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ORIGINAL RESEARCH PAPER

Developing a web-based instruction platform using RME approach to support students' conceptual understanding

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Abstract
Trigonometry is often considered one of the most difficult topics for high school students, with many struggling due to a weak conceptual understanding. This study aims to develop a web-based instruction (WBI) platform called Sine and Shine using the Alessi and Trollip development model. It is a structured web-based teaching program and self-regulated learning resource designed to strengthen the students' understanding of trigonometry concept. We designed the WBI to have various characteristics, such as interactive features, contextual problems, guided feedback, and integrating the principles of Realistic Mathematics Education (RME) in it. We involved 21 students as the participants to evaluate the platform using a mixed-method approach. In terms of validity, the experts unanimously judged that the Sine and Shine platform is strongly valid. In terms of practicality, the teacher and students feedback confirmed that the platform was very practical. In terms of effectiveness, we conducted a statistical analysis and found out that the mean score of post-test was 83.44, significantly higher than the school's minimum mastery criteria (t = 6.1602, p = 2.87e-06), and the paired sample t-test between pre- and post-tests yielded p = 7.20e-16. The normalized gain score was 0.72, indicating a high level of improvement in conceptual understanding. These results demonstrate that Sine and Shine is a valid, practical, and effective digital learning tool that significantly enhances the students' understanding of trigonometry and promotes self-regulated learning.

Keywords: conceptual understanding, instructional media, RME, trigonometry, web-based instruction

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INTRODUCTION

The internet is used widely and has become a very important part of daily life, helping with many activities. It is no longer just a place to find information, but also a flexible way to learn. Data from Haryanto (2024) shows that more people in Indonesia are using the internet, reaching 79.5% (215 million people) in 2024. Kemp (2024) predicts this number will grow to 250 million by 2027. This shows that digital technology has a big chance to make education better, especially in math, by using online learning tools. Students today, especially Generation Z, spend a lot of time learning with digital tools and prefer online learning environments that are interactive and easy to use, rather than relying only on books or classroom lectures, which can help them learn at their own pace and style (Princes et al., 2024).

Websites are a good way to get learning materials online. Web-based Instruction (WBI), as explained by Khan (1998), is a teaching program that uses the internet to create a useful learning space. WBI can put together text, pictures, sounds, and videos, making it very flexible for different subjects. Its benefits include helping with global education skills (Salleh et al., 2012), making learning more flexible and fun (Karabatak & Turhan, 2017), and removing limits on when and where people can learn (Asuman et al., 2018). Research also shows that students' positive attitudes toward digital technology, such as feeling confident using online learning tools and having good digital literacy, help them engage more and stay motivated when learning online (Getenet et al., 2024).

Good learning websites are very important, especially for math, which needs interactive activities. Teachers can use websites to give lessons, practice problems, and interactive tasks that help students think critically and learn on their own. Good websites have features like interactivity, support for independent learning, easy access, and rich content (Hasibuan et al., 2018). Ekarini (2020) also says that a website's quality depends on how easy it is to use, clear navigation, attractive look, helpful content, compatibility with different devices, fast loading, and good functions. With these points in mind, websites can be interactive and meaningful learning tools. Interactive and visual materials, such as animations and simulations, are especially helpful for students because they support deeper understanding and keep learners interested, rather than just reading text (Tugtekin & Dursun, 2022).

Even though there are many learning websites in Indonesia, both paid and free, not many of them meet the standards of a good learning website, use a specific teaching method, or focus on particular math skills. Also, many free websites have annoying pop-up ads that can make it hard for students to focus and learn effectively (Foroughi et al., 2014).

Given the large number of internet users, the benefits of WBI, the lack of high-quality websites, and the shortage of free, specialized websites that use certain teaching methods or focus on math skills, it is very important to create a website based on Realistic Mathematics Education (RME). This kind of website should focus on understanding concepts and solving problems. Therefore, there is a need to develop a free, ad-free website that includes learning materials, interactive tools, evaluations, and is based on a specific teaching approach or model. Such a website would better support students' learning goals because it matches the way they prefer to learn: with digital, interactive, and flexible resources that help them understand and apply mathematical ideas.

This website will mainly cover trigonometry, aiming to help students better understand its core ideas. A strong grasp of math concepts is key to doing well in school, which is in line with the Indonesian 2013 Curriculum and the Merdeka Curriculum. Students are expected to understand math facts, ideas, rules, and how they relate, and then use this knowledge to solve problems. Knowing concepts well allows students to connect new information with what they already know (Kilpatrick, 2001). Skemp (1971) also stressed the importance of understanding concepts, saying that students who get the concepts can use them and link them together to solve problems. This is especially important for students who struggle with abstract topics, because understanding the idea behind rules, not just memorizing formulas, improves their success and confidence in learning mathematics.

Trigonometry is often one of the hardest subjects for high school students. In the 2019 National Examination, only 38.4% of students answered trigonometry questions correctly, and fewer than 45% of students could apply it to real-world situations (Pusat Penilaian Pendidikan, 2020). The 2021 AKM results showed that only 41% of students were good at understanding numbers and space, which is important for trigonometry (Roebianto et al., 2022). These numbers suggest that students struggle not just with using formulas, but also with understanding what the concepts mean (Sari & Firman, 2023). Mistakes often happen because students don't understand trigonometry concepts well (Susanti et al., 2023; Fajri & Nida, 2019; Kusnadi et al., 2021). So, the main goal of this WBI is to build a strong foundation for understanding trigonometry concepts, preparing students to solve related problems.

To deal with these difficulties, we need a teaching method that helps students actively build their own understanding. There are three common methods: the scientific approach (using logical thinking), the contextual approach (connecting material to real life), and Realistic Mathematics Education (RME). RME guides students to build math concepts from simple ideas to more formal ones. This method has been shown to improve understanding through everyday experiences and helps students see how formulas work in real problems. RME is a good fit for teaching design because it focuses on how students learn, making math more meaningful and useful, and it has been proven to improve learning results (Mahmudah & Rusmining, 2022; Rochmat et al., 2025). By linking lessons to students' real-life experiences, RME makes students more involved, which boosts their motivation and learning outcomes. RME is a great option for improving how well students understand concepts.

Using RME in online learning is still quite new; most past studies used RME in traditional classroom settings. While WBI has been shown to increase motivation to learn (Rahmawati et al., 2022), a full integration of teaching methods like RME has not been common. Combining RME with WBI offers a smart way to deal with the challenges of teaching trigonometry in the digital age. A teaching design that uses real-world examples and interactive tools helps students gradually build understanding through visuals, simulations, and support. Also, quick assessments and automatic feedback encourage students to think about their own learning and check their progress. This method fits well with the principles of Universal Design for Learning (UDL), which aims to help all students learn in different ways (Center for Applied Science Technology, 2018).

This research will develop and test how valid, practical, and effective a web-based learning platform that uses RME for high school trigonometry is. The main goal is to show that students' understanding of trigonometry concepts improves. This research will also clearly describe the features of the developed WBI. This is important for showing how the learning tool was designed and put into action to reach learning goals. These features will include how the content is organized, how interactive it is, how much it supports independent learning, and how well it fits with RME. A clear description is necessary to measure how well the tool works, to allow others to use it, and to contribute to academic knowledge.

It is hoped that the results of this research will add to the theory by creating a combined framework that includes WBI, RME, and the traits of Generation Z. In a practical sense, this interactive learning platform can be a useful, real-world learning resource for both teachers and students. Checking how easy and pleasant it is to use will ensure the tool is effective for teaching, comfortable, and simple to use. Developing this WBI can also be another way to teach that supports deep learning in the Merdeka Curriculum, following its ideas of being mindful, meaningful, and joyful.

RESEARCH METHOD

This study is a research and development (R&D) study. It aims to develop an instructional media in the form of a website to support the learning process. The development model applied in this study refers to the Alessi and Trollip model, which provides a systematic framework for designing, developing, and evaluating educational media. The development procedure based on this model is illustrated in the Figure 1.

Evaluation design

The developed product, which takes the form of web-based instruction, requires a series of evaluations to ensure its effectiveness and quality. The evaluation is intended to gather constructive feedback and suggestions for improvement prior to finalizing the product. This stage includes two types of evaluation based on the Alessi and Trollip (2000) development model: alpha testing and beta testing.

Alpha testing is conducted through expert review involving media experts and subject matter experts, who assess the product's content validity, design quality, and technical aspects. Beta testing, on the other hand, is carried out in a real classroom setting involving teachers and students to evaluate the practicality, usability, and learning impact of the product.

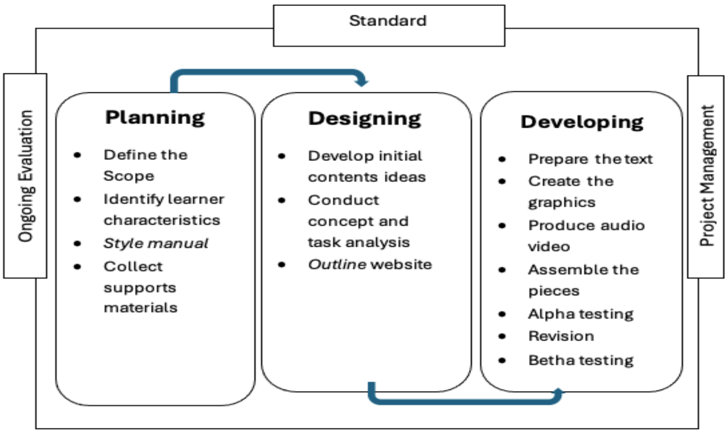

Figure 1. Development model, adopted from Alessi & Throllip model.

The outcomes from both evaluations serve as the basis for product refinement and are used to assess the feasibility and overall quality of the developed web-based instructional media. Figure 2 shows the evaluation design of this study.

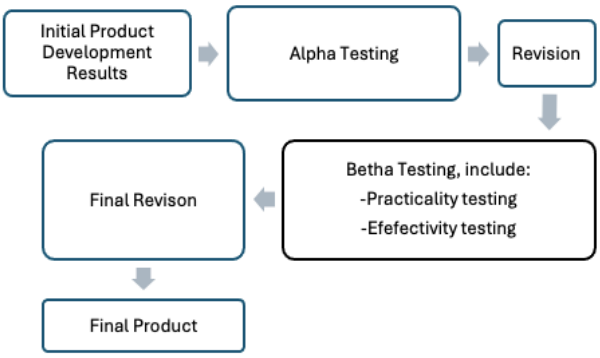

Figure 2. Evaluation design.

Data analysis

After all research data were collected—including input from validators, teacher and student assessments, and trial results—data analysis was conducted using both qualitative and quantitative approaches. The qualitative analysis focused on evaluating comments and suggestions from validators, students, teachers, and observers as the basis for refining and improving the product. The quantitative analysis was used to measure the validity, practicality, and effectiveness of the web-based instruction "Sine and Shine" in classroom learning.

The evaluation of the web-based instruction "Sine and Shine" involved both validity and practicality analyses, which were carried out using quantitative methods. The validity aspect was assessed through expert judgment involving two evaluators: a content expert and a media expert. Meanwhile, the practicality aspect was evaluated through questionnaires completed by teachers and students as end users. The data obtained from these instruments were analyzed using the validity calculation formula proposed by Widoyoko (2017), and the same formula was used to interpret the practicality scores (See Table 1).

Table 1. Validity and practicality criteria

Interval	Validity Categories	Practicality Categories
$S_{min} + 4I < X \leq S_{max}$	Strongly valid	Very practical
$S_{min} + 3I < X \leq S_{min} + 4I$	Valid	Practical
$S_{min} + 2I < X \leq S_{min} + 3I$	Less valid	Less practical
$S_{min} + I < X \leq S_{min} + 2I$	Invalid	Not practical
$S_{min} \leq X \leq S_{min} + I$	Strongly invalid	Not practical at all

At Table 1, the value of I was calculated using formula in Equation (1).

$$I = \frac{S_{max} - S_{min}}{\sum K_i} \quad (1)$$

with:

X : empirical score

I : Interval

S_{max} : maximum score

S_{min} : minimum Score

$\sum K_i$: number of interval classes

The content expert's evaluation instrument consisted of 19 items, the media expert's questionnaire included 22 items, and the practicality questionnaire completed by both teachers and students contained 18 items. All items used a five-point Likert scale with response options: Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D), and Strongly Disagree (SD). For positive items, scores ranged from 5 (SA) to 1 (SD), and for negative items, the scoring was reversed. Based on the number of items in each questionnaire and the interval formula presented in table 1, the assessment criteria intervals for each rating category can be determined accordingly. Table 2 displays the calculated score ranges used to interpret the level of validity and while table 3 present the level of practicality, based on the number of items in each evaluation instrument.

Table 2. Interpretation of interval score for validity aspect

Content Expert Interpretation Interval	Media Expert Interpretation Interval	Category
$79{,}8 < X \leq 95$	$92{,}4 < X \leq 110$	Strongly valid
$64{,}6 < X \leq 79{,}8$	$74{,}8 < X \leq 92{,}4$	Valid
$49{,}4 < X \leq 64{,}6$	$57{,}2 < X \leq 74{,}8$	Less valid
$34{,}2 < X \leq 49{,}4$	$39{,}6 < X \leq 57{,}2$	Invalid
$19 \leq X \leq 34{,}2$	$22 \leq X \leq 39{,}6$	Strongly invalid

The decision criterion for the media validation results is determined based on expert judgment from both the content and media experts. The media is considered valid if the total score obtained from the validation instruments, both for content and media aspects, reaches at least the "valid" category according to the classification intervals previously established. This classification ensures that the developed web-based instruction meets the minimum requirements for content relevance, instructional design quality, and technical presentation before proceeding to further stages of implementation or revision. Table 3 presents the data of practicality evaluation.

Table 3. Interpretation of interval score for practicality aspect

Interval	Interval in Percentage	Category
$75{,}6 < \bar{X} \leq 90$	$83\% < \bar{X} \leq 100\%$	Very practical
$61{,}2 < \bar{X} \leq 75{,}6$	$68\% < \bar{X} \leq 83\%$	Practical
$46{,}8 < \bar{X} \leq 61{,}2$	$52\% < \bar{X} \leq 68\%$	Less practical
$32{,}4 < \bar{X} \leq 46{,}8$	$36\% < \bar{X} \leq 52\%$	Not practical
$18 \leq \bar{X} \leq 32{,}4$	$20\% < \bar{X} \leq 36\%$	Not practical at all

The media is considered practical if it meets all of the following conditions: (1) the students' evaluation of the media reaches at least the "good" category, (2) the teachers' evaluation of the media also reaches at least the "good" category, (3) the average percentage of instructional implementation (as observed during classroom use) is greater than or equal to 80%.

In terms of effectiveness, the web-based instruction is considered effective if the average posttest score of students' conceptual understanding exceeds the school's passing grade, which is 75, and there is an observed improvement in posttest scores. The KKTP at the school where the beta testing was conducted is set at 75. To statistically verify whether the average posttest score surpasses the KKTP, a one-sample t-test can be used. Meanwhile, to examine whether there is a significant improvement in students' scores, a paired t-test is employed.

RESULTS AND DISCUSSION

We present the results into three stages, the planning, the designing, and the developing stage, as follows.

Planning

The planning stage began with determining the scope of the material, which focused on trigonometry. This decision was based on literature indicating that students often struggle with understanding trigonometric concepts (Khairunnisa et al., 2019; Rahmawati et al., 2023; Sinambela & Rombe, 2021). Studies have shown that such difficulties frequently lead to errors in solving problems, with some findings reporting that up to 80.95% of students' mistakes are due to conceptual misunderstandings (Fajri & Nida, 2019; Kusnadi et al., 2021; Hamzah et al., 2021). National examination results from 2019 also highlighted low performance in geometry and trigonometry. Moreover, interviews with a physics teacher confirmed the importance of mastering trigonometry for success in physics-related topics.

Identifying learner characteristics was the next step. Students in the 2024/2025 academic year largely belong to Generation Z (born between 1996 and 2010), who are known for their preference for interactive, technology-integrated learning environments (Nicholas, 2020; Hampton et al., 2020). Integrating digital resources into instruction aligns with their learning preferences and has been shown to improve engagement and academic achievement (Shorey et al., 2021; Hillmayr et al., 2020). The planned web-based instruction incorporates dynamic activities using geometry software to offer simulations and immediate feedback, which enhances conceptual understanding and class participation (Olive et al., 2010; Wang et al., 2017).

Classroom observations revealed that students have access to tablets and reliable internet, yet these tools are underutilized for academic purposes. To address this, the web-based instruction was designed to fully engage students with interactive simulations, accessible content, and integrated exercises throughout the lesson. Google Sites was selected as the development platform due to its user-friendly templates that support clear layout, intuitive navigation, and an uncluttered design conducive to focused learning.

Designing

In the design phase, several key activities were carried out, including concept and task analysis, the development of a web-based instruction outline, and evaluation and revision. The goal was to ensure that the instructional media aligned with the intended learning outcomes and supported students in mastering conceptual understanding.

The first step was conducting a thorough concept and task analysis. This involved studying the learning objectives, specifying instructional goals, selecting relevant content, and designing appropriate assessment tools. These assessments were carefully aligned with conceptual mastery indicators and competency achievement standards, in line with the media's focus on supporting conceptual understanding. Two instructional design models served as the foundation: the Hypothetical Learning Trajectory (HLT) and a concept-supporting activity design based on Realistic Mathematics Education (RME). The HLT helped map students' expected learning paths, anticipate difficulties, and structure meaningful learning experiences. Meanwhile, the activity design incorporated real-life contexts and interactive simulations using GeoGebra to facilitate students' exploration of trigonometric concepts, guiding them from informal to formal mathematical reasoning. The instructional design of the web-based instruction that can support conceptual understanding is shown on Table 4.

Table 4. Instructional features supporting conceptual understanding

Conceptual Understanding Indicators	Interactive Features/Activities
Restating concepts	• Interactive GeoGebra: identify and define sides based on position. • Downloadable worksheet (LKPD) guiding students to define sides (opposite, adjacent, hypotenuse). • Interactive quizzes on identifying side types.
Giving examples and non-examples	• GeoGebra-based quizzes to identify various triangle sides. • Conceptual quizzes: e.g., "Which of these is a correct example of angle-side relation?"
Representing concepts in multiple forms	• Situational questions using real-world contexts (e.g., triangles, observers, angles). • Matching real-life situations with correct mathematical representations.
Connecting mathematical ideas	• GeoGebra tasks to explore trigonometric ratios using variable triangle dimensions. • Interactive quizzes asking students to determine missing ratios using known side values.
Applying concepts in new contexts	• Word problems and contextual tasks requiring students to apply trigonometric concepts.

The next step was creating an outline for the web-based instruction. This outline served as a blueprint for the website's structure, detailing the organization of pages, categories, and interconnections. It was designed to ensure logical navigation, identify the types of content required, and streamline the development and revision process. A well-structured outline contributes to a more accessible and organized learning platform.

Website interface and learning feature

The Sine and Shine Web-Based Instruction (WBI) teaching program was developed with careful attention to interface design and instructional features that support students' conceptual understanding of trigonometry. The website structure, interactive activities, and feedback mechanisms were designed to align with Realistic Mathematics Education (RME), dynamic visualization, and formative assessment principles. Screenshots are included to show how these design elements were implemented to create a meaningful and student-centered digital learning environment.

Figure 3 shows the homepage of the Sine and Shine web-based learning platform. The interface uses a simple layout, clear navigation, and readable fonts. This design helps students focus on learning trigonometry concepts without distraction. A clear interface reduces cognitive load and allows learners to concentrate on understanding mathematical ideas rather than managing the system (Hassenzahl, 2010; Sweller et al., 2011). This supports students in building conceptual understanding by making learning materials easy to access, explore, and follow independently.

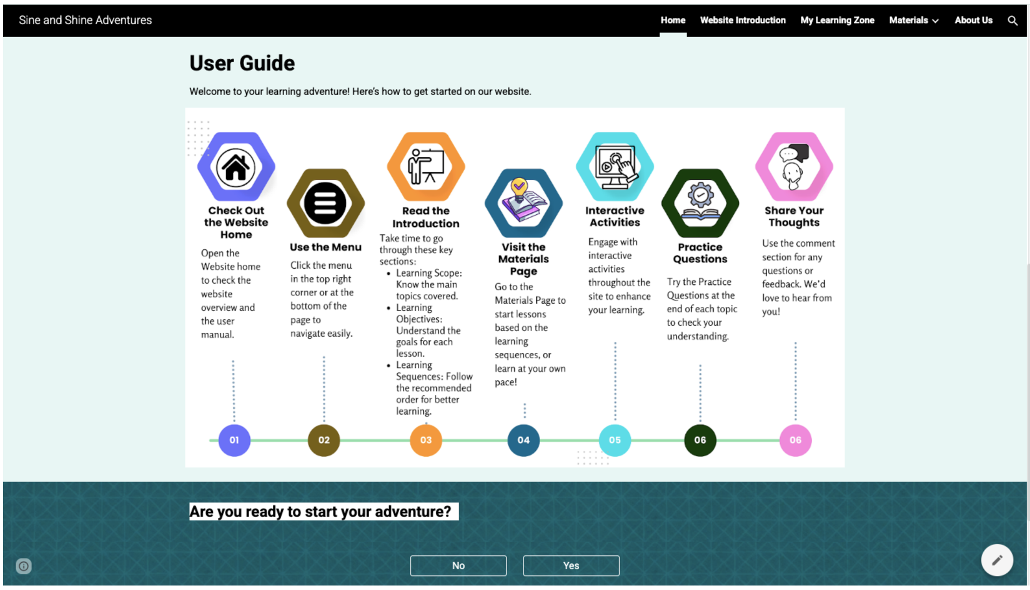

Figure 3. Homepage of the Sine and Shine Web-Based Instruction (WBI) teaching program showing simple layout, clear navigation, and readable interface design.

The material section organizes trigonometry topics in a logical sequence, from basic ratios to problem-solving applications (See Figure 4). This structure supports progressive concept development, where students move from simple ideas to more complex reasoning. Research shows that structured digital materials help students connect concepts and improve mathematical understanding (Mayer, 2024; Park & Choi, 2009). This organization helps students develop strong trigonometry concepts rather than memorizing formulas mechanically.

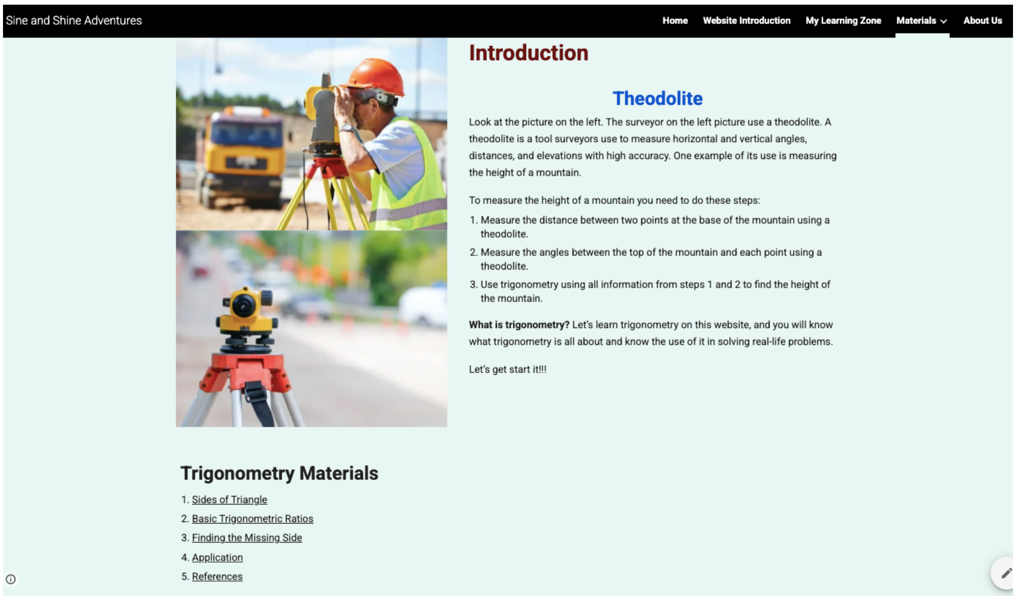

Figure 4. Materials section of the Sine and Shine WBI teaching program displaying organized trigonometry topics arranged progressively from basic ratios to problem-solving applications.

The Will It Hit Your House? activity (See Figure 5) applies the Realistic Mathematics Education (RME) approach by starting with a real-life problem involving angles, distances, and height estimation. Students are guided to translate the context into mathematical models and interpret the results. Learning through realistic contexts helps students understand why trigonometric concepts work and how they are used in daily life (Gravemeijer & Doorman, 1999; National Council of Teachers of Mathematics, 2014). This activity directly supports conceptual understanding by helping students connect trigonometric ratios to meaningful situations.

Figure 5. Screenshot of the Will It Hit Your House? activity illustrating the use of real-life contextual problems based on the RME approach.

The platform integrates dynamic GeoGebra-based interactive activities. In Activity 2, students can drag the vertices of a right triangle, change its size and orientation, and select different reference angles (See Figure 6).

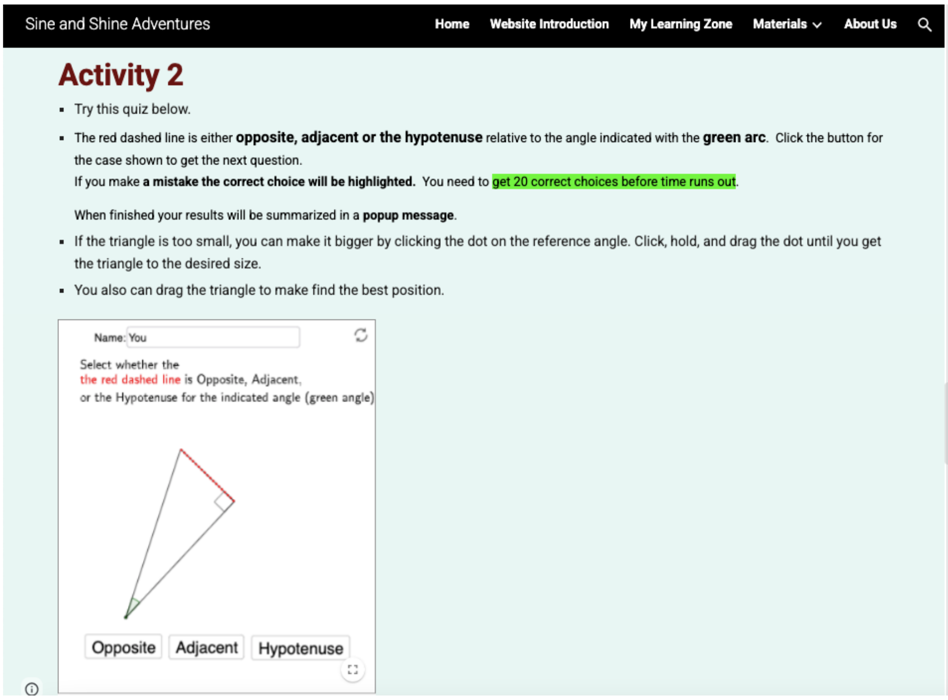

Figure 6. GeoGebra-based interactive activity allowing students to manipulate triangle size, orientation, and reference angles to explore relationships among opposite, adjacent, and hypotenuse sides dynamically.

As the triangle changes, the opposite, adjacent, and hypotenuse sides update automatically. This dynamic manipulation allows students to observe invariant trigonometric relationships and develop conceptual understanding through exploration rather than memorization. Dynamic geometry environments are known to support conceptual reasoning and mathematical meaning-making (Höffler & Leutner, 2007; Sinclair & Yerushalmy, 2016).

The platform also includes interactive quizzes in which students identify trigonometric components or solve ratio problems and receive immediate feedback after each response (See Figure 7). Students can repeat the quiz as many times as needed. This direct feedback helps students monitor their understanding level, recognize misconceptions, and strengthen their trigonometry concepts through repeated practice. Research shows that formative assessment with instant feedback improves conceptual learning and self-regulated learning in mathematics (Shute, 2008; Nicol & Macfarlane-Dick, 2006; Van der Kleij et al., 2015).

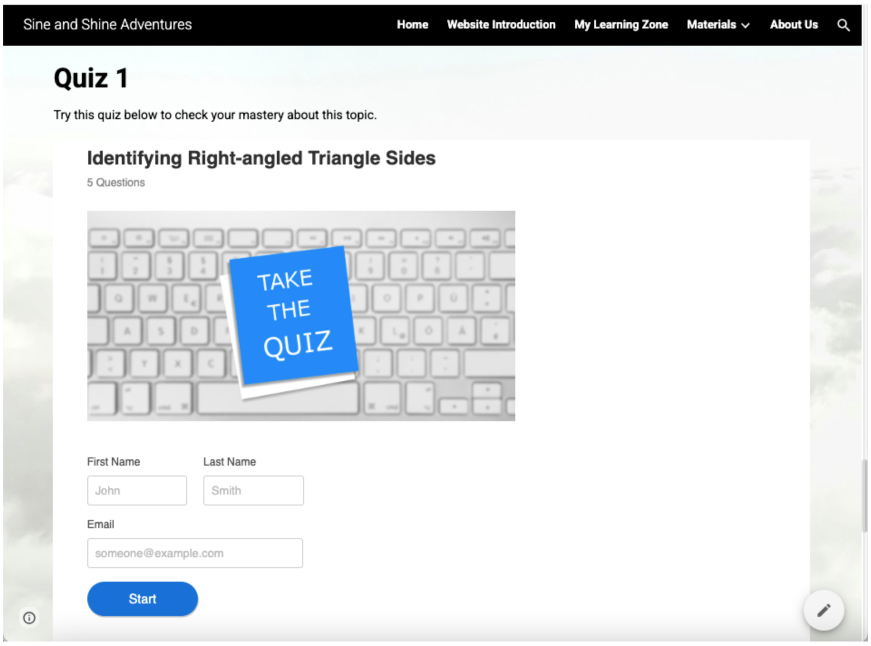

Figure 7. Interactive quiz interface providing immediate feedback to help students monitor their understanding and strengthen trigonometry concepts through repeated practice.

Overall, the website interface and learning features were developed to support students' conceptual understanding of trigonometry through structured content, real-life contexts, dynamic visual exploration, and feedback-based practice. These features follow best practices in web-based learning design (Park & Choi, 2009). Thus, the platform not only delivers trigonometry content but also promotes meaningful conceptual learning, which is essential for long-term mathematical understanding, especially for Generation Z learners who prefer interactive and self-directed online environments.

Developing

The development of the Sine and Shine web-based instruction for trigonometry was carried out based on a previously constructed outline. This process involved the creation of various instructional components, including textual explanations, interactive activities, visuals, audio, and video content. These elements were then integrated using Google Sites to build an interactive digital learning platform designed to support students' conceptual understanding of trigonometry.

Due to the limited features available in Google Sites, several external applications were employed to enrich the learning experience. MathJax was integrated to present mathematical notation professionally and accurately using LaTeX syntax. GeoGebra was used to develop dynamic and interactive simulations that allowed students to manipulate geometric and trigonometric representations directly. ProProfs Quiz Maker enabled the creation of interactive quizzes that could be embedded into the website without requiring user login, providing immediate feedback to students. In addition, Commoninja was used to embed a comment widget, offering students a space to ask questions, engage in discussions, and provide feedback directly on the learning content.

Web-based instruction quality

The Sine and Shine web-based instruction underwent validation by two experts from the Mathematics Education Department at FMIPA UNY, each bringing a different focus—content and media. The content expert awarded a high score of 89 out of 95, praising the strong alignment between learning objectives, instructional content, and activities, which reflects the principles of effective multimedia design (Clark & Mayer, 2024). Minor revisions were also recommended, such as using technical terms more consistently and including a references page. Meanwhile, the media expert gave a score of 100 out of 110, highlighting the interface's usability, efficient navigation, and cohesive visual design. The integration of images, color schemes, and multimedia elements like audio and video was aligned with Mayer's Cognitive Theory of Multimedia Learning (Mayer, 2024), enhancing both clarity and engagement. Together, the evaluations confirm that Sine and Shine is a highly valid learning resource, both in terms of content quality and digital design, requiring only minimal refinements to maximize its effectiveness in supporting student learning.

The practicality of the Sine and Shine web-based instruction was evaluated through a beta test involving 13 high school mathematics teachers who teach trigonometry. Using a media practicality questionnaire, the platform received an average score of 79.31 (88%), which exceeds the 85% threshold for the "Very Good" category, indicating the platform is highly practical and ready for classroom use. Student feedback also supported this finding, with an average score of 75.7, slightly above the previous trial's 74.6, reflecting improved quality after revisions. Each aspect: usability, functionality, visual communication, and pedagogy, received average scores above 80%, with pedagogy scoring highest at 88.5%. Although functionality and pedagogy could benefit from further refinement, the enhancements made after earlier testing clearly contributed to better performance. Classroom observations further confirmed this practicality: lesson implementation reached 100% in the first session and 92% in the second, averaging 96%. Notably, teachers observed increased engagement and focus among typically passive students, suggesting that Sine and Shine not only functions well but also positively influences student participation, underscoring its strong practical value for teaching trigonometry.

To evaluate the effectiveness of the Sine and Shine web-based instruction, student performance on pretests and posttests was analyzed. The average pretest score was 39.10, which significantly improved to 83.52 on the posttest, well above the school's mastery criterion (KKTP) of 75. This claim is statistically supported by a one-sample t-test, showing that the posttest scores are normally distributed ($p = 0.8364$) and significantly higher than 75 ($p<0.001$). A paired t-test comparing pretest and posttest scores further confirms a significant improvement ($p<0.001$), with an n-gain score of 0.72, indicating a high level of learning gain. Moreover, 90.4% of students scored above the KKTP threshold, demonstrating substantial conceptual understanding. Specific indicators of concept mastery also showed strong results: 87% could restate concepts, 81% represented them in different forms, 78% could identify examples and non-examples, 82% made connections between concepts, and 81% applied trigonometric ratios to solve problems. In addition, nearly all students (20 out of 21) scored above 75% on essay questions that required procedural application, highlighting the product's success in promoting both conceptual and procedural understanding. Collectively, these outcomes show that the Sine and Shine media, grounded in Realistic Mathematics Education (PMR), is highly effective in enhancing students' trigonometric concept comprehension while fostering independent, meaningful learning. The findings not only affirm the academic value of this digital learning tool but also suggest its practical relevance for classroom use and its potential as a model for future policy in 21st-century digital education.

CONCLUSION

Based on the findings of this study, the Sine and Shine Web-Based Instruction (WBI) developed using the Realistic Mathematics Education (RME) approach demonstrates strong characteristics as an effective digital teaching program for trigonometry learning. The WBI was developed with key instructional features, including structured content organization, real-life contextual problems, dynamic GeoGebra-based interactive activities, visual representations, and direct-feedback quizzes, all of which are designed to support students' conceptual understanding of trigonometry. These features allow students to actively explore mathematical relationships, manipulate geometric objects, and monitor their own learning progress, so it can help students improve their conceptual understanding of trigonometry.

The product was validated by two experts and achieved an average empirical score of 88%, categorized as very valid, indicating that its content accuracy, instructional design, and alignment with RME principles are appropriate for instructional use. Practicality testing involving teachers and students also yielded high average scores of 79.31 (88%) from teachers and of 75.7 from students, both falling within the very practical category. These results show that the WBI is easy to use, functionally effective, and visually clear, enabling students to engage with trigonometry concepts without unnecessary difficulty.

Furthermore, effectiveness testing through descriptive and inferential analysis revealed significant improvements in students' conceptual understanding of trigonometry. The average posttest score (83.52) exceeded the school's minimum mastery criterion (KKTP), and the normalized gain score (n-gain) of 0.72 indicates a high level of learning improvement. These learning gains are closely related to the website's interactive features, particularly the dynamic triangle manipulation and immediate feedback from quizzes, which help students identify misconceptions and strengthen conceptual reasoning.

Overall, these results confirm that the Sine and Shine WBI is valid, practical, and effective in enhancing students' conceptual mastery of trigonometry. By combining RME-based contextual learning with interactive digital features, the developed WBI supports deep conceptual understanding and independent learning, making it a suitable instructional alternative for mathematics learning in digital environments.

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DECLARATION

Author contribution

All authors contribute in the research and/or writing the paper, and approved the final manuscript.

Ika Surtiani	Conceptualizing the research idea, leading the investigation, setting up the methodology, analyzing the data, and writing the original draft.
Hartono	Assisting the investigation, reviewing the validity of the methodology, and enriching the data analysis.

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Conflict of interest
All authors declare that they have no competing interests.

Ethics declaration
We as authors acknowledge that this work has been written based on ethical research that conforms with the regulations of our institutions and that we have obtained the permission from the relevant institutes when collecting data. We support the International Journal on Education Insight (IJEI) in maintaining the high standards of personal conduct, practicing honesty in all our professional practices and endeavors.

The use of artificial intelligence
We do not use any generative AI tools to write any part of this paper.

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