tasks and the integration of the lesson. The analysis shows that learning and teaching can be implemented according to the description, namely, tasks that require high cognitive demands and integrated teaching. The integration of teaching is reflected in Rifdah's ways of selecting student work, organizing discussions, and, most importantly, identifying student reasoning that is aligned with lesson objectives. We suggest that teaching can be more effective when tasks require high cognitive demands and focus on overarching lesson objectives.

D. Conclusion

In this research, the definition of student-centered learning is teaching that supports the classroom where (a) proofs that students construct on worksheets are presented in front of the class, (b) all students are involved in mathematical proofs in the form of discussion and collaboration between friends. peers, (c) teacher guidance to help students during the proof flow so that students' proofs are valid, and (d) students explore, guess, write evidence, and carry out justifications. One of the main conclusions from this research is that relying only on worksheets, teaching materials, and lively class discussions does not provide guidance from the teacher to help with the flow of student evidence, and when students make justifications, it will not produce student-centered learning.

The teaching carried out by Mrs. Rifdah exemplifies the implementation of learning that shows the teacher's role in directing, guiding, and accompanying students in reasoning during the flow of proof, with a focus on students' mathematical proofs (exploration, guessing, writing proof, and justifying), which results in student-centered teaching. with the discovery learning process. In addition to the quality of implementation, the flow of teacher-guided proofs plays a very important role in student-centered teaching because it allows teachers to know the reasoning students use when carrying out proofs. In other words, teacher guidance to help students' reasoning supports the teaching of other proofs.

In this research, the use of guidance by teacher Rifdah makes a different contribution to the learning situation. The instructional approach, which changes from planning to stages of student-centered, evidence-based learning, substantially alters specific and systematic aspects related to the guidance provided by the teacher, who remains directed and generally looks neat. However, the guidance provided during the proof process reduces student independence. Further research may be able to use tools that can guide students during exploration and help students make guesses, and the teacher can act as a guide when students explore with these tools, for example, technology. Furthermore, although this analysis was conducted with prospective teachers undertaking educational internships, we did not attempt to draw conclusions based on the objectives of the internship activities. Further research can modify the implementation mechanism of teaching.

We also note that guidance to stimulate student reasoning, which is explicitly included during the proof flow, can be implemented to achieve learning goals and improve student reasoning and proof. Then it is connected to an explicit student-centered teaching approach. For example, students exploring, guessing, and justifying can be revised to: Involving technology to help students explore, suspect, and justify.

Rifdah's case offers a new perspective on student-centered teaching practices for developing students' reasoning and proof. To involve students in making justifications, teachers must have a deep understanding of what is meant by justification, be aware of students' difficulties, understand how concepts are interconnected, and know how to teach in a way that supports reasoning (Lo & McCrory, 2009). Most importantly, teachers need to guide and trigger students' reasoning so that they can make initial efforts to formulate conjectures, test them, and provide justifications. Teachers' attention to the process of understanding, guessing, and justifying is complex (Melhuish et al., 2020). The complexity lies in the fact that making conjectures, assumptions, and justifications serves as “a tool that students use to increase their understanding of mathematics” (Staples et al., 2012) and as a way of doing mathematics itself.

Lastly, we note that throughout the teaching process, to the learning stages of everything, our focus is on generating students' mathematical proofs from the series of reasoning that students carry out. Guidance, discussions, questions, and answers that stimulate students' reasoning, which are integrated in classroom social play, play an important role in students' reasoning and proof. However, focusing on students' generating mathematical proofs is just one element involved in attending to and supporting the successful reasoning and proofs of all students (Van Zoest et al., 2017) and (Louie et al., 2021). We suggest further consideration of technology in exploring mathematics, including how teachers facilitate the transition from guessing to formal proof construction, as well as the discoveries during the proof flow that require guidance from the teacher as the authority on whether the student's argument is valid or not.

Acknowledgement

The authors are grateful to Lembaga Pengelola Dana Pendidikan (LPDP/Indonesia Endowment Fund for Education), which is part of the Ministry of Finance of the Republic of Indonesia, for supporting our doctoral studies and this publication. Rifdah as a student in the Mathematics Education Study Program, Faculty of Teacher Training and Education, Sriwijaya University. Weni Dwi Pratiwi and Yusuf Hartono as reviewers for this research instrument

References

Bandura, A. (1977). *Self-efcacy: Toward a unifying theory of behavior change* (Vol. 84). Psychological Review.

Bleiler-Baxter, S. K., Kirby, J. E., & Reed, S. D. (2023). Understanding authority in small-group co-constructions of mathematical proof. *The Journal of Mathematical Behavior*, *70*, 101015. https://doi.org/https://doi.org/10.1016/j.jmathb.2022.101015

Buchbinder, O., & McCrone, S. (2022). *Guiding principles for teaching mathematics via reasoning and proving*. https://hal.archives-ouvertes.fr/hal-03746878v2

Cai, J. (2009). Effective mathematics teaching from teachers' perspectives: National and cross-national studies. *(No Title)*.

Carrillo, J., Climent, N., Montes, M., Contreras-González, L., Flores-Medrano, E., Escudero-Ávila, D., Vasco Mora, D., Rojas, N., Flores, P., Aguilar-González, Á., Ribeiro, M., & Catalán, M. C. (2018). The mathematics teacher's specialised knowledge (MTSK) model. *Research in Mathematics Education*, *20*. https://doi.org/10.1080/14794802.2018.1479981

Cohen, E. G., Lotan, R. A., Scarloss, B. A., & Arellano, A. R. (1999). Complex instruction: Equity in cooperative learning classrooms. *Theory Into Practice*, *38*(2), 80–86. https://doi.org/10.1080/00405849909543836

Conner, A., Singletary, L., Smith, R., Wagner, P., & Francisco, R. (2014). Teacher support for collective argumentation: A framework for examining how teachers support students' engagement in mathematical activities. *Educational Studies in Mathematics*, *86*. https://doi.org/10.1007/s10649-014-9532-8

Ellis, A. B., Bieda, K., & Knuth, E. (2012). *Developing essential understanding of proof and proving for teaching mathematics in grades 9-12*. NCTM.

Häsä, J., Westlin, L., & Rämö, J. (2023). Undergraduate students' attitudes towards mathematical proving in an introduction to proof course. *Educational Studies in Mathematics*, 1–23. https://doi.org/10.1007/s10649-023-10239-8

Jacobs, V. R., & Spangler, D. A. (2017). Research on core practices in K-12 mathematics teaching. *Compendium for Research in Mathematics Education*, 766–792.

Lo, J.-J., & McCrory, R. (2009). Proof and proving in a mathematics course for prospective elementary teachers. *ICME Study*, *19*(2), 41–46.

Louie, N., Adiredja, A. P., & Jessup, N. (2021). Teacher noticing from a sociopolitical perspective: the FAIR framework for anti-deficit noticing. *ZDM – Mathematics Education*, *53*(1), 95–107. https://doi.org/10.1007/s11858-021-01229-2

Melhuish, K., Thanheiser, E., & Guyot, L. (2020). Elementary school teachers' noticing of essential mathematical reasoning forms: justification and generalization. *Journal of*

Mathematics Teacher Education, *23*(1), 35–67. https://doi.org/10.1007/s10857-018-9408-4

Remillard, J. T. (1996). *Changing texts, teachers, and teaching: The role of curriculum materials in mathematics education reform*. Michigan State University.

Schoenfeld, A. H. (2010). *Handbook of International Research in Mathematics Education* (L. D. English & D. Kirshner, Eds.). Routledge. https://doi.org/10.4324/9780203930236

Scristia, S., Meryansumayeka, M., Safitri, E., Araiku, J., & Aisyah, S. (2022). *Development of Teaching Materials Based on Two-Column Proof Strategy on Congruent Triangle Materials*.

Selden, A., & Selden, J. (2013). The Roles of Behavioral Schemas, Persistence, and Self-Efficacy in Proof Construction. *Proceedings of the Eighth Congress of the European Society for Research in Mathematics Education [CERME-8]. B. Ubuz, C. Hasar, & M. A. Mariotti (Eds.). Available Online.*, 246–255.

Staples, M. (2007). Supporting Whole-class Collaborative Inquiry in a Secondary Mathematics Classroom. *Cognition and Instruction*, *25*(2–3), 161–217. https://doi.org/10.1080/07370000701301125

Staples, M. E., Bartlo, J., & Thanheiser, E. (2012). Justification as a teaching and learning practice: Its (potential) multifacted role in middle grades mathematics classrooms. *The Journal of Mathematical Behavior*, *31*(4), 447–462.

Stein, M. K., Engle, R. A., Smith, M. S., & Hughes, E. K. (2008). Orchestrating Productive Mathematical Discussions: Five Practices for Helping Teachers Move Beyond Show and Tell. *Mathematical Thinking and Learning*, *10*(4), 313–340. https://doi.org/10.1080/10986060802229675

Stein, M. K., & Smith, M. S. (1998). Mathematical Tasks as a Framework for Reflection: From Research to Practice. *Mathematics Teaching in the Middle School*, *3*(4), 268–275. https://doi.org/10.5951/MTMS.3.4.0268

Stephens, A. C., Ellis, A. B., Blanton, M., & Brizuela, B. M. (2017). Algebraic thinking in the elementary and middle grades. *Compendium for Research in Mathematics Education*, 386–420.

Stylianides, A., & Stylianides, G. (2022). Introducing students and prospective teachers to the notion of proof in mathematics. *The Journal of Mathematical Behavior*, *66*, 100957. https://doi.org/10.1016/j.jmathb.2022.100957

Stylianides, G. J. (2007). Investigating the Guidance Offered to Teachers in Curriculum Materials: The Case of Proof in Mathematics. *International Journal of Science and Mathematics Education*, *6*(1), 191–215. https://doi.org/10.1007/s10763-007-9074-y

Thanheiser, E., & Melhuish, K. (2023). Teaching routines and student-centered mathematics instruction: The essential role of conferring to understand student thinking and reasoning. *Journal of Mathematical Behavior*, *70*. https://doi.org/10.1016/j.jmathb.2023.101032

The National Council of Teachers of Mathematics. (2000). *Principles and Standards for School Mathematics. The National Council of Teachers of Mathematics, Inc.*

Turner, E., Dominguez, H., Maldonado, L., & Empson, S. (2013). English Learners' Participation in Mathematical Discussion: Shifting Positionings and Dynamic Identities.

Journal for Research in Mathematics Education, *44*(1), 199–234. https://doi.org/10.5951/jresematheduc.44.1.0199

Van Zoest, L. R., Stockero, S. L., Leatham, K. R., Peterson, B. E., Atanga, N. A., & Ochieng, M. A. (2017). Attributes of Instances of Student Mathematical Thinking that Are Worth Building on in Whole-Class Discussion. *Mathematical Thinking and Learning*, *19*(1), 33–54. https://doi.org/10.1080/10986065.2017.1259786

International Journal of Research in Mathematics Education
Vol. 3 No. 2, December 2025, 133-144
Universitas Islam Negeri Prof. K.H. Saifuddin Zuhri Purwokerto
e-ISSN: 3025-7638, p-ISSN: 3025-1842

The Effect of VAK (Visualization, Auditory, Kinesthetic) Learning Model Assisted by Baamboozle Game on the Mathematical Communication of Grade VIII Students at SMP Negeri 2 Sumpiuh

Nevada Carribia[1]✉; Maria Cristine Joy V. Anter[2]

[1]Universitas Islam Negeri Profesor Kiai Haji Saifuddin Zuhri Purwokerto, Indonesia
[2]UM Digos College, Philippines

✉ *Corresponding email:* pakleajah@gmail.com

Received April 2, 2025
Accepted November 17, 2025
Published December 31, 2025

https://doi.org/10.24090/ijrme.v3i2.13524

Abstract: This research was conducted due to the low mathematical communication skills of class VIII students of SMP Negeri 2 Sumpiuh. Based on the preliminary test results indicating low mathematical communication skills among eighth-grade students, a solution is required. The purpose of this study was to determine whether there was an effect of the VAK (Visualization, Auditory, Kinesthetic) learning model assisted by the Baamboozle Game on the mathematical communication of grade VIII students at SMP Negeri 2 Sumpiuh. This study employed a quantitative experimental design . The analysis of this study used the N-Gain test and the t-test. The results of this study indicate that the experimental class obtained an average N-Gain value of 0.6491, which indicates that the learning model is categorized as quite effective, while the control class obtained an average N-Gain value of 0.3661, which means that the learning model used is not effective. Furthermore, based on the t-test of the N-Gain values between the two groups, a significance value of 0.000 < 0.05 was obtained. It can be concluded that there is a difference in the average N-Gain value of the experimental class and the control class. Therefore, there is an effect of the VAK (Visualization, Auditory, Kinesthetic) learning model assisted by the Baamboozle Game on the mathematical communication of grade VIII students at SMP Negeri 2 Sumpiuh.

Keywords: baamboozle game; mathematical communication; VAK

A. Introduction

Education is a conscious and planned effort to create a learning environment and a learning process that can develop students' potential. Based on Law Number 20 of 2003 concerning the National Education System, Article 3, the purpose of education is to develop the potential of students to become individuals who are faithful and devoted to God Almighty, have noble character, are healthy, knowledgeable, capable, creative, independent, and become democratic and responsible citizens (Narotama, 2020).

One of the important components in education is mathematics. Mathematics plays a significant role in daily life, serving as the foundation for the development of modern technology and supporting the development of logical, critical, and systematic thinking. Mathematics is also a mandatory subject at every level of education because it is structured and interconnected between topics (Sari & Putri, 2024). Therefore, mathematics learning requires not only memorizing concepts but also understanding and applying them comprehensively.

Effective mathematics learning must encourage students to build understanding through experience and active engagement. According to the National Council of Teachers of Mathematics (NCTM), there are five important standards in the mathematics learning process, namely conceptual understanding, reasoning, communication, connections, and problem-solving (Maulyda, 2020). Among these standards, mathematical communication is one of the key aspects that support the learning process.

Mathematical communication skills encompass the delivery and understanding of mathematical ideas, both verbally and nonverbally, in a careful, analytical, and evaluative manner. According to the indicators from the Ontario Ministry of Education (2005), mathematical communication skills consist of three aspects: Written Text, which means conveying ideas through one's own language, graphics, concrete models, and algebra; Drawing, which represents mathematical ideas with real objects, images, or diagrams; and Mathematical Expression, which transforms everyday events into symbols or mathematical language (Hendriana, 2021).

However, based on a preliminary study conducted in the eighth-grade class at SMP Negeri 2 Sumpiuh, the students' mathematical communication skills are still considered low. Out of the 34 students who were given the test, the average score obtained was only 37 out of 100. An interview with the mathematics teacher, Romeli, A.Md. Pd., also revealed that many students have difficulty understanding word problems, translating questions into mathematical symbols, and finding ideas for problem-solving. These indicate difficulties in reading and critical thinking skills, which directly impact students' low mathematical communication abilities. Additionally, the teaching methods employed in the classroom remain less effective in promoting active student engagement. So far, mathematics learning at SMP Negeri 2 Sumpiuh has primarily employed the lecture method, which tends to make students passive. Therefore, an update in the learning approach is needed to enhance student engagement in the learning process.

This condition is influenced by the teaching approach currently used in the classroom, which relies heavily on the lecture method. This conventional method fails to encourage active engagement, rendering students passive and unable to develop the robust communication skills necessary to articulate complex mathematical ideas. This highlights a significant gap in pedagogical practice, the urgent need for an engaging, student-centered learning intervention that actively caters to diverse student needs and enhances communicative competence. To bridge this critical gap and enhance student engagement, a shift towards interactive and motivating learning models is necessary. Research by Romelan P. et al. shows that interactive learning models encourage students to actively convey mathematical ideas and participate in problem-solving. Thus, this model can help students build a deeper understanding of mathematics (Ariani, 2017). Additionally, Widoretno noted that the use of games in learning can enhance concentration, foster reasoning skills, and lower stress levels in students (Siti Marwah & Nurul Ain, 2022). Therefore, the use of game-based learning can be an interesting alternative to enhance student motivation, especially in mathematics learning, which is often considered difficult and stressful.

One of the learning models that can accommodate this need is the VAK model (Visual, Auditory, Kinesthetic) learning model. The VAK model facilitates students to learn in various styles, namely through seeing, hearing, and moving. Thus, this model is capable of creating a more engaging and interactive learning atmosphere. The use of interactive media, such as the Baamboozle Game, can further optimize the VAK learning model. Baamboozle Game is a medium that can capture students' attention, encourage their active involvement, and make learning more enjoyable. Research by Nadia Ikhwan and Budi Hermawan shows that the VAK model assisted by interactive media can enhance student engagement, as it aligns with the various learning styles possessed by each student (Nurhuda et al., 2021).

To effectively combine these benefits, this study proposes the VAK (Visual, Auditory, Kinesthetic) model, which facilitates multiple learning styles (seeing, hearing, and moving), further optimized by the use of the Baamboozle Game. This game-based media is specifically chosen for its capacity to immediately capture student attention, encourage team-based participation, and make the learning process enjoyable. While both VAK and game-based learning have been studied separately, the specific combination of the VAK model and the Baamboozle Game as an integrated strategy to target mathematical communication skills remains under-explored in current education research, particularly within the context of SMP Negeri 2 Sumpiuh. This research, therefore, offers an innovative contribution by examining the synergy of multi-sensory instruction (VAK) with high-engagement digital gaming (Baamboozle) to address the defined deficiency. The novelty of this study lies in providing empirical evidence for this combined approach as an effective solution for improving the mathematical communication skills of eighth-grade students.

Thus, this research aims to investigate the effect of the VAK (Visualization, Auditory, Kinesthetic) learning model assisted by the Baamboozle game on the mathematical communication of grade VIII students at SMP Negeri 2 Sumpiuh. Interactive and enjoyable learning is expected to create a more engaging learning environment.

B. Methods

This research used a quantitative method with an experimental design. The experimental design employed was a quasi-experiment using a pretest-posttest control group design.

Table 1. Research Design

Subject	Initial Test	Treatment	Final Test
Experimental Class	$X_{1(1)}$	A	$Y_{1(1)}$
Control Class	$X_{1(2)}$	B	$Y_{1(2)}$

Information:

X1(1) : Initial test for experimental class
X1(2) : Initial test for control class
Y1(1) : Final test for experimental class
Y1(2) : Final test for control class
A : Using the effect of VAK (Visualization, Auditory, Kinesthetic) learning model assisted by baamboozle game
B : Using conventional learning models

The research was conducted at SMP Negeri 2 Sumpiuh, located at Jl. Giritomo, Kebokura Village, Sumpiuh District, Banyumas Regency, Central Java Province, during the 2024/2025 academic year in the even semester. The population in this study includes all 8th-grade students at SMP Negeri 2 Sumpiuh, totaling 271 students. The research sample consists of two classes: the experimental class (VIII D) and the control class (VIII B), each with 34 students.

This research is based on the background that students' mathematical communication skills remain low, as evidenced by test results. Therefore, the researcher applies the VAK (Visualization, Auditory, Kinesthetic) learning model assisted by the interactive media platform Baamboozle Game to overcome this problem. This research uses a test as the instrument to measure the research variable. The test questions given must correspond to indicators of mathematical communication skills. There are two types of tests used: pretest (given before the treatment) and posttest (given after the treatment).

There are two stages in evaluating the research instrument: validity testing and reliability testing (Yudhanegara, 2018). The researcher tested the item validity by administering 6 mathematical communication test items (both pretest and posttest) to class IX H of SMP Negeri 2 Sumpiuh, comprising a total of 30 respondents. Based on a significance level of 5% and an $r_{tabel} = 0.361$ Three questions were found to be valid: items number 1, 4, and 6, for both the pretest and posttest.

Table 2. Pretest Item Validity Test Results

Number	r_{value}	r_{table}	Result
1.	0.543	0.361	Valid
2.	0.347	0.361	Not Valid
3.	0.317	0.361	Not Valid
4.	0.687	0.361	Valid
5.	0.331	0.361	Not Valid
6.	0.706	0.361	Valid

Table 3. Posttetest Item Validity Test Results

Number	r_{value}	r_{table}	Result
1.	0.675	0.361	Valid
2.	0.295	0.361	Not Valid
3.	0.193	0.361	Not Valid
4.	0.874	0.361	Valid
5.	0.360	0.361	Not Valid
6.	0.854	0.361	Valid

The results of the reliability test showed a Cronbach's Alpha of 0.699 for the pretest, indicating the test was reliable since $r_{xy} \geq r_{tabel}$ or $0.699 > 0.6$. Meanwhile, the posttest obtained a Cronbach's Alpha of 0.884, also indicating reliability as $0.884 > 0.6$.

Data analysis is the stage carried out after all data have been collected to address the research problem. Accuracy in using analytical tools significantly influences the validity of the conclusions. In this study, the researcher used the N-Gain test as the data analysis technique (Yudhanegara, 2018). This test aims to determine the effectiveness of the applied learning model. The N-Gain test is also used to identify significant differences in posttest scores between the experimental and control groups. Furthermore, prerequisite tests, the normality test and the homogeneity test, must be conducted before the t-test to determine whether significant differences exist and to ensure the sample used can represent the current population.

C. Results and Discussion

This research was conducted at SMP Negeri 2 Sumpiuh, in the even semester of the 2024/2025 academic year. The population of the study was all class VIII with a total of 271 students, and the research sample was carried out using the Simple Random Sampling technique. Class VIII D was obtained as an experimental class with a total of 34 students, and VIII B was a control class with a total of 34 students. With this, the experimental class treatment with the VAK (Visualization, Auditory, Kinesthetic) learning model assisted by the Baamboozle Game, and the control class will use a conventional or lecture learning model. This research was conducted in 4 meetings for each experimental class and control class. In the first meeting, the Pretest on mathematical communication skills was administered to the experimental class and control class.

1. Pretest and Posttest Data for Experimental Class

The Pretest was given to students before treatment. While the Posttest was given after treatment using the VAK (Visualization, Auditory, Kinesthetic) learning model, assisted by the Baamboozle Game on the material of relations and functions in class VIII, to measure mathematical communication skills. The data on the Pretest and Posttest scores of the Experimental Class are presented in the following table:

Table 4. Pretest and Posttest Results of Experimental Class

Result	Prettest Score	Posttest Score
Total	1244	2603
Avarage	36.588	76.55882
Lowest	22	43
Highest	64	100

2. Pretest and Posttest Data for Control Class

A pretest was given to students before treatment. The posttest was administered after treatment using conventional learning models or lectures on the material of relations and functions in class VIII to measure mathematical communication skills. The data on the Pretest and Posttest scores of the Control Class, which are presented in the form of a table as follows:

Table 5. Pretest and Posttest Results of Control Class

Result	Pretest Score	Posttest Score
Total	1168	1973
Avarage	34.35294	58.02941
Lowest	22	22
Highest	50	86

3. Results and Discussion of the N-Gain Test

The N-Gain Test is a test that uses data from the comparison of the difference between Posttest and Pretest scores and the difference between the ideal maximum score and Pretest. The N-Gain Test aims to determine the effectiveness of the learning model used.

Table 6. N-Gain Statistic Data Table for Experimental Class

Statistical Data of N-*Gain*	
Number of students	34
Mean N-*Gain*	0.649117647
Maximum N-*Gain*	1
Minimum N-*Gain*	0,27

Table 7. N-Gain Statistic Data Table for Control Class

Statistical Data of N-*Gain*	
Number of students	34
Mean N-*Gain*	0.649117647
Maximum N-*Gain*	1
Minimum N-*Gain*	0.27

Then, after obtaining the results of the N-Gain test, the experimental class was given treatment using the VAK (Visualization, Auditory, Kinesthetic) learning model, and the control class was given treatment using the conventional or lecture learning model, so it is necessary to interpret the effectiveness of the N-Gain value according to the predetermined categories. The following is a table of interpretation categories of the effectiveness of the N-Gain value (Supriadi, 2021):

Table 8. N-Gain Effectiveness Interpretation Category

Percentage	Interpretation
$0 < efektivitas \leq 40$	Not Effective
$40 < efektivitas \leq 55$	Less Effective
$55 < efektivitas \leq 75$	Quite Effective
$75 < efektivitas \leq 100$	Effective

Based on Table 8, the interpretation category of N-Gain effectiveness, the results of the Interpretation of the experimental class and control class are as follows:

Table 9. Interpretation of N-Gain Score Effectiveness

Class	Mean N-*Gain Score*	Precentage	Interpretation
Experiment Class	0.6491	64.9%	Less Effective
Control Class	0.3661	36.6%	Not Effective

Based on Table 9. The VAK (Visualization, Auditory, Kinesthetic) learning model, assisted by the Baamboozle Game, is considered to meet the interpretation criteria, with the interpretation of the effectiveness of the experimental class based on the average N-Gain score of 0.6491, and the percentage is 64.9%, so it is quite effective in improving students' mathematical communication skills. While the interpretation of the effectiveness of the control class with the conventional learning model, based on the average N-Gain score, is 0.3661, and the percentage is 36.6%, so it is not effective in improving students' mathematical communication skills.

4. Result And Discussion of Normality Test

The normality test was conducted to determine whether the research data from the experimental and control classes followed a normal distribution. In principle, the normality test aims to ensure whether the sample used in the study can represent the population and help researchers in choosing the right type of statistical analysis. In this study, the researcher used the N-Gain score from both sample classes as data to test its normality (Mubarak, 2021). This normality test was conducted using the SPSS version 23 program. According to Triton, data is considered normal if the probability value (Sig.) Is greater than 0.05 in the normality test using the Kolmogorov-Smirnov test (One Sample K-S). While for the hypothesis test, as follows:

H_0: The data are normally distributed
H_1: The data are not normally distributed
The conclusion is drawn as follows:
If the significance value (Sig.) ≤ 0.05, then H_0 is rejected and H_1 is accepted
If the significance value (Sig.) > 0.05, then H_0 is accepted and H_1 is rejected
The following are the results of the normality test:

Table 10. Normality Test Results

Tests of Normality

	Kelas	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Hasil	Kelas Eksperimen	.110	34	.200*	.969	34	.434
	Kelas Kontrol	.135	34	.123	.961	34	.266

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

… w that the expe …) > 0.05. Similarly, the normality test result of the control class also obtained a significance value $(Sig.) > 0.05$, namely $0.123 > 0.05$. Therefore, it can be concluded that H_0 is accepted and H_1 is rejected, which means that the data are normally distributed.

1. Result And Discussion of Homogeneity Test

The homogeneity test is conducted to determine whether the variances of two or more sample groups in the population are equal or homogeneous (Mubarak, 2021). The homogeneity test used is Levene's Test, conducted using SPSS version 23. The decision-making criteria for the homogeneity test are as follows: if the significance value is ≥ 0.05, then H_0 is rejected and H_1 is accepted. If the significance value is < 0.05, then H_0 is accepted and H_1 is rejected. The hypotheses for the test are as follows:

H_0: The data are not homogeneous
H_1: The data are homogeneous

Table 11. Homogeneity Test Results

Test of Homogeneity of Variance

		Levene Statistic	df1	df2	Sig.
Hasil	Based on Mean	7.668	1	66	.007
	Based on Median	6.057	1	66	.016
	Based on Median and with adjusted df	6.057	1	61.301	.017
	Based on trimmed mean	7.598	1	66	.008

Based on Table 11, the results of the homogeneity test using N-Gain scores showed a significance value of $0.007 < 0.05$, thus H_0 is accepted and H_1 is rejected. Therefore, based on the hypothesis test above, the variances of the two groups are not homogeneous. However, according to Field, the assumption of homogeneity of variance can be violated, and it is still appropriate or accurate to proceed with the t-test (Andy Field, 2013).

5. Results and Discussion of the t-Test

A t-test was conducted to measure the effect of using the VAK learning model assisted by the Baamboozle game in the experimental class, which implemented the model, compared to the control class that did not use it, in an effort to improve the mathematical communication skills of eighth-grade students. This was carried out to determine whether there is a significant difference between the average N-Gain scores of the experimental class and the control class.

The research hypothesis testing is as follows (Sahir, 2022):

H_0 : There is no significant difference in the average N-Gain scores between the experimental and control classes.

H_1 : There is a significant difference in the average N-Gain scores between the experimental and control classes.

The t-test was conducted by comparing the significance value $(sig.)$ with the alpha value of 5% or 0.05. If the significance value $(sig.) < 0.05$, then H_0 is rejected and H_1 is accepted. The results of the t-test are as follows:

Table 12. t-Test Results

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Hasil	Equal variances assumed	7.668	.007	5.451	66	.000	28.327	5.196	17.952	38.702
	Equal variances not assumed			5.451	58.543	.000	28.327	5.196	17.927	38.726

Based on Table 12, the results of the t-test using the N-Gain scores showed a significance value of $0.000 < 0.05$, thus H_0 is rejected and H_1 is accepted. It can be concluded that there is a difference in the average N-Gain scores between the experimental class and the control class. This is also supported by the results of the homogeneity test, which showed a significance value of 0.007, indicating that the variances are not homogeneous. Therefore, the results are referred to under Equal variances not assumed, where the $Sig.(2-tailed)$value is 0.000. Thus, it can be concluded that the VAK (Visualization, Auditory, Kinesthetic) learning model assisted by the Baamboozle Game has an effect on the mathematical communication skills of eighth-grade students at SMP Negeri 2 Sumpiuh.

D. Conclusion

Based on the research results, it was found that the VAK (Visualization, Auditory, Kinesthetic) learning model assisted by the Baamboozle Game had an effect on the mathematical communication skills of eighth-grade students. This is evidenced by the effectiveness of the learning model used, as indicated by the average N-Gain scores between the experimental and control classes. The experimental class obtained an average N-Gain score of 0.6491, which means the learning model used in the experimental class was quite effective. Meanwhile, the control class obtained an average N-Gain score of 0.3661, indicating that the learning model used was ineffective. Furthermore, based on the results of the t-test on the N-Gain scores between the two sample classes, a significance value of $0.000 < 0.05$ was obtained, thus H_0 is rejected and H_1 is accepted. It can be concluded that there is a significant difference in the average N-Gain scores between the experimental and control classes. Therefore, it can be inferred that the VAK learning model assisted by the Baamboozle Game has an effect on the mathematical communication skills of eighth-grade students at SMP Negeri 2 Sumpiuh.

This important study suggests that to actively encourage students' capacity to represent and explain mathematical concepts, math teachers should incorporate engaging and multisensory models, such as VAK, utilizing technology like the Bamboozle Game. For the application to be successful, teachers must consider the students' needs and ensure that they have grasped the material. Students are also expected to keep a positive and focused attitude and actively participate in the learning process in order to maximize their comprehension and communication skills.

E. Acknowledgement

I would like to express my deepest gratitude to all parties who have supported the completion of this thesis. My sincere thanks go to the Rector, Deans, and Vice Deans of the Faculty of Tarbiyah and Teacher Training, as well as the Head and Head of the Mathematics Education Study Program at UIN Prof. K.H. Saifuddin Zuhri Purwokerto. I also thank all lecturers and academic staff, especially my supervisor, Fitria Zana Kumala, S.Si., M.Sc., for her guidance and support. Appreciation is extended to the principal, teachers, and staff of SMP Negeri 2 Sumpiuh, especially Mr. Romeli, A.Md. Pd., for assisting in the research process. Special thanks to my beloved parents, Sugiono and Paikemawati, my sister Nindy Zevita Laviana and nephew Alzam Khairi Adi, my dearest friends Frisca, Rista, Miyana, and Dea, and my college friends Dwi, Evi, Nina, Alfi, Uli, the 2021 TMA C class, and all who have supported me. Lastly, I thank myself for staying strong and completing this journey despite all the challenges.

References

Andy Field. (2013). *Discovering Statistics Using IBM SPSS Statistics* (M. Carmichael (ed.); 4th ed.). SAGE Publications.

Ariani, D. N. (2017). Strategi Peningkatan Kemampuan Komunikasi Matematis Siswa. *Muallimuna Jurnal Madrasah Ibtidaiyah*, *3*(1), 96–107. https://doi.org/http://dx.doi.org/10.31602/muallimuna.v3i1.958

Hendriana, E. E. dan H. (2021). *Hard Skill dan Soft Skill Matematik Siswa* (R. Aditama (ed.)).

Khaq, Astafil, and Maghfira Febriana. "The Effect of Think Pair Share Learning

Model with the Help of Geogebra Software on Students' Mathematical

Communication Skills." International Journal of Research in Mathematics

Education 1, no. 2 (2023): 151‑62. https://doi.org/10.24090/ijrme.v1i2.9265.

Maulyda, M. A. (2020). Paradigma Pembelajaran Matematika NCTM. In cakti indra Gunawa (Ed.), *Paradigma Pembelajaran*. CV IRDH.

Mubarak, Z. (2021). *Penelitian Kuantitatif dan Statistika Pendididikan* (Kedua). Pustaka Turats Press.

Narotama. (2020). *Tujuan Pendidikan Nasional Menurut Undang-Undang, Mencerdaskan Kehidupan Bangsa*. Nariotama.Ac.Id. https://narotama.ac.id/berita/detail/27599-tujuan-pendidikan-nasional-menurut-undang-undang,-mencerdaskan-kehidupan-bangsa

Nurhuda, N. I., Hendrawan, B., & Sunanih. (2021). Pengaruh Model Pembelajaran Visual, Auditori Dan Kinestetik (VAK) Berbantuan Media Jam Sudut Terhadap Prestasi Belajar Siswa. *Buana Pendidikan: Jurnal Fakultas Keguruan Dan Ilmu Pendidikan*, *17*(1), 14–20. https://doi.org/https://doi.org/10.36456/bp.vol17.no1.a3086

Sahir, S. H. (2022). *Metodelogi Penelitian* (T. Koryati (ed.); 1st ed.). Penerbit KBM Indonesia.

Sari, T., & Putri, J. H. (2024). Pembelajaran Matematika sebagai Wadah Meningkatkan Kualitas Proses Belajar Siswa. *OMEGA: Jurnal Keilmuan Pendidikan Matematika*, *3*(2), 73–79. https://doi.org/https://doi.org/10.47662/jkpm.v3i2.686

Siti Marwah, S., & Nurul Ain, Z. (2022). Jurnal PGMI UNIGA (JPU) Studi Literatur: Baamboozel Sebagai Media Pembelajaaran Yang Interaktif. *Junal PGMI UNIGA (JPU)*, *1*(2), 69–75. https://journal.uniga.ac.id/index.php/pgmi/article/view/41607

Supriadi, G. (2021). *Statistik Penelitian Pendidikan* (A. Y. Ngadimin (ed.); 1st ed., Vol. 10, Issue 2). UNY PRESS.

Yudhanegara, K. E. L. dan M. R. (2018). *Penelitian Pendidikan Matematika* (Anna (ed.)). Refika Aditama.

This page has been intentionally left blank.

International Journal of Research in Mathematics Education
Vol. 3 No. 2, December 2025, 145-156
Universitas Islam Negeri Prof. K.H. Saifuddin Zuhri Purwokerto
e-ISSN: 3025-7638, p-ISSN: 3025-1842

The Effect of The Two Stay Two Stray Learning Model Assisted by The Wizer.Me Application on The Problem-Solving Ability of Grade XI Students

Triyas Sayekti[1]✉; Aura Nawamadani Amrah[2]

[1]Universitas Islam Negeri Profesor Kiai Haji Saifuddin Zuhri Purwokerto, Indonesia
[2]Ankara University Türkiye, Turkey

✉ *Corresponding email:* triyasayekti@gmail.com

Received April 22, 2025
Accepted November 18, 2025
Published December 31, 2025

https://doi.org/10.24090/ijrme.v3i2.13528

Abstract: This study aims to determine the effect of the Two Stay Two Stray (TSTS) learning model, assisted by the Wizer.me application, on the mathematical problem-solving abilities of class XI students at a vocational school in Banyumas Regency. This study was motivated by the low ability of students in solving mathematical problem-solving problems. This study employed a quantitative approach with a quasi-experimental design, specifically the Nonequivalent Control Group Design type. The subjects of the study consisted of two classes: the experimental class, which used the TSTS model assisted by Wizer.me, and the control class, which used conventional learning methods. Each class consisted of 25 students. The instruments used in this study were pretest and posttest essay tests arranged based on problem-solving indicators according to Polya. Data analysis techniques included normality, homogeneity, t-test, and N-Gain tests. The results of the t-test showed a significant difference between the posttest scores of the experimental class and the control class, with a significance value of $0.000 < 0.05$. In addition, the average value of N-Gain in the experimental class was higher than that of the control class. These results indicate that the TSTS learning model assisted by the Wizer.me application positively affected students' mathematical problem-solving abilities.

Keywords: problem solving; two stay two stray; wizer.me; mathematics

A. Introduction

Mathematics is a basic subject that forms students' logical thinking and problem-solving skills. According to the National Council of Teachers of Mathematics (NCTM, 2000; Novikasari, 2022), one of the main objectives of mathematics learning is to develop mathematical problem-solving skills. This ability not only prepares students to tackle mathematical problems but also equips them to address real-life situations that require analytical and strategic thinking (Polya, 2014). However, in various educational institutions, students still face difficulties in achieving optimal performance in problem-solving. This difficulty is caused by various factors, including a lack of understanding of mathematical concepts, passive learning models, and limitations in addressing contextual problems (Amalina & Vidákovich, 2023). The learning environment in Vocational High Schools (SMK) in Indonesia often still emphasizes memorization rather than problem solving (Qotrunada & Furqon, 2024). Based on initial observations and interviews with mathematics teachers at a vocational school in Banyumas Regency, it is evident that students often struggle to understand mathematical story problems, select the appropriate solution strategy, and verify their answers. This is exacerbated by the use of conventional learning methods that tend to be teacher-centered. As a result, students tend to be passive recipients of information and often fail to connect mathematical theory with its practical applications (Ang et al., 2021). This condition highlights the disparity between the objectives of mathematics education and the realities encountered in the field. In the independent curriculum, learning is directed at developing critical thinking and problem-solving competencies. However, its implementation has not been fully effective, especially at the vocational high school level, which is oriented towards vocational skills. One-way learning restricts students' ability to explore ideas, discuss, and test their hypotheses independently. This leads students to rely solely on memorization and minimal cognitive engagement in the learning process (Dantas & Cunha, 2020).

To address these issues, a learning approach is needed that fosters independent learning and encourages constructive social interaction among students. One alternative is the application of the Two Stay Two Stray (TSTS) cooperative learning model. This model , offering students the chance to engage in meaningful discussions, exchange ideas, and foster a deeper understanding. According to Irfanto et al. (2019), TSTS not only encourages cooperation and individual responsibility but also trains communication and critical thinking skills.

The integration of the TSTS model with digital learning media, such as Wizer.me, can be an innovative solution for presenting interesting and meaningful learning. Wizer.me is a web-based platform that enables teachers to create interactive worksheets with various question types and multimedia content. Through this interactive feature, students can access materials flexibly, get direct feedback, and explore mathematical concepts in a more applicable context (Kaliappen et al., 2021). Technological support in learning enables the creation of an adaptive and participatory learning environment, in line with the principles of 21st-century learning.

Several previous studies have particularly in enhancing learning outcomes in science and language subjects. Research by Idyawati et al. (2022) revealed that the use of Wizer.me can significantly increase students' interest in learning and understanding of concepts. However, research specifically examining the effect of TSTS and Wizer.me integration on mathematical problem-solving abilities remains very limited, especially at the vocational high school level.

Based on this background, this study aims to fill the research gap by empirically examining the effect of the Two Stay Two Stray learning model assisted by the Wizer.me application on students' mathematical problem-solving abilities at at vocational school in Banyumas Regency. This research is expected to contribute to the development of innovative, context-based, and technology-driven learning models that enhance the quality of mathematics learning at the vocational high school level.

This study also aims to strengthen the argument that collaborative learning supported by digital technology can be a strategic alternative in facing the challenges of 21st-century education. In addition, through this research, teachers are expected to gain new insights in designing learning that is more participatory and responsive to student needs. The results of this study can serve as a basis for policy-making in developing learning methods that are tailored to the characteristics of vocational school students, particularly in enhancing their mathematical problem-solving abilities.

In line with these objectives, this study focuses on two main things, namely: (1) testing whether there is a difference in mathematical problem-solving abilities between students who learn using the Two Stay Two Stray model assisted by Wizer.me and students who learn using conventional learning models; and (2) analyzing whether the use of the Two Stay Two Stray model assisted by Wizer.me has a significant positive influence on improving students' mathematical problem-solving abilities. This formulation serves as the basis for conducting empirical research to evaluate the effectiveness of a learning model integrated with digital technology.

B. Methods

employed an experimental research method with a quantitative approach. Quantitative research is research that presents data in numerical form, where the type of data can be directly measured or calculated statistically. The research employed a pretest-posttest control group design. The research was conducted at a vocational school in Banyumas Regency in October 2023. The population in this study consisted of 106 students from class XI. The sampling technique employed was purposive sampling, and two classes were selected: Class XI RPL as the experimental class and Class XI MM as the control class, each comprising 25 students.

The independent variable in this study is the Two Stay Two Stray (TSTS) learning model assisted by the Wizer.me application, while the dependent variable is students' mathematical problem-solving ability. Data collection methods included tests (pretest and posttest) and documentation. The test instruments used were essay questions constructed based on indicators of mathematical problem-solving ability. Problem-solving indicators included understanding the problem, devising a plan, carrying out the plan, and looking back (Novikasari, 2022). The instruments were validated by expert judgment to ensure both content and construct validity. Additionally, the instruments were tested for validity using Pearson Product-Moment correlation and for reliability using Cronbach's Alpha to ensure the consistency of student responses. To analyze the data, prerequisite tests were conducted, including normality and homogeneity tests. mathematical problem-solving abilities between the two groups. Furthermore, the N-Gain test was used to measure the effectiveness of the TSTS model, which was assisted by Wizer.me. The N-Gain interpretation was based on the following criteria:

Table 1 The N-Gain interpretation

Percentage (%)	Interpretation
≤ 40%	Ineffective
41% - 55%	Less Effective
56% - 75%	Effective Enough
≥ 76%	Effective

In accordance with the results derived from the t-test, utilizing a significance threshold of 5% ($\alpha = 0.05$), the established decision rule is as follows: Should the significance value be greater than or equal to 0.05, the null hypothesis (H_0) is upheld while the alternative hypothesis (H_1) is dismissed; conversely, if the significance value is less than 0.05, the null hypothesis (H_0) is dismissed and the alternative hypothesis (H_1) is upheld. This methodological framework enables researchers to draw substantiated conclusions about their hypotheses, based on the statistical evidence obtained from their data analysis.

C. Results and Discussion

1. Result

a. Validity Test

In this study, the validity of the research instruments was tested using construct validity and content validity. Construct validity was employed to assess whether the instrument was grounded in relevant concepts and theories within mathematics education. This validity was assessed through expert judgment by a mathematics education lecturer, IFN, who evaluated the instrument and declared it appropriate after several improvements were made. Meanwhile, content validity was established by consulting UFL, a mathematics teacher at a vocational school in Banyumas Regency. She reviewed the instrument to ensure its alignment with the curriculum and confirmed that it was appropriate for the subject matter taught in class XI.

In addition to expert validation, the researcher also conducted statistical validity tests for both the pre-test and post-test instruments related to students' mathematical problem-solving abilities. These tests involved analyzing students' responses using SPSS version 23 and Microsoft Excel, with a total of 25 respondents in the experimental class.

The results of the validity test for the pre-test instrument are as follows:

Table 2 Validity test for the pre-test instrument

No	r-count	r-table	Information	Validity Interpretation
1	0.505	0.431	Valid	Good Enough
2	0.498	0.431	Valid	Good Enough
3	0.496	0.431	Valid	Good Enough
4	0.620	0.431	Valid	Good Enough

The post-test instrument validity results are shown below:

Table 3 Post-test instrument validity results

No	r-count	r-table	Information	Validity Interpretation
1	0,657	0,431	Valid	Good Enough
2	0,543	0,431	Valid	Good Enough
3	0.553	0,431	Valid	Good Enough
4	0,540	0,431	Valid	Good Enough

Based on the tables above, it can be concluded that for both the pre-test and post-test, four out of five items were declared valid, specifically items 1, 2, 3, and 4. Therefore, only the valid items were used in the subsequent data analysis in this study.

b. Reliability Test

After conducting the validity test, the researcher continued with the reliability test of the research instrument. This was carried out using SPSS version 22. Below is a reliability test table for the pre-test questions:

Table 4 Reliability test for the pre-test

Reliability Statistics	
Cronbach's Alpha	N of Items
.652	4

Based on table 4, it is stated that the Cronbach alpha value is 0.652 > 0.60. Since the Cronbach's Alpha value was greater than 0.60, the data were considered reliable.

Table 5 Reliability test for the pos-test

Reliability Statistics	
Cronbach's Alpha	N of Items
.690	4

Based on Table 5, it is stated that the Cronbach Alpha value is 0.690 > 0.60. Therefore, a Cronbach's Alpha value greater than 0.60 indicates that the data is considered reliable.

c. Normality Test

The normality test was conducted to determine whether the data were normally distributed or not. This test employed the Kolmogorov-Smirnov method with a significance criterion of $p < 0.05$.

		Kolmogorov-Smirnov			Shapiro-Wilk		
	Kelas	Statistic	Df	Sig.	Statistic	Df	Sig.
Hasil	Pretest (Eksperimen)	.156	25	.119	.931	25	.094
	Pretest (Kontrol)	.159	25	.103	.940	25	.151

Postest (Eksperimen)	.141	25	.200*	.953	25	.298
Postest (Kontrol)	.125	25	.200*	.969	25	.630

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 6 Test of Normality

Based on Table 14 in the normality test with the Kolmogorov-Smirnov test, it can be seen that the data are normally distributed, with a probability value (Sig) greater than alpha, for both the experimental class and the control class. The sig value of the pretest experimental class is 0.119>0.05, while in the control class, the sig value is 0.103>0.05. The sig value of the post-test experimental class is 0.200>0.05, and the sig value in the control class is 0.200>0.05. So it can be concluded that the values of the experimental and control classes are normally distributed.

d. Homogeneity Test

The homogeneity test aimed to determine whether the populations of the experimental and control classes were homogeneous. The Levene test was used with a significance criterion of ≥ 0.05.

Table 7 Test Of Homogeneity

		Levene Statistic	df1	df2	Sig.
Hasil	Based on Mean	.083	1	48	.774
	Based on Median	.076	1	48	.783
	Based on Median and with adjusted df	.076	1	47.807	.783
	Based on the trimmed mean	.079	1	48	.779

Since the significance value is 0,774 > 0,05, it can be concluded that the data comes from populations with homogeneous variance.

e. N-Gain Test

The N-Gain test was conducted to determine the effect of the Two Stay Two Stray learning model assisted by the wizer.me application on problem-solving abilities in the control and experimental classes. The presentation uses normalized N-Gain

f. N-Gain Test of Experimental Class

Table 8 Distribution of N-Gain Values of Control Class

No.	Gain Index	Categori	Frequency	Percentage
1	N-Gain≥0,70	High	16	64%
2	0,30<N-Gain<0,70	Medium	9	36%
3	N-Gain≤0,30	Low	0	0%
	Total		25	100%

From Table 8, it can be seen that out of 25 students, 16 students (64%) had high category N-Gain scores, 9 students (36%) had medium category N-Gain scores, and 0 students (0%) had low category N-Gain scores.

Table 9 Descriptive Statics

	N	Minimum	Maximum	Mean	Std. Deviation
Presentase N-Gain Score	25	51	93	75.29	11.086
Valid N (listwise)	25				

Based on Table 9, it can be seen that the average value of N-Gain in the experimental class is 75.29, so it is seen in its interpretation as effective. There is a significant increase in problem-solving ability with the Two Stay Two Stray learning model, assisted by the wizer.me application.

g. Control Class

Table 10 Distribution of N-Gain Values of Control Class

No.	Gain Index	Categori	Frequency	Percentage
1	Ngain≥0,70	High	4	16%
2	0,30<N-Gain<0,70	Medium	14	56%
3	N-Gain≤0,30	Low	7	28%
	Total		31	100%

From Table 10 it can be seen that out of 25 students, 4 students (16%) had high category N-Gain scores, 14 students (56%) had medium category N-Gain scores, and 7 students (28%) had low category N-Gain scores.

Table 11 Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Percentage N-Gain Score	25	28	83	53.24	16.584

Valid N (listwise)	25

Based on Table 11, it can be seen that the average value of N-Gain for the control class is 53.24, so it can be seen from the interpretation that it is less effective.

h. T Test

The t-test was used to determine whether there was a significant difference in the average mathematical problem-solving ability of class XI students between the class that was taught using the Two Stay Two Stray (TSTS) cooperative learning model assisted by the Wizer.me application and the class that was not. This test used a two independent t-test. The criterion for the t-test is that if the probability value (Sig.) ≤ 0.05, then there is a significant difference in the average scores. The following table shows the t-test results using SPSS version 22.

Table 12 Independent Sample Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Nilai	Equal variances assumed	.083	.774	5.651	48	.000	11.240	1.989	7.240	15.240
	Equal variances not assumed			5.651	47.890	.000	11.240	1.989	7.240	15.240

Based on the results of the t-test, the Sig. (2-tailed) value is $0.000 < 0.05$, which means H_0 is rejected and H_1 is accepted. This indicates that the average mathematical problem-solving ability of students taught using the TSTS model assisted by Wizer.me is significantly different from those taught without it.

2. Discussion

Based on the empirical findings, the mean pretest score for the experimental cohort was 36.4, with a range of 20 to 55. In juxtaposition, the control cohort exhibited a mean score of 35.16, characterized by a maximum score of 60 and a minimum score of 20. Consequently, the outcomes derived from the experimental and control cohorts disclosed a marginal disparity. Therefore, the problem-solving competencies exhibited by both cohorts appear to be relatively congruent. Following the pretest, both the experimental and control cohorts received an intervention. The experimental cohort was instructed to use the Two Stay Two Stray pedagogical model, integrated with the wizer.me application, whereas the control cohort was engaged in a traditional instructional model. Both methodologies were designed to evaluate problem-solving skills, which were subsequently analyzed to ascertain which approach exerted a more pronounced effect on mathematical problem-solving capabilities. To appraise the ramifications of the intervention, a post-test was administered. The results from the post-test of the experimental cohort indicated a mean score of 84.44, with the highest score reaching 95 and the lowest at 90. The control chart, on the other hand, achieved a mean score of 73.2, with the highest score being 90 and the lowest score being 65. The findings denote a significant distinction in the post-test outcomes. This assertion is corroborated by the prerequisite assessments, which encompass the normality test and the homogeneity test.

The normality assessment determines whether the data adhere to a normal distribution using the Kolmogorov-Smirnov method, revealing that the data conform to a normal distribution with a probability value (P-Value) exceeding the alpha level for both the experimental and control cohorts. The pretest significance value for the experimental cohort is 0.119, which is greater than 0.05. In contrast, the control cohort exhibits a significance value of 0.103, which is also greater than 0.05. The post-test significance value for the experimental cohort is 0.200 > 0.05, and the control cohort similarly presents a significance value of 0.200 > 0.05. The homogeneity test outcomes indicate significance at 0.774> 0.05. Thus, it can be inferred that the post-test data for both the experimental and control cohorts are homogeneously distributed. While the N-Gain and t-test outcomes suggest that the Two Stay Two Stray pedagogical model, augmented by the wizer.me application, demonstrates enhanced efficacy relative to traditional learning methods, it is pertinent to acknowledge certain counterarguments. Firstly, the mean score of the experimental cohort stands at 75.29, and while this may suggest effectiveness, it may not adequately represent the diverse learning styles and requirements of all students. A uniform approach, even when supplemented by technology, risks overlooking individual variances, which can potentially lead to disengagement among certain learners.

Moreover, the interpretation that the control cohort's mean of 53.24 is "less effective" does not inherently capture the quality of the learning experience. Traditional pedagogical methods may cultivate problem-solving abilities in ways that are not easily quantified solely through N-Gain scores. The reliance on statistical significance, exemplified by a t-test result of 0.000, may prove misleading; it does not necessarily reflect the practical significance of the findings within authentic classroom environments.

Furthermore, the integration of technological tools within educational frameworks should not eclipse the fundamental principles governing teaching and learning (Bećirović, 2023). An excessive focus on digital resources may result in a superficial understanding of core concepts, as students may prioritize technology over the subject matter itself. Additionally, the presumption that technology inherently enhances student engagement may not be universally applicable, particularly for students who perceive technology as distracting or overwhelming.

Lastly, the conclusions derived from the study may not be universally applicable across diverse educational contexts or subject areas. The effectiveness of a particular learning model may fluctuate significantly based on variables such as class size, subject matter, and the unique dynamics of the instructional environment (Moser & Zumbach, 2018). Hence, while the findings warrant attention, they should be approached with prudence and a critical perspective, acknowledging the multifaceted nature of educational efficacy that transcends mere statistical results. It is essential for educators and policymakers to consider these nuances when implementing technology in classrooms, ensuring that strategies are tailored to meet the diverse needs of all learners. This tailored approach not only enhances the learning experience but also promotes equity, allowing each student to thrive in an environment that recognizes their individual strengths and challenges.

D. Conclusion

Based on the research that has been carried out, it can be concluded that he influence of learning using the Two Stay Two Stray learning model assisted by the wizer.me application on students' problem-solving abilities at a vocational school in Banyumas Regency. From the results of the t-test showing a sig. (2-tailed) A value of 0.000 < 0.05 indicates that the null hypothesis is rejected and the alternative hypothesis is accepted. Therefore, there is a statistically significant difference in the average value of problem-solving abilities after treatment. The experimental class utilizes learning through the Two Stay Two Stray learning model, assisted by the wizer.me application, while the control class employs conventional learning methods, including lectures. It can be concluded that learning using the Two Stay Two Stray learning model assisted by the wizer.me application in the experimental class is more effective than conventional learning with the lecture method in the control class. The N-Gain results show that the experimental class achieved an average value of 75.29, indicating its effectiveness, as seen in the interpretation table. For the class of 53.24, it is evident from the interpretation that it is less effective. So in this study, there is an influence of the Two Stay Two Stray learning model assisted by the wizer.me application on students' problem-solving abilities. These findings suggest that incorporating interactive and collaborative learning strategies, such as the Two Stay Two Stray model, can significantly enhance students' engagement and understanding, leading to improved academic performance in problem-solving tasks.

References

Amalina IK, Vidákovich T. (2023). Cognitive and socioeconomic factors that influence the mathematical problem-solving skills of students. *Heliyon*, 9(9). https://doi.org/10.1016/j.heliyon.2023.e19539.

Afinda, D. A. N. (2023). The effect of Student Team Achievement Divisions model assisted with GeoGebra media on understanding of mathematical concepts of circle materials in class VIII students of SMP. *International Journal of Research in Mathematics Education*, 1(1), 23–34.

Ang, Karyne C.S., Afzal, F., & Crawford, L. H. (2021). Transitioning from passive to active learning: Preparing future project leaders. *Project Leadership and Society*, 2. https://doi.org/10.1016/j.plas.2021.100016.

Bećirović, S. (2023). Challenges and Barriers for Effective Integration of Technologies into Teaching and Learning. In: *Digital Pedagogy*. SpringerBriefs in Education. Springer, Singapore. https://doi.org/10.1007/978-981-99-0444-0_10.

Dantas, L. A., & Cunha., A. (2020). An integrative debate on learning styles and the learning process. *Social Sciences & Humanities Open*, 2(1). https://doi.org/10.1016/j.ssaho.2020.100017.

Idyawati, I., Nurdin, dan Nasir. (2022). Efektivitas Penggunaan Media Interaktif Wizer.Me Terhadap Mata Pelajaran IPA Pada Siswa Kelas XI SMA. *Jurnal Pendidikan dan Pembelajaran*, 2(2), 105–18. https://doi.org/10.62388/jpdp.v2i2.170.

Irfanto, W., Y., Mustaji, M., & Jacky, M. (2019). The Effect of Cooperative Learning Model Type Two Stay Two Stray and Learning Style on Social Sciences Learning Outcomes of Grade IV Elementary School Students. *International Journal for Educational and Vocational Studies*, 1 (3), 212-216.

Kaliappen, N., Ismail, W., Ghani, A., & Sulisworo, D. (2021). Wizer.Me and Socrative as Innovative Teaching Method Tools: Integrating TPACK and Social Learning Theory." *International Journal of Evaluation and Research in Education (IJERE)*, 10(3). https://doi.org/10.11591/ijere.v10i3.21744.

Millati, H. A. (2023). Influence of Quizizz Application as Quantum Learning Model Toward the Concept of Understanding Mathematics Ability. *International Journal of Research in Mathematics Education*, 1(1), 35–42.

Moser, S., & Zumbach, J. (2018). Exploring the development and impact of learning styles: An empirical investigation based on explicit and implicit measures. Computers & Education, 125. https://doi.org/10.1016/j.compedu.2018.05.003.

NCTM. (2000). *Principles and standards for school mathematics*. Reston, VA: NCTM.

Novikasari, I. (2022). *Ketrampilan Berfikir Matematika*. Purwokerto: Saizu Publisher.

Polya, G. (2014). *How to solve it*. Princeton University Press.

Qotrunada, A., & Furqon, S. (2024). Development of Interactive Game-Based Learning Media Using Realistic Approach to Improve Students' Mathematical Problem-Solvingin Social Arithmetic Materials for Grade VII. *International Journal of Research in Mathematics Education*, *2*(1), 79–104. https://doi.org/10.24090/ijrme.v2i1.11466

This page has been intentionally left blank.

International Journal of Research in Mathematics Education
Vol. 3 No. 2, December 2025, 191-202
Universitas Islam Negeri Prof. K.H. Saifuddin Zuhri Purwokerto
e-ISSN: 3025-7638, p-ISSN: 3025-1842

Examining Ordinary Level Secondary Students' Connections Between Classroom-Learned Mathematics with Their Real-Life Experiences

Emmanuel Deogratias[1]✉; Majura Hezron[1]; Thabita Lupeja[1]

[1]Sokoine University of Agriculture, United Republic of Tanzania

✉ *Corresponding email:* emmanuel.mbita@sua.ac.tz

Received September 9, 2025
Accepted November 19, 2025
Published December 31, 2025

https://doi.org/10.24090/ijrme.v3i2.15203

Abstract: Mathematics is termed as a difficult subject by most of the students in secondary schools, and the majority of them perform poorly in their final examinations. This study investigated the extent to which ordinary level secondary students in Tanzania secondary schools connect classroom learned mathematics knowledge with their actual living experiences. The study was constructed in the lens of the pragmatist approach to learning, which highlights that in education, students should be taught things that are practical to the real world and useful in their daily living environment. In this study, 220 ordinary-level secondary students were randomly selected as the study sample. Questionnaires were used in data collection. The collected data were analysed through descriptive statistics using statistical graphs and percentages. The study revealed that secondary students in Tanzania rarely connect classroom learned mathematics knowledge with their actual living experiences, and most of them failed to explain precisely how learned mathematical topics/knowledge are helpful in their day-to-day living experiences. The study recommends that classroom learned mathematics should be authentic to students' real-life experiences.

Keywords: classroom learned mathematics knowledge; real-life experiences; students in secondary schools

A. Introduction

Education in Tanzania is run under the Ministry of Education, Science, and Technology in collaboration with the President's Office, Regional Administration, and Local Government. The education structure of the country comprises two years of Pre-primary schools, seven years of Primary schools, four years of Ordinary level secondary schools, two years of Advanced level secondary schools, plus colleges and university levels of education (Mazana et al., 2020). Tanzania conducts formative assessment at institutional levels while summative assessments is done centrally by the National Examination Council of Tanzania (NECTA), which supervise Standard Four National Assessment (SFNA), Primary schools Leaving Examination (PSLE), Form Two National Assessment (FTNA), Certificate of Secondary Education Examination (CSEE) and Advanced Certificate of Secondary Education Examination (ACSEE). In all lower levels of education in Tanzania, mathematics is a compulsory subject, taught from primary school to ordinary level secondary school.

Even though mathematics is a foundation of all science subjects as well as part and parcel of human life, many students in Tanzania face difficulties in learning this subject and most of them perform poorly in their final examinations. Putting into consideration that mathematics is an obligatory subject in ordinary-level secondary schools in Tanzania, the results in NECTA examinations show that the performance in mathematics is always low for many years. For example, the percentages of students passing mathematics in the consecutive five years were as follows: 2018 (21%), 2019 (22%), 2020 (20%), and 2021 (19%) for CSEE examinations (NECTA, 2018, 2019, 2020, 2021). Again in 2022, about 79% of students got F (failed) in mathematics in their Certificate of Secondary Education Examination (NECTA, 2023). Worse enough in FTNA 2022, about 83% more than 528344 candidates out of 636560 in Form TWO National Assessment got F/ Failed in Mathematics (NECTA, 2023). Despite various approaches and studies, mass failure in mathematics remains a national disaster. His study investigated the extent to which ordinary-level secondary students in Tanzania connect classroom-learned mathematics knowledge with their actual living experiences.

During the teaching and learning process, it is essential for learners to connect classroom-learned mathematics knowledge with their real-life experiences (Laurens et al., 2018). Authentic mathematics teaching and learning are significant to students (Gravemeijer et al. 2017) and should prepare them to apply mathematical skills in all categories of work and in everyday situations. According to Arthur et al. (2018) connections between classroom-learned mathematics with the real-life experience of the learner are important since it help the learner to establish meaningful associations between what is learned in class his/her daily life practices. For mathematics to be useful and interesting, learners should be able to apply mathematical skills in real-world contexts (Vos, 2018).

Connecting classroom-learned mathematics with students' daily life experiences plays a crucial role in enhancing their mathematical skills and overall development in their learning process. The ability of students to connect classroom learning mathematics with their actual living practices helps to enhance understanding and retention of mathematical skills (Laurens et al., 2018). Speaking on the same subject, Burkhardt et al. (2024) insist that students are more likely to remember and retain mathematical concepts when they see their practical application in their daily life activities. Applying mathematical concepts to real-life situations makes mathematical ideas more tangible and easier to understand. Again, effective connections between what students learn in the class and their actual living experiences increase engagement and interest in the subject (Gravemeijer et al., 2017). When students see the relevance of mathematics in their actual life experiences, they are more motivated to learn and engage with the subject. Real-life application of classroom learned mathematics to students' lives sparks curiosity and encourages students to explore mathematical concepts to the maximum.

In a typical teaching and learning environment, students should be able to connect the mathematical knowledge they have learned in the classroom with their real-life experiences. Effective mathematics teaching and learning should help students to connect mathematics knowledge learned in the classroom with their actual living experiences (Baki & Çakiroğlu, 2010). To connect classroom learned mathematics knowledge in real-life does not merely mean application of mathematics to tell time or to purchase goods, rather it should go deep into knowing the actual meaning of different mathematical concepts such as quadratic expressions, radical or other mathematical related concepts they learn at school in their normal living involvements (Arthur et al., 2018). In addition to these narrations, Aronson & Laughter (2016) note that classroom learned mathematical knowledge is meaningful if students can see the utility of the learned contents in their actual living experiences.

Although the importance of connecting classroom learned mathematical knowledge to learners' real-life experiences is emphasized in the curriculum of Tanzania and in the teaching theories such as Realistic of Mathematics Education (RME) (Laurens et al., 2018), researchers show that most students in ordinary level secondary schools perceive mathematics as a difficult subject (Mazana et al., 2018). RME aims at changing mathematics learning into a fun (Laurens et al., 2018) and meaningful experience for students by introducing them to problems in contexts. In Realistic of Mathematics Education, mathematical contents and contexts (Do et al., 2021) are related to learners' daily life activities. RME addresses problems of abstract mathematics learning and has helped most of the countries performing better in mathematics, such as the USA, the Netherlands, Singapore, and Vietnam (Laurens et al., 2018). For students to increase their masterly capacity and performance in mathematics, they should be able to mathematise classroom learned contents into real world connections.

According to the pragmatist approach, learning becomes interesting to students when what they learn reflects their real-world practices (Axtelle, 1968). This means that in mathematics, students should be able to integrate what they have learned in the classroom with their actual living experiences. Failures of students to connect classroom learning mathematics with their actual living experiences make them not interested in the subject and face a lot of difficulties in understanding and mastering that subject (Ojose, 2011). Again, inabilities of students to connect classroom learning mathematics knowledge to their actual living familiarities make them suffer from mathematics phobia (Kunwar, 2020). This study investigated the connections between classroom learned mathematics with students real life experiences, putting into consideration that despite of many studies which have been done articulating factors leading to poor mathematics performance (Micheal, 2015), students attitudes towards mathematics (Mazana et al., 2018) as well as trends of mathematics performance (Mazana et al., 2020), still majority of students are performing poor in mathematics in their final examinations. The findings of this study may help to pave the way in finding the solutions to massive failures in mathematics experienced in ordinary level secondary schools in Tanzania for many years.

This study is guided by the pragmatist theory and the approach of learning in education. According to pragmatism approach, factual education should bear a social function (Axtelle, 1968). This means that, the certainty of an idea/education practice deceits in its observable real-world consequences. The pragmatic approach stipulates that in education, students should be taught things that are practical for their lives and applicable to the real world (Rai & Lama, 2020). Hence, classroom learned mathematics knowledge should bear a social function in students' day-to-day activities. Pragmatism theory helped much in guiding this study by opening the quantitative method of data gathering as well as overseeing the applicability of classroom learned mathematics to students' real-life experiences (Axtelle, 1968).

B. Methods

To enhance data gathering, the study used both closed and open-ended questions provided to respondents to gather their feedback on how they relate/connect classroom learned mathematics with their actual living environment. Questionnaire items involving themes connecting mathematics to students' real-life experiences, such as how they connect what they learn in the class with their day-to-day activities, were submitted to students to fill out their responses was selected since the study involved large number of respondents, about 220 students thus making the method suitable to cover the all sample accordingly (Stadtländer, 2009). Again, the method was chosen since all respondents of the study were able to read the questions and write their responses themselves without the assistance of another person (Gates, 2008). To ensure the validity and reliability of the collected information, the prepared questionnaire items were sent to research experts and supervisors for review. The researcher also did a trial test (piloting) to test the correctness of the questionnaires before the overall process of data collection. Piloting test helped to figure out some language difficulties and other misconceptions observed, hence reading one question after another and giving clarifications where necessary to allow students to fill the questions correctly and avoid skipping some questions.

To smooth the process of filling the questionnaire items, which were constructed in the English language, while most of the respondents are fluent in the Swahili language, the researcher interpreted the questions to the respondents and provided clarifications where necessary to ensure the correctness of the gathered information. The collected feedback was screened by filtering the unnecessary responses and filling in the missing parts, such as the education level of the respondents and other demographic details. Before the process of data analysis, the collected information was coded and transcribed into different themes regarding how students connect classroom learned mathematics to their actual living experiences. In this process, each of the selected schools was given numbers from 1 to 12, and each question item's responses were numbered from 1 to 3 for easy transcription of the data in SPSS software. Each of the question items was then transcribed into a particular aspect regarding the research problem. The transcribed data was then analyzed through descriptive statistics by frequency distribution tables and statistical measures of central tendencies, followed by the generation of the manuscript document.

C. Results and Discussion

The major aim of this study was to examine the extent at which ordinary level secondary students connect classroom learned mathematics to their actual living experiences. It entailed investigating different areas or aspects through which classroom learned mathematics is useful to students' actual living environment. Data was collected through questionnaire method by providing respondents with both closed and open-ended questions to fill their responses regarding the subject matter. Below is a simple description of the collected information and its implications regarding connections between classroom-learned mathematics and students' actual living, familiar experiences.

1. Frequencies at Which Ordinary Level Secondary Students Connect Classroom Learned Mathematics Knowledge to their Actual Living Environment

The collected information indicated that rarely do ordinary-level secondary students connect what they learn in mathematics with their actual living environment. In this aspect, respondents asked questions intended to know how classroom learned mathematical contents/topics relates to their real-life environment. Provided questions demanded them to state the extent to which they can see the direct connections between what they learned in mathematics in classrooms and their actual living experiences by choosing among the given alternatives and then providing justifications for their selection. The data showed that 71% of the defendants rarely connected classroom learned mathematics to their actual living environment, as per the frequency distribution table below.

Table 1. Frequency of Connection Between Classrooms Learned Mathematics to Students' Actual Living Experiences

Responses	Frequency	Percent	Cumulative Percent
Always	42	20.6	20.6
Rarely	144	71.1	82.7
No connection at all	16	8.3	100.0
Total	202	100.0	

From the table above, approximately 71% of students in ordinary-level secondary schools rarely connect the mathematics they learn in the classroom with their actual living experiences. This means that most of the topics that students learn in mathematics are not directly linked to their actual living environment. Even those who opted for a positive response (always) (20.6%) failed to justify how the learned contents mentioned above relate to their day-to-day activities. The failures of most students to connect classroom learned mathematics to their actual living experiences imply that mathematics is learned as abstract knowledge, and most students cannot identify the utility and usefulness of what they learn in mathematics in their actual living environment. Inability of most students to connect classroom learned mathematics to their real-life experiences facilitates rote learning of mathematics, which may result in massive failure as experienced in NECTA examination for many years. A great number of students stating rare connections between classroom learned mathematics with their actual living experiences signify that most students struggle/face difficulties in learning mathematics, which may result in partial understanding and insincere mastery of this subject, and eventually poor performance.

These results match what was observed by other scholars since Mazana et al. (2018) reported that the disconnection between classroom learned mathematics and students' real-life experiences is one of the key issues that makes most students in secondary schools dislike mathematics and promotes negative attitudes towards the subject. Negative attitudes observed by such scholars align with misconnections identified in this study, and these might be reasons spearheading the massive failures observed in mathematics in different ordinary-level secondary schools. Again, failures of most students to realize the connection between what they learn in mathematics with their actual living experiences misalign with the true meaning of education and the pragmatism approach in education since Rai and Lama (2020) emphasize that the subject becomes meaningful and interesting to students if it is realistic to their actual living environment and reality in the real world. For any education practice to be productive, learners should be able to manipulate classroom learned contents into their real-world experiences, as suggested in the pragmatist approach of learning (Axtelle, 1968). This means that students should be able to practice and use what they learn in mathematics in their actual life. In so doing, students develop a full understanding and mastery of the subject. Hence, for students to be interested and capable with mathematics, they should be helped to connect the subject to the real world and use the learning concepts in solving their day-to-day problems.

2. The Ways That Students Apply Classroom Learned Mathematics in Their Actual Living Environment

During investigations, respondents were asked open-ended questions to indicate how they apply different concepts/topics learned in mathematics to their actual living environment. The assigned questions necessitated them to ascertain the topic(s) and explain how it is useful to their actual living experiences. The collected data revealed that most respondents failed to demonstrate the real-world application of mathematics learned in the classroom in their day-to-day activities. The table below recapitulates their responses as collected in the fields.

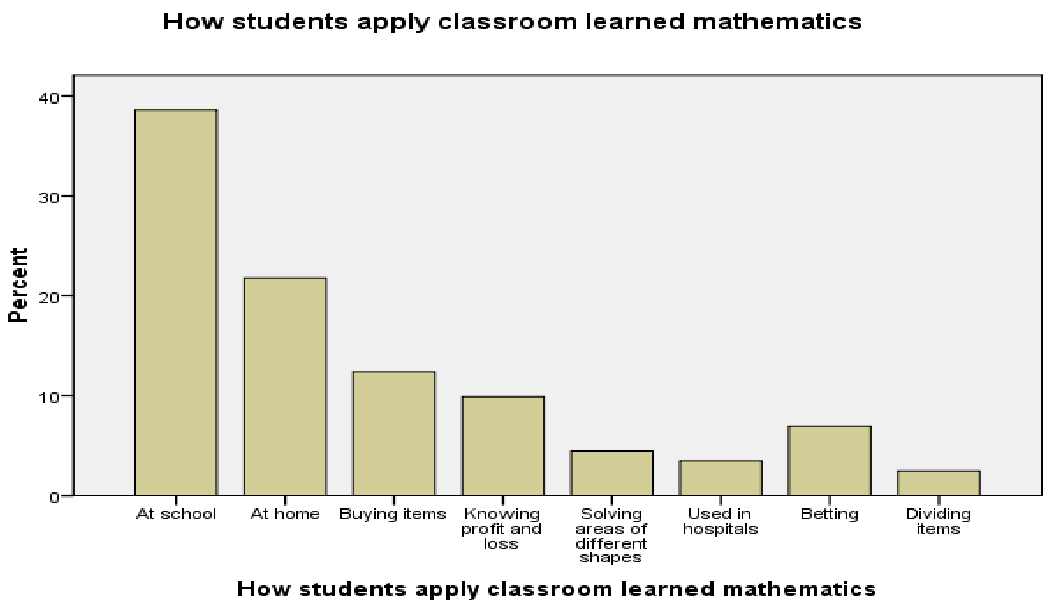


Figure 1. Experiences of Students on Applying Classrooms Learned Mathematics in Their Actual Living Environment

From the summarized data above, it is evident that most students failed to apply the mathematics they learned in the classroom to their actual living experiences. Most of them responded that they apply classroom learned mathematics at school to solve different problems assigned by their teachers. Others pondered that they use classroom learned mathematics in their homes, but failed to specify the task/activity aided by the learned mathematics knowledge/skills. Again, some of them mentioned areas such as shops, hospitals, betting, or markets without a vibrant description of the definite application relieved by acquired mathematical skills. All these responses show that most students have just pictures or formulas of mathematics, but they cannot articulate the real application of classroom learned mathematics in their day-to-day activities (Hayal, 2018). Inability of students to apply classroom learned mathematics with their real-life experiences may be attributed by inadequate use of real-life examples or projects during mathematics teaching and learning as Deogratias (2022) reported that most pre-service mathematics teachers rarely use real-life examples or projects to orient the subject since they see the process of innovating actual tools as time-consuming.

This results align with what other scholars observed regarding connections between classrooms learned mathematics with student's actual living experiences since Ahmed et al. (2004) note that most students provides insincere application of classroom learned mathematics in their life. They went further and contend that when speaking of mathematics, many people in society are pictured with various formulas and shapes without knowing the actual exemplification of them in the real world. Adjoining to these argumentations, McNeil et al. (2009) claim that most students faces difficult in applying classroom learned mathematics in their actual living experiences since in most cases mathematics is facilitated as intangible knowledge. These findings are irrelevance to pragmatism theory of knowledge generation in education as Axtelle (1968) connotes that trues knowledge should be realistic to students actual life and usable in figuring out their daily life problems.

3. Experiences of Students on Using Live-hood Environment in Responding to Mathematical Problems

The study revealed that most students were unable to apply home/living experiences in responding to mathematical questions assigned by teachers or during classroom hours. To figure out how living experiences help students in responding to asked mathematical questions, respondents were required to state whether their actual living environment may help them in responding to mathematical questions. As the table below depicts, 56.9% of students responded negatively regarding the application of real-life experiences in answering mathematical problems compared to 43.1% of students who responded positively to a particular problem.

Table 2. Experiences of Students on Using Live-hood Environment in Responding to Mathematical Problems

Responses	Frequency	Percent	Cumulative Percent
Yes	85	43.1	56.9
No	115	56.9	100.0
Total	202	100.0	

Taking into consideration that, in the lens of constructivist approach, there are connections between classroom learned contents with students' actual living experiences (V &

A, 2016) and that students learn by taking what they learn in the class and add it to what they already know, since most students (56.9%) showed that they cannot use real-life experiences to solve mathematical problems, this signifies that to a great extent majority of mathematical concepts learned in mathematics have no direct linkage with students' daily life experiences**.** The study revealed further that those who responded positively (43.1%) failed to cite the real environment as well as the mathematical problems solved. Inabilities of students to use their real-life experiences in responding to mathematical questions show that there are no connections between what is learned in classrooms and students' actual living experiences.

According to Kunwar (2020) failures of students to use home environment in responding to mathematical problems cause what is called mathematics phobia as classroom learned mathematics are intangible to their daily life activities. Their inability to apply actual living practices in responding to mathematical problems shows that mathematical skills/knowledge learned in classrooms are not constructed from learners' real-world familiarities. This makes them struggle in solving and understanding mathematical skills that have no utility in their day-to-day activities. Failures of students to reflect/use daily living experiences in responding to mathematics problems deviate from pragmatism approach of learning since in education students should be taught things that are practical for their life and applicable to the real world (Rai & Lama, 2020). There is a need to conceptualize mathematical skills learned in ordinary level secondary schools to be directly linked and applicable to students' day-to-day activities.

4. Relationship Between What Students Learn in Classrooms with Their Real-life Experiences

During visitations, the researcher discovered that most of what students are being taught in mathematics is negatively related to their actual living experiences. The table below shows how students responded when asked to locate the relationship between classroom-learned mathematics and their real-life experiences.

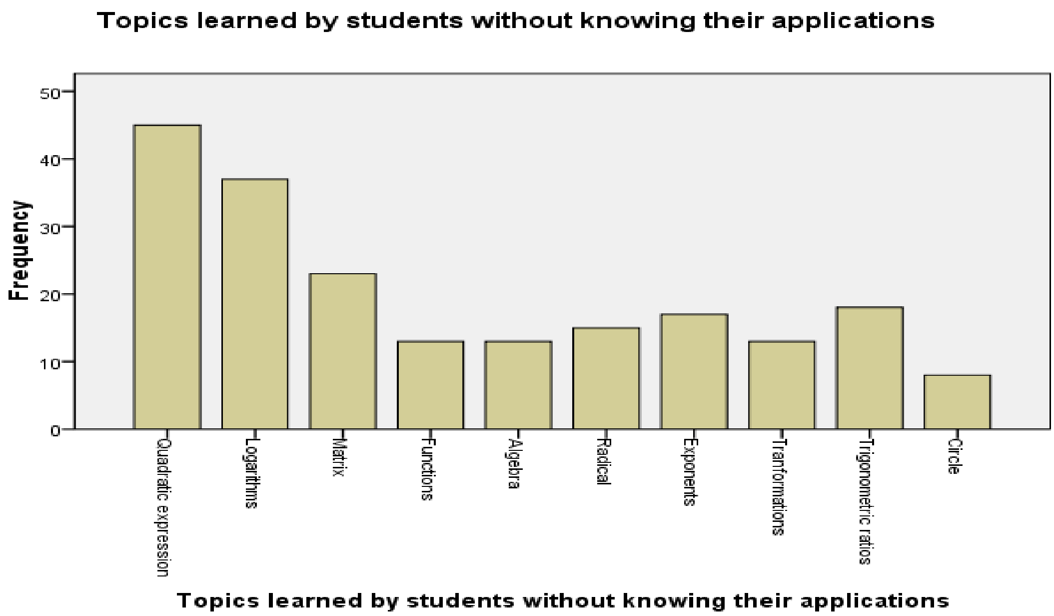
Table 3. Relationship Between Classrooms Learned Mathematics with Student's Real-Life Experiences

Responses	Frequency	Percent	Cumulative Percent
Yes	39	22.8	59.6
No	132	77.2	100.0
Total	171	100.0	

The field data, as displayed in the table above, shows that 77.2% of the respondents provided negative feedback when asked to show the relationship between different mathematical concepts/topics and their actual living experiences. This indicates that most students in secondary schools struggle to recognize the connection between mathematical concepts and their real-life experiences. This implies that in most cases mathematics in ordinary level secondary schools is taught as abstract knowledge where students learn by just claiming the formulas or shapes of the presented concepts without understanding their meaning or application in the real world. Most students cannot locate what logarithms, quadratic, or other mathematical concepts mean/represent in their actual living environment. According to Laurens et al. (2018) classroom learned mathematics should be realistic to learners real world practices and taught as a fun. Students will be interested with learned mathematics if it relate to their day to day activities (Gravemeijer et al., 2017) and prepare them to positively engage with their communities. Again failure of students to connect classroom learned mathematics with their actual living experiences cause most students to dislike mathematics which results into massive failure in mathematics experienced in different levels of education in Tanzania (Mazana et al., 2018). The investigations from the study deviates from pragmatism approach in educations as postulated by Axtelle, 1968) that in education students should be taught things which are real and practical to their actual life.

5. Topics that Students Learn in Mathematics Without Knowing its Applications to Their Real-Life Experiences

Respondents were asked to mention all the topics they learn in mathematics but unfortunately, they are unaware of its application in their real-life experiences. In responding to the asked item, apprentices identified some of the common topics learned in ordinary level secondary schools, without knowing where they are applied. The graph below summarizes some of the most entitled topics narrated by respondents as unfamiliar when they are applied in daily life experiences.



Graph 2. Topics That Are Unknown Their Applications to Students' Real-Life Experiences

From the displayed data above, some of the topics learned in ordinary level secondary schools are unfamiliar to learners, where they can apply them in the actual living environment. Quadratic expressions, logarithms, and matrices were the most mentioned topics learned by students without knowing their actual applications in their lives as well as in the real world at large. This means students learn the topics and solve associated problems; however, they do not know the actual utility of these topics in their real-life involvements. According to Da (2023) the tendency of students to learn mathematics without knowing its real application in their actual life involvements cause some of them to lose interest with mathematics and unfortunately perform worse in that subject. Adjoining to these argumentation, Micheal (2015) alludes that disconnection between mathematics and students real life familiarities are one of the factors contributing to massive failure in mathematics in secondary schools. The above results mimic with what reported by Mazana et al. (2018) that lack of practicability between what students learn in mathematics with their day to day familiarities promote negative attitude and interest to majority of students in various levels of education in Tanzania. Absence of connection between classroom learned mathematical topics with students real life practices mismatch with pragmatism approach of learning since Rai and Lama (2020) insist that knowledge becomes meaningful to students if and only if it reflect their actual living experiences.

D. Conclusion

This study revealed that, in most cases, ordinary-level secondary students cannot connect the mathematics knowledge they learn in the classroom with their actual living experiences. It was found that most students were able to report wide-ranging application of only few familiar topics in life, but they failed to explicate precisely how those topics are mirrored in their day to day living familiarities. The study went further and identified that most of the applications reported by students were too general such as at schools, at home and in markets sometimes depending on their parents/guardian's occupations. Yet some of the topics like quadratic expression, logarithms, matrix and algebra seemed to be unfamiliar to students where they are applied in real world practices. This spearheads rote learning and partial mastering of mathematics which may result into poor performance in this subject as evidenced in NECTA examination for many years. The study recommends that for students to have a clear picture of what they are learning in mathematics and get full mastering of the subject, teachers should work at maximum to ensure they use real life examples and provide tangible meanings (realistic of mathematics education) which concur with learners' real-life involvements. Further investigations may be conducted on the following areas to comprehend mathematics in real word setting, investigating the strategies that emphasize experiential learning or project based approaches in mathematics, Investigating how integrating mathematics with other disciplines (science, art or social studies) influences students understanding and application of concepts, Examining the challenges teachers face in incorporating real world applications into their mathematics instruction as well as exploring how teachers training programs can better equip educators to link classroom mathematics to real life contexts.

Acknowledgement

Sincerely, we would like to give much gratitude to ordinary level secondary students and teachers in the researched secondary schools for their collaboration and maximum engagement in providing responses during the overall process of data gathering in this study. Finally, we would like to thank all members of the school of education at Sokoine University of Agriculture for the valuable comments during the preparation of this manual script.

References

Ahmed, A., Clark-Jeavons, A., & Oldknow, A. (2004). How can teaching aids improve the quality of mathematics education. *Educational Studies in Mathematics*, *56*(2–3), 313–328. https://doi.org/10.1023/B:EDUC.0000040412.39121.e0

Aronson, B., & Laughter, J. (2016). The Theory and Practice of Culturally Relevant Education: A Synthesis of Research Across Content Areas. *Review of Educational Research*, *86*(1), 163–206. https://doi.org/10.3102/0034654315582066

Arthur, Y. D., Owusu, E. K., Asiedu-Addo, S., & Arhin, A. K. (2018). Connecting Mathematics To Real Life Problems: A Teaching Quality That Improves Students' Mathematics Interest. *IOSR Journal of Research & Method in Education*, *8*(4), 65–71. https://doi.org/10.9790/7388-0804026571

Axtelle, G. E. (1968). Pragmatism in education. In *Studies in Philosophy and Education* (Vol. 6, Issue 1, pp. 6–13). https://doi.org/10.1007/BF00367794

Baki, A., & Çakiroğlu, Ü. (2010). Learning objects in high school mathematics classrooms: Implementation and evaluation. *Computers and Education*, *55*(4), 1459–1469. https://doi.org/10.1016/j.compedu.2010.06.009

Burkhardt, H., Pead, D., & Stacey, K. (2024). Learning and Teaching for Mathematical Literacy. *Learning and Teaching for Mathematical Literacy*. https://doi.org/10.4324/9781003303503

Da, N. T. (2023). Realistic mathematics education and authentic learning: A combination of teaching mathematics in high schools. *Journal of Mathematics and Science Teacher*, *3*(1), em029. https://doi.org/10.29333/mathsciteacher/13061

Deogratias, E. (2022). The importance of using real objects for teaching and learning a mathematical concept with pre-service teachers of mathematics conditions of the Creative Commons Attribution license (CC BY-NC-ND) (http://creativecommons.org/licenses/by-nc-nd/4.0/). In *International Journal of Curriculum and Instruction* (Vol. 14, Issue 1).

Do, T. T., Hoang, K. C., Do, T., Trinh, T. P. T., Nguyen, D. N., Tran, T., Le, T. T. B. T., Nguyen, T. C., & Nguyen, T. T. (2021). Factors influencing teachers' intentions to use realistic mathematics education in Vietnam: An extension of the theory of planned behavior. *Journal on Mathematics Education*, *12*(2), 331–348. https://doi.org/10.22342/JME.12.2.14094.331-348

Gates, S. (2008). Mixing It Up: The Role of Theory in Mixed-Methods Research. In *Qualitative Methods* (Issue 2005).

Gravemeijer, K., Stephan, M., Julie, C., Lin, F. L., & Ohtani, M. (2017). What Mathematics Education May Prepare Students for the Society of the Future? *International Journal of Science and Mathematics Education*, *15*, 105–123. https://doi.org/10.1007/s10763-017-9814-6

Hayal, M. Y. (2018). Examining Mathematics Department Students' Views on the Use of Mathematics in Daily Life. *International Online Journal of Education and Teaching (IOJET*, *5*(1), 61–80.

Kunwar, R. (2020). Mathematics Phobia : Causes ,. *International Journal of Creative Research Thoughts (IJCRT)*, *8*(8), 818–822.

Laurens, T., Batlolona, F. A., Batlolona, J. R., & Leasa, M. (2018). How does realistic mathematics education (RME) improve students' mathematics cognitive achievement? *Eurasia Journal of Mathematics, Science and Technology Education*, *14*(2), 569–578. https://doi.org/10.12973/ejmste/76959

Mazana, M. Y., Montero, C. S., & Casmir, R. O. (2018). Investigating Students' Attitude towards Learning Mathematics. *International Electronic Journal of Mathematics Education*, *14*(1), 207–231. https://doi.org/10.29333/iejme/3997

Mazana, M. Y., Montero, C. S., & Casmir, R. O. (2020). Assessing Students' Performance in Mathematics in Tanzania: The Teacher's Perspective. *International Electronic Journal of Mathematics Education*, *15*(3), em0589. https://doi.org/10.29333/iejme/7994

McNeil, N. M., Uttal, D. H., Jarvin, L., & Sternberg, R. J. (2009). Should you show me the money? Concrete objects both hurt and help performance on mathematics problems. *Learning and Instruction*, *19*(2), 171–184. https://doi.org/10.1016/j.learninstruc.2008.03.005

Micheal, I. (2015). *Factors Leading To Poor Performance in Mathematics Subject in Kibaha Secondary Schools*.

NECTA. (2023). the United Republic of Tanzania Ministry of Education, Science and Technology National Examinations Council of Tanzania Candidates' Item Response Analysis Report on the Certificate of Secondary Education Examination (CSEE) 2022 History. *Https://Onlinesys.Necta.Go.Tz/Cira/Acsee/2022/131_PHYSICS.Pdf*, *Csee*. https://onlinesys.necta.go.tz/cira/acsee/2022/131_PHYSICS.pdf

Ojose, B. (2011). Mathematics literacy : are we able to put the mathematics we learn into everyday use? *Journal of Mathematics Education*, *4*(1), 89–100.

Rai, P. C., & Lama, R. (2020). PRAGMATISM AND ITS CONTRIBUTION TO EDUCATION. In *International Journal of Creative Research Thoughts* (Vol. 8, Issue 3). www.ijcrt.org

Stadtländer, C. T. K.-H. (2009). Qualitative, Quantitative, and Mixed-Methods Research. *Microbe Magazine*, *4*(11), 485–485. https://doi.org/10.1128/microbe.4.485.1

V, D., & A, Y. (2016). Constructivism: A Paradigm for Teaching and Learning. *Arts and Social Sciences Journal*, *7*(4), 66–70. https://doi.org/10.4172/2151-6200.1000200

Vos, P. (2018). "How real people really need mathematics in the real world"—authenticity in mathematics education. *Education Sciences*, *8*(4). https://doi.org/10.3390/educsci8040195

IJRME
International Journal of Research in Mathematics Education
Vol. 3 No. 2, December 2025, 173-184
Universitas Islam Negeri Prof. K.H. Saifuddin Zuhri Purwokerto
e-ISSN: 3025-7638, p-ISSN: 3025-1842

The Influence of Self-Confidence on Students' Mathematical Reasoning Ability at SMA Negeri 3 Purwokerto

Tobingatus Salimah[1]✉; Sofiana Mardiyantiningsih[2]

[1]Universitas Islam Negeri Profesor Kiai Haji Saifuddin Zuhri Purwokerto, Indonesia
[2]Universitas Terbuka, Indonesia

✉ *Corresponding email:* *tobingatus.salimahs1@gmail.com*

Received April 26, 2025
Accepted November 19, 2025
Published December 31, 2025

https://doi.org/10.24090/ijrme.v3i2.14188

Abstract: Mathematical reasoning is a fundamental skill that students need to develop in the process of learning mathematics. This skill is crucial, as one of the primary objectives of mathematics education is to enable students to apply reasoning in understanding mathematical forms and properties, perform mathematical manipulations to develop generalizations, construct factual knowledge, and articulate mathematical arguments and statements. Among the various factors that may influence students' mathematical reasoning ability, one of them is self-confidence. Students with a high level of self-confidence tend to exert greater effort in problem-solving, demonstrate persistence in overcoming difficulties, and are less likely to give up when faced with challenges in mathematics. This study aims to analyze and describe the influence of self-confidence on the mathematical reasoning ability of students at SMA Negeri 3 Purwokerto. The research employed a quantitative approach using a survey method. The study was conducted at SMA Negeri 3 Purwokerto with a population comprising 396 eleventh-grade students. The sample was selected through simple random sampling, using Slovin's formula, which resulted in a total sample of 199 students. Data were collected using two instruments: a questionnaire to measure the self-confidence variable and a test to assess students' mathematical reasoning abilities. The findings suggest that self-confidence has a significant impact on students' mathematical reasoning abilities. The degree of influence is reflected in the coefficient of determination (R^2) value of 0.203, indicating that self-confidence accounts for 20.3% of the variance in students' mathematical reasoning ability. The remaining 79.7% is attributed to other factors not examined in this study. These results underscore the importance of cultivating self-confidence in students as part of efforts to enhance their mathematical reasoning skills.

Keywords: mathematical reasoning ability; self-confidence; mathematics

A. Introduction

Education is an effort systematically designed and prepared to develop the talents and potential of students through a learning process based on humanist principles, fostering superior behavior characterized by independent and resilient personality traits (character) as a guideline for daily interactions among individuals and society. Participants are taught to learn actively, recognize and develop their potential and character in terms of spiritual intelligence, emotional intelligence, and IQ, and acquire other necessary skills (Purnomo, 2019).

Mathematics is the queen and servant of science. Mathematics, as a queen, means that it can serve as a source of other knowledge. Concepts in mathematics are often used as a basis for developing existing theories. For example, many theories and branches in physics and chemistry courses are obtained and developed using the concept of calculus, especially theories and branches related to differential equations (Ernawati et al., 2021).

Reasoning is one of several important competencies that students must have in learning mathematics. This ability reflects the logical thinking process carried out through two approaches, namely inductive and deductive. The inductive approach involves providing a number of logical evidences that are used to draw a conclusion in the context of learning. In contrast, the deductive approach is based on an understanding of scientifically proven concepts, which are then applied in problem-solving. Through these two approaches, students are trained to draw logical conclusions based on available facts (Ahmad et al., 2018).

Mathematical reasoning is essential in everyday human life. Mathematical reasoning ability is one of the most important and essential mathematical skills for high school students, as it aligns with the purpose of mathematics in meeting future needs. Reasoning ability is essential for students to possess because almost every mathematical problem requires critical thinking. Through reasoning, students are expected to be able to understand that mathematics is a rational and logical lesson (Agustin, 2016). Students with good mathematical reasoning skills will be able to know more facts and solve a problems using a variety of methods (Hidayat & Aripin, 2019).

Mathematics learning should not only emphasize the achievement of final results, but also focus on a meaningful process for students. Presenting meaning in the mathematics learning process is something that needs to be a priority in order to achieve optimal learning goals (Ardiansyah et al., 2023). One of the cognitive attitudes needed in solving mathematical problems is reasoning ability. Students' mathematical reasoning ability is important because this ability is one part of the goals to be achieved in mathematics learning which is stated in the content standards and process standards of the Regulation of the Minister of National Education Number 22 of 2006, namely the ability to reason patterns and properties, perform mathematical arithmetic operations, draw general conclusions, compile evidence, and explain mathematical ideas and statements (Kusumaningtyas et al., 2021).

However, the reality in the field, according to the research results of Ika Purwati and Debby Amaliah Putri, is that most students get low grades when given assignments. This is caused by students' suboptimal understanding of the material that has been delivered, their inability to estimate and apply the appropriate formula in carrying out calculations systematically, and their rare rechecking of the answers they have made. Lack of study time and the tendency to easily forget the material that has been studied are also other causal factors (Ika Purwati & Maria Ulpah, 2023).

One of the factors that can influence students' mathematical reasoning ability is self-confidence, where students who have high self-confidence will try as hard as possible to solve mathematical problems, are persistent in increasing their efforts, and do not give up easily (Mukuka et al., 2021). Students who have high self-confidence tend to be able to fulfill all indicators of mathematical reasoning ability, in the form of presenting mathematical statements, making conjectures, mathematical manipulation, drawing conclusions, proving the truth of a statement, and finding patterns of mathematical phenomena (Marfu'ah et al., 2023).

Self-confidence is the belief that you have the potential to complete tasks and achieve certain goals through the actions you take (Fattah, 2017). A person with a high level of self-confidence tends to strive to optimize their potential, including in terms of mathematical reasoning ability. This is in line with the research findings of Aprisal and Arifin, which show a relationship between self-confidence and reasoning ability (Wahyuningsih et al., 2021).

Self-confidence plays a crucial role in shaping students' attitudes and behavior when they encounter math problems. Students with high self-confidence tend to have more confidence in solving problems, dare to try new strategies, and are less likely to give up easily when facing difficulties. However, on the other hand, students with low self-confidence tend to be hesitant, passive, and give up quickly, which ultimately has an impact on their low mathematical abilities (Nada et al., 2024).

According to research by Muhamad Akrom (Akrom, 2021) it was found that the relationship between self-confidence and mathematical reasoning ability was moderate and positive with a correlation coefficient of 0.362, so that the higher the student's self-confidence, the higher the student's mathematical reasoning ability, with an R square value of 0.131 which means that the contribution of self-confidence to students' mathematical reasoning ability was 13.1%, while the rest was influenced by other variables.

Based on the results of preliminary observations by conducting interviews that the researcher conducted on Tuesday, March 19, 2024 with Mrs. Tyas Widyastuti, S.Pd. who is also one of the mathematics subject teachers in class XI of SMA Negeri 3 Purwokerto and interviews with several class XI students and tests of students' mathematical reasoning abilities using problems obtained from student learning books, information was obtained that students' reasoning abilities and self-confidence varied, this was evidenced by some students who were able to examine the problems given by the teacher and some who were not yet able to. The results of observations from 36 grade XI students, based on the questions given, showed that 71% of students were able to answer with moderate ability, 18% achieved high scores, and 11% received low scores. As a result, there are students who cannot provide estimates on existing problems, so they have difficulty finding patterns or properties of mathematical phenomena to make generalizations. The level of student confidence is also classified as moderate. There are students who are embarrassed to express their opinions, students mostly play alone and are not serious about learning, and students do not yet possess the reasoning ability to solve mathematical problems.

B. Methods

This type of research employs a quantitative approach using a survey method. Quantitative research is a research method carried out by examining a population or sample to be studied to prove a hypothesis that has been established in a study so that the hypothesis and conclusions can be proven true, which uses data collection and analysis numerically or using numbers, where there are quantitative/statistical research instruments that aim to prove the hypothesis testing made by researchers (Attamimi et al., 2023). This research is aimed at students of class XI of SMA Negeri 3 Purwokerto in the Even Semester of the 2024/2025 academic year. The population in this study consisted of the entire class XI, comprising a total of 396 students. Determination of the number of samples in this study used the Slovin formula approach so that a sample of 199 students was obtained.

The data collection techniques used were interviews, tests, and questionnaires. Interviews were conducted with several grade XI students and one of the grade XI Mathematics teachers of SMA Negeri 3 Purwokerto. The instruments used in the study were written tests in the form of descriptions with a total of 5 mathematical reasoning ability questions, and questionnaires used to determine students' self-confidence levels, consisting of 40 statements, 20 positive statements, and 20 negative statements. The Likert scale is used as an answer format to assess the level of Self-Confidence. Each question item provides four answer choices: Always (SL), Often (SR), Sometimes (KD), and Never (TP). In this study, a questionnaire was used to measure the level of students' Self-Confidence. The Self-Confidence variable, which consists of four indicators, was developed into 40 questions, where each indicator includes two types of questions, namely positive and negative. The following grid is arranged according to the indicators of the Self-Confidence variable. The research questionnaire and test used were tested on 30 students, then obtained a Pearson correlation = 0.361 with a significance level of 5%. The researcher utilized SPSS version 25 software to facilitate the analysis process of the validity test of the research instrument, then tested its validity, which resulted in 27 statement items being declared valid and 5 test questions being declared valid. The material used to measure students' mathematical reasoning abilities was the circle material for Class XI Semester II. Data analysis used Pearson correlation analysis and simple linear regression.

C. Results and Discussion

1. Results

a. Validity Test

The validity of an item in an instrument aims to measure the extent to which the item accurately reflects the entire construct measured through the total score. Validity testing is done by correlating the score of each item with the total score of the instrument (Novikasari, 2016). In this study, the validity test of the research instrument used the product-moment correlation technique.

To determine whether an instrument is valid or not, it can be done by comparing the r_{xy} with the r_{table} using the $r_{table\ pearson}$. The instrument can be said to be valid if $r_{xy} \geq r_{table\ pearson}$ with a significance level of 5%, but if otherwise, then the instrument is not valid (Sugiyono, 2019). The instrument was tested on 30 students of class XI of SMA Negeri 3 Purwokerto, and obtained $r_{table\ pearson} = 0.361$ with a significance level of 5%.

Table 1. Validity Test Results of Mathematical Reasoning Ability Instruments

No.	r_{xy}	$r_{table\ pearson}$	Information
1	0,695	0,361	Valid
2	0,658	0,361	Valid
3	0,656	0,361	Valid
4	0,526	0,361	Valid
5	0,611	0,361	Valid

From the table it can be concluded that there are 5 valid instruments, so that they can be used in research.

b. Reliability Test

Reliability testing is a testing process that aims to assess the extent to which an instrument can be relied on (has a level of trust) in measuring the variables being studied. An instrument is considered to have high reliability if its test results consistently show stability. Therefore, the problem of instrument reliability is closely related to the accuracy of the results obtained. Through this reliability test, the level of stability of the measuring instrument used can also be determined (Kurniawan & Puspitaningtyas, 2016).

An instrument can be considered reliable if it produces a Cronbach's Alpha $r_{hitung} \geq 0.60$, and is not reliable if $r_{hitung} < 0.60$ (Sarjono & Julianita, 2020).

Table 2. Reliability Test Results of Mathematical Reasoning Ability Instruments

Reliability Statistics	
Cronbach's Alpha	N of Items
.609	5

The results of the reliability test show that Cronbach's Alpha value on the mathematical literacy ability test is 0.609 > 0.60, so it can be interpreted that the test questions have a fairly good consistency of the respondents' answers.

c. Normality Test

Normality test is conducted to meet the requirements of normality in parametric statistical data analysis. However, to conduct a parametric statistical data analysis test, the data must be normally distributed. Therefore, a normality test must be conducted. The normality test can be conducted with the help of the SPSS 25 for Windows program using the Kolmogorov-Smirnov test. The decision-making criteria are as follows: if the sign. value ≥ 0.05, then the data is declared to be normally distributed (H_0 is accepted). However, conversely, if the sig. value < 0.05, then the data is declared not normally distributed (H_0 is rejected) (Widana & Muliani, 2020).

Tabel 3. Normality Test Results

One-Sample Kolmogorov-Smirnov Test		
		Unstandardized Residual
N		199
Normal Parameters[a,b]	Mean	.0000000
	Std. Deviation	2.25948596
Most Extreme Differences	Absolute	.062
	Positive	.040
	Negative	-.062
Test Statistic		.062
Asymp. Sig. (2-tailed)		.061[c]

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.

From Table 3, it can be seen that the Asymp. Sig value is 0.061. Based on the decision criteria in the normality test, the data is considered normally distributed if the significance value is greater than 0.05. Because the Asy,mp. Sig value is 0.061 > 0.05, the data obtained on students' self-confidence and mathematical reasoning abilities are normally distributed, and H_0 is accepted.

d. Linearity Test

The linearity test is a requirement for conducting a regression test in order to determine whether the resulting regression equation model is linear or not. Essentially, good data exhibits a linear relationship between the independent variable (X) and the dependent variable (Y). The linearity test uses SPSS version 25, using a certain probability reference or significance level. The decision-making criteria are if the sig. If the deviation from linearity is≥ 0.05, then there is a linear relationship between the two variables. Whereas if sig. If the deviation from linearity is < 0.05, then the relationship between the variables is not linear.

Tabel 4. Linearity Test Results

ANOVA Table							
			Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
*Kemampuan Penalaran * Kepercayaan Diri*	Between Groups	(Combined)	554.292	50	11.086	2.300	.000
		Linearity	256.693	1	256.693	53.264	.000
		Deviation from Linearity	297.600	49	6.073	1.260	.147
	Within Groups		713.245	148	4.819		
	Total		1267.538	198			

Based on Table 4 above, the results of the linearity test are shown in the Anova Table. In the table, the significance value in the "Deviation from L, linearity" row, between self-confidence and mathematical reasoning ability, is 0.147. Based on the decision-making criteria for the linearity test, because the significance value of 0.147 > 0.05, it means that there is a linear relationship between self-confidence and mathematical reasoning ability, so that H_0 is accepted.

e. Regression Significance Test

To determine whether the relationship between the independent variable and the dependent variable is significant, allowing it to be used as a predictive tool, a regression significance test must be conducted. During testing, the researcher used SPSS Version 25. The criteria for making decisions are if the sig. value > 0.05, then the regression is not significant, or the relationship between variables is not significant (H_0 is accepted). However, conversely, if the sig. value ≤ 0.05 then the regression is significant, or the relationship between variables is significant (H_0 is rejected).

Tabel 5. Results of Regression Significance Test

ANOVA Table							
			Sum of Squares	df	Mean Square	F	Sig.
*Kemampuan Penalaran * Kepercayaan Diri*	Between Groups	(Combined)	554.292	50	11.086	2.300	.000
		Linearity	256.693	1	256.693	53.264	.000
		Deviation from Linearity	297.600	49	6.073	1.260	.147
	Within Groups		713.245	148	4.819		
	Total		1267.538	198			

Based on the results of Table 5 above, it can be seen that the significant value, si in Linearity is 0.000 so that ≤ 0.05, it can be concluded that the self-confidence variable with the student's mathematical reasoning ability variable has a meaningful relationship.

f. Simple Linear Regression Test

A hypothesis in research is an assumption or temporary response to the formulation of the problem. In this study, the hypothesis was tested using a simple linear regression test. Regression calculations must be carried out to determine whether the assumption or temporary answer is accepted or not. This regression calculation is obtained from the independent variable, self-confidence, and the dependent variable, mathematical reasoning ability. Research analysis using SPSS Version 25.

Table 6. Simple Linear Regression Test Results

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	7.086	1.056		6.712	.000
	Kepercayaan Diri	.098	.014	.450	7.073	.000
a. Dep$endent Variable: Kem$$ampuan Penalaran						

The values of a and b are determined first to calculate the regression equation. Based on the table above, it can be seen that the values of a and b from column B, namely a is 7.086 and b is 0.98, so that the regression equation is :

$$\hat{Y} = a + bX$$

$$\hat{Y} = 7{,}086 + 0{,}098X$$

Based on the equation above, the calculation results can be analyzed as below.:

a. From the Coefficients table, the regression equation is obtained, $\hat{Y} = 7{,}086 + 0{,}098X$ This means that the constant, a of 7.086, indicates that when self-confidence (X) is worth 0, then the student's mathematical reasoning ability (Y) is worth 7.086. Meanwhile, the regression coefficient, b, of 0.098 indicates that a one-unit increase in self-confidence will increase the student's mathematical reasoning ability by 0.098.

b. From the Coefficients table, there is a value at the constant, meaning that there is an influence of self-confidence on the mathematical reasoning abilities of class XI students at SMA Negeri 3 Purwokerto.

g. Hypothesis Test

H_0 : There is no influence of self-confidence (X) on the mathematical reasoning ability (Y) of students at Purwokerto 3 State High School.

H_a : There is an influence of self-confidence (X) on the mathematical reasoning ability (Y) of students at Purwokerto 3 State High School.

The criteria for making a decision are that H0 is accepted if the Sign value is ≥ 0.05, so there is no effect of self-confidence on the mathematical reasoning ability of students at SMA Negeri 3 Purwokerto. However, H_a is accepted if the Sign value. < 0.05, so that there is an influence of self-confidence on the mathematical reasoning ability of students of SMA Negeri 3 Purwokerto.

Table 7. Research Hypothesis Test Results

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	256.693	1	256.693	50.026	.000[b]
	Residual	1010.845	197	5.131		
	Total	1267.538	198			

a. Dependent Variable: Kemampuan Penalaran
b. Predictors: (Constant), Kepercayaan Diri

Based on Table 7, it can be seen that the Sign value is 0.000 < 0.05, so that H_0 is rejected and H_a is accepted. It can therefore be concluded that self-confidence has an influence on students' mathematical reasoning abilities.

h. Analysis of the R2 determinant coefficient

Analysis of the R^2 determinant coefficient is needed to determine the extent of the influence of self-confidence on mathematical reasoning ability. The coefficient of determination is a measure that indicates the proportion of variation in the dependent variable that is explained by the independent variable.

Tabel 8. Results of Determinant Coefficient Analysis R^2

Model Summary				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	.450[a]	.203	.198	2.265
a. Predictors: (Constant), Kepercayaan Diri				

In the Model Summary table above, it can be seen that the percentage value of the influence of the independent variable on the dependent variable, also known as the coefficient of determination, is 0.450 and the correlation value is 0.450 from the square of R. From this table, a determination coefficient of 0.203 or 20.3% is obtained, indicating that there is an influence between variable X (Self-Confidence) on variable Y (Mathematical Reasoning Ability).

2. Discussion

After the research was conducted, descriptive statistical analysis of the questionnaire and test was used to interpret the findings. The questionnaire results showed a minimum score of 46, a maximum score of 108, a mean score of 75.20, and a standard deviation of 11.601. The test results showed a minimum score of 8, a maximum score of 20, a mean score of 14.47, and a standard deviation of 2.530. These results were used to categorize students' self-confidence and mathematical reasoning abilities into low, medium, and high levels. After categorizing, it was found that 14.6% of students had low self-confidence, 66.3% had medium self-confidence, and 19.1% had high self-confidence. Meanwhile, 14.1% of students have low reasoning ability, 72.9% of students have moderate mathematical reasoning ability, and 13.1% of students have high mathematical reasoning ability, so the percentage of self-confidence and mathematical reasoning ability of class XI students at SMA Negeri 3 Purwokerto is moderate.

This study examines the impact of self-confidence on the mathematical reasoning ability of class XI students at SMA Negeri 3 Purwokerto. The results of the simple linear regression analysis showed that tcount = 7.073 > ttable = 1.97208, with a significant p-value. 0.000 then H_0 is rejected and H_a is accepted. It can be concluded that self-confidence has an influence on students' mathematical reasoning ability. The magnitude of the influence of self-confidence on students' mathematical reasoning ability is 20.3%; the rest is influenced by other variables not examined in this study.

In line with Muhammad Akrom's research, which concluded that self-confidence contributes to students' mathematical reasoning ability. Although the conclusions obtained are the same, the magnitude of the influence is different. This is due to the differences in subjects and instruments used in the study. In Muhammad Akrom's research, it was influenced by 13.1% (Akrom, 2021). Likewise, the research conducted by Hasna Salsabila Jati and Joko Soebagyo, the results of which showed an influence of 3.4% (Jati & Soebagyo, 2023). Meanwhile, this study found an influence of 20.3%.

D. CONCLUSION

After conducting research and analyzing the data, it was found that self-confidence has an influence on the mathematical reasoning ability of class XI students at SMA Negeri 3 Purwokerto. The data was analyzed using a simple linear regression equation with a determination coefficient of 0.203. This means that the influence of self-confidence on students' mathematical reasoning ability is 20.3% while the remaining 79.7% of mathematical reasoning ability is influenced by other factors not discussed in this study.

After conducting research and discussing the results of the study related to the influence of self-confidence on the mathematical reasoning ability of grade XI students of SMA Negeri 3 Purwokerto, , the author provides several suggestions, namely, Teachers need to increase interaction with students to increase students' self-confidence and mathematical reasoning abilities. On the other hand, teachers also need to use a variety of learning methods and develop relevant and interesting open materials. Thus, teachers can improve their teaching skills and help students increase their self-confidence and mathematical reasoning abilities, which can ultimately achieve more perfect mathematics learning goals. Students who already possess a high level of mathematical reasoning are encouraged to maintain it, while those in the medium or low category need to increase their learning motivation to boost their self-confidence and mathematical reasoning abilities. Students also need to increase their participation in learning to develop, enabling the achievement of the objectives of mathematics learning. For researchers, it is essential to enhance the quality of research instruments to improve the validity and reliability of the data. Researchers also need to develop research designs that are relevant to students' self-confidence and mathematical reasoning abilities and improve data analysis skills. By employing a range of research methods, researchers can enhance the quality of their research results and make a more significant contribution to improving students' self-confidence and mathematical reasoning abilities. Researchers can combine other internal factors in their research to identify the internal factors that simultaneously influence students' mathematical reasoning.

REFERENCES

Agustin, R. D. (2016). Kemampuan Penalaran Matematika Mahasiswa Melalui Pendekatan Problem Solving. *Pedagogia : Jurnal Pendidikan*, *5*(2), 179–188. https://doi.org/10.21070/pedagogia.v5i2.249

Ahmad, G., Akbar, M., Diniyah, A. N., Akbar, P., Nurjaman, A., Bernard, M., & Siliwangi, I. (2018). Analisi Kemampuan Penalaran Dan Self Confidance Siswa SMA Dalam Materi Peluang. *Journal On Education*, *1*(1), 14–21. https://doi.org/https://doi.org/10.31004/jopengertiane.v1i1.5

Akrom, M. (2021). Kontribusi Kepercayaan Diri Terhadap Matematis Siswa SMA di Kota

Surakarta Kemampuan Penalaran. *Jurnal Pendidikan MIPA Dan Aplikasinya*, *1*(1), 46–55. https://ejournal.baleliterasi.org/index.php/lambda/article/view/70

Ardiansyah, A. S., Adi, Y. W., Choirunnisa, F. R., Wardani, D. F., & Raharani, F. A.-N. (2023). Integration of Ethnomathematics of Masjid Al Mahdi in Discovery Learning-based Textbook on Students' Reasoning Ability. *International Journal of Research in Mathematics Education*, *1*(1), 1–11. https://doi.org/10.24090/ijrme.v1i1.7865

Attamimi, H. R., Harahap, K., Damanik, D., Fauzi, H., Ramba, H. La, Oktafiani, D., Yulianto, A., & Syam, S. (2023). Metode Penelitian. In *Metode Penelitian Kualitatif* (Vol. 3, Issue 17). Literasi Nusantara Abadi Grup. http://repository.unpas.ac.id/30547/5/BAB III.pdf

Ernawati, Zulmaulida, R., Saputra, E., Munir, M., Zanthy, L. S., Rusdin, Wahnyuni, M., Irham, M., Akmal, N., & Nasruddin. (2021). Problematika Pembelajaran Matematika. In M. Supratman (Ed.), \ (Vol. 2, Issue 1). Yayasan Penerbit Muhammad Zaini. https://doi.org/10.18860/gjppm.v2i1.4122

Fattah, H. (2017). *Kepuasan Kerja dan Kinerja Pegawai: Budaya Organisasi, Perilaku Pemimpin, dan Efikasi Diri*. Elmatera.

Hidayat, W., & Aripin, U. (2019). The improvement of students' mathematical understanding ability influenced from argument-driven inquiry learning. *Journal of Physics: Conference Series*, *1157*(3). https://doi.org/10.1088/1742-6596/1157/3/032085

Ika Purwati, & Maria Ulpah. (2023). The Effect of Mind Mapping Methods Types of Mind Map Syllabus on Mathematics Problem Solving Ability in Flat Side Space Construction Materials of Class VIII Students of Smp Negeri 1 Karangreja District Purbalingga. *International Journal of Research in Mathematics Education*, *1*(2), 126–135. https://doi.org/10.24090/ijrme.v1i2.9285

Jati, H. S., & Soebagyo, J. (2023). the Influence of Self-Confidence on the Mathematical Reasoning Ability of Junior High School Students. *Prima: Jurnal Pendidikan Matematika*, *7*(1), 67. https://doi.org/10.31000/prima.v7i1.7321

Kurniawan, A. W., & Puspitaningtyas, Z. (2016). Metode Penelitian Kuantitatif. In *Sustainability (Switzerland)* (Vol. 11, Issue 1). Pandiva Buku. http://scioteca.caf.com/bitstream/handle/123456789/1091/RED2017-Eng-8ene.pdf?sequence=12&isAllowed=y%0Ahttp://dx.doi.org/10.1016/j.regsciurbeco.2008.06.005%0Ahttps://www.researchgate.net/publication/305320484_SISTEM_PEMBETUNGAN_TERPUSAT_STRATEGI_MELESTARI

Kusumaningtyas, N., Parta, I. N., & Susanto, H. (2021). Kemampuan Penalaran Matematis Siswa dalam Memecahkan Masalah Matematika pada Saat Pembelajaran Daring. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, *6*(1), 107–119. https://doi.org/10.31004/cendekia.v6i1.1019

Marfu'ah, S., Masrukan, & Walid. (2023). Analysis of Mathematical Reasoning Ability in View of Self Confidence in the Project Based Learning Model with Performance Assessment. *International Journal of Education and Research*, *11*(5), 11–20.

www.ijern.com

Mukuka, A., Mutarutinya, V., & Balimuttajjo, S. (2021). Mediating effect of self-efficacy on the relationship between instruction and students' mathematical reasoning. *Journal on Mathematics Education*, *12*(1), 73–92. https://doi.org/10.22342/JME.12.1.12508.73-92

Nada, Y. Q., Yulianto, A. R., & Iffah, R. D. L. (2024). The Analysis of Mathematical Literacy Skills Based on the Self-Efficacy of Junior High School Students A . *International Journal of Research in Mathematics Education*, *2*(2), 201–216. https://doi.org/https://doi.org/10.24090/ijrme.v2i2.12354

Novikasari, I. (2016). *Uji Validitas Instrumen* (Vol. 1, Issue 1, p. 56). Institut Agama Islam Negeri Purwokerto.

Purnomo, H. (2019). *Psikologi Pendidikan* (T. Wahyono (ed.)). Lembaga Penelitian, Publikasi, dan Pengabdian Masyarakat (LP3M), Universitas Muhammadiyah Yogyakarta. https://books.google.com/books?hl=en&lr=&id=kKJfEAAAQBAJ&oi=fnd&pg=PP1&dq=pendidikan&ots=prv7-EkLVc&sig=p-qdflpd2ywOArfzqtCaabYcPN4%0Ahttp://digilib.stiem.ac.id:8080/xmlui/bitstream/handle/123456789/610/Psikologi Pendidikan.pdf?sequence=1&isAllowed=y

Sarjono, H., & Julianita, W. (2020). *SPSS VS LISREL Sebuah Pengantar Aplikasi Riset*. Salemba Empat.

Sugiyono. (2019). *Metodelogi Penelitian Kuantitatif dan Kualitatif dan R&D*. Alfabeta.

Wahyuningsih, R., Abidin, Z., & Ilmi, Y. I. N. (2021). Analisis Kemampuan Penalaran Matematis ditinjau dari Self- Efficacy pada Materi Perbandingan Peserta Didik Kelas VII SMP Negeri 2 Trawas. *Jp3*, *16*(19), 160–170.

Widana, W., & Muliani, P. L. (2020). Uji Persyaratan Analisis. In T. Fiktorius (Ed.), *Klik Media*.

IJRME International Journal of Research in Mathematics Education
Vol. 3 No. 2, December 2025, 185-190
Universitas Islam Negeri Prof. K.H. Saifuddin Zuhri Purwokerto
e-ISSN: 3025-7638, p-ISSN: 3025-1842

Factors Influencing Students' Interest in Mathematics

Agosto Olo Tomé[1]✉

[1]*Instituto Superior Cristal, Indonesia, Timor Leste*

✉ *Corresponding email:* [*oloagus12@gmail.com*](mailto:oloagus12@gmail.com)

Received September 2, 2025
Accepted November 18, 2025
Published December 31, 2025

https://doi.org/10.24090/ijrme.v3i2.15196

Abstract: This study presents a fresh perspective on the perceptions of junior high school students toward mathematics learning in Timor-Leste, with a specific focus on seventh-grade students at Ensino Básico 3º Ciclo Santo António de Oe-Cusse. The research directly explores students' learning experiences from their own viewpoint, which has rarely been documented in the educational context of the Oe-Cusse region. A descriptive, qualitative approach was employed to understand the factors that shape students' interest in mathematics. Eight students were purposively selected and asked to respond to the open-ended question: "What do you like about math lessons?" The findings reveal four main factors contributing to students' enjoyment of mathematics: (1) clear teacher explanations that make the material easier to understand, (2) enjoyment of calculation activities such as addition, subtraction, and geometry, (3) the presence of games or puzzles that challenge concentration and creativity, and (4) awareness of mathematics' relevance to daily life. These results indicate that students' motivation to learn mathematics in this region is influenced by a unique combination of pedagogical, cognitive, and contextual factors, highlighting the importance of instructional approaches that integrate clear explanations, varied calculation activities, playful or puzzle-based elements, and real-world applications. This study offers valuable insights for developing mathematics teaching strategies tailored to the characteristics of students in Timor-Leste, particularly in border areas such as Oe-Cusse, and opens avenues for further research on innovative teaching methods grounded in students' perceptions and experiences.

Keywords: mathematics, student perceptions, learning motivation, Oe-Cusse, contextualized learning

A. Introduction

Mathematics plays a central role in developing logical thinking, analytical skills, and problem-solving abilities (Shirawia et al., 2023). These skills are crucial not only for academic success but also for navigating everyday life situations. However, students' attitudes and perceptions toward mathematics often vary; some find it challenging and enjoyable, while others perceive it as difficult and tedious (Ampadu & Anokye-poku, 2022). Gaining a deeper understanding of students' positive perceptions is essential for designing effective teaching strategies.

In the context of Timor-Leste, particularly in the Oe-Cusse region, studies on students' perceptions of mathematics remain limited. *Ensino Básico 3º Ciclo Santo António de Oe-Cusse* has unique characteristics, both in its learning environment and students' backgrounds. At the seventh-grade level, students begin to encounter more complex mathematical concepts, including geometry, problem-solving, and logic, which require teaching strategies that are both motivating and relevant to their lives.

This study focuses on exploring the reasons why seventh-grade students enjoy mathematics from their own perspective, an approach rarely undertaken in this region. The research not only identifies key factors shaping students' interest, such as clarity of teacher explanations, calculation activities, game or puzzle elements, and real-life relevance, but also provides contextual insights that can inform the design of more engaging and meaningful mathematics instruction for students in the border areas of Timor-Leste.

B. Methods

1. Research Approach and Type

This study employed a qualitative approach with a descriptive research design. According to Oranga & Matere (2023), qualitative research is a research method that tries to describe the real conditions faced by research subjects. The qualitative approach was chosen to gain a deep understanding and depiction of students' perceptions of mathematics lessons based on their direct responses. The descriptive design was used to present the data as it is, without manipulating any variables, allowing for an authentic representation of students' views.

2. Research Subjects

The subjects of this study were seventh-grade students at *Ensino Básico 3º Ciclo Santo António de Oe-Cusse.* A total of 8 students participated, selected through purposive sampling based on the following criteria:

a) Actively engaged in mathematics lessons.
b) Willing to provide written responses to the research questions.

3. Research Location

The study was conducted at Ensino Básico 3º Ciclo Santo António de Oe-Cusse.

4. Research Instrument

The research instrument consisted of an open-ended question: "What do you like about math lessons?" This question was designed to explore students' reasons and perspectives in depth without restricting their responses.

5. Data Collection Technique

Data were collected using an open-ended questionnaire. In an open-ended questionnaire, research subjects can provide limited answers to the questions asked (Taherdoost, 2022). Students were asked to write their answers freely based on their own experiences and feelings. This approach allowed the researcher to obtain rich and diverse qualitative data.

6. Data Analysis Technique

The data were analyzed using thematic analysis through the following steps:

a) Reading all student responses to understand the general meaning.
b) Identifying main themes based on similarities in the content of the answers.
c) Categorizing responses into themes such as clarity of teacher explanations, calculation skills, elements of games or puzzles, and relevance to everyday life.
d) Drawing conclusions based on patterns emerging from the themes and linking them to relevant theories and previous research.

C. Results and Discussion

1. Result

Based on research conducted with several students at the research site, it was demonstrated that students enjoy mathematics due to the clarity of teacher explanations, calculation skills, elements of games or puzzles, relevance to everyday life, and connections to learning motivation theories. The following is an excerpt from an interview with the research subjects.

> *I like math lessons because of the teacher's explanation, and I like addition and subtraction. [S1]*
>
> *I like math lessons because we learn a lot of things like counting, and when the teacher gives homework, we have to count to get the result. [S2]*
>
> *I like mathematics because it also has puzzles, and when there are puzzles, it makes us concentrate fully on the subject. [S3]*
> *I like mathematics because we count a lot, but it does not make us bored because mathematics has puzzles that make us happy. [S4]*
>
> *My favorite math lesson is geometry because we learn to count the angles of squares, and so on. [S5]*
>
> *I like mathematics because it is always used in everyday life, and mathematics is the basis of all subjects. [S6]*
>
> *I like mathematics because it is the basis of our lives. Since I started school in the first cycle, my parents always taught me to count, so I like it when there is mathematics. [S7]*
>
> *I like math because it makes me enjoy counting, and there are puzzles about numbers. [S8]*

2. Discussion

Based on the questionnaires completed by the students, several key reasons emerged for their enjoyment of mathematics. To establish the primary findings, these qualitative statements were subjected to Inductive Thematic Analysis. This systematic method involved coding the raw data and clustering conceptually similar responses to yield four core themes: (1) clarity of teacher explanations, (2) proficiency in calculation skills, (3) the inclusion of games or puzzle elements, and (4) the perceived relevance of mathematics to everyday life. This rigorous grouping process ensures the themes accurately reflect the students' authentic perspectives. Furthermore, the findings demonstrate that student interest in mathematics is shaped by a unique combination of pedagogical, cognitive, and contextual factors within this environment. Specifically, pedagogical factors are represented by theme (1), highlighting the necessity of effective instruction; cognitive factors are evidenced by themes (2) and (3), reflecting the students' enjoyment of personal competence and intellectual challenge; and contextual factors are captured by theme (4), underscoring the importance of real-world applicability in their specific setting.

a. Clarity of Teacher Explanations

Some students indicated that they enjoyed mathematics because their teachers explained concepts clearly and understandably (e.g., S1). This aligns with Zheng (2021) view that teaching quality, including clarity in delivering content, significantly influences student engagement and learning outcomes. Teachers who present concepts systematically help reduce students' anxiety toward mathematics, a subject often perceived as challenging.

b. Calculation Skills

Another reason mentioned was the enjoyment of calculation activities, such as addition, subtraction, or measuring angles in geometry (S2, S5, S8). These activities were seen as both challenging and enjoyable. According to skill acquisition theory, successfully mastering fundamental skills like calculations boosts students' confidence, which in turn strengthens their motivation to learn (Akendita et al., 2024; Khawwaf et al., 2024; Oumelaid et al., 2025).

c. Elements of Games or Puzzles

Some students (S3, S4, S8) reported enjoying mathematics due to the presence of puzzles or challenges that require full concentration. This suggests that incorporating game-based learning can be an effective strategy for enhancing students' cognitive engagement. Mageed (2024), Nairo et al. (2023), Rahmawati & Wahyudi (2025) highlights that challenge- and puzzle-based approaches promote creative thinking and encourage students to persist in problem-solving.

d. Relevance to Everyday Life

Students also related mathematics to real-life applications, as expressed by S6 and S7. They perceived mathematics as foundational not only to other subjects but also to essential life skills. This finding is consistent with the National Council of Teachers of Mathematics (NCTM), which asserts that learning mathematics becomes more meaningful when students understand its connection to real-world contexts (Nasution & Suyanto, 2023). Recognizing these connections helps foster intrinsic motivation, as students can directly see the value of what they are learning.

e. Connection to Learning Motivation Theories

Overall, the students' responses reflect strong intrinsic motivation, driven by enjoyment, intellectual challenge, and awareness of practical benefits. This aligns with Nguyen-Viet & Nguyen-Viet (2025), which emphasizes the fulfillment of three basic psychological needs: competence (feeling capable), autonomy (choosing enjoyable learning approaches), and relatedness (connecting learning to real life) as essential for sustaining long-term learning motivation.

D. Conclusion

This study offers a novel contribution to understanding students' perceptions of mathematics learning in the Oe-Cusse region of Timor-Leste, focusing specifically on seventh-grade students at *Ensino Básico 3º Ciclo Santo António de Oe-Cusse*. The findings indicate that students' interest in mathematics is shaped by a unique combination of pedagogical, cognitive, and contextual factors within this environment. Four key factors motivating students were identified: (1) clear teacher explanations that facilitate understanding, (2) enjoyment of calculation activities such as addition, subtraction, and geometry, (3) the presence of games or puzzles that challenge concentration and creativity, and (4) awareness of the relevance of mathematics to everyday life.

References

Akendita, P. A., Obeng, B. A., Abil, M., & Ahenkorah, M. (2024). Investigating the effect of socio-constructivist mathematics teaching on students' mathematics achievement : The mediating role of mathematics self-efficacy. *Educational Point*, *1*(2), e110. https://doi.org/10.71176/edup/15662%0AARTICLE

Ampadu, E., & Anokye-poku, D. (2022). Influence of Personal , Motivational and Learning Environment Factors on Students' Attitudes toward Mathematics. *International Journal of Research in Education and Science (IJRES)*, *8*(2), 378–392. https://doi.org/https://doi.org/10.46328/ijres.2666

Khawwaf, Z. Z., Mahdad, A., Gatfan, M. S., & Farhadi, H. (2024). The Impact of Learning Strategies, Self-Efficacy Perception, Self-Esteem, Self-Regulation, and Academic Achievement on Academic Motivation among Students at the University of Dhi Qar: The Moderating Role of Gender and the Mediating Role of Psychological C. *International Journal of Education and Cognitive Sciences*, *5*(4), 150–164. https://doi.org/10.61838/kman.ijecs.5.4.16

Mageed, I. A. (2024). The Mathematization of Puzzles or Puzzling Mathematics Innovative Teaching of Mathematics. *Preprints.Org*. https://doi.org/10.20944/preprints202409.0609.v1

Nairo, M. A. I., Kase, E. B. S., & Maly, E. I. D. J. (2023). The Impact of Puzzle Games on the Creative Thinking Skills of Kindergarten Students at St. Maria Ratu Rosario Waipaddi Southwest Sumba. *Multidisciplinary Journal*, *2*(1), 43–56. https://doi.org/10.56916/jirpe.v4i3.1383

Nasution, K., & Suyanto, S. (2023). A Comparison of Students' Mathematical Communication Ability taught by Contextual Teaching and Learning versus Problem Based Learning.

Jurnal Pendidikan Progresif, *13*(2), 255–267. https://doi.org/10.23960/jpp.v13.i2.202309

Nguyen-Viet, B., & Nguyen-Viet, B. (2025). The synergy of immersion and basic psychological needs satisfaction: Exploring gamification's impact on student engagement and learning outcomes. *Acta Psychologica*, *252*, 104660. https://doi.org/10.1016/j.actpsy.2024.104660

Oranga, J., & Matere, A. (2023). Qualitative Research: Essence, Types and Advantages. *Open Access Library Journal*, *10*, 1–9. https://doi.org/10.4236/oalib.1111001

Oumelaid, N., Boukari, B. El, & Ghordaf, J. El. (2025). Analyzing the impact of digital classrooms on mathematics calculation skills and learners' motivation. *Journal of Education and Learning (EduLearn)*, *19*(3), 1270–1278. https://doi.org/10.11591/edulearn.v19i3.22564

Rahmawati, N., & Wahyudi. (2025). Enhancing Mathematical Problem-Solving Skills Through the Development of Mission-Based Puzzle Learning Media in Primary Education. *Journal of Innovation and Research in Primary Education*, *4*(3), 521–531. https://doi.org/10.56916/jirpe.v4i3.1383

Shirawia, N., Alali, R., Wardat, Y., Tashtoush, M. A., Saleh, S., & Helali, M. (2023). Logical Mathematical Intelligence and its Impact on the Academic Achievement for Pre-Service Math Teachers. *Journal of Educational and Social Research*, *13*(6), 239–254. https://doi.org/10.36941/jesr-2023-0161

Taherdoost, H. (2022). Designing a Questionnaire for a Research Paper: A Comprehensive Guide to Design and Develop an Effective Questionnaire. *Asian Journal of Managerial Science*, *11*(1), 8–16. https://doi.org/10.51983/ajms-2022.11.1.3087

Zheng, J. (2021). A Functional Review of Research on Clarity, Immediacy, and Credibility of Teachers and Their Impacts on Motivation and Engagement of Students. *Frontiers in Psychology*, *12*, 1–10. https://doi.org/10.3389/fpsyg.2021.712419

International Journal of Research in Mathematics Education
Vol. 3 No. 2, December 2025, 203-216
Universitas Islam Negeri Prof. K.H. Saifuddin Zuhri Purwokerto
e-ISSN: 3025-7638, p-ISSN: 3025-1842

Teachers' Experiences with Students' Learning Obstacles in Geometric Thinking: Insights from the van Hiele Framework

Nur'aini Muhassanah[1]✉; Muhammad 'Azmi Nuha[2]; Riski Aspriyani[3]

[1]*Department of Mathematic, Universitas Nahdlatul Ulama Purwokerto, Indonesia*
[2]*Departement of Mathematics Education, Universitas Islam Negeri Profesor Kiai Haji Saifuddin Zuhri Purwokerto, Indonesia*
[3]*Departement of Mathematics, Universitas Nahdlatul Ulama Al Ghazali Cilacap, Indonesia*

✉ *Corresponding email:* *nuraini.muhassanah8790@gmail.com*

Received October 23, 2025
Accepted November 18, 2025
Published December 31, 2025

https://doi.org/10.24090/ijrme.v3i2.15429

Abstract: Understanding geometric concepts is often a challenge for students because it requires spatial thinking and deductive reasoning skills that develop gradually. This study aimed to describe the barriers to student learning in geometric thinking based on teacher perceptions, using Van Hiele's theoretical framework. The research approach used was qualitative with a phenomenological design, involving 49 junior high school mathematics teachers from 35 schools across seven districts. Data were collected through questionnaires and in-depth interviews, and then analyzed thematically. Interview data were collected from only six teachers selected through purposive sampling. The study's results showed that students' learning barriers increased as their geometric thinking level improved. At level 0 (Visualization), the barriers were moderate (58.63%) because students were still able to recognize shapes visually. At level 1 (Analysis), the barriers increased to 64.61% (high category) because students struggled to identify relationships between the properties of shapes. At level 2 (Informal Deduction), the barriers reached 72.48% (high category), especially in the use of formal mathematical language and the preparation of logical arguments. In addition, the results showed that epistemological barriers were related to a weak mastery of basic concepts, ontological barriers were related to the misclassification of geometric objects, and didactic barriers stemmed from external factors, such as learning strategies and learning motivation. Overall, these results highlight the importance of developing contextual, tiered, and exploratory geometry learning designs to mitigate learning barriers at every level of student thinking.

Keywords: geometric thinking; learning obstacles; van hiele theory; mathematics teachers' perceptions; didactical design

A. Introduction

Geometry is a fundamental domain of mathematics that plays a crucial role in fostering students' spatial reasoning and logical thinking abilities. As noted by Jones (2000), geometry not only enables students to recognize and describe shapes and spatial relationships but also cultivates deductive reasoning and complex problem-solving skills. Furthermore, through geometry learning, students are expected to develop a deep understanding of conceptual relationships and apply mathematical reasoning in diverse real-world contexts (NCTM, 2000).

Therefore, geometry is a fundamental discipline in fostering students' higher-order thinking skills.

Ideally, students should develop geometric abilities that include a conceptual understanding of shape properties, the capacity to analyze relationships between concepts, and the skill to construct logical arguments. Van de Walle et al. (2001) emphasized that strong geometric abilities are reflected in students' understanding of mathematical ideas through visual, symbolic, and verbal representations. Consequently, geometry instruction should cultivate students' skills in abstraction, generalization, and formal proof, rather than merely recognizing shapes or applying formulas.

The challenges of learning geometry at the junior high school level in Indonesia remain considerable. According to the 2019 Trends in International Mathematics and Science Study (TIMSS), Indonesian students' mathematical abilities, particularly in the geometry domain, are still below the international average. The average mathematics score for Indonesian students was 397, significantly lower than the international average of 500. By content domain, Indonesian students' performance in geometry was approximately 392, lower than in the number domain (399), data and probability (403), and algebra (398) (Mullis et al., 2020)(OECD, 2023). These findings suggest that mastering geometric concepts remains a significant challenge for Indonesian students.

Furthermore, the 2022 Program for International Student Assessment (PISA) results indicate that Indonesian students' mathematical literacy remains below the OECD average. The average mathematics score for Indonesian students was approximately 366 points, considerably lower than the OECD average of 472 points. This gap highlights a significant global disparity in students' mastery of mathematical concepts and reasoning. Moreover, only about 18% of Indonesian students achieved at least Level 2 in mathematics, compared to an average of approximately 69% among OECD countries (OECD, 2023).

These findings reveal a substantial gap in the mastery of mathematical concepts and reasoning worldwide, including in geometry. One factor contributing to this low achievement is the learning obstacles that students encounter. Brousseau (1997) defines learning obstacles as conceptual difficulties that emerge from a misalignment between students' cognitive approaches and the knowledge structures being taught.

In the context of geometry, these obstacles can include students' limitations in understanding basic geometric concepts (Firdaus & Robandi, 2025; Fitria & Maarif, 2021), difficulties in understanding definitions and relationships between shapes, including reading, modeling, solving, and concluding geometric problems (Fitria & Maarif, 2021; Nu'man & Azka, 2023), and students also experience difficulties in applying concepts and visualizing geometric objects (Noto et al., 2019). These obstacles make it difficult for students to progress from one stage of thinking to the next.

This learning obstacle is inextricably linked to field learning practices that do not fully support students' development of geometric thinking. According to research by Yurniwati & Soleh (2021)Geometry learning in schools is still dominated by procedural approaches and formula memorization, while reasoning and conceptual exploration receive less attention. As a result, students prefer to recognize shapes based on visual appearance rather than understanding their underlying properties. This mismatch between teaching strategies and students' thinking levels makes geometry learning less effective in building conceptual understanding.

One relevant framework for understanding the development of students' geometric thinking is van Hiele's theory of levels of thinking (van Hiele, 1986). This theory posits that geometric thinking develops through five hierarchical levels: Level 0 (Visualization), Level 1 (Analysis), Level 2 (Informal Deduction), Level 3 (Formal Deduction), and Level 4 (Rigor) (Crowley, 1987; MdYunus et al., 2019; Usiskin, 1982). Usiskin (1982) emphasized that each level has distinct characteristics and cognitive demands, making it essential for teachers to identify students' current levels to tailor instructional strategies appropriately. Therefore, van Hiele's theory provides a systematic framework for understanding how students learn and reason geometrically.

Based on this theory, to design effective geometry instruction, teachers need to identify the learning barriers that students encounter at each level of thinking. The process of moving from one level to the next requires structured learning experiences that align with students' thinking characteristics. Without understanding the learning barriers at each level, learning risks not matching students' cognitive readiness (Fuys et al., 1984).

Understanding learning obstacles based on van Hiele's levels of thinking also plays a crucial role in developing geometry didactic design. Identifying learning obstacles can serve as a basis for teachers in conducting didactic analysis, which involves adapting learning designs to students' learning potential and difficulties (Suryadi, 2013). Thus, analyzing learning obstacles not only illustrates students' difficulties but also contributes to the development of more contextual and thought-oriented learning strategies

Based on this context, in-depth research is necessary to investigate students' learning obstacles in geometric thinking from the perspective of teachers. As direct observers of students' learning processes in the classroom, teachers can offer valuable insights into the factors contributing to students' difficulties in understanding geometry. This study aims to explore teachers' experiences in identifying and addressing these learning obstacles, using van Hiele's theory as the analytical framework.

B. Methods

This study employed a qualitative approach with a phenomenological design, aiming to explore teachers' experiences in depth in identifying students' learning obstacles in geometry instruction, based on van Hiele's theoretical framework. The phenomenological approach was chosen because it enables researchers to understand the meanings and subjective experiences of teachers within the context of everyday classroom practice (Creswell, 2019). The research subjects consisted of 49 junior high school mathematics teachers from 35 schools across seven districts. The teachers' teaching experience ranged from 1 to 35 years, providing a representative sample that captures variations in background, professional experience, and geometry teaching practices in the field.

The research data were collected using two main techniques: a questionnaire and semi-structured interviews. First, quantitative-descriptive data were obtained through a five-point

Likert scale questionnaire, with the following categories: 1 = very rare, 2 = rare, 3 = sometimes, 4 = often, and 5 = very often. The questionnaire comprised nine statements, grouped according to three levels of geometric thinking based on van Hiele's theory: Level 0 (Visualization), Level 1 (Analysis), and Level 2 (Informal Deduction). Each statement was designed to identify the types of learning obstacles frequently encountered by students, as observed and experienced by teachers during the teaching and learning process.

The questionnaire data on students' learning obstacles in geometry, based on van Hiele's theory, were analyzed using descriptive frequency analysis. This analysis aimed to determine the intensity of learning obstacles experienced by students, as perceived by teachers, at each level of geometric thinking. The percentage score for each indicator is calculated using the following formula:

$$P = \frac{SR}{SM} x \ 100\%$$

Explanation:
P = Percentage score obtained
SR = Total score obtained
SM = Maximum possible score

The obtained percentage scores were subsequently classified into categories of learning obstacle levels to facilitate data interpretation. The classification scheme was adapted from Purwanto (2012), as presented in the following table.

Table 1. Categories of Students' Learning Obstacle Levels

Percentage of Learning Obstacle (P)	**Category**
81,25 ≤ P ≤ 100	Very High
62,5 ≤ P < 81,25	High
43,75 ≤ P < 62,5	Moderate
25 ≤ P < 43,75	Low
≤ 25	Very Low

These categories were used to interpret and describe the levels of students' learning obstacles at each stage of geometric thinking, based on teachers' perceptions. Accordingly, the analysis provides an overall picture of the extent to which learning obstacles occur in geometry learning, as framed by van Hiele's theoretical framework.

Next, in-depth interviews were conducted with six teachers, selected through purposive sampling based on the results of the questionnaire. The interviews aimed to gain deeper insights into teachers' experiences in addressing students' difficulties in geometry, particularly the learning obstacles encountered during instruction. Data analysis followed the qualitative analysis procedures outlined by Bogdan & Biklen (2007), which include: (1) data organization, (2) data reduction, (3) categorization and coding, (4) identification of main themes, and (5) drawing conclusions and verification.

The questionnaire data were analyzed using descriptive quantitative methods to examine teachers' perceptions of learning obstacles at each level of geometric thinking. Meanwhile, the interview data were analyzed thematically to identify patterns of meaning and experiences emerging from teachers' narratives. The results from both data sources were then validated through methodological triangulation to obtain a more comprehensive understanding of geometry learning obstacles from the teachers' perspective.

C. Results and Discussion

1. Results of the Questionnaire on Students' Learning Obstacles

The analysis of questionnaire responses from 49 junior high school mathematics teachers revealed variations in students' learning obstacle levels in geometry across the three stages of geometric thinking, as outlined in van Hiele's theory. A summary of the percentage calculations and corresponding categories is presented in Table 2.

Table 2. Students' Learning Obstacle Percentages by van Hiele Levels of Thinking

No	van Hiele Level of Thinking	Percentage (%)	Category
1	Level 0 (Visualization)	58,63	Moderate
2	Level 1 (Analysis)	64,61	High
3	Level 2 (Informal Deduction)	72,48	High

Based on Table 2, it can be observed that students' learning obstacles increase with higher levels of geometric thinking. At level 0 (Visualization), the learning obstacle percentage was 58.63%, classified as moderate, indicating that students were still able to recognize geometric shapes visually. At level 1 (Analysis), the learning obstacle percentage rose to 64.61%, indicating that some students still struggled to understand the concept of shape properties, even though they could accurately identify visual forms. At level 2 (Informal Deduction), the learning obstacle percentage reached 72.48%, the highest among the three levels. This indicates that students began to encounter difficulties in understanding relationships between shape properties and in making simple generalizations.

These findings suggest that the higher the level of geometric thinking required, the greater the learning obstacles students encounter. This is consistent with van Hiele's (1986) assertion that the development of geometric thinking is hierarchical, whereby students cannot reach higher levels of thinking without engaging in learning experiences that support transitions from the preceding levels.

Table 3. Students' Learning Obstacles in Geometry by van Hiele Levels of Thinking

No	**Learning Obstacle**	**Percentage (%)**	**Category**
Level 0 (Visualization)			
1	Students only recognize shapes by their appearance without understanding their properties.	60	Moderate
2	Students often struggle to state the properties of plane/solid shapes.	56,41	Moderate

No	Learning Obstacle	Percentage (%)	Category
3	Teachers find it challenging to guide students to understand shape properties beyond memorizing names.	59,48	Moderate
Level 1 (Analysis)			
4	Students struggle to understand that one property of a shape can be derived from other geometric properties.	66,15	High
5	Students often struggle to make generalizations from geometric properties.	66,67	High
6	Teachers find it challenging to train students to see relationships between shape properties.	61,02	High
Level 2 (Informal Deduction)			
7	Students often struggle to construct logical arguments to prove geometric statements.	70,25	High
8	Students are not yet accustomed to using formal mathematical language.	74,36	High
9	Teachers find it challenging to teach formal proofs because students are not yet familiar with deductive reasoning patterns.	72,82	High

Based on Table 3, the results of the questionnaire analysis indicate that students' learning obstacles in geometry vary across the different van Hiele levels of thinking. In general, learning obstacles at Level 0 (Visualization) fall within the moderate category, whereas those at Level 1 (Analysis) and Level 2 (Informal Deduction) are categorized as high. These findings suggest that the higher the level of geometric thinking, the greater the difficulties students experience in understanding concepts and engaging in mathematical reasoning. To provide a deeper understanding, the following section presents a detailed description of the findings at each van Hiele level of thinking.

At Level 0 (Visualization), students' learning obstacles fall within the moderate category, with an average percentage of 58.63%. The most frequent obstacles identified include students' tendency to recognize shapes solely based on their visual appearance without understanding their properties (60%), and their difficulty in describing the characteristics of plane and solid figures (56.41%). In addition, teachers reported challenges in guiding students to move beyond memorizing shape names toward developing a conceptual understanding of their characteristics (59.48%). These findings suggest that at the visualization stage, students' understanding remains limited to recognizing concrete shapes without associating them with their geometric properties. This aligns with van Hiele's (1986) At the initial stage of geometric thinking, students tend to rely on visual perception rather than logical reasoning to comprehend geometric concepts.

Learning obstacles at the Analysis level are categorized as high, with an average percentage of 64.61%. The most common difficulties experienced by students include making generalizations from the properties of geometric figures (66.67%) and understanding that one property of a shape can be derived from another (66.15%). These obstacles indicate that most students are not yet able to think analytically to identify logical relationships among geometric properties. In addition, teachers reported challenges in training students to recognize interrelationships among geometric attributes (61.02%), suggesting that reasoning-based instructional approaches remain limited. This finding is consistent with Jones (2000), who stated that many students struggle to connect geometric concepts hierarchically because instruction often emphasizes memorization of shape properties rather than analyzing conceptual relationships.

At the Informal Deduction level, students' learning obstacles are categorized as high, with an average percentage of 72.48%. The most dominant difficulties occur in students' ability to use formal mathematical language (74.36%), followed by challenges in constructing logical arguments to justify geometric statements (70.25%). Teachers also reported similar difficulties, particularly in teaching formal proofs, as students are not yet accustomed to deductive patterns of reasoning (72.82%). These findings indicate that most students have not yet reached the level of informal deductive thinking as described in the van Hiele theory. Such difficulties often arise because students do not experience a systematic and sequential learning process from visualization to deduction, which limits their development of logical reasoning and the use of formal mathematical language (Usiskin, 1982)

2. Results of Teacher Interviews

Based on interview data obtained from six junior high school mathematics teachers, various forms of learning obstacles experienced by both students and teachers in geometry learning were identified. The data reduction process involved selecting statements relevant to the research focus and grouping them into themes with similar meanings. Each reduced theme was then analyzed in depth to determine the underlying types of learning obstacles that contributed to the difficulties in geometry learning, specifically epistemological, ontological, and didactical obstacles.

The categorization enables researchers to identify the sources and nature of the difficulties that arise during geometry learning—whether they stem from students' modes of thinking and knowledge structures, from their understanding of the nature of geometric objects, or from the instructional situations designed by teachers. This analytical process provides a comprehensive overview of the underlying causes of learning obstacles in geometry education. Table 4 presents the results of data reduction, the emerging themes, and the relationships between these themes and the identified types of learning obstacles.

Table 4. Results of Data Reduction, Emerging Themes, and the Relationship Between Themes and Types of Learning Obstacles in Geometry Learning

Theme	Associated Type of Learning Obstacle
Students' low ability to abstract geometric figures.	Epistemological Obstacle
Students' prerequisite knowledge of geometry is very limited.	
Students experience difficulties in understanding geometric concepts	
Students struggle to determine the properties of geometric shapes	
Students have weak basic arithmetic skills	
Students find it difficult to distinguish between types of geometric figures	Ontological Obstacle

Theme	Associated Type of Learning Obstacle
Students often struggle to differentiate between the surface area, perimeter, and volume of solids.	
Students have varying levels of ability	
Students lack motivation to learn mathematics	
Teachers face challenges in using appropriate learning media	
Students show poor preparation before starting lessons	Didactical Obstacle
Teachers face challenges in integrating technology-based media in teaching	
Limited instructional time for mathematics learning	
Teachers find it difficult to develop effective instructional methods and media	

Based on Table 4, three main categories of learning obstacles were identified in geometry learning: epistemological, ontological, and didactical obstacles. Epistemological obstacles include students' limited ability to abstract geometric figures, inadequate prerequisite knowledge, difficulties in understanding the properties of geometric shapes, and weak computational skills. These obstacles emerge when students' prior knowledge is insufficient to construct new concepts, resulting in procedural rather than conceptual understanding. This finding aligns with Brousseau's (Brousseau, 2002) view that knowledge which is valid in one context may become an obstacle when applied in a new context, indicating that misconceptions or incomplete understanding can hinder the development of more advanced geometric thinking.

Ontological obstacles are evident when students misclassify geometric objects or quantities, such as perceiving area, perimeter, and volume as having the same meaning. This difficulty reflects students' lack of understanding of the nature and dimensionality of geometric objects. Such misconceptions suggest that students have not yet developed an adequate conceptual framework to differentiate between geometric attributes. Therefore, instructional approaches that emphasize visual exploration and manipulative learning experiences are crucial in helping students construct more accurate conceptual distinctions among geometric categories.

Meanwhile, didactical obstacles arise from learning situations that are not sufficiently adaptive to students' characteristics. Variations in students' abilities, low motivation, limited access to instructional media and technology, as well as restricted classroom time, hinder the overall learning process. These challenges underscore the need to develop contextual and varied instructional designs that effectively integrate technology to cater to students' diverse needs and foster more meaningful learning experiences.

Overall, the three types of learning obstacles are interrelated. Epistemological and ontological obstacles stem from the structure of students' knowledge, while didactical obstacles arise from teachers' instructional strategies and the broader learning context. The identification of these obstacles provides a critical foundation for developing didactical designs aimed at enhancing students' conceptual understanding and geometric reasoning.

3. Discussion

The questionnaire analysis revealed that students experienced varying degrees of learning obstacles at each level of geometric thinking, as outlined in van Hiele's theory. The increase in obstacle percentages from 58.63% (moderate category) at the Visualization level, to 64.61% (high category) at the Analysis level, and 72.48% (high category) at the Informal Deduction level indicates a hierarchical pattern in students' difficulties with geometric reasoning. This finding supports van Hiele's view that the development of geometric thinking is gradual and sequential, where students cannot progress to higher levels of reasoning without learning experiences that facilitate transitions from previous levels.

At level 0 (Visualization), most students recognize geometric figures primarily based on their visual appearance rather than their conceptual properties. This finding aligns with Clements and Battista (1992), who state that at the initial stage of geometric thinking, students rely more on visual perception than on logical reasoning. Teachers also reported that students tend to memorize the names of shapes without understanding their characteristics (59.48%), indicating a limited ability to abstract. This supports the view that understanding geometry depends not only on visual recognition but also on the ability to transition from visual to conceptual representations.

At level 1 (Analysis), learning obstacles increased (64.61%) as students began to struggle in identifying relationships among the properties of geometric figures and in making simple generalizations. This difficulty indicates that some students are not yet capable of the analytical thinking required to derive one property from another. Jones (2000) explains that many students fail to perceive the hierarchical relationships among geometric concepts because classroom instruction remains focused on memorizing properties rather than on reasoning and conceptual analysis. This finding illustrates that students' thinking processes are still predominantly procedural rather than conceptual.

At level 2 (Informal Deduction), learning obstacles reached their highest point (72.48%), particularly in students' ability to use formal mathematical language (74.36%) and construct logical arguments for geometric proofs (70.25%). These difficulties indicate that students are not yet accustomed to deductive reasoning. Usiskin (1982) and Senk (1989) emphasized that the transition from empirical to deductive reasoning requires systematic and exploratory learning experiences. However, teachers in this study acknowledged that classroom instruction has not yet fully provided students with opportunities to practice logical reasoning and construct mathematical arguments. Therefore, these findings highlight that the development of students' geometric thinking requires a structured and continuous instructional design (Crowley, 1987).

Interviews with six junior high school mathematics teachers revealed three main categories of learning obstacles in geometry learning: epistemological, ontological, and didactical obstacles. These three categories provide a more comprehensive understanding of the sources and nature of students' difficulties in learning geometry.

Epistemological obstacles are related to students' limited prior knowledge and abstraction abilities. Students tend to understand geometric concepts procedurally without connecting them to deeper conceptual meanings. According to Brousseau (Brousseau, 2002)Epistemological obstacles arise when knowledge that is valid in one context becomes a barrier in a new context. In this case, students rely on visual recognition strategies that were previously effective but become inadequate when they are required to understand the properties and relationships among geometric figures in a more formal and abstract manner.

Ontological obstacles arise when students misclassify geometric objects and quantities, such as perceiving area, perimeter, and volume as equivalent concepts. This misconception suggests that students' understanding of the nature and dimensionality of geometric objects remains immature. Radford (Radford, 2002) explains that ontological obstacles stem from a conflict between how students conceptualize mathematical objects and their formal definitions. Therefore, visual and manipulative exploration-based learning is necessary to help students accurately reconstruct the meaning of geometric concepts and develop a more coherent conceptual framework.

Didactical obstacles stem from learning contexts that are not aligned with students' cognitive readiness. Teachers face various challenges, such as differences in students' abilities, low learning motivation, limited instructional media and technology, and restricted instructional time. Barquero (2015) notes that didactical obstacles can emerge when the *didactic contract* between teachers and students fails to adapt to students' conceptual needs. Therefore, teachers need to design instructional strategies that are more adaptive, contextual, and technology-based to enhance the effectiveness of geometry learning and support students' conceptual development.

These three types of learning obstacles are interrelated and collectively influence the overall effectiveness of geometry learning. Epistemological and ontological obstacles originate from students' cognitive structures, whereas didactical obstacles arise from instructional situations that fail to support students' cognitive development. This aligns with Brousseau's (2002) theory, which asserts that learning difficulties cannot be overcome merely by improving instructional content, but by reconstructing learning situations that foster meaningful conceptual interaction between students, teachers, and the mathematical knowledge itself.

An important implication of these findings is the need to develop contextual, hierarchical, and exploratory didactical designs in geometry instruction. Approaches such as inquiry-based learning, the use of dynamic geometry software (e.g., *GeoGebra*) (Afinda, 2023)Visual manipulative activities can facilitate students in constructing logical and progressive connections among geometric concepts. Battista (Clements & Battista, 1992) emphasizes that effective geometry learning should focus on fostering spatial and relational reasoning, rather than merely recognizing shapes or memorizing formulas.

D. Conclusion

Based on the analysis results, students' learning obstacles in geometry increase as their geometric thinking levels progress, in line with van Hiele's theory. At level 0 (Visualization), the obstacles are relatively moderate (58.63%), as students are generally able to recognize geometric shapes visually, although they have not yet developed a conceptual understanding of their properties. At level 1 (Analysis), the obstacles rise to 64.61% (high category), indicating that students begin to experience difficulties in identifying logical relationships among geometric properties and in making generalizations. Meanwhile, at level 2 (Informal Deduction), the obstacles reach the highest level (72.48%, high category), particularly in students' ability to use formal mathematical language and construct logical arguments in geometric proofs.

In addition, the analysis identified three main categories of obstacles in geometry learning: epistemological, ontological, and didactical. Epistemological obstacles arise from students' weak mastery of fundamental concepts and limited abstraction skills, resulting in a predominantly procedural understanding rather than a conceptual one. Ontological obstacles emerge when students misclassify geometric objects or quantities, indicating an incomplete understanding of the fundamental nature of geometric concepts. Meanwhile, didactical obstacle*s* stem from external factors such as differences in students' abilities, limited instructional media, low learning motivation, and less adaptive teaching strategies.

Overall, these three types of obstacles are interrelated and collectively influence the effectiveness of geometry learning. Therefore, it is essential to design contextual, sequential, and exploration-based didactical approaches that facilitate the gradual development of students' conceptual understanding and help minimize learning obstacles at each level of geometric thinking.

Acknowledgement

The author would like to express sincere gratitude to the junior high school mathematics teachers who participated in this study for their willingness and valuable contributions in sharing their experiences regarding geometry learning. Appreciation is also extended to the schools and education offices across the seven districts for their support and permission during the data collection process. The author would also like to thank colleagues and research supervisors for their insightful feedback and guidance in preparing and refining this article. This research was successfully conducted with the help and support of many parties who cannot be mentioned individually.

References

Afinda, D. A. N. (2023). The Effect Of Student Team Achviement Divisions Model Assisted With Geogebra Media On Understanding Of Mathematical Concepts Of Circle Materials In Class VIII Students Of SMP Muhammadiyah 1 Purwokerto. *International Journal of Research in Mathematics Education*, *1*(1), 23–34. https://doi.org/10.24090/ijrme.v1i1.8540

Barquero, B., & Bosch, M. (2015). *Didactic Engineering as a Research Methodology: From Fundamental Situations to Study and Research Paths*. Springer International Publishing Switzerland. https://doi.org/10.1007/978-3-319-09629-2_8

Bogdan, R. C., & Biklen, S. K. (2007). *Qualitative research for education: An introduction to theories and methods (5th ed.)*. Pearson.

Brousseau. (2002). Theory of Didactical Situations in Mathematics. In *Theory of Didactical Situations in Mathematics*. Kluwer Academic Publishers. https://doi.org/10.1007/0-

306-47211-2

Clements, & Battista. (1992). *Geometry and spatial reasoning*. Macmillan Publishing.

Creswell, J. W. (2019). Educational Research: Planing, Conducting, and Evaluating Quantitative and Qualitative Reseach. In *Sustainability (Switzerland)* (Vol. 1, Issue 4). http://scioteca.caf.com/bitstream/handle/123456789/1091/RED2017-Eng-8ene.pdf?sequence=12&isAllowed=y%0Ahttp://dx.doi.org/10.1016/j.regsciurbeco.2008.06.005%0Ahttps://www.researchgate.net/publication/305320484_SISTEM_PEMBETUNGAN_TERPUSAT_STRATEGI_MELESTARI

Crowley. (1987). The van Hiele model of the development of geometric thought. *Learning and Teaching Geometry, K-12*, 1–16. http://www.csmate.colostate.edu/docs/math/mathactivities/june2007/The van Hiele Model of the Development of Geometric Thought.pdf

Firdaus & Robandi. (2025). Analisis Hambatan Belajar Siswa Pada Materi Geometri di Sekolah Dasar. *Jurnal Basicedu*, *9*(1), 105–113.

Fitria, S. D., & Maarif, S. (2021). Hambatan epistemologi pada pembuktian geometri sederhana siswa smp ditinjau dari resiliensi matematis. *JPMI: Jurnal Pembelajaran Matematika Inovatif*, *4*(3), 529–540. https://doi.org/10.22460/jpmi.v4i3.529-540

Fuys, Tischler, & Geddes. (1984). *The Van Hiele model of thinking in geometry among adolescents.* National Institute of Education, City University of New York.

Hiele, P. M. van. (1986). *Structure and insight : a theory of mathematics education*. Academic Press.

Jones, K. (2000). *Critical Issues in the Design of the Geometry Curriculum*. https://www.researchgate.net/publication/228477699

MdYunus, A. S., Ayub, A. F. M., & Hock, T. T. (2019). Geometric thinking of Malaysian elementary school students. *International Journal of Instruction*, *12*(1), 1095–1112. https://doi.org/10.29333/iji.2019.12170a

Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020). *TIMSS 2019 International Results in Mathematics*.

NCTM. (2000). *Principles and Standards for School Mathematics.* National Council of Teachers of Mathematics.

Noto, M. S., Priatna, N., & Dahlan, J. A. (2019). Mathematical proof: The learning obstacles of pre-service mathematics teachers on transformation geometry. *Journal on Mathematics Education*, *10*(1), 117–125. https://doi.org/10.22342/jme.10.1.5379.117-126

Nu'man, M., & Azka, R. (2023). Kesulitan Siswa dalam Menyelesaikan Masalah Geometri. *Polynom : Journal in Mathematics Education*, *3*(Knpmp I), 164–171. https://publikasiilmiah.ums.ac.id/bitstream/handle/11617/6955/17_154_Makalah Rev Della Narulita.pdf?sequence=1

OECD. (2023). *PISA 2022 Results:The State of Learning and Equity in Education(Volume I)*. OECD Publishing. https://doi.org/10.1787/53f23881-en

Purwanto. (2012). *Evaluasi hasil belajar*. Pustaka Pelajar.

Radford, L. (2002). The Seen, the Spoken and the Written: a Semiotic Approach to the Problem of Objectification of Mathematical Knowledge. *For the Learning of Mathematics*, *22*(22), 14–23.

Senk, S. L. (1989). Van Hiele Levels and Achievement in Writing Geometry Proofs. *Journal for Research in Mathematics Education*, *20*(3), 309. https://doi.org/10.2307/749519

Suryadi, D. (2013). DIDACTICAL DESIGN RESEARCH (DDR) DALAM PENGEMBANGAN PEMBELAJARAN MATEMATIKA. *Prosidang Seminar Nasional Matematik Dan Pendidikan Matematika*, *1*(1), 3–12.

Usiskin, Z. (1982). Van Hiele Levels And Achievement In Secondary School Geometry. In *Sustainability (Switzerland)* (Vol. 11, Issue 1). University of Chicago. http://scioteca.caf.com/bitstream/handle/123456789/1091/RED2017-Eng-8ene.pdf?sequence=12&isAllowed=y%0Ahttp://dx.doi.org/10.1016/j.regsciurbeco.2008.06.005%0Ahttps://www.researchgate.net/publication/305320484_SISTEM_PEMBETUNGAN_TERPUSAT_STRATEGI_MELESTARI

Van de Walle, J. (2001). Geometric thinking and geometric concepts. *Elementary and Middle School Mathematics: Teaching Developmentally.*, *4th*, 306–312.

Yurniwati, & Soleh, D. A. (2021). Analyzing Conceptual and Procedural Knowledge of Geometry Among Prospective Teachers: Indonesian Perspective. *Journal of Physics: Conference Series*, *1752*(1), 012067. https://doi.org/10.1088/1742-6596/1752/1/012067

This page has been intentionally left blank.