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The Effectiveness of the Math Expert Application in Improving Students' Mathematical Reasoning in Trigonometry

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Abstrak

Kemampuan pemecahan masalah dan penalaran matematis adalah aspek krusial dalam pembelajaran matematika. Namun, ketergantungan siswa pada teknologi dalam menyelesaikan soal justru memicu penurunan kemampuan penalaran tersebut. Penelitian ini bertujuan menganalisis kemampuan penalaran matematis siswa SMK menggunakan aplikasi Math Expert. Melalui metode campuran (mixed method) tipe embedded design, penelitian ini melibatkan 86 siswa kelas X SMK di Cianjur yang terbagi ke dalam kelas eksperimen dan kontrol. Data dikumpulkan melalui kuesioner, observasi, wawancara, dan instrumen tes penalaran matematis berdasarkan standar NCTM. Hasil penelitian menunjukkan perbedaan signifikan pada enam indikator penalaran NCTM, yang meliputi kemampuan: justifikasi kesimpulan; pengujian dugaan matematis; evaluasi argumen; variasi metode solusi; pengorganisasian data masalah; serta penilaian terhadap hasil kerja orang lain. Secara keseluruhan, penggunaan aplikasi Math Expert terbukti efektif meningkatkan kemampuan penalaran matematis siswa SMK, meskipun tingkat peningkatan pada setiap indikator bervariasi.
Kata Kunci: *Kemampuan Matematis; Trigonometri; Aplikasi Pembelajaran; Teknologi; Deep Learning.*

Abstract

Problem-solving and mathematical reasoning are crucial aspects of mathematics education. However, students' over-reliance on technology for problem-solving has triggered a decline in these specific reasoning abilities. This study aims to analyze the mathematical reasoning skills of vocational high school (SMK) students through the implementation of the Math Expert application. Utilizing a mixed-methods approach with an embedded design, the research involved 86 tenth-grade students in Cianjur, divided into experimental and control groups. Data were collected via questionnaires, observations, interviews, and mathematical reasoning tests based on NCTM standards. The findings indicate significant differences across six NCTM reasoning indicators, including the ability to: justify conclusions; test mathematical conjectures; evaluate arguments; employ diverse solution methods; organize situational problem data; and assess the work of others. Overall, the results demonstrate that the Math Expert application effectively enhances students' mathematical reasoning skills, although the degree of improvement varies across the specific indicators.
Keywords: Mathematical Ability; Trigonometry; Learning Application; Technology; Deep Learning.

I. INTRODUCTION

The rapid growth of the digital age technology in the 21st century has notably influenced education, including to develop human resources (Sadriani et al.., 2023). There is a strong indication that information and communication technology (ICT) including internet has changed several dimensions of people's lives. This transformation has been one of the major challenges in 21st- matid century education (Fisher & Kusumah, 2018). Indonesian education is at a point of articulation where it faces many challenges and opportunities, that will affect the future existence of Indonesian education. As a result, the national education system also need regular attention and exactly calculated move. The government has initiated several mechanisms to enhance the quality of education through adoption of new curriculum, enhancing teacher's salaries and benefits, equipment for schools (Identif 2025).

Deep Learning is one of the new technologies being encouraged in learning by government. In the Guidelines for Curriculum and Learning ASD-MOE Republic of Indonesia, deep learning is described as an approach that respects learners by creating a rich, mindful and enjoyable space for leering. This model focuses on enhancing potential in various aspects of the student's development: intellectual, ethical, aesthetic and kinesthetic (Pusat Kurikulum dan Pembelajaran, 2025). This concept is in line with the objectives of Islamic education based on the teachings of the Qur'an and hadith, which encourage its followers to progress and act as caliphs on earth (Mustagfirin & Zaman, 2025; Raup et al., 2022).

The connections between deep learning and mathematics education are quite prominent. Every aspect is created to encourage students to access and understand depth of knowledge in mathematics so that they can apply it to all aspects of life! The perception of mathematics as a subject but also a significant ability in reasoning and problem solving (Raup et al., 2022) is likely to be affected by that. Problem solving and mathematization are bases of learning mathematics. Reasoning is not independent of mathematics as every activity to learn new mathematics includes logical thinking, so reasoning abilities indicate the level of a student's mastery of mathematics (Fisher, 2017).

In contemporary learning, some difficulties stem from the various cognitive styles of students in the way they comprehend and figure out mathematical concepts (Maswar et al., 2022). The ability of mathematical reasoning is a process of logical thinking which refers to the facts and sources accurately in each phase from analyzing patterns, evaluating assumptions and made conclusions (Utomo et al., 2021; Heron, 2025; Hačatrjana et al., 2024). Through deep learning, these sculptor-like skills (v.-transform) can be nurtured in active, reflective, integrative and collaborative learning activities which include group discussions, contextualized problem-solving tasks, exploring concepts and end of course reflection processes. (Wahyudi, 2025). Mathematical reasoning skills are very important, especially when dealing with non-routine problems, such as those tested in the Mathematical Olympiad (Tohir et al., 2023; Saputri et al., 2024).

According to NCTM (2000), there are six indicators of mathematical reasoning skills, namely: (1) recognizing reasoning and evidence in mathematical arguments; (2) making and investigating mathematical conjectures; (3) developing and evaluating mathematical arguments and evidence; (4) selecting and using various types of reasoning and methods of proof; (5) creating and using mathematical representations to organize, record, and communicate ideas; and (6) analysing and evaluating mathematical representations created by others. Although technology-based learning can support the development of these skills, the reality in the field shows that many students are overly dependent on technological assistance in solving problems, resulting in a decline in mathematical reasoning skills.

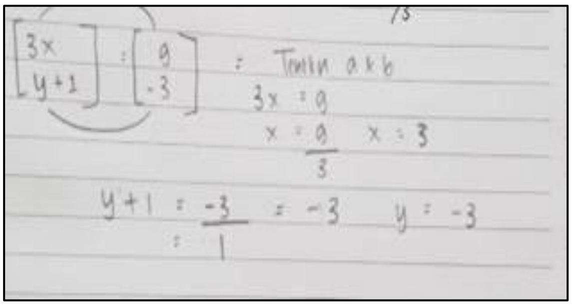


Figure 1. Examples of students' mathematical reasoning abilities.

Based on Figure 1, students are able to imitate the steps to solve the given examples. However, when the questions are slightly modified, they tend to make mistakes. This shows their weak reasoning skills in understanding concepts and applying them to new contexts (Nababan, 2020; Amalia & Hadi, 2020; Saniyyah & Winiati, 2020; Purwosetiyono et al., 2022).

Trigonometric ratios is one of those topics which needs good amount of logical reasoning. The concept is, in principle, very important as a foundation for other mathematics (Suendarti & Liberna, 2021; Cholid et al., 2022), but it is often considered to be difficult by students. Trigonometry is a difficult concept to understand, but is rationalized with reference to work in concrete form through triangle illustrations unit diagrams and visual technology applications (Winaldi et al., 2019; Sudarman & Vahlia, 2018; Gani & Marlinda, 2017). Moreover, trigonometry is useful since individuals use it in everyday activities such as the measurement of heights of buildings, determination of distances or finding angles for elevation and depression etc. Studying trigonometry also needs spatial thinking, accuracy and skills in associating the concepts of angles and sides with their algebraic symbols (Alenitsyn et al., 2020; Spangenberg, 2021).

Given the diversity of problems with learning trigonometry, teachers must look for new ways and methods. One of strategies that can be implemented in accordance with the principles of deep learning is technology-based learning media. Technology is also important in designing effective and meaningful learning (Hargardayani et al., 2022; Fauzi et al., 2024). Technology can be used to make abstract mathematical ideas become concrete, so that they a more easily understood. Human-driven software and digital environments offer the chance for students to work more independently, get real-time feedback, correct errors, and make deeper connections (Ritter et al., 2020; Outhwaite et al., 2023).

One the mediums is the Math Expert app; it is a technology enhanced learning platform that allows individuals to tackle authentic math problems with relative ease whether on mobile or desktop format. The apps provide ranging from the simple to the complicated counting and processing capability for writing the problems down for automatic processing (Dewi, 2016; Khasanah & Oktaviani, 2017; Websis, 2018). Several studies describe apps that, like Math Expert, allow learners to submit problems and receive worked solutions, often extending the classroom into a virtual practice space. Other advantages of Math Expert include: The application can function as a mediator and facilitator of mathematics learning for elementary school students, integrating expert system or AI capabilities for problem-solving and explanation; and a platform where students upload difficult problems, creating a pool of authentic problems and providing rapid feedback on the topics they struggle with most (Mustafa, 2022; Mandal & Naskar, 2021; Deshpande, 2025).

This research is dedicated to the enhancement of students' mathematical thinking on trigonometric ratios through the Math Expert application. The purpose of this study is to analyse the extent to which the use of this application can help students develop logical and systematic reasoning regarding trigonometric concepts, with reference to NCTM indicators. The novelty of this study lies in the integration of mathematical reasoning ability analysis and the use of the Math Expert application in the context of mathematics learning in vocational schools, which has rarely been studied. The results of this study are expected to provide empirical and practical contributions for teachers in optimizing technology-based learning to develop students' mathematical reasoning abilities. Overall, this study recommends the use of digital media such as Math Expert as an innovative strategy to improve the quality of mathematics learning in the digital age.

II. Method

The type of research used is mixed method type embedded design with a descriptive method, which is research that seeks to develop important details from the results of data analysis obtained from various sources to build a complete picture of the individuals or events being studied (Indrawan & Yaniawati, 2024). Qualitative research using quasi-experiments design with a case study design focuses on a specific phenomenon that needs to be understood in depth, setting aside other phenomena outside the focus of the research (Rahmi et al., 2021). The research subjects consisted of students in class X TJKT 1 as the experimental class and class X TJKT 3 as the control class, each with 43 students, from a vocational school in Cianjur Regency.

This study applies triangulation as validation techniques of findings, through the use of several sources, data gathering techniques and viewpoints in order to get thicker description and realize the validity of the datal (Indrawan & Yaniawati, 2024).

The research instruments were: 1) Test early ability, to test students' thinking mathematics before treatment; 2) Questionnaires, to find out how the student responds while learning; 3) Observation, for recording the activity of a student and participation in the learning process; 4) Interviews, to explore how the views and experiences of students learned using Math Expert application; 5) Final competency tests are designed based on the applications used Math Expert to measure growth thinking mathematics after being given treatment.

There was no other special device necessary to carry out this study, except the already downloaded Math Expert on each student's mobile phone. This app has several important features to the learning of math, including question writing and show problem solving steps all the way up from a simple addition to complex operations.

The research instrument used in this study was an essay test to measure students' mathematical reasoning abilities, which were then categorized into high, medium, and low mathematical reasoning abilities (Rahmawati et al., 2022). Next, the test developed by researchers and validated in accordance with the NCTM (2000) indicators, which developed six categories of students' mathematical reasoning abilities, namely (1) recognizing reasoning and evidence in mathematical arguments; (2) making and investigating mathematical conjectures; (3) developing and evaluating mathematical arguments and evidence; (4) selecting and using various types of reasoning and methods of proof; (5) creating and using mathematical representations to organize, record, and communicate mathematical ideas; and (6) analysing and evaluating mathematical representations created by others. In this case, an analysis of the proportion of students who have obtained scores on each of these indicators was conducted.

III. RESULT AND DISCUSSION

Data analysis in this study included three main components, namely pretest results, post test results, and students' perception scale of learning using the Math Expert application. The pretest was used to measure students' readiness and mastery of prerequisite material before studying Trigonometric Ratios, while the post test was used to assess mathematical reasoning skills after the treatment was given by comparing the two groups of students (experimental and control). Meanwhile, the perception analysis aimed to determine students' responses to the application of Math Expert in the learning process.

Figure 2. Features of the Math Expert Application.

A. Initial Ability Test Data Analysis

Initial ability data was obtained from test results on Triangles and Pythagorean Theorem material given to the experimental and control groups as a prerequisite before learning Trigonometric Ratios.

Table 1.
Initial Ability Test Results for Experimental and Control Classes

Class	N	Student Initial Ability Test Scores					
		Max Score	Min Score	Mean	Med	Mod	SD
Exp	43	100	0	40,00	29,41	17,65	33,22
Con	43	100	0	42,32	29,41	29,41	32,17

Based on Table 1, the initial abilities of the two groups were not significantly different. The almost identical mean values indicate that the initial conditions of the students were at a balanced level. The high standard deviation in both groups indicates diversity in ability among students; that is, there is considerable variation between high- and low-ability students. Thus, the differences in results obtained at the final stage can be more reliably attributed to the Math Expert learning treatment rather than differences in students' baseline abilities.

B. Mathematical Reasoning Ability Test Data Analysis

After the learning process was completed, a final test was conducted to measure students' mathematical reasoning skills about Trigonometric Ratios. The results are presented in Table 3 below.

Table 2.
Mathematical Reasoning Ability Test of Experimental and Control Class

Class	N	Mathematical Reasoning Ability Test Scores					
		Max Score	Min Score	Mean	Med	Mod	SD
Exp	43	100	60	80,96	80.00	90,67	12,29
Con	43	93	51	72,37	77,33	50,67	14,64

From Table 2, mathematical reasoning ability of students in the experimental class was better than that in control class. The higher mean (and median) scores in the experimental class show use of Math Expert application significantly affected quality of student's mathematical reasoning. The relatively stable of the scores' distribution and low standard deviation show that majority of students can follow well on the lessons, and they were able to get results more consistently except for some outliers (Maghfirah et al., 2022; Hawa et al., 2020).

In the control class, scores were lower with greater variability, which reflected that traditional style of learning is not yet successful to fully develop students' mathematical reasoning. The findings of this study are consistent with previous studies claiming that computer-based learning and innovative models have contributed to a significant increase in mathematical reasoning compared to traditional one (Sufvinia et al., 2021; Prihono & Khasanah, 2020; Fanany et al., 2019; Purwani et al., 2015; Astriani et al., 2024; Wibowo, 2017).

C. Analysis Based on Mathematical Reasoning Ability Indicators

The results of students' math-reasoning-score in each indicator are listed in Table 4.

Table 3.

Student score data

Indicators of Mathematical Reasoning Ability	Mean Score	Max Score	Min Score	Percentage by Category
1. Recognize reasoning and evidence in mathematical arguments	9,19	10	0	High 88% Mod 7% Low 5%
2. Create and use representations to organize, record, and communicate mathematical ideas	16,58	20	0	High 60% Mod 14% Low 26%
3. Make and investigate mathematical conjectures	9,19	10	0	High 84% Mod 16% Low 0%
4. Develop and evaluate mathematical arguments and proofs	9.42	10	0	High 88% Mod 12% Low 0%
5. Analyse and evaluate mathematical representations created by others	12,05	20	0	High 28% Mod 28% Low 44%
6. Select and use various types of reasoning and methods of proof	4,30	5	0	High 86% Mod 0% Low 14%

According to Table 3, student achievement differs across measures of mathematical reasoning skills. Math experts apply all six indicators in an integrated manner: they construct conjectures, choose representations, test and revise arguments, and construct formal proofs (Stylianides, 2008). Under measure 1, a large majority of students (88%) fell in the high category revealing that they could recognize reasoning and evidence in mathematical arguments successfully. It implies that the strong concept basic understanding becomes an essential underpinning to develop the reasoning ability in mathematics (Lestari & Arifah, 2025) (Cahyani & Sritresna, 2023; Isnaeni et al., 2018).

The second indicator, which is to develop and use representations to organize and record mathematical thinking, remains at contrast levels with 60% of students in the high category and 26% of them in the low category. Some fellows find difficult to invent the right mathematical models of a certain physical phenomenon having making sense (Tupamahu et al., 2023; Ratumanan et al., 2022; Utami et al., 2019).

The third index, mathematical creativity and inquiry ability had very good results (84% of the participants are in high level). The students were able to make the conjectures and examine mathematical patterns well because the high- ability students had systematically been able to go through all stages of thinking of mathematics: understand the problem, explore, formulating, and prove a lot of conjecture (Matematika et al., 2023; Astawa et al.,2017; Muthmainnah et al., 2022).

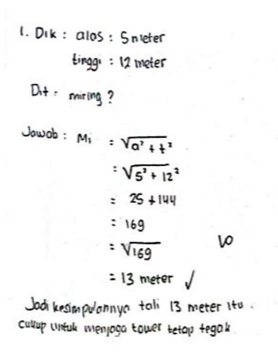
The fourth indicator, constructing and evaluating mathematical arguments, again demonstrated high achievement (88% at the high level). {Students constructed logical arguments as well as evaluated evidence correctly. High students were capable of verifying validity based on mathematical principles, but moderate students still had some miscalculation or justification errors (Trymelynda & Ekawati, 2023; Kurniawan et al., 2023).

In the 5th indicator, with analyzing and evaluating mathematical representations produced by others´ student performance is considerably lower however. Only 28% of students are in the high category, while 44% of students are still in the low category. This shows that many students still have difficulty assessing and understanding mathematical representations presented by others. These difficulties are partly due to a lack of understanding of basic concepts and a tendency to imitate the teacher's steps without understanding their meaning (Marliani & Puspitasari, 2022; Ainunnisa et al., 2021; Silviani et al., 2021).

As for the sixth indicator, namely the ability to choose and use various types of reasoning and proof methods, most students (86%) were in the high category. This shows that the use of the Math Expert application supports flexibility in thinking and helps students choose the appropriate proof method according to the context of the question. Previous studies have also confirmed that a contextual and collaborative learning environment can increase the variety of students' reasoning methods (Fraihat et al., 2022; Ramírez-Uclés & Ruiz-Hidalgo, 2022; Marasabessy, 2021).

Overall, the results of the study indicate that the use of the Math Expert application contributes positively to improving the mathematical reasoning abilities of vocational high school students, especially in the aspects of recognizing evidence, developing arguments, and forming conjectures. However, strengthening is still needed in the aspects of representation and evaluation of other people's representations so that students' mathematical reasoning abilities develop more comprehensively.

Student Work Results in Mathematical Reasoning Ability Using the Math Expert Application



$hypotenuse = \sqrt{base^2 + height^2}$

$hypotenuse = \sqrt{5^2 + 12^2}$

$hypotenuse = \sqrt{25 + 144}$

$hypotenuse = \sqrt{169}$

$hypotenuse = 13$

Therefore, a 13-metre rope is sufficient to keep the tower upright

Figure 3. Answer to Question No. 1

Analysis of Indicator 1: Recognizing Reasoning and Evidence in Mathematical Arguments

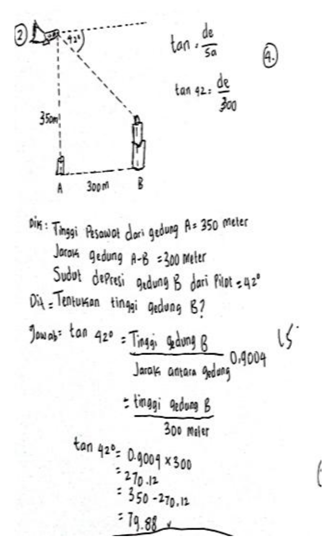
This indicator relates to students' ability to understand and identify logical relationships and the basis of reasoning used in mathematical arguments. In a question about Rafi wanting to determine whether a 13-meter rope is long enough to support a 12-meter tower with the base of the rope 5 meters from the base of the tower, students are required to recognize the form of reasoning used in determining the truth of this statement.

Students who can solve this problem correctly demonstrate an understanding that solving the problem requires deductive reasoning, because the conclusion is obtained through the application of a previously proven principle or theorem, namely the Pythagorean Theorem. Through this process, students realize that the mathematical argument used to determine the sufficient length of the rope is based on logical evidence from the application of the theorem. As a result, the size of the rope needed is exactly 13 meters, and therefore by mathematics its square can keep us tower standing upright.

Therefore, this indicator is manifested in the students' way of reasoning related to the identification of the use type of reason (deductive) and understanding how the proof is built and associated with logical conclusion that suit their phraseological context. And through arguments and proof tasks like this, learners come to see that the truth in mathematics is built up from a body of logically coherent systematized thinking rather than mere recall (Durand- Guerrier et al., 2023; Kollosche, 2021).

Developing, analyzing and evaluating mathematical proofs supports learners to develop an understanding of the structure of mathematics, the connections between different mathematical concepts, critical thinking skills etc. While working with these indicators, we accustom students to evaluate the correctness of an argument and the need of evidence for all mathematical claims (Herbert & Williams, 2021; Komatsu & Jones, 2021; Miyazaki et al., 2017; Nathan & Walkington, 2017).

Furthermore, students engaged in reasoning and evidence-based practice are more likely to make links between ideas, understand the reasons for formulas and not just rote learn procedures. Knowing the architecture of proof and logic will lead students to be more able to construct new knowledge, critically evaluate arguments, and use mathematics in applications outside the classroom.



$tan = \frac{opposite}{adjacent}$

$\tan 42^o = \frac{opposite}{300}$

$0{,}9004 = \frac{opposite}{300}$

$opposite = 0{,}9004 \times 300$

$opposite = 270\ metre$

Therefore, the height of building B is 350 – 270 = 80 metres

Figure 4. Answer to Question No. 2

Analysis of Indicator 2 Generating and Using Mathematical Representations to Organize, Record, and Communicate Mathematical Ideas

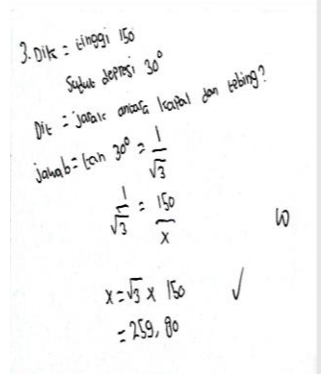
This measure focus on the capacity of students to capture contextual situation and translate it in a coherent mathematical model. One problem involves the location of an airplane with respect to two buildings; students are asked to find the height of building B given that angle of depression is 42° and they give them other two distances plus its position.

Students start the problem by drawing a right triangle that shows how the airplane, building A, and building B are related visually to each other; and planning space to include critical data such as their height on the right side of the airplane trip through mid-air across from themselves (the top-down flight altitude) or object altitudes versus width separation going in front of us. Once students have grasped the geometric situation, they can then begin to make their mathematical ideas explicit by writing down the relevant trigonometric relationships; in this instance, calculating the height difference between the plane and building B using the tangent function.

The operational processes reflect on students' capability to connect graphical representation (pictures) with symbolic representations (formulas and equations). Once they have arrived at their calculations, students articulate a coherent argument around mathematics by describing the steps involved in understanding the question itself, formulating a mathematical model and reaching an outcome for building B's height.

Hence, this factor measures the students' capability of applying mathematical representations meaningfully to comprehend and solve real-life situation-based mathematical problems. These findings indicate that students can not only comprehend which mathematical procedures to use, but also write mathematically in logical and organized ways across different types of representation.

Nevertheless, the results also suggest that some students continue to have difficulties with the generalization of concrete situations into mathematical concepts. Several previous studies show that the level of student mastery of visual representations is still around 42.5% in the "sufficiently proficient" category, indicating that the process of moving from contextual understanding to mathematical symbols remains a challenge (Marliani & Puspitasari, 2022; Silviani et al., 2021). Therefore, teachers need to provide varied and contextual exercises so that students become accustomed to using various forms of representation in understanding and solving mathematical problems.



$tan = \frac{opposite}{adjacent}$

$\tan 30^o = \frac{opposite}{adjacent}$

$\frac{1}{\sqrt{3}} = \frac{150}{x}$

$x = 150\sqrt{3}$ metre

$x = 259,81$ metre

Therefore, the height is 259,81 metres

Figure 5. Answer to Question No. 3

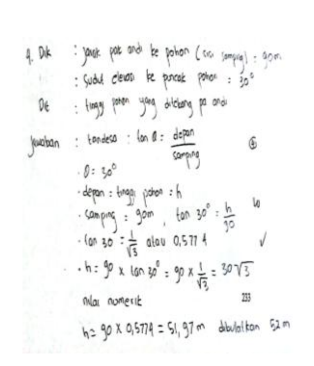
Analysis of Indicator 3: Creating and Investigating Mathematical Conjectures

This indicator relates to students' ability to make assumptions or conjectures about a mathematical relationship based on a given pattern or situation, then test its validity through logical reasoning and mathematical calculations. In the context of a question about a climber who sees a ship at sea from a cliff 150 meters high at an angle of depression of 30°, students are expected to be able to construct conjectures about the relationship between the height of the cliff, the angle of depression, and the distance of the ship from the foot of the cliff.

Students who understand this concept can develop the hypothesis that the greater the angle of depression, the closer the distance between the ship and the cliff will be, and conversely, the smaller the angle of depression, the further away the ship will be. Students mathematically model the real-world situation as a right triangle to verify this prediction. Using trigonometry, in this case tangent (tan 30° = 150/distance of ship), the validity of this conjecture is tested and proven, they will actually calculate how far the distance to the ship is supposed to be.

Through this operation, students, in addition to operate with numbers are allowed to manifest inductive thinking power: they formulate hypothesis source of patterns of the relationship among quantities and conduct deductive thinking procedure that justify what was predicted through valid and logical mathematical operations. As such, this measure demonstrates students' capability to make mathematical conjectures based on a context, check the truth of these statements by using formal mathematical language and concepts, and justify their reasoning using calculation information.

Existing literature indicates that misconceptions that students have in reading angles of elevation (AE), object heights and horizontal distances can be a source of common errors in trigonometry. Misinterpretations of these aspects may induce mistakes in building mathematical models and verifying conjectures (Gradini et al., 2022; Setiawan, 2021). Therefore, instruction should to focus on strong conceptual knowledge before training students in inductive and deductive reasoning using anchored problems.



$$tan = \frac{opposite}{adjacent}$$
$$\tan 30^o = \frac{opposite}{adjacent}$$
$$\frac{1}{\sqrt{3}} = \frac{x}{90}$$
$$\sqrt{3}x = 90$$
$$x = \frac{90}{\sqrt{3}} = \frac{90\sqrt{3}}{3}$$
$$x = 30\sqrt{3}$$
$$= 51{,}96\ metres$$

Figure 6. Answer to Question No. 4

Analysis of Indicator 4: Developing and Evaluating Mathematical Arguments and Proofs

This criterion focuses on the students' capacity to reason in a mathematical context and to verify that an answer is reasonable. In the question where Mr. Andi can see the top of a tree in elevation angle x 30 ° from up to above 90 meters, students are required to develop a mathematical argument of whether there is any relationship among viewing distance, the elevation angle, and tree height.

The students start off by modeling the problem situation with a right triangle, which includes Mr. Andi's location, the top of the tree, and how far away he is horizontally from it. Based on the model, students presented the following argument: The height of the tree can be found using trigonometry function tangent since tangent of the angle is also equal to the ratio of front side (height of tree) and side (the distance between Mr. Andi with tree). Students write the equation tan 30° =

tree height / 90 from this relationship and calculate the height of the tree using the multiplication 90 × tan 30°.

Upon getting the results, students challenge their proofs and evidence by testing the exchanged steps against trigonometric ideas and the sensibility of results in terms of reality (e.g., would the height of a tree found to be proportional to the observed distance). During the course of this exercise, students are expected to prove that they can elucidate the mathematical reasoning supporting each step in the solutions, justify correctness using relevant principles and appraise correctness/logic of responses respectively.

Some pupils are still thought to struggle with evaluation based on research findings. And 17.16% of test takers made errors by failing to review their responses when there was time remaining. This indicates that the reflective capabilities in confirming the validity of mathematical proofs must be enhanced. Students who have the ability to analyze arguments and evidence usually have the capability of reasoning solutions logically, mathematically, showing a higher order of mathematical thinking process (Gradini et al., 2022; Pradiarti & Subanji, 2022).

Accordingly, this indicator focuses on the mastery of reflective thinking processes in learning mathematics so that students are capable not only to solve problems correctly, but also can comprehend and criticize their thinking process that they employ in order to certainty and rationality of results.

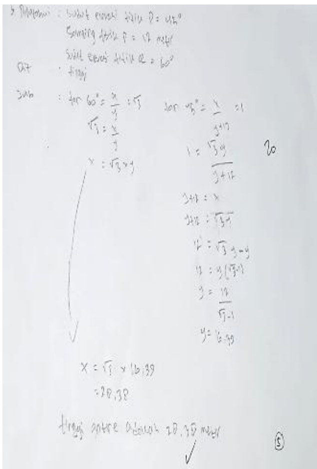
	$\tan = \frac{opposite}{adjacent}$ $\tan 60^o = \frac{opposite}{adjacent}$ $\sqrt{3} = \frac{y}{x}$ $\boldsymbol{y = \sqrt{3}x}$ $\tan 45^o = \frac{opposite}{adjacent}$ $\tan 45^o = \frac{y}{x+12}$ $1 = \frac{\sqrt{3}x}{x+12}$ $x + 12 = \sqrt{3}x$ $12 = \sqrt{3}x - x$ $12 = x(\sqrt{3} - 1)$ $x = \frac{12}{\sqrt{3}-1} x \frac{\sqrt{3}+1}{\sqrt{3}+1}$ $x = \frac{12(\sqrt{3}+1)}{2}$ $\boldsymbol{x = 6(\sqrt{3}+1)}$ $y = \sqrt{3}x$ $y = \sqrt{3}\, x\, 6(\sqrt{3} + 1)$ $y = 18 + 6\sqrt{3} = 28{,}39$ Therefore, the height is 28,39 metres

Figure 7. Answer to Question No. 5

Analysis of Indicator 5: Analysing and Evaluating Mathematical Representations Created by Others

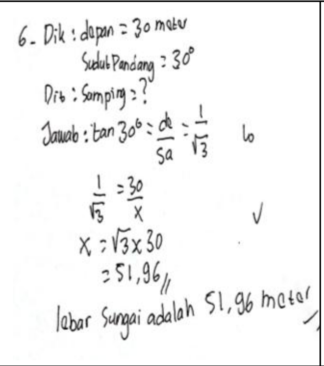
This measure refers to the ability of students to analyze, evaluate and critically interpret from others in which way they have described or modelled mathematical problems. In the next item on Andika's observation and representation of an antenna that he sees from two locations at 45° and 60°, students are invited to make sense of, analyzing how mathematical representations as drawings, triangular models, or sequences of steps in solving problems can be developed by others.

In this question, learner interpret sketch or model of right triangle with positions of Andika (points P and Q), the horizontal distance between the points and the line of antenna's height as perpendicular side. Next students look at whether the drawn model accurately reflects what's happening, for example comparing the angle of elevation and setting that up in a drawing and considering do the horizontal spots agree with distances or side length given in the problem.

Second, students check the work of others, such as solving two trigonometric equations and determining if the substitution or elimination process is done correctly leading to a value for antenna height that makes sense with respect to the context.

Therefore, this indicator is represented by the students' capability of determining the strength and weakness of mathematical representations used by others, judging whether or not the relationship between applied concepts is accurate, and providing mathematical reasons on why it can be considered as correct or incorrect in a modelling and solution process (Mardarani & Apriyono, 2023; Narianti & Masriyah, 2020; Habibi et al., 2020).

This makes students think for themselves when it comes to other people's calculations and not just taking a number as given. Students who manage to undertake such an evaluation show a certain degree of mathematical literacy; they are capable of comprehending, exploring and evaluating mathematical representations and arguments on the basis of logic and evidence (Marliani, & Puspitasari, 2022; Silviani et al., 2021).



$tan = \frac{opposite}{adjacent}$

$\tan 30^o = \frac{opposite}{adjacent}$

$\frac{1}{\sqrt{3}} = \frac{30}{x}$

$x = 30\sqrt{3}$ metre

$x = 51{,}96$ metre

Therefore, the width of the river is 51,96

Figure 8. Answer to Question No. 6

Analysis of Indicator 6: Selecting and Using Various Types of Reasoning and Methods of Proof

This index reflects the student's capacity to select appropriate heuristic reasoning according to the type of problem and apply corresponding proof method. In a thing-style question about a biologist who wishes to measure the width of a river without traversing it students are given an applied context where they need to use so criminology in order to determine a distance that cannot be directly measured.

In order to Ideally, the students should use deductive reasoning here-that is, deriving another relationship between some of the quantities listed given basic definitions of trigonometry. From the context of the problem, a right triangle model can be constructed, with point A as the position of the biologist, point C as the point across the river, and the angle of view at point A as 30°. Based on this model, students use the trigonometric function tangent, with the relationship tan 30° = river width / 30. Through this calculation, students are able to mathematically prove the width of the river by calculating the unknown side using the applicable formula.

In addition, some students also demonstrated inductive reasoning skills, comparing patterns of relationships between angles and distances in similar situations to estimate results before performing formal proofs. The use of both types of reasoning, inductive and deductive, demonstrated the flexibility of students' thinking in adapting their problem-solving strategies to the characteristics of the problems they faced (Lestari & Arifah, 2025; Fadilah, 2019).

After obtaining the results, students then evaluate the accuracy of their findings by reviewing the suitability of the solution steps in relation to the properties of right triangles and assessing the reasonableness of the calculation results in a real-world context, for example, whether the width of the river obtained is reasonable compared to the observation distance (Fadilah, 2019; Gradini et al., 2022).

Thus, this indicator is evident through students' ability to choose the appropriate form of reasoning, either inductive or deductive, and to use mathematical proof methods logically and systematically to solve contextual problems. This capability has a very high level of mathematical thinking since students can not only use the formula but also understand logically about proof and are able to assess their truth logically (Pradiarti & Subanji, 2022).

Students' Perceptions of the Use of the Math Expert Application in Trigonometric Ratio Learning

According to the questionnaire and interview, we have conducted that learning mathematics especially Trigonometric Ratios using Math Expert application developed is well responded by students. Up to 80% of students indicated they like learning math through this application, and 81% confirmed that the application could enhance their attitude and motivation toward studying.

These results are consistent with the existing literature that has demonstrated technology-based learning applications enhance students' interest, attention and motivation when practicing mathematics. Interactive media and digital applications enhance learning by making it more flexible, intriguing and personalized. Studies by Suherman et al. (2024) presented a comparatives study also having as results the fact that most of students had response to implementation of educational applications using technology, especially for subject meters seen as difficult, such as trigonometrical. Enhancing motivation and engagement via digital applications of mathematics leads to a more effective and efficient learning experience in the classroom.

In addition, 84% of students reported that Math Expert enhanced their comprehension of contents and 77% of students had positive attitudes toward problem-based learning with the integration of this application. The factor of learning motivation based on visualization had the highest percentage was 85%, it indicates that illustration, images and visual display in application were strongly helped students to understand trigonometry concept and make them able to develop their interest on learning.

Also, 84% of students think the topic rural would give them new insights and makes study interesting. Visual presentations using images, videos and animations can help make abstract concepts more tangible and tangible approach is a better way to motivate students and increase their understanding. These findings are consistent with those of Pebriani (2017), the influence of animated media also has a positive effect on increasing motivation and learning outcomes as the presentation of teaching materials become clearer, interesting and easy to understand.

However, 24% of students are still finding it hard to learn concepts on their own through the app and independent learning should be focused on. While experimentation and discovery are possible, the meaning behind the stickies is not always clear to students without teacher guidance. 77 students who thought they can improve their grade using the APP were asked whether it helped with studying and collaboration, 80% of students reported that using the app made me discuss and work with my classmates on subject-matter'', 81% of them felt that the interactive evaluation tool on the app helped me to test the material that compared trigonometric functions''. Constructive feedback led to reflective processes where mistakes were corrected by students and students' results improved (Siregar, 2022; Saraswati & Novallyan, 2018).

A majority of 84% of the students perceived that Math Expert application was an appropriate and the relevant strategy to be implemented in problem-based approach for learning mathematics. This result is consistent with the study by Prihatini et al. (2022), Mirlanda (2020) and Husein, (2021) that technology integration facilitates for effectiveness in mathematics learning to arise as reasoning and engagement improves.

Therefore, it can be concluded that the Math Expert app is not just a calculation tool but also acts as an interactive learning environment that can enhance motivation, conceptual understanding and collaboration, which assists on argumentation-based learning in an authentic context for the learners.

IV. CONCLUSION

According to the results of study already proposed, it can be noted that they are better improvement in term of mathematical reasoning skill for students learns with Math Expert application than those who using conventional learning. Applications the Math Expert Application on Trigonometric Ratio Material has a positive impact in the improvement of mathematical reasoning abilities, especially the understanding of concepts, organizing information and applying logical reasoning to solve problem tuck.

Applications Based Learning leads to student involvement in more discovery of ideas, type of proof and formulation of arguments. As revealed by this study, the implementation of mobile-based technology in learning mathematics can be a powerful strategic development as an alternative to increase quality of student learning outcomes as well as their motivation and engagement. As such Math Expert is thus a computational tool, but at the same time also an innovative learning environment for assisting students to develop their reasoning and mathematical literacy in the information society. In addition, Math Expert offers several specific conveniences for teachers compared to regular math applications, especially in terms of personalization, monitoring, and teaching efficiency.

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