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Enhancing Students' Learning Outcomes through the Guided Inquiry Learning Model in Trigonometry

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ABSTRACT

Learning trigonometry remains a challenge for many students due to teacher-centered instruction and limited opportunities for conceptual exploration. This issue highlights the urgency of implementing innovative learning models that actively engage students in constructing their understanding. This study aimed to improve students' learning outcomes in trigonometry through the Guided Inquiry learning model. The research was conducted as Classroom Action Research (CAR) in two cycles, each consisting of two meetings, involving 30 Grade X vocational school students in Denpasar. Data were collected using essay tests to measure students' competence in trigonometry and analyzed quantitatively based on cognitive test results. The findings showed a steady improvement in learning outcomes: prior to the intervention, only 46.67% of students achieved mastery with an average score of 61.33; in Cycle I, mastery increased to 66.67% with an average score of 73.90; and in Cycle II, mastery reached 80% with an average score of 81.97. These results indicate that the Guided Inquiry learning model effectively enhanced students' understanding of trigonometric concepts and overall learning achievement. This improvement was influenced by the implementation of the Guided Inquiry learning model syntax, which encouraged students to develop a deeper understanding of trigonometry concepts. Therefore, it can be concluded that the Guided Inquiry learning model is effective in enhancing students' learning outcomes.

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Introduction

Mathematics is a highly important discipline in education. The National Council of Teachers of Mathematics (NCTM, 2000) stated that there are five core process standards in mathematics learning, namely problem-solving, reasoning, connections, communication, and representation. The Indonesian Ministry of Education and Culture Regulation No. 22 of 2016 establishes a comprehensive framework for mathematics learning objectives. The first objective is for students to understand mathematical concepts and apply them accurately and efficiently. Reasoning skills are emphasized through pattern analysis and the ability to construct mathematical arguments and statements. The third objective focuses on problem-solving, where students are expected not only to understand and model problems but also to find appropriate solutions. Finally, mathematical communication is highlighted, enabling students to convey ideas clearly through various representations such as diagrams, tables, or symbols. The extent to which these objectives are achieved can be seen from students' learning outcomes (Fernando, Andriani, & Syam, 2024). The success of education in schools can be monitored through the learning outcomes attained by students (Yanuar & Pius, 2023).

Learning outcomes serve as one of the primary benchmarks in education, as they indicate the competencies acquired by students after undergoing a series of learning experiences. They encompass three domains: cognitive (knowledge and understanding), affective (attitudes and values), and psychomotor (skills and physical performance). These domains are interrelated and collectively define students' overall competence. Furthermore, learning outcomes act as evaluative tools for teachers in assessing students' progress and the effectiveness of the teaching–learning process, as well as in determining subsequent instructional steps. Despite their crucial role, evidence from the field shows that learning outcomes remain far from expectations, thus posing a serious challenge in education (Rayahu, 2019). Data from the Programme for International Student Assessment (PISA) released in December 2023 confirmed that Indonesian students' numeracy skills remain low, ranking among the bottom 12 of all participating countries. The 2023 PISA results placed Indonesia in the bottom 12 out of 81 countries in numeracy (OECD, 2023). This assessment covered mathematical reasoning, problem-solving, and the application of mathematics in real-life contexts. These findings highlight the urgent need to improve Indonesian students' mathematical abilities, particularly in reasoning and problem-solving.

In addition, classroom observations reveal that many students still struggle with mathematics. Findings indicate that many students do not fully understand the subject, are passive during lessons, and lack interest in mathematics. Teachers often rely on lecture-based methods, which fail to motivate students to engage actively in learning. Interviews with a mathematics teacher at SMK Negeri 5 Denpasar revealed that students' average mathematical ability was still below standard. Students struggled to solve problems that differed from the examples previously taught. These difficulties reflect their lack of conceptual understanding. This aligns with Ayu et al. (2021), who reported that one of the main causes of students' difficulties in solving mathematical problems is insufficient conceptual understanding.

The issue of students' lack of conceptual understanding requires solutions, as it is one of the main factors behind low learning outcomes (Arrosyad et al., 2023). Low learning outcomes are often the result of instructional approaches that do not actively involve students. Conventional teacher-centered models tend to make students passive and hinder deeper understanding of the material. Hence, a shift in instructional practice is needed to improve learning outcomes. Achieving quality learning outcomes requires the use of appropriate instructional models (Cholid, et al., 2022). Therefore, a learning model that increases students' direct engagement in the learning process is essential, as the choice of instructional model greatly influences learning outcomes (Hasanah et al., 2025). One such model is Guided Inquiry.

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According to Ariesta & Awalludin (2021), the use of guided discovery learning can transform the learning atmosphere from passive to active and creative, shifting the focus from teacher-centered to student-centered learning. The Guided Inquiry model emphasizes students' active participation in the learning process while still receiving guidance from the teacher. Through prompting questions, teachers act as facilitators who help students discover new concepts based on their prior knowledge (Syaifuddin & Iswar, 2022; Marto et al., 2023).

Over the past decade, numerous studies have investigated the use of Guided Inquiry to improve learning outcomes, yielding significant results (Hartati, 2019; Sundari & Indrayani, 2019; Marhaeni, 2020; Fahmia, Karjiyati, & Dalifa, 2020; Segara et al., 2023). For instance, Segara et al. (2023) demonstrated that an inquiry-based approach improved mathematics learning outcomes among Grade VIII students at SMP Negeri 2 Bekri in the topic of plane figures during the 2021/2022 academic year. Students' mastery increased from 65.8 in the pre-cycle to 78.39 in Cycle I and 84.35 in Cycle II. These findings suggest that Guided Inquiry can enhance students' learning outcomes.

Similarly, Hartati (2019) found that the use of the Guided Inquiry model improved Grade X students' mathematics learning outcomes in trigonometry. Previous studies thus indicate that Guided Inquiry has been widely applied at elementary, junior high, and senior high school levels, as well as in various subjects. However, relatively few studies have specifically implemented Guided Inquiry in vocational schools, particularly in mathematics learning on trigonometry. This presents an opportunity to further explore the effectiveness of Guided Inquiry in vocational education, which is characterized by more applied learning.

Internationally, the concern with improving mathematics outcomes has long been tied to the role of instructional models and teacher workload. As early as the 1950s, Skinner (1958) argued that instructional innovations could "lighten the teacher's load" by automating repetitive tasks and enabling teachers to focus on higher-order guidance. Although Skinner's "teaching machines" are now technologically outdated, the underlying principle remains relevant: effective pedagogy should both enhance learning outcomes and reposition the teacher from transmitter of knowledge to facilitator of meaningful engagement. Within this perspective, inquiry-based learning represents a modern continuation of the same logic. By structuring classroom processes so that learners are actively involved in constructing knowledge, models such as Guided Inquiry address students' conceptual gaps while also promoting a more sustainable and impactful teaching role. This dual focus on learner outcomes and teacher effectiveness positions Guided Inquiry as a timely response to the persistent challenges highlighted by both international assessments (OECD, 2023) and local classroom observations. As early as the 1960s, Bruner (1961) highlighted that discovery-based approaches encourage learners to construct knowledge more meaningfully, laying the foundation for modern guided inquiry models. The Guided Inquiry Design framework developed by Kuhlthau et al. (2015) emphasizes structured stages of exploration supported by scaffolding, making it particularly well suited to mathematics classrooms where learners often struggle with abstract concepts.

Specifically, this study aims to examine whether the implementation of the Guided Inquiry learning model can improve students' learning outcomes. By integrating Guided Inquiry, the study seeks to provide clearer insights into improving both students' learning outcomes and active engagement in trigonometry.

Method

Type of Research

This study employed Classroom Action Research (CAR). The research was carried out through four stages as proposed by Kemmis and McTaggart (Afandi, 2011), namely: (1) planning, (2) acting, (3) observing, and (4) reflecting. A cycle in this context refers to a sequence of activities consisting of planning, action, observation, and reflection (Afandi, 2011). The classroom action research model developed by Kemmis and McTaggart is a refinement of Kurt Lewin's basic concept. The main difference lies in the integration of the acting and observing stages into a single unit, as both are considered interrelated processes that cannot be separated in practice (Purba et al., 2021). The stages were implemented in two cycles, with each cycle consisting of two meetings. The research procedure is illustrated in Figure 1.

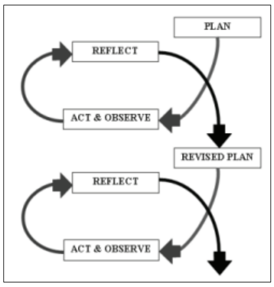

Figure 1. Classroom Action Research Model by Kemmis & McTaggart (Afandi, 2011)

Research Subjects and Objects

The subjects of this study were 30 Grade X-PH.2 students of SMK Negeri 5 Denpasar in the 2024/2025 academic year. The object of the study was the improvement of students' mathematics learning outcomes through the implementation of the Guided Inquiry learning model. The sampling technique employed was purposive sampling, which is a method of selecting data sources based on specific considerations (Sulistiyo, 2019, p. 37). The researcher selected the research subjects by considering the particular difficulties experienced by the students.

Instruments

The test instrument used in this study was an essay-type test constructed based on the competency achievement indicators for the trigonometry topic. In terms of content validity, the items were reviewed by peer teachers and confirmed to be aligned with the learning objectives and the basic competencies outlined in Regulation of the Ministry of Education and Culture No. 22 of 2016. The test items covered skills in understanding concepts, analyzing quadrants, and applying trigonometric identities, thereby fulfilling construct validity as they reflect mathematical thinking skills (NCTM, 2000). With regard to reliability, the instrument was designed with consistent item structures to objectively measure learning outcomes. Although it was not statistically tested, the consistency of format, clarity of instructions, and relevance of the items indicated that the instrument possessed theoretically acceptable reliability. Therefore, the instrument was considered appropriate for assessing students' learning outcomes in this study. An example of the research instrument is presented in Table 1

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Table 1. Research Instrument

Tasks	Task Characteristics
Item 1 Given $Sin\ \alpha = \frac{1}{2}$, $Cos\ \alpha = -\frac{1}{2}\sqrt{3}$. Determine $tan\ \alpha$!	Students determine $tan\ \alpha$, given $sin\ \alpha$ and $cos\ \alpha$
Item 2 Given $Sin\ \alpha = \frac{8}{17}$ with α in Quadrant II and $Cos\ \beta = \frac{9}{15}$ with β in Quadrant IV. Determine $tan\ \alpha$ and $tan\ \beta$	Students determine $tan\ \alpha$ using $sin\ \alpha$ and $cos\ \alpha$ and the quadrant of α, and determine $\tan\beta$ using $cos\ \beta$ and the quadrant of β.
Item 3 Given $\cos\ \alpha = -\frac{1}{3}$ and α in Quadrant II. Determine $3\ sin\ \alpha - 4\ tan\ \alpha$!	Students compute $3\sin\alpha - 4\tan\alpha$ by first finding $\sin\alpha$ and $\tan\alpha$ from the given $\cos\alpha$, taking the quadrant into account.

Procedures

The data collection method employed was the test technique. During the reflection stage, students were given essay-type questions to measure their learning outcomes. A test is an instrument consisting of a set of questions used to collect data on students' abilities, particularly in the cognitive domain. The tests administered to students included a pre-test in the pre-cycle, followed by tests conducted after the implementation of the learning activities.

Analysis

In this study, the data analysis conducted was quantitative analysis. The quantitative data were obtained from students' cognitive learning outcome tests, in which students answered the test items provided. The researcher collected quantitative data from the tests administered before the intervention and at the end of each cycle. The formulas for determining learning mastery are as follows:

Individual Learning Mastery

$$S = \frac{R}{N} \times 100\%$$

Description:
S = Percentage of Individual Mastery
R = Score obtained
N = Maximum score

Classical Learning Mastery (Zainal, 2008)

$$PK = \frac{JT}{JS} \times 100\%$$

Description:
PK = Percentage of Classical Mastery
JT = Number of students who achieved mastery
JS = Total number of students

Results

The research activities began with a pre-cycle stage to determine students' initial abilities. Out of a total of 30 students, 16 students (53.33%) had not achieved mastery, while 14 students (46.67%) had achieved mastery. The highest score obtained by the students was 100, while the lowest score was 20. The relatively low class average score of only 61.33 and the high percentage of non-mastery (53.33%) indicated the need to conduct Classroom Action Research (CAR) in accordance with the design outlined in the previous section. The frequency distribution of pre-cycle learning outcomes is presented in Table 2.

Table 2. Pre-Cycle Results

No	Mastery Status	Frequency	Percentage
1	Achieved Mastery	14	46,67%
2	Not Achieved	16	53,33%
Maximum Score: 100			
Minimum Score:20			
Mean: 61,33			
Minimum Mastery Criterion: 75			

Subsequently, the intervention was carried out in Class X-PH.2 through the implementation of the Guided Inquiry learning model. The research stages included: (1) planning, (2) implementation and observation, and (3) reflection. At each reflection stage, students were given essay-type tests to measure their learning outcomes after participating in lessons using the Guided Inquiry model. A comparative analysis of the research findings was conducted by examining students' learning outcomes in the pre-cycle, Cycle I, and Cycle II, as presented in Table 3.

Table 3. Comparative Results of Pre-Cycle, Cycle I, and Cycle II

No	Mastery Status	Pre-Cycle (F/%)		Cycle I (F/%)		Cycle II (F/%)	
1	Achieved Mastery	14	46.67%	20	66.67%	24	80%
2	Not Achieved	16	53.33%	10	33.33%	6	20%
Average Score		61,33		73,90		81,97	
Maximum Score		100		100		100	
Mean		20		30		50	
Minimum Mastery Criterion		75		75		75	

Based on Table 3, the percentage of students achieving mastery at the pre-cycle stage, with the minimum mastery criterion (MMC) set at 75, was 46.67%. After the implementation of Cycle I, the percentage of students achieving mastery increased to 66.67%. At the end of Cycle II, the percentage rose significantly to 80%. In terms of average learning outcomes, there was a significant improvement across the pre-cycle, Cycle I, and Cycle II. This improvement is illustrated in Figure 2.

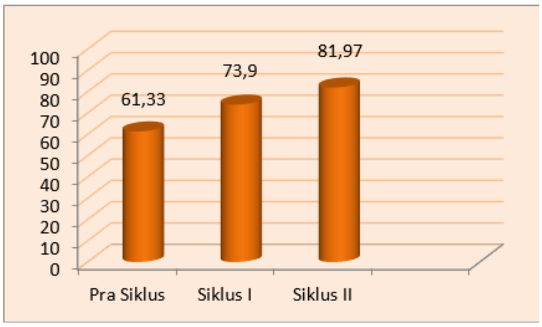

Figure 2. Improvement of Students' Learning Outcomes in the Pre-Cycle, Cycle I, and Cycle II

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Based on Figure 2, there was a significant improvement in learning outcomes from the pre-cycle to Cycle I and subsequently to Cycle II. In the pre-cycle stage, the average student score was only 61.33. In Cycle I, the average score increased to 73.9, and in Cycle II, it further increased to 81.97.

Discussion

The improvement of students' learning outcomes in trigonometry in this study demonstrates that the use of an appropriate instructional approach significantly influences students' conceptual understanding. One of the main factors contributing to this improvement is students' active engagement in mathematical thinking, as facilitated by the Guided Inquiry learning model. This model enables students to independently discover trigonometric concepts through systematic stages such as orientation, problem formulation, hypothesis development, exploration, and drawing conclusions. Such a process makes learning more meaningful and not merely focused on memorizing formulas. This finding is consistent with Nastiti & Syaifuddin (2020), who concluded that conceptual understanding has a significant effect on mathematics learning outcomes. In the context of trigonometry, concepts such as the relationships among trigonometric functions and quadrant analysis require deep understanding in order for students to apply them in various situations. Guided Inquiry clarifies these concepts by providing guided exploration, enabling students not only to know what steps to take but also to understand the rationale behind them.

Furthermore, the application of the Guided Inquiry model can enhance students' reasoning abilities. This is in line with Suparman & Rahayu (2021), who found that inquiry-based learning models improve students' mathematical reasoning and problem-solving skills. In trigonometry, both skills are essential, for instance, when determining the sign of functions based on quadrants or constructing trigonometric expressions from limited information. Such reasoning processes rarely develop if students are only given examples and exercises without being encouraged to investigate the concepts first. In addition to cognitive aspects, the use of the Guided Inquiry model also had an impact on students' affective dimensions. Students appeared more enthusiastic, actively engaged in group discussions, and demonstrated increased confidence in presenting their work. This finding supports Astuti & Jannah (2022), who reported that inquiry-based learning increases student participation and learning motivation by fostering a more communicative and collaborative classroom environment. Such emotional engagement further strengthens learning outcomes as students feel more comfortable and involved in the learning process. The findings of this study also resonate with broader educational debates on the evolving role of teachers in inquiry-oriented classrooms. Guided Inquiry redistributes responsibility for learning: students engage directly with problems, test hypotheses, and justify reasoning, while teachers act as facilitators and questioners. This echoes earlier pedagogical visions, such as Skinner's (1958) call to reduce routine teacher burdens so that professional effort can be concentrated on more valuable instructional interactions. In this way, Guided Inquiry not only enhances student outcomes but also aligns with a wider trajectory of educational innovation aimed at balancing efficiency with quality.

Moreover, the model directly addresses the competencies emphasised in global benchmarks such as PISA, where Indonesian learners have consistently underperformed in reasoning and problem-solving tasks (OECD, 2023). By engaging students in structured exploration, Guided Inquiry cultivates precisely these higher-order skills, positioning it as an approach with both local and international relevance. In line with prior studies (Suparman & Rahayu, 2021; Astuti & Jannah, 2022), this research underscores that inquiry-based models contribute not only to cognitive gains but also to motivational and participatory outcomes.

These combined effects strengthen the argument that Guided Inquiry should be integrated more systematically into mathematics instruction to meet both national policy goals and international benchmarks. Research in STEM education confirms the effectiveness of inquiry-based learning for fostering conceptual understanding and problem-solving, with Prince & Felder (2006) identifying strong gains in student outcomes across disciplines. In mathematics education specifically, Artigue & Blomhøj (2013) demonstrated how inquiry-based approaches support reasoning and problem-solving, echoing the improvements found in this study. A systematic review by Pedaste et al. (2015) outlined key phases of inquiry orientation, conceptualization, investigation, conclusion, and discussion, many of which were evident in the implementation of the Guided Inquiry model in this research. Moreover, Hmelo-Silver (2004) noted that inquiry and problem-based learning approaches are particularly powerful in vocational contexts, as they link abstract knowledge with applied problem-solving, which is central to the vocational school setting of this research.

Therefore, it can be concluded that the implementation of Guided Inquiry is effective in improving students' mathematics learning outcomes in trigonometry. These findings provide a basis for educators to extend the application of this model to other topics, with necessary adjustments to the needs and characteristics of learners.

Conclusion

Based on the results of the classroom action research conducted in two cycles, it can be concluded that the implementation of the Guided Inquiry learning model was effective in improving students' mathematics learning outcomes in trigonometry. This improvement was reflected in increased student engagement, better conceptual understanding, and the attainment of learning outcomes in accordance with mastery criteria. The learning process became more meaningful as students actively constructed knowledge through systematic inquiry stages. In addition, students demonstrated positive developments such as greater curiosity, confidence in expressing opinions, and active participation, particularly during discussions and concept investigations. Even students who were initially passive became more involved through opportunities for exploration and questioning facilitated during the lessons. Nevertheless, this study had several limitations, including limited time for implementing the learning cycles and the presence of some students who were less focused due to distractions in the learning environment. Furthermore, as the study was conducted in only one class with a limited number of students, the application of the findings to a wider population should be considered with caution. For future research, it is recommended that the Guided Inquiry model be implemented over a longer duration and combined with more effective classroom management strategies to minimize learning disruptions. Moreover, future studies would benefit from examining the influence of this model on other aspects such as critical thinking, collaboration, and students' learning motivation.

Conflict of Interest

The authors declare that there is no conflict of interest.

Authors' Contributions

Author A.H. was responsible for designing the study, developing the research ideas, collecting data, analyzing, and processing the data. The second author (K.A.W.) actively contributed to the development of the theoretical framework, methodology, discussion of results, and approval of the final version of the manuscript. The third author (M.S.) provided substantial feedback

and constructive suggestions to improve the quality of the manuscript, ensuring that it met academic standards and aligned with the journal's requirements. All authors declare that they have read and approved the final version of this paper. The overall contribution percentages for the conceptualization, preparation, and revision of this manuscript are as follows: A.H.: 60%, K.A.W.: 30%, and M.S.: 10%.

Data Availability Statement

The authors declare that the data supporting the findings of this study will be made available by the corresponding author, [A.H.], upon reasonable request.

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