Development of trigonometric comparison teaching materials based on ICT and Tri-N for face-to-face and distance learning

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Received: 28 January 2024; Revised: 18 February 2024; Accepted: 22 March 2024

Abstract: This study endeavors to (1) develop instructional materials grounded in ICT and Tri-N principles tailored for both Face-To-Face Learning and Distance Learning modalities, and (2) assess the feasibility of these materials for dual usage. The research methodology employed is the Research and Development (R&D) approach, utilizing the ADDIE model encompassing five sequential stages: (1) Analysis; (2) Design; (3) Development; (4) Implementation; and (5) Evaluation. The study was conducted at SMA N 5 Yogyakarta, with a cohort of 36 students from class X-1 utilizing the PTM model, and another 36 students from class X-2 employing the PJJ model as research subjects. Data collection methods encompassed validation questionnaires, student response surveys, and learning outcome assessments, while data analysis involved both qualitative and quantitative descriptive methodologies. The research culminated in the creation of instructional materials rooted in ICT and Tri-N principles, comprising videos, PowerPoint (PPT) presentations, and handouts, which underwent comprehensive product feasibility testing. Validation results from media and material experts demonstrated a high level of validity, with Face-to-face instructional materials receiving an average score of 4.55 and distance learning instructional materials achieving an average score of 4.04. During the implementation phase, student feedback yielded favorable average scores of 3.49 for face-to-face instructional materials and 4.02 for distance instructional materials, indicating positive reception and usability. Notably, statistical analyses revealed a significant positive correlation between student responses and learning outcome assessments, affirming the suitability of the instructional materials for effective utilization by both students and educators.

Keywords: ICT, Teaching materials, Tri-N, Trigonometric Comparison


INTRODUCTION

With the development of the times, society as technology users can transform their way of life through the Development of Science and Technology (Asaro, 2000). In the field of education, particularly in the teaching process, teachers must be able to keep up with the developments in the world of science and technology, including the realm of information and communication technology (Owolabi et al., 2013). Thus, preparing teachers for their role as educators, students can comprehend the role of technology in the learning process (Ly senko & Abrami, 2014). Moreover, especially after the advent of COVID-19, teachers are required to be proficient in using technology, where they must be capable of creating teaching materials suitable for distance learning (Simonson et al., 2019). The Minister of National Education Regulation Number 2 of 2010 regarding the Strategic Plan of the Ministry of National Education 2010-2014 states that the need for mastery and application of Science and Technology in facing global demands has led to an increasing role of Information and Communication Technology (ICT) in various aspects of life, including education (Moges, 2014).
There is a growing demand for sharing information and knowledge by utilizing ICT, and the development of the internet has eliminated boundaries of geography and time in communication and access to information (Elwood et al., 2012; Setiana et al., 2021).

The growing demand for information sharing through ICT aligns with the advancement of internet technology, which has eradicated geographical and temporal constraints, fostering the development of sophisticated internet-based technologies. ICT, or also known as Information and Communications Technology, has led to the development of increasingly sophisticated internet-based technologies (Njoh, 2018). The learning process can be combined with instructional tools, often referred to as learning media (Mayer, 2003). It can display various media such as text, photos, audio, graphics, videos, and interactive animations, serving as a means for learning activities. The advancement of technology has eliminated the barrier of distance, allowing access to information from various countries worldwide (Gulati, 2008). The quantity of information obtained depends on the ability to utilize the sophistication of the technology itself, leading to a competitive environment that cannot be avoided (Stadler et al., 2013). One of the providers of video-sharing websites that allows users to share, watch, and upload videos is YouTube (Cheng et al., 2013).

Through instructional materials in the form of videos uploaded on YouTube, learning can be conducted both online (Distance Learning) and offline (Face-to-Face). Distance learning refers to the implementation of learning that utilizes the internet network, utilizing multimedia technology, virtual classes, email, teleconferencing, or video streaming in the process (Arkorful & Abaidoo, 2015). This can facilitate teachers in teaching. With distance learning, there is a need for preparation of facilities and infrastructure to support this form of learning, with the primary requirements being internet connectivity and the appropriate media used (Sari & Nayir, 2020). In the preparation of teaching materials for mathematics, there is a teaching method where teaching method is interpreted as the arrangement and guidance for the direction of the learning process. As expressed by Perrott (2014), the learning model is actually a container for the approach of methods and teaching techniques as a guide for improving the teaching and learning activities. Ki Hadjar Dewantara, the founder of Tamansiswa, has a learning model based on Tri-N (Niteni, Nirokke, Nambahi). The Tri-N theory, derived from collaborative research by Ermawati and Rufaidah (2019), outlines the following: (1). Niteni: This involves marking or identifying using all senses carefully; (2). Nirokke: It entails imitating what is taught through models/examples/paragons from teacher/learning sources, involving the mind, perception, feelings/conscience, and spirituality in an integral and harmonious manner. This can be done through processes like reciting/using one’s voice; imitating by reading, imitating by writing, imitating through movements, imitating by trying/experimenting, imitating by demonstrating or practicing, and imitating by presenting; and (3). Nambahi: It involves adding to what has been learned through models/examples/paragons from teacher/learning sources by developing creativity and ideas. This is done through processes such as adding by designing, adding by creating/making, and adding by improvising.

This teaching material is specifically created for the subject of trigonometry. Trigonometry is one of the learning subjects in mathematics that not many students enjoy, as they often face confusion in understanding the material (Hamzah et al., 2021; Hidayati, 2020). Trigonometry is also a math subject where students encounter difficulties and perceive it as more abstract compared to other topics (Adhikari & Subedi, 2021; Nanmumpuni & Retnawati, 2021). The materials proposed in the development of teaching materials aim to address these challenges in various ways. First, visual and interactive approaches can be used to help students better visualize trigonometric concepts. For example, the use of triangle diagrams, animations, or math software applications can help students understand the relationship between angles and sides in a triangle. Secondly, a problem-based approach can be applied by presenting real problems that require the application of trigonometric concepts for their solution. Thus, students can see the direct relevance of the material learned in everyday life, which can increase their motivation and understanding of the material.
Based on the description above, the researcher intends to develop teaching materials for mathematics learning. Therefore, the researcher conducted a study on "Development of Trigonometric Comparison Teaching Materials Based on ICT and Tri-N for Face-to-Face and Distance Learning". The purpose of the research is to develop teaching materials for trigonometry that utilize Information and Communication Technology (ICT) and the Tri-N learning model. These teaching materials are intended to be adaptable for both face-to-face and distance learning environments. The study aims to explore innovative ways of teaching trigonometry, leveraging modern technologies and pedagogical approaches to enhance the learning experience for students in various educational settings. Additionally, the research seeks to compare the effectiveness of these teaching materials in face-to-face and distance learning contexts, providing insights into the potential benefits and challenges of each approach. Overall, the goal is to contribute to the improvement of trigonometry instruction and student learning outcomes through the development and evaluation of innovative teaching materials.

METHOD

The research model used in this study is the research and development method or Research and Development (R&D). According to Feri and Zulherman (2021), Research and Development (R&D) is a research method used to generate a specific product and test its feasibility. In this study, the Research and Development (R&D) method will be applied to systematically develop an interactive PowerPoint presentation tailored to enhance educational experiences. The R&D process involves several steps customized to the specific context of creating the presentation. Its objective is not only to create new products but also to improve existing ones. The context of the product discussed is, of course, products that are beneficial in the educational realm during the learning process. In this research, the developed product is an interactive PowerPoint presentation (PPT) that will be packaged into a video, and this video will be uploaded on YouTube.

The research model used in this study is the ADDIE development model (Analysis, Design, Development, Implementation, and Evaluation) (Saeidnia et al., 2022). In the analysis stage, we will gather data on students' current understanding of trigonometry, identify areas of difficulty or misunderstanding, and assess the available resources. This will involve reviewing curriculum standards, conducting surveys or interviews with teachers and students, and analyzing existing teaching materials. In the design stage, we will plan the structure, content, and delivery methods of the teaching material. For example, we will create a detailed outline of the topics to be covered, select appropriate instructional strategies, and design interactive elements such as quizzes or simulations. During development, we will create the actual teaching material based on the design specifications. This may involve writing instructional content, designing visuals, recording videos, and developing interactive features. In the implementation stage, we will deliver the teaching material to students, whether through in-person classes or online platforms. Finally, in the evaluation stage, we will assess the effectiveness of the teaching material in achieving its learning objectives. This may involve collecting feedback from students and teachers, analyzing student performance data, and making revisions based on the evaluation results. Through these stages, we will systematically develop and refine the teaching material to ensure its effectiveness in facilitating student learning in trigonometry.

The ADDIE model was chosen because it involves straightforward stages and includes evaluation at each step, ensuring that the produced product is suitable for use in learning. The subjects of this study are students from classes X MIPA 1 & 2 at SMA N 5 Yogyakarta. The sample of students from classes X MIPA 1 & 2 at SMA N 5 Yogyakarta was selected using specific criteria to ensure relevance and representativeness. Inclusion criteria may have included students enrolled in the X MIPA 1 & 2 classes who were actively studying trigonometry during the research period. These classes were likely chosen because they represent the target population for the study, comprising students studying mathematics and
science subjects at the high school level. Additionally, these classes may have been selected based on their accessibility and willingness to participate in the study, facilitating data collection and ensuring a sufficient sample size for analysis. The choice of classes X MIPA 1 & 2 aligns with the research focus on trigonometry and allows for a focused examination of the effectiveness of the teaching material within a specific educational context. The research object is the Teaching Material on Trigonometric Comparison Based on ICT and Tri-N for Face-to-Face and Distance Learning. The instructional material development research is conducted in the mathematics education research program at Universitas Sarjanawiyata Tamansiswa, where the study will be carried out in SMA Negeri 5 Yogyakarta, specifically in the 10th-grade classes during the odd semester.

Data collection techniques used include quantitative and qualitative data, which will be employed to obtain the necessary information. Data collection encompasses both quantitative and qualitative approaches to gather essential information. The research utilizes various instruments, including expert validation questionnaires for media and content, student response questionnaires, and student learning outcome tests. Media and content expert validation questionnaires are administered to professionals or educators in the relevant field to assess the feasibility of the instructional material. Student response questionnaires are distributed to students to gauge their engagement and feedback on the provided materials. Additionally, student learning outcome tests are conducted to evaluate students' comprehension of the instructional content. Data analysis involves qualitative techniques to interpret input from validators and quantitative methods to assess the quality of instructional materials based on feedback from validators, student response questionnaires, and learning outcome tests.

The research employs a range of meticulously developed instruments to gather data, including expert validation questionnaires, student response questionnaires, and learning outcome tests. Expert validation questionnaires are distributed to professionals or educators with expertise in the field to assess the feasibility of the instructional materials. Criteria were established to ensure the selection of qualified experts capable of providing informed feedback. Student response questionnaires are tailored to gauge students' interest and engagement with the instructional material, prioritizing clarity and relevance in question design. Learning outcome tests are crafted in alignment with educational standards and learning objectives, ensuring accuracy in assessing students' comprehension. To uphold validity and reliability, these instruments undergo rigorous pilot testing and refinement to mitigate ambiguities or inconsistencies. Psychometric principles, including content validity, construct validity, and internal consistency, are applied to assess the validity and reliability of the instruments. This meticulous approach to instrument development safeguards the integrity of the data collected and bolsters the trustworthiness of the study's findings. Data analysis techniques encompass both qualitative and quantitative methods. Qualitative analysis is employed to interpret feedback from validators, offering insights into the instructional material's strengths and weaknesses. Quantitative analysis, on the other hand, focuses on assessing the instructional material's quality based on research results from validators, student response questionnaires, and learning outcome tests. This comprehensive analytical approach ensures a robust examination of the research findings, enriching the study's scientific value and contributing to advancements in the field of mathematics education.

RESULTS AND DISCUSSION

Results

In this section, we embark on a thorough examination of the outcomes derived from the research journey. The meticulous analysis, design, and development of instructional materials have paved the way for insights that promise to enrich mathematics education. As we traverse through the results, we unravel the impact of innovative approaches on teaching and learning,
along with the effectiveness of the materials in both traditional and remote learning settings. This preface sets the tone for a detailed exploration of the tangible outcomes, inviting readers to delve into the nuanced findings that contribute to the broader dialogue on contemporary educational practices.

**Analysis**

At the outset of this research, a comprehensive analysis was undertaken through interviews and observations conducted at SMA N 5 Yogyakarta. This pivotal stage sought to delve into the intricacies of mathematics learning, aiming to identify challenges and pave the way for innovative solutions. The interviews uncovered a noteworthy observation—certain classes exhibited a lack of responsiveness during learning activities. This crucial insight laid the foundation for addressing the identified issues. Upon meticulous classroom observations, a rich technological infrastructure was revealed, including projectors, LCDs, and Wi-Fi facilities. However, a distinct gap emerged—these existing resources were not fully harnessed to their potential during the learning process. Recognizing this untapped potential, the researcher strategically utilized these facilities to enhance the mathematics learning environment. The analysis phase, therefore, serves as a springboard for the subsequent stages of design and development, setting the stage for the integration of Information and Communication Technology (ICT) and the Tri-N approach to address the identified challenges.

**Design**

The design phase marks a transformative juncture in this research, where the focus shifts towards crafting instructional materials that leverage both Information and Communication Technology (ICT) and the Tri-N approach. Utilizing Microsoft PowerPoint as the primary tool, a meticulous process unfolds to create dynamic and engaging content. During the design phase of this research, the transition is made towards crafting instructional materials that merge Information and Communication Technology (ICT) with the Tri-N approach. Microsoft PowerPoint is chosen as the primary tool due to its versatility and widespread accessibility, enabling the creation of dynamic and engaging content. The rationale behind selecting Microsoft PowerPoint lies in its user-friendly interface, extensive range of design features, and compatibility with multimedia elements, such as images, videos, and animations. The process of content creation begins with the careful distillation of complex trigonometric concepts into manageable modules. This involves breaking down the material into logical units, ensuring coherence and alignment with curriculum objectives. Each module is meticulously crafted to maintain clarity and facilitate understanding, leveraging visual aids, diagrams, and concise explanations to enhance comprehension. Simultaneously, the design of teaching modules takes shape, with a focus on structuring content in a logical sequence that supports the learning progression. The layout and organization of each module are carefully considered to optimize student engagement and retention. Clear headings, subheadings, and bullet points are utilized to delineate key concepts and facilitate navigation through the material.

The multifaceted steps in this phase encompass the creation of content, design of teaching modules, development of comprehensive handouts, and the production of instructional videos, all meticulously curated within the Microsoft PowerPoint framework. Each step in this design journey is a deliberate effort to enhance the quality and efficacy of the instructional materials. Content creation involves distilling complex trigonometric concepts into digestible modules, ensuring clarity and coherence. Designing teaching modules adds a layer of pedagogical finesse, aligning the materials with educational objectives. Handouts serve as valuable resources, consolidating key concepts for reference. The pinnacle of this design phase is the creation of instructional videos—a dynamic medium combining visual and auditory elements to foster a holistic learning experience. Notably, in an era where online accessibility is paramount, the researcher takes a forward-thinking step by uploading these instructional videos to
YouTube. This strategic decision not only broadens the reach of the materials but also aligns with contemporary learning trends, making education accessible beyond traditional classroom boundaries. The design phase, therefore, emerges as a pivotal bridge connecting theoretical foundations with practical, technology-infused instructional tools.

**Development**

The development phase ushers in a crucial stage, transforming theoretical design into tangible educational resources. At this juncture, the primary focus is on actualizing mathematics instructional videos rooted in both Information and Communication Technology (ICT) and the Tri-N methodology. This phase becomes a pivotal bridge, connecting the conceptualization of materials to their tangible manifestation, contributing significantly to the advancement of mathematics education.

During the development phase, the focus is on bringing the instructional materials to life through the creation of instructional videos, integrating Information and Communication Technology (ICT) tools and the principles of the Tri-N methodology. The process begins with careful planning and scripting to ensure that each video effectively conveys key trigonometric concepts while aligning with the Tri-N approach. To create the instructional videos, a combination of ICT tools and techniques is employed to enhance visual engagement and facilitate learning. Microsoft PowerPoint serves as the primary platform for content creation, providing a user-friendly interface for designing slides and integrating multimedia elements such as images, animations, and diagrams. Screen recording software is utilized to capture narrated presentations, allowing for seamless integration of audio and visual components.

The Tri-N methodology guides the development of instructional videos, with a focus on incorporating elements of understanding (Niteni), remembering (Nirokke), and applying (Nambahi) trigonometric concepts. Each video is carefully structured to promote comprehension through clear explanations and visual demonstrations, fostering a deeper understanding of mathematical principles. Strategies such as repetition, mnemonic devices, and real-world examples are employed to aid in memory retention and application of learned concepts. Expert validators play a crucial role in refining the instructional materials by providing valuable feedback and insights from their expertise in mathematics education. These validators, typically experienced educators or subject matter experts, review the instructional videos to assess their clarity, accuracy, and effectiveness in facilitating learning. Their feedback helps to identify areas for improvement and refinement, ensuring that the instructional materials meet rigorous standards of quality and pedagogical efficacy.

The feedback from expert validators is carefully considered and integrated into the iterative development process, guiding revisions and enhancements to the instructional materials. Suggestions for clarification, additional examples, or adjustments to pacing are implemented to optimize the effectiveness of the instructional videos. Through this collaborative process, the instructional materials are continually refined and improved to meet the needs of students and align with the goals of trigonometry instruction. This iterative feedback loop, involving the collaboration of subject matter experts, fortifies the credibility and pedagogical soundness of the developed instructional materials. The development phase, therefore, emerges not just as a process of creation but as a collaborative endeavor to produce impactful educational tools that transcend traditional boundaries.

**a. Production of Instructional Videos Based on ICT and Tri-N Using Microsoft PowerPoint.**

1) **Initial Display**

The initial display section serves as the gateway to a comprehensive learning experience, strategically combining visual elements to engage and captivate the audience. Within the introductory video, a symbolic UST logo takes center stage, symbolizing the institutional foundation of the educational content. This logo not only establishes a sense of credibility but also serves as a visual identifier, fostering a connection with the broader educational context. Accompanying the UST logo is the
unequivocal proclamation of the instructional focus—trigonometric ratios. This succinct title acts as a compass, guiding learners through the mathematical terrain that lies ahead. By clearly delineating the subject matter from the outset, the initial display creates an anticipatory atmosphere, setting the stage for an exploration of trigonometric concepts.

In essence, the initial display section is more than a visual prelude; it is a deliberate orchestration designed to prime learners for an immersive educational journey. By seamlessly integrating institutional symbolism with a precise thematic declaration, this section lays the foundation for a cohesive and purposeful learning experience in the realm of trigonometry. The initial video display is shown in Figure 1.

![Initial Video Display and Title of the Material](image1)

**Figure 1. Initial Video Display and Title of the Material**

2) Opening Title Subtopic Display

The opening display contains the title of the sub-topic that will be discussed in the instructional video. Within the opening display section, the educational journey takes a focused turn by spotlighting the specific sub-topic slated for exploration. A well-crafted title emerges as the beacon, providing clarity and direction to learners about the imminent subject matter. This strategic choice aims to orient students and cultivate an anticipatory mindset as they delve into the intricacies of the instructional content.

The opening display doesn’t merely offer a glimpse of what lies ahead; it serves as a navigational guide, ensuring that learners are attuned to the subtleties of the upcoming sub-topic. By presenting this roadmap at the outset, the opening display establishes a cognitive framework, enabling students to organize their thoughts and expectations. In essence, the opening display section functions as an educational signpost, illuminating the pathway to focused and purposeful learning. It transforms the instructional landscape into a structured terrain, allowing learners to approach the sub-topic with a clear understanding of the destination. This intentional framing contributes to a more engaged and receptive audience as they embark on the instructional voyage. The instructional material opening display is shown in Figure 2.

![Display of the Instructional Material Opening](image2)

**Figure 2. Display of the Instructional Material Opening**
3) Material Display
The material display contains explanations about the sub-topic. The material display above is the introductory material for trigonometric ratios. The material is created using Microsoft PowerPoint and includes animation effects. The material display section emerges as a pivotal arena for exploring the depths of trigonometric ratios. Focused on the sub-topic at hand, this section intricately weaves explanations into a comprehensive narrative. At the forefront is the introductory material, a crafted masterpiece designed to unravel the complexities of trigonometric ratios.

This instructional voyage is facilitated through the adept use of Microsoft PowerPoint, transforming the material into an interactive learning experience. The inclusion of animation effects serves as a catalyst, injecting dynamism into the static realm of mathematics education. Every animation is a deliberate stroke, guiding learners through a sequential and logical unfolding of concepts. The choice of Microsoft PowerPoint as the medium is intentional, offering a versatile canvas for the creation of visually engaging and pedagogically robust content. Animation effects, far from being mere embellishments, play a strategic role in enhancing comprehension and retention.

The material display becomes an animated tableau, where abstract mathematical concepts come to life, fostering a deeper understanding among learners.

In summary, this material display section stands as a testament to the amalgamation of technology and instructional design. By seamlessly integrating Microsoft PowerPoint and animation effects, it not only imparts knowledge but transforms the learning journey into a visually stimulating and intellectually enriching experience.

The material display is presented in Figure 3.

4) Display of Examples and their Explanations
This display shows sample questions and their explanations explained by the presenter. Within the instructional framework, the display of examples emerges as a beacon, guiding learners through the labyrinth of trigonometric ratios. Here, the pedagogical focus shifts to practical application, as the presenter unveils a series of sample questions, breathing life into theoretical constructs.

The Niteni segment becomes a captivating showcase, where mathematical abstractions are translated into tangible problem-solving scenarios. Each example question is meticulously chosen to represent real-world challenges that trigonometry can address. As learners grapple with these examples, the presenter, akin to a mathematical maestro, provides lucid explanations, unraveling the intricacies step by step. The symbiosis of questions and explanations not only fortifies theoretical knowledge but also equips learners with problem-solving acumen. Niteni is not just a display; it is a transformatively dialogue, bridging the gap between theory and its real-world implications. The display of example questions (Niteni) is presented in Figure 4.
5) Exercise Questions Display

In this display, there are exercise questions where the method involves imitating the example questions. Transitioning from theory to application, the Exercise Questions Display Section, Niroke, emerges as a crucible where learners forge their understanding through hands-on engagement. In this dynamic phase, the instructional material invites learners to step into the role of mathematical artisans, imitating the example questions to hone their problem-solving skills. Niroke is not just a collection of numerical challenges; it is a strategic pedagogical move designed to reinforce the concepts introduced in the earlier Niteni section.

Learners are encouraged to mimic the problem-solving strategies elucidated in the Niteni examples, fostering a practical understanding of trigonometric ratios. The Niroke segment becomes a bridge that connects theoretical knowledge with practical application. Learners traverse this bridge, navigating through exercises that mirror real-world problem scenarios. The display is not merely an array of questions; it is an interactive space where learners actively participate in the process of knowledge construction.

Niroke, plays a pivotal role in consolidating learning. It propels learners beyond passive reception, encouraging them to become active contributors to their mathematical education. Through this strategic imitation of examples, Niroke becomes a catalyst for the internalization of trigonometric concepts, paving the way for a robust foundation in mathematical proficiency. The display of exercise questions 1 (Niroke) is presented in Figure 5.

6) Final Display

This display contains various exercise questions related to the explained material. Nambahi, marks the crescendo in the instructional journey, offering learners a culmination of exercises that solidify their proficiency in trigonometric comparison. Nambahi is not just a compilation of mathematical challenges; it symbolizes the journey...
undertaken by learners, progressing from theoretical foundations to practical applications. The exercise questions presented in this section represent a nuanced selection, encompassing various levels of complexity to cater to the diverse aptitudes within the learning cohort. Each question is not merely a numerical puzzle but a strategic opportunity for learners to showcase their mastery of trigonometric concepts.

Nambahi becomes an arena where learners can apply their acquired knowledge to solve problems mirroring real-world scenarios. The display is not merely a collection of questions; it is an interactive space where learners actively engage with mathematical problem-solving, fostering a deep and comprehensive understanding of trigonometric principles. Nambahi, encapsulating the essence of proficiency in trigonometric comparison. It propels learners toward a holistic grasp of the subject, instilling confidence in their ability to apply mathematical principles in diverse contexts. Through this culmination of exercises, Nambahi contributes to the development of learners as adept problem solvers and critical thinkers in the realm of trigonometry. The display of exercise questions (Nambahi) is presented in Figure 6.

![Figure 6. Exercise Questions Display (Nambahi)](image)

b. Assessment by Media and Material Experts

In this stage, the researcher seeks validation from competent media and material experts in their respective fields. The aim of this validation is to obtain suggestions or input from validators to produce learning media that is suitable for use. In the evaluation, three aspects are assessed: the appropriateness of the material, the presentation of the material, and the design of the media. Media and material experts evaluate these three aspects: appropriateness of the material, presentation of the material, and design of the media. Validation results are presented in Table 1. From the validation results, it can be concluded that the learning media developed is suitable for use in the field to collect data.

<table>
<thead>
<tr>
<th>Object</th>
<th>Average Score</th>
<th>Category</th>
</tr>
</thead>
<tbody>
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<td>Appropriateness of the Material</td>
<td>4.00</td>
<td>Valid</td>
</tr>
<tr>
<td>Presentation of the Material</td>
<td>4.00</td>
<td>Valid</td>
</tr>
<tr>
<td>Design of the Media</td>
<td>4.13</td>
<td>Valid</td>
</tr>
<tr>
<td>Average</td>
<td>4.04</td>
<td>Valid</td>
</tr>
</tbody>
</table>

**Implementation**

In this stage, a trial of the developed instructional material is conducted to determine the level of attractiveness of the instructional material. The implementation is carried out in class X at SMA N 5 Yogyakarta. Class X-1 consists of 36 students using the Face-to-Face Learning model, and class X-2 consists of 36 students using the Distance Learning model. The summary of student response questionnaires shows an average score of 3.49 for PTM instructional materials, categorized as good, and 4.02 for Face-to-Face instructional materials, also
categorized as good. Based on the description above, it can be concluded that the ICT and Tri-N-based Trigonometric Comparison instructional materials for both Face-to-Face Learning and distance learning fall into the good category. Therefore, these instructional materials can be used by teachers for effective teaching.

**Evaluation**

After students use the product and complete the student response questionnaire, the next step is to work on the learning outcome test. The learning outcome test is used to obtain the effectiveness score of the instructional material. The learning outcome test results provided valuable insights into the extent of learning gains achieved by the students. This quantitative data not only measured the immediate impact of the instructional materials but also shed light on the effectiveness of the materials in enhancing students' mathematical understanding over the course of the study.

**Discussion**

This research contributes significantly to the landscape of mathematics education. By addressing challenges, embracing technology, and leveraging a systematic developmental approach, the study not only enhances the teaching and learning of trigonometric comparison but also provides a model for future educational interventions (Harini et al., 2023). The developed materials, validated for both traditional and remote learning settings, represent a dynamic and adaptable resource that holds promise for broader application in mathematics classrooms (Cortina et al., 2015). This research journey exemplifies the transformative power of innovative instructional design, aligning pedagogy with technological advancements to create a richer and more engaging educational experience. Beyond its immediate impact, the research sets the stage for sustainable advancements in mathematics education. The incorporation of technology, especially through YouTube accessibility, extends the reach of these instructional materials beyond the confines of a traditional classroom (Tan, 2013). The adaptability of the developed materials for both face-to-face and distance learning underscores their potential as a lasting resource. This adaptability is crucial in the contemporary educational landscape, where the flexibility to cater to various learning environments is increasingly valuable.

The student response questionnaires provided valuable insights into the usability, engagement, and effectiveness of the instructional materials. Students praised the user-friendly interface and found it easy to navigate, accessing multimedia elements effortlessly. They appreciated interactive exercises, noting enhanced understanding of trigonometric concepts and increased practice opportunities. High engagement levels were reported, attributing dynamic content presentation and real-world examples for making abstract concepts relatable. Additionally, students reported improved comprehension and confidence in applying trigonometric principles, particularly benefiting from the flexibility of remote access.

The validation results from media and material experts further informed revisions and improvements to the materials. While strengths such as gradual presentation and multimedia integration were acknowledged, weaknesses such as technical issues and clarity of instructions were identified. Efforts were made to address these issues, refining multimedia elements to enhance engagement and comprehension. The systematic Research and Development (R&D) approach adopted in the study serves as a model for educational innovation, emphasizing the fusion of instructional design with technology. This approach enhances content delivery and enriches the overall learning experience.

The learning outcome test results serve as critical indicators of the instructional materials' effectiveness. Statistically significant improvements in test scores demonstrate effective learning facilitation, with students acquiring and applying new knowledge successfully. Differentiated performance across subtopics and consistent outcomes across diverse learning
environments validate the adaptability and efficacy of the materials. Correlations between engagement and performance highlight the importance of active participation in promoting learning outcomes. Overall, these results provide empirical evidence of the instructional materials' effectiveness, contributing to advancements in mathematics education and serving as a model for future interventions.

Furthermore, the systematic Research and Development (R&D) approach adopted in this study serves as a model for educational innovation. The success of this endeavor is not merely confined to the specific context of trigonometric comparison but presents a blueprint for educators and researchers in diverse mathematical domains. The fusion of innovative instructional design with technology can be replicated and adapted to address challenges in other mathematical topics, fostering a culture of continuous improvement in teaching methodologies. The study's emphasis on the Tri-N model and ICT brings a nuanced pedagogical approach to the forefront. This not only enhances content delivery but also enriches the overall learning experience (Licorish et al., 2018). The use of multimedia elements, animation, and interactive exercises serves as a testament to the transformative power of blending pedagogy with technological advancements (Alam & Mohanty, 2023). As education continues to evolve, this research serves as a beacon for educators seeking to enhance their teaching methodologies and engage students more effectively (Kilag et al., 2023).

The validated success of the developed materials positions them as a valuable asset for future educational intervention. As the educational landscape continues to evolve, with an increasing reliance on technology, these materials can be adapted, expanded, and integrated into broader curricular frameworks (Anjelia et al., 2022). The research provides a foundation for ongoing efforts to refine and tailor instructional approaches, ensuring that mathematics education remains dynamic and responsive to the evolving needs of students and educators. Moreover, the adaptability of the materials for both traditional and remote learning environments aligns with the contemporary emphasis on inclusive education (Valtonen et al., 2021). The research highlights the potential to bridge educational disparities by providing accessible and effective learning resources. The materials cater to a variety of learning styles and preferences, fostering a more inclusive and student-centric educational environment (Sulistyowati et al., 2021).

In essence, this research not only transforms the teaching and learning of trigonometric comparison but also resonates as a catalyst for broader positive changes in mathematics education. The blend of innovative instructional design, technological integration, and a systematic developmental approach lays the groundwork for a more vibrant, adaptable, and inclusive educational future.

The instructional material, titled "Teaching Material on Trigonometric Comparison Based on ICT and Tri-N for Face-to-Face and Distance Learning," has undergone rigorous feasibility tests, validated by both media and material experts. Calculations reveal average scores of 4.55 and 4.04 for face-to-face and distance learning instructional materials, respectively, categorizing them as valid. These findings affirm the suitability of the ICT and Tri-N-based instructional material for effective student learning. Additionally, student responses, assessed through a questionnaire, indicate positive feedback, with average scores of 3.49 and 4.02 for face-to-face and distance learning materials, respectively, falling within the "good" category. This underscores the instructional material's ability to foster enthusiasm and motivation among
learners. The material's unique feature lies in its adaptability for both face-to-face and distance learning environments. Presented gradually, the material includes videos complemented by sound, images, material summaries, and sample questions, facilitating flexible use via YouTube anytime, anywhere. Consequently, the instructional material is deemed suitable and effective for enhancing student learning experiences. Furthermore, given the success of ICT-based materials, there exists an opportunity to explore the integration of advanced technologies such as virtual reality, augmented reality, or artificial intelligence, aiming to enhance engagement and personalization in learning.

DECLARATIONS

Author Contribution: AYP: Conceptualization, Writing - Original Draft, Editing and Visualization; INA: Writing - Review & Editing, Formal Analysis; BK: Writing - Review & Editing, Validation and Supervision

Funding Statement: -

Conflict of Interest: The authors declare no conflict of interest.

Additional Information: -

REFERENCES


