

Deep Learning in Mathematics Using a 360-Degree Virtual Tour of the Senapelan Grand Mosque in Elementary Schools

Citra Azzahra Putri^{1*}, Nailah Septina¹, Viona Dinata¹, Aulia Zahra¹, Zaskia Vhalantika Ikram¹, Zetra Hainul Putra¹

¹Faculty of Teacher Training and Education, University of Riau, Pekanbaru, Indonesia

Article Info

Article history:

Received: January 24th, 2026

Revised: February, 20th, 2026

Accepted: March 15th, 2026

Keywords:

Deep Learning
360-Degree Virtual Tour
Senapelan Grand Mosque
Mathematics Learning

ABSTRACT

A 360-degree Virtual Tour is a learning tool that can help students understand concepts in a contextual way by exploring real-world environments in a digital format. In mathematics education, particularly when teaching the area and perimeter of two-dimensional shapes, this tool allows students to observe objects in their surroundings that have geometric shapes. This innovation is designed to enhance students' understanding of mathematical concepts through interactive and contextual learning experiences. The research focuses on how the integration of technology-based media can foster students' engagement and interest in learning mathematics. The study employed a design research method involving fifth-grade elementary school students. Data were collected through observation, interviews, documentation, and analysis of student worksheets. The results indicate that students became more active, were able to connect mathematical concepts to real-life contexts, and began to understand the material more deeply. It can be concluded that this learning medium is effective in supporting meaningful and contextual mathematics learning.

This is an open access article under the [CC BY-NC-SA](#) license.



Corresponding Author:

Citra Azzahra Putri

Faculty of Teacher Training and Education, University of Riau, Pekanbaru, Indonesia

Email: citra.azzahra4547@student.unri.ac.id

INTRODUCTION

The development of digital technology in the era of globalization demands that the education sector continuously adapt and innovate to create an effective and engaging learning environment for students. Elementary school students, who belong to the digital generation, tend to grasp

material more easily through visual and interactive media. However, in reality, in mathematics education, students' low interest and understanding of mathematical concepts taught conventionally, coupled with learning that tends to be mechanistic and rote-based, often make it difficult for students to understand concepts deeply and apply them in daily life (Maharani et al., 2025). This leads students to perceive mathematics as a difficult and boring subject. The use of technology in education is an advanced process capable of overcoming various challenges in traditional classroom teaching (Yulianti, 2024).

Mathematics should be studied as a discipline closely tied to daily life and with numerous applications in the surrounding environment. Therefore, a learning approach is needed that can connect mathematical concepts to real-world contexts. Technology can be used to stimulate and facilitate the learning process so that students can better understand mathematical concepts conceptually (Yulianti, 2024). The deep learning approach in education is one solution that can be utilized, as it emphasizes deep conceptual understanding, critical thinking skills, and problem-solving abilities. The Deep Learning approach is designed to shift the learning paradigm which previously focused more on memorization and repetition toward a constructive and reflective learning process (Mutmainnah et al., 2025). Through this approach, students are not only expected to memorize information but also to gain a deep understanding of the meaning behind each concept they learn.

Nevertheless, the implementation of deep learning requires innovative learning media capable of capturing students' attention. One such medium is the 360-degree Virtual Tour, a technology that allows students to explore a location virtually with realistic and interactive visuals (Lubis et al., 2025). Virtual Reality (VR) Tour is a technology that allows users to explore a digital environment immersively, as if they were physically present at the location (Indrayani et al., 2025). The use of this medium can provide a more concrete learning experience, thereby helping students understand abstract mathematical concepts.

The Senapelan Grand Mosque, as one of Pekanbaru's cultural and religious landmarks, holds great potential as a source of contextual learning. The building incorporates various mathematical elements such as two-dimensional and three-dimensional shapes, symmetry, patterns, and measurement concepts that can be observed directly. In the field of mathematics education, particularly when exploring three-dimensional concepts in solid figures, a VR Tour can be used to visualize three-dimensional space (Indrayani et al., 2025). By utilizing the 360-degree Virtual Tour, students can explore parts of the building and relate them to the mathematics material being studied, thereby making learning more meaningful and relevant to real life.

Based on the above discussion, an educational innovation in the form of Deep Learning in Mathematics assisted by the 360-degree Virtual Tour of the Senapelan Grand Mosque is needed in elementary schools. This innovation is expected to deepen students' understanding of mathematical concepts, foster a love of learning, and create an interactive and contextual learning experience. Therefore, this study is important to examine the implementation and effectiveness of using this medium in mathematics learning at the elementary school level.

LITERATURE REVIEW/ THEORETICAL FRAMEWORK

Deep Learning

The term "deep learning" has two distinct meanings in various fields of literature, in the field of artificial intelligence and in the field of education. Due to this difference in terminology, the concept of deep learning in the field of education is often mistakenly understood as part of artificial intelligence (AI) technology based on the theory of artificial neural networks, which are designed

to mimic the functioning of neural networks in the human brain through layered neuron models (Liu & Zhu, 2025). In the area of pedagogy, global education systems increasingly prioritize the cultivation of creativity, critical thinking, and problem-solving abilities, rather than focusing solely on content delivery as is commonly practiced in conventional teaching approaches. The emergence of deep learning models has brought about a transformation in the field of education, as they focus more on the holistic development of students' abilities so that they can adapt to the rapid changes in society (Chen & Singh, 2024). Students are no longer simply expected to memorize material instead, they are encouraged to understand the meaning of the lessons, connect various fields of knowledge, and solve real-world problems. Consequently, the role of teachers has also changed. Teachers no longer merely deliver content, they have become mentors, designers of learning activities, and learning leaders capable of reflective thinking and evaluation (Fitrah et al., 2025).

The application of deep learning is now increasingly important for addressing various global challenges, particularly in preparing human resources to be ready to face developments in the digital age (Zebua, 2025). The deep learning approach supports the development of 21st-century skills such as critical thinking, creativity, communication, and collaboration. Through this approach, students do not only understand concepts in theory, but also learn how to analyze, evaluate, and use their knowledge in real-life situations. These competencies are essential for navigating the demands of the digital era and globalization (Isnayanti et al., 2025). This perspective is reinforced by (Taqiyya et al., 2025), The study showed that using deep learning can greatly improve students' critical thinking, creativity, and ability to adapt. In addition, this approach helps students work better with others and reflect on their learning, creating a classroom atmosphere that is more meaningful, relevant, and interesting. The results also suggest that deep learning fits well with the needs of modern education and has strong potential to support an inclusive and sustainable learning system.

The deep learning approach consists of three main principles: mindful, meaningful, and joyful. Mindful refers to a learning process characterized by full attention, consistent concentration, and self-management skills in students (Alim et al., 2025). Meaningful learning refers to the principle of linking new knowledge with students' prior understanding or their real-life experiences. Meanwhile, Joyful represents a key component of the deep learning approach, highlighting the role of positive emotions, active engagement, and opportunities for creative expression. Feelings of enjoyment, excitement, and fulfillment in the learning process not only deepen students' experiences but also contribute to improved cognitive performance, better memory retention, and increased motivation to learn (Andayanie et al., 2025). These three main principles need to be included in deep learning because learning is not only about improving academic results, but also about helping students understand their own learning, connect it to real life, and maintain positive and stable emotions.

Elementary Mathematics Education

In the field of education, mathematics is one of the most important subjects to study because it plays a key role in developing students' logical, critical, systematic, and creative thinking skills. Mathematics serves as a tool for students to tackle various problems and challenges in their daily lives, whether in their personal lives, the community, or the workplace. Therefore, it is important for educators to equip students with a solid understanding of mathematics so that they can apply it to problem-solving and comprehend the various issues around them (Hayati & Jannah, 2024). Consequently, mathematics instruction must be designed to be meaningful, focusing not merely on memorizing formulas but on understanding their underlying concepts. Fundamentally, mathematics education encompasses three main aspects: product, process, and attitude. The

product aspect refers to the ideas and basic principles in mathematics. The process aspect is about the ways or steps used to learn and understand mathematical knowledge. Meanwhile, the attitude aspect includes scientific attitudes such as beliefs, views, and values that students of mathematics should have and maintain (Afsari et al., 2021).

Mathematics instruction involves abstract concepts; therefore, in elementary school, the presentation of mathematical material should be linked to real-life contexts. The goal is for students to discover the concepts they are learning on their own and to develop their mathematical skills based on their prior experiences and knowledge (Purnamatati & Madani, 2023). Thus, the effectiveness of mathematics learning in elementary school is closely tied to the teacher's ability to design and implement appropriate instructional strategies. In elementary school mathematics, students often encounter calculation problems involving large numbers, which can be difficult for them to solve. Meanwhile, according to Piaget's theory of cognitive development, elementary school students are still in the concrete operational stage (Surya, 2018).

Effective mathematics teaching emphasizes the importance of actively involving students in the learning process. Teachers are expected to enhance both the quality of instruction and students' mathematical competencies. In their role as facilitators, educators foster a supportive atmosphere that allows learners to explore, construct, and rediscover mathematical ideas independently. At the elementary school level, improving students' comprehension requires shifting the focus from merely "how to teach" to "how to encourage learning" and "how students learn best." To support this goal, instructional models that align with learning objectives are essential. Learning approaches like Problem-Based Learning (PBL), Discovery Learning, and Contextual Teaching and Learning (CTL) are very suitable because they help students develop critical thinking and problem-solving skills. Through these methods, students are guided to observe, question, experiment, and formulate their own conclusions, ultimately creating a more meaningful learning experience (Misqa et al., 2024).

In general, mathematics instruction can be considered effective if it connects the material or concepts to students' real-life situations. Additionally, instruction should actively engage students, utilize appropriate teaching materials, and focus on the thinking process rather than just the final outcome. If the right approach is used, mathematics will no longer be viewed as a difficult or intimidating subject. Instead, mathematics can serve as a tool for developing logical, critical, and systematic thinking skills that are useful in daily life.

Virtual Tour 360°

A 360° Virtual Tour is a digital medium that allows users to explore an environment virtually with a comprehensive view, as if they were physically present at the location. Virtual Tours are often understood as visual representations based on virtual reality technology or 360° video that provide an immersive and interactive experience. (Rosendahl & Wagner, 2024) explain that 360° technology provides a more in-depth learning experience because users can control the viewing direction and feel a higher level of engagement in the learning process. Meanwhile, (Argyriou et al., 2020) emphasize that 360° video-based Virtual Tours can create an immersive experience by allowing users to determine their own viewpoint, just as they would in the real world. From these various perspectives, it can be concluded that a 360° Virtual Tour is an interactive digital technology-based medium that combines panoramic visuals and interactivity to provide a virtual spatial exploration experience.

In an educational context, Virtual Tours serve not only as a visual medium but also as a tool for contextual learning capable of providing learning experiences that are difficult to obtain in person. (Garcia et al., 2023) demonstrate that the use of 360°-based virtual field trips can enhance

student engagement and understanding compared to standard videos due to their more interactive and exploratory nature. Furthermore, (Makransky & Mayer, 2022) found that immersive experiences in virtual reality can improve conceptual understanding through higher cognitive engagement. Thus, Virtual Tours can be viewed as a learning medium that supports experiential learning approaches because they can provide real-world experiences in a virtual form.

The development of Virtual Tours is also closely linked to advancements in virtual reality and interactive multimedia technologies. (Zhao et al., 2023) emphasize that VR and AR technologies in education are rapidly evolving and contribute to creating more innovative and engaging learning experiences. Meanwhile, (Li et al., 2024) explain that Virtual Tours can help users understand environments more comprehensively through interactive spatial visualization. This indicates that Virtual Tours serve not only as a presentation medium but also as an exploration tool that supports spatial and conceptual understanding.

In terms of characteristics, 360° Virtual Tours are generally constructed from a collection of panoramic images or videos arranged so that users can move interactively from one point to another. (Gafar et al., 2022) explain that 360° panoramic Virtual Tours are a combination of images processed so that they can be enjoyed virtually as if they were real. Additionally, (Cardona et al., 2023) note that Virtual Tours based on educational facilities can provide a flexible visit experience without the constraints of space and time. Thus, the key characteristics of Virtual Tours lie in their interactive, immersive, and flexible nature in presenting information.

In line with the need for practical educational media, Virtual Tours can now be created using various platforms, one of which is the Theasys application. This application allows developers to compile 360° photos into interactive Virtual Tours with user-friendly navigation features, thereby supporting the creation of more engaging and accessible educational media. In the context of this study, the Virtual Tour media developed utilizes the Theasys application to create an interactive and contextual learning experience tailored to the needs of students.

Senapelan Grand Mosque

In the discourse on education development rooted in local contexts, cultural spaces are often not fully utilized as learning resources. One intriguing yet often overlooked example is the Senapelan Grand Mosque. This mosque is not merely a place of worship but also embodies a long historical legacy, Malay cultural identity, and educational potential relevant to 21st-century learning needs. Therefore, it is important to view this mosque not merely as a religious artifact but as a hub connecting the past, social values, and contemporary educational practices.

Historically, the Senapelan Grand Mosque is known as the first mosque in the city of Pekanbaru, founded around 1762 CE by Sultan Abdul Jalil Muazzam Syah, the fourth ruler of the Siak Sri Indrapura Kingdom. Construction of the mosque was later continued by Sultan Muhammad Ali Abdul Jalil Muazzam Syah, who strengthened the mosque's role as a center for both religious and social activities of the community (Bogar, 2023). This fact demonstrates that from the very beginning, the mosque did not stand as a standalone entity but rather as an integral part of the governance system and the daily life of the Malay community. In subsequent developments, the Senapelan Grand Mosque in Pekanbaru also underwent a relocation, being moved approximately 40 paces from the site of the original structure. The reconstruction of the mosque following this relocation was led by the Chairman of the Mosque Construction Committee, H. Sulaiman, with a committee formed in 1927 (Ramadhani et al., 2021). In other words, the mosque became a center of civilization that integrated spiritual, political, and social values within the same space.

More than just an old building, the Senapelan Grand Mosque has also been designated as a national cultural heritage site through Decree No. KM.13/PW.007/MKP/2004 of the Minister of Culture and Tourism of the Republic of Indonesia (Yanto, 2017). This designation affirms that the mosque's value lies not only in its age or physical form but also in the historical and cultural significance it embodies. In the surrounding area lies the Marhum Pekan cemetery complex, which is closely linked to the history of the Siak Sri Indrapura Kingdom (Cheris & Repi, 2017), thereby reinforcing the area's status as a cohesive historical landscape. In this context, the mosque can be understood as a space that records and preserves the collective memory of the community, reflecting their historical journey over time.

From a cultural perspective, the existence of the Senapelan Grand Mosque reflects the identity of the Malay community, which is religious and rooted in tradition. The religious activities taking place within it serve not only as spiritual rituals but also as a means of transmitting values, norms, and knowledge across generations. This demonstrates that the mosque plays a strategic role in shaping the social character of the community. However, in formal educational practice, this potential is often not fully utilized. The mosque is still viewed merely as a site for visits, rather than as a living and contextual source of learning.

From an architectural perspective, this mosque showcases a blend of traditional Malay styles and external influences that have evolved over time. The Senapelan area itself is known for its historic buildings featuring distinctive Malay architectural characteristics, which form the identity of the city of Pekanbaru (Cheris & Repi, 2017). The renovations carried out did not entirely erase its historical value but rather introduced adaptations to meet the needs of the times. This uniqueness actually opens opportunities to use the mosque as a medium for interdisciplinary learning, for example, in understanding geometric concepts through the building's structure, or in social studies through the cultural symbols embedded in its architecture. Thus, the mosque is not merely an object to be observed but can also be scientifically interpreted.

In the context of contemporary education, particularly that emphasizing meaningful learning, the Senapelan Grand Mosque holds strong relevance as a contextual learning resource. The use of technology such as 360° Virtual Tours allows students to explore the mosque's spaces more interactively, even without being physically present. This approach not only enhances learning engagement but also helps students connect abstract concepts with the reality they know (Iqbal et al., 2025). In other words, the mosque can transform from merely a historical object into a dynamic learning medium.

Taking these various aspects into account, it can be concluded that the Senapelan Grand Mosque is not merely a religious symbol, but also a multifaceted representation of history, culture, and educational potential that are deeply intertwined. This perspective underscores that the utilization of local cultural spaces in education is not merely an alternative, but a necessity for creating more contextual and meaningful learning experiences. In the context of preservation, it should be noted that in 2009 the Pekanbaru Grand Mosque was included in a revitalization project that resulted in only about 20% of the mosque's original structure remaining, while approximately 80% has been replaced with new construction. This situation led to a change in its status, from a cultural heritage building to a cultural heritage structure (Utomo, 2022). Therefore, a study of this mosque is relevant as an effort to revive local values that have long been underutilized in formal educational practices, without getting trapped in a purely descriptive approach.

METHOD

Research Setting and Timeline

This study was conducted at SDN 168 Pekanbaru, located in Payung Sekaki District, Pekanbaru City. The study was carried out on April 28, 2026. The research schedule was aligned with the fifth-grade mathematics class schedule to ensure the research process could proceed smoothly without disrupting teaching and learning activities at the school. The research activities included an introductory phase, the learning process, and a final phase for data collection.

Research Methods

This study employs the Design Research (DR) method. This method was selected as it is well-suited for developing and evaluating instructional designs directly within the classroom setting. In this method, the researcher not only designs the instruction but also implements and evaluates the design iteratively to achieve optimal results. Design Research emphasizes the process of developing learning that aligns with students' real-world conditions. This is crucial in mathematics education, as students cannot rely solely on memorizing formulas; they must deeply understand concepts through meaningful learning experiences. This underscores that well-designed learning can help students actively build conceptual understanding rather than merely engaging in rote memorization.

Furthermore, research by (Asokawati et al., 2024) indicates that Design Research involves systematic and effective stages in developing context-based learning, particularly in mathematics. In this study, Design Research was used to develop mathematics learning based on a deep learning approach with the aid of a 360-degree Virtual Tour of the Senapelan Grand Mosque. The deep learning approach was used to encourage students to understand concepts deeply, rather than merely memorizing them, while the 360-degree Virtual Tour was used to provide a more realistic and interactive learning experience.

Design Research Procedure

This research procedure follows the three main stages of design research: the design stage, the implementation stage, and the evaluation stage.

1. Design Phase

At this stage, the researcher develops the instructional design to be used in the study. The activities carried out include:

- a) Student needs analysis the researcher identified the students' initial conditions, including their prior knowledge, the difficulties they faced in learning mathematics, and their learning characteristics.
- b) Curriculum analysis the researcher aligned the instructional materials with the current curriculum, particularly regarding plane figures in fifth grade.
- c) Development of Instructional Materials The materials developed include Lesson Plans, Student Worksheets, and a 360-degree Virtual Tour.
- d) Selection of geometric shape-related content linked to specific parts of the Senapelan Grand Mosque, such as the floor, windows, and architectural ornaments.

This stage aims to produce instructional designs that meet students' needs and effectively connect the material to real-world contexts. This underscores that effective instructional planning plays a crucial role in the success of the learning process.

2. Implementation Phase

At this stage, the instructional design that had been developed was implemented directly in the fifth-grade class at SDN 168 Pekanbaru. The activities conducted include:

- a) Implementing instruction using a deep learning approach,
- b) Using the Virtual Tour 360 platform to explore the various parts of the Senapelan Grand Mosque,
- c) Administering a pretest to assess students' initial proficiency
- d) Conducting worksheet-based learning activities,
- e) Administering a posttest to measure improvements in learning outcomes,
- f) Observing student activities throughout the learning process.

At this stage, students were encouraged to actively observe, discuss, and relate the material on plane figures to real-world objects. This type of learning can increase student engagement and help them understand concepts more deeply (Harahap et al., 2025).

3. Retrospective Analysis Phase

This stage is the final stage of the research, involving the analysis of all the data that has been collected. The activities carried out include:

- a) Analyzing the pretest and posttest results to assess improvements in student understanding,
- b) Analyzing student activities during instruction,
- c) Analyzing student responses to the instruction,
- d) Identifying the strengths and weaknesses of the instructional design.

The results of this stage are used to improve and refine the instructional design. In Design Research, the evaluation stage is crucial as it serves as the foundation for developing more effective instruction (Asokawati et al., 2024)

Research Subjects

The subjects of this study were 26 fifth-grade students at SDN 168 Pekanbaru. The selection of fifth-grade students was based on their cognitive development stage, which is the concrete operational stage, a stage in which students begin to understand abstract concepts when linked to real objects or situations. At this stage, students no longer rely solely on memorization but have begun to think logically in simple ways, group objects, and recognize relationships between concepts, including in mathematics, particularly regarding the perimeter of two-dimensional shapes.

Types and Sources of Data

This study utilized two types of data: quantitative and qualitative data. Both types of data were used together so that the research findings would not only present numbers or final results but also describe how the learning process took place in the classroom. The quantitative data in this study were obtained from the results of the pretest and posttest administered to the students. From the results of these two tests, the researcher was able to identify changes or improvements in student learning outcomes in a more measurable way.

Meanwhile, qualitative data was collected through observation and interviews. Observations were conducted during the learning process to observe student activities. Through these observations, the researcher was able to understand firsthand how the students' learning process unfolded in the classroom. In addition to observations, qualitative data was also obtained through interviews conducted with three students after class ended. From these interviews, the researcher was able to determine whether the students felt engaged, motivated, and supported in understanding the concept of the perimeter of two-dimensional shapes through the lesson provided.

The data used in this study are divided into two categories: primary data and secondary data. Primary data refers to information collected directly from the research subjects, namely fifth-grade students at SDN 168 Pekanbaru, through methods such as tests, observations, and interviews. This

data serves as the primary source in the study because it reflects the actual conditions that occur during the learning process. Secondary data, on the other hand, is gathered from various sources such as books, academic journals, and prior studies related to the research topic. This type of data is utilized to reinforce the theoretical framework and support the research findings, ensuring they are more valid and scientifically reliable. The simultaneous use of quantitative and qualitative data in this study aims to provide a more complete and comprehensive picture of the effectiveness of learning. This is not only assessed through improvements in student grades but also through the learning process, learning experiences, and student responses during the learning process. This is consistent with the perspective of (Maharani et al., 2025), who argue that integrating both types of data can produce a more thorough and comprehensive analysis in educational research.

Data Collection

The instruments used included tests, observation sheets, interviews, and documentation. The first instrument was a test, consisting of a pretest and a posttest. The pretest was administered before instruction began to assess students' initial understanding of the concepts to be studied. Next, the posttest is administered after the learning process is complete to determine the improvement in students' understanding following deep learning-based instruction with the aid of a 360-degree Virtual Tour. Test questions are designed based on understanding indicators, namely procedural, conceptual, and problem-solving aspects.

The second instrument is an observation sheet, which is used to observe student activities during the learning process. Observations are conducted directly in the classroom to assess student engagement in learning, such as their willingness to ask questions, ability to collaborate in groups, and participation in identifying two-dimensional shapes using the Virtual Tour 360 platform at the Senapelan Grand Mosque. The observation sheet is systematically designed to ensure that the data collected is focused and easy to analyze.

The third instrument was an interview, which was conducted with three students after the lesson concluded. This interview aimed to gauge the students' responses to the lesson, particularly regarding the use of the 360-degree Virtual Tour and the deep learning approach. During the interview, students were asked to share their opinions on their level of interest, how easy it was to understand the material, and their overall learning experience throughout the lesson.

The fourth instrument is documentation, which is used as supporting data in the study. This documentation consists of photographs of learning activities and students' work samples. This documentary data serves to reinforce the findings of observations and provide a concrete picture of the learning process taking place in the classroom. The use of these various instruments aims to obtain more complete and accurate data. With tests, observations, questionnaires, and documentation, researchers can see not only students' learning outcomes but also their learning processes and experiences during the learning process. This aligns with the research by (Fiqri et al., 2025), which states that the use of technology-based media in learning can increase student engagement and motivation.

Data Analysis

The data analysis techniques used in this study combined quantitative and qualitative methods to ensure that the research findings provided a more comprehensive picture. The analysis was conducted in stages according to the type of data collected during the study. Quantitative analysis was performed on the pretest and posttest data. This data was analyzed by calculating the mean score, the percentage of learning mastery, and the improvement in student learning outcomes. The improvement in learning outcomes can be seen from the difference between the pretest and posttest

scores obtained by the students. Through this analysis, the researcher can determine whether the instruction provided was effective in improving students' understanding of the material. The researcher can also determine whether the improvement was consistent across all students or limited to only some students.

Meanwhile, qualitative analysis was conducted on data from observations and interviews. Observation data were analyzed by describing students' activities during the learning process. Interview results were analyzed by examining trends in students' responses to determine their reactions to the learning activities that had taken place. The qualitative data analysis process involved several stages: data reduction, data display, and conclusion drawing. During the data reduction stage, the researcher selected and simplified the data that were relevant to the study. Next, the data was presented in descriptive form to make it easier to understand. The final stage involved drawing conclusions based on the analyzed data.

The analysis in this study also follows the stages of Design Research, namely the design, implementation, and evaluation stages. The analysis was conducted to determine whether the instructional design that had been developed was functioning effectively or still needed improvement. The results of this analysis were then used to draw conclusions regarding the effectiveness of deep learning-based instruction using a 360-degree Virtual Tour in enhancing students' understanding of plane figures. This underscores that systematic data analysis is crucial for assessing the success of an instructional approach.

RESULTS

Description of the Teaching and Learning Process

The subject matter used in this study was the mathematics curriculum, specifically the chapter on the perimeter of two-dimensional shapes, with a focus on the concept of the perimeter of two-dimensional shapes. This study was conducted in a single session with a time allocation of 2 x 35 minutes. The learning process took place in the classroom with the support of digital devices such as laptops, allowing students to directly access and explore a virtual environment.

During the introductory activities, the teacher needs to prepare a lesson plan in the form of a teaching module. The teacher begins the class by greeting the students. The class monitor leads the group in a prayer before the lesson begins. The teacher ensures the class is ready to participate in the lesson and checks the attendance list. To boost students' enthusiasm for learning, the teacher provides motivation first. A spark question is posed to arouse curiosity and encourage students to think more deeply, such as "If we want to install a fence around the garden, how do we determine the length of fence needed?" and a pretest is administered to assess students' initial abilities. Before beginning the lesson, the teacher administered a pre-test to assess the students' initial proficiency. The pre-test consisted of 10 questions on the perimeter of two-dimensional shapes.

Introduction

In the first step, the teacher instructed the students to form four groups, with each group consisting of 6–7 students. After forming the groups, each group is provided with a laptop to open and explore the 360° Virtual Tour of the Senapelan Grand Mosque. Students observe the floor, courtyard, and building areas that form two-dimensional shapes. At the same time, the teacher guides the students' focus through the worksheet with the instruction: "Observe the shapes of the floor or courtyard found in the Virtual Tour!"



Figure 1, The teacher provides instructions on how to use the 360-degree Virtual Tour

Problem Statement

Based on the second instruction, students engage in group discussions based on the observations they made during the Virtual Tour activity. During the observation process, students are guided to formulate questions found in the provided worksheets, such as identifying the shapes of the two-dimensional figures they see and determining how to calculate the perimeter of those figures. Throughout the activity, the teacher plays a role in guiding and directing students so that they are able to formulate problems accurately, systematically, and in accordance with the established learning objectives.

Data Collection

At this stage, students observe the objects in the Virtual Tour once again to reinforce and deepen their understanding of various two-dimensional shapes. Afterward, the teacher provides supporting data listed in the worksheet, such as the length and width of the observed shapes. Based on the results of their observations and the provided data, students then record this information systematically and in a structured manner in the worksheet to facilitate the subsequent analysis process.



Figure 2, Students explore a 360-degree Virtual Tour

Data Processing

In this stage, students identify the sides of a two-dimensional shape based on their observations of the Virtual Tour object. Next, students calculate the perimeter of the shape by adding up the lengths of all its sides. Afterward, the results are discussed with group members to verify the accuracy of the answers and ensure a shared understanding of how to accurately determine the perimeter of a two-dimensional shape.

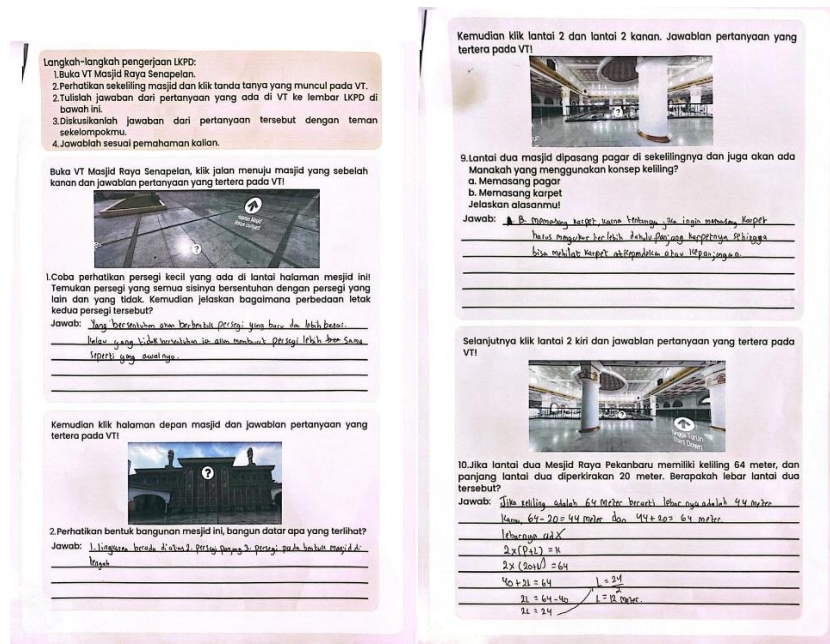


Figure 3, Worksheet question formats for students

Verification

Students review the calculation steps they have written in their worksheets to ensure the accuracy of the process and the results. At this stage, the teacher provides feedback and reinforces the concept of the perimeter of two-dimensional shapes to ensure students' understanding is as thorough as possible.

Generalization

In this stage of the activity, students draw conclusions on the worksheet regarding the concept of the perimeter of two-dimensional shapes based on what they have learned. At the end of the activity, the teacher and students together conclude that the perimeter is the total length of the sides of a two-dimensional shape.

Closing Activities

Before ending the class, the teacher administered a post-test as a self-assessment for the students. The post-test consisted of 10 essay questions. After completing the test, students received reinforcement in the form of appreciation for their participation and effort. To make the learning experience more meaningful, students engaged in a brief reflection on the learning process, their feelings, the challenges they faced, and what they had mastered. The lesson concluded with a group prayer and closed with a farewell greeting.



Figure 4, Students are taking the post-test

Analysis Description

Based on the results of the data analysis, the average pretest score was 46.92 and the average posttest score was 60.75. This indicates that there was an improvement in student learning outcomes following the implementation of media-assisted instruction used in this study.

Normality Test

The data in Table 1 present the results of the normality test, which were analyzed using IBM SPSS 20. The results indicate a p-value greater than the significance level (0.05), which means the data are normally distributed.

Table 1. Tests of Normality

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Pretest	.122	26	.200*	.935	26	.100
Posttest	.144	26	.178	.945	26	.181

Analysis of hypothesis

Subsequently, a hypothesis test was conducted based on the prerequisite tests to determine whether there were differences in learning outcomes before and after the intervention in the study class. The hypothesis test in this study used a paired-sample t-test (Table 2).

Table 2. Paired Samples Test

		Paired Differences							
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		t	df	Sig. (2-tailed)
					Lower	Upper			
Pair 1	Pretest - Posttest	- 13.8269	14.0028	2.7462	-19.4828	-8.1711	-5.035	25	.000

Table 2 shows the results of hypothesis testing using a t-test on the pretest and posttest scores of the class under study. Based on the t-test results, a significance value of 0.000 was obtained. This value is smaller than the significance level of 0.05, so it can be concluded that there is a significant difference between the pretest and posttest results. Therefore, deep learning assisted by a 360-degree Virtual Tour of the Senapelan Grand Mosque has a significant effect on students' understanding of the perimeter of two-dimensional shapes.

DISCUSSION

This study aims to deepen students' understanding of mathematical concepts, foster an interest in learning, and create interactive and contextual learning experiences through the use of a 360-degree Virtual Tour of the Senapelan Grand Mosque in teaching the perimeter of two-dimensional shapes to fifth-grade elementary school students. This study is motivated by the fact that current mathematics instruction remains conventional and teacher-centered. Under these conditions, students are not actively engaged in learning activities, such as discussing, exploring, or expressing their opinions. This results in students' limited ability to deeply understand mathematical concepts (Sani et al., 2025). Therefore, the researcher conducted this study to assist both students and teachers in mathematics instruction. A potential solution is to implement deep learning supported by a 360-degree Virtual Tour using the Senapelan Grand Mosque as the location, making the learning experience more relatable and contextual for students. The results of this study are expected to provide teachers with an option for using engaging learning media that supports more meaningful and interactive learning.

The findings of this research reveal that the implementation of a deep learning approach, enhanced by a 360-degree Virtual Tour of the Senapelan Grand Mosque, positively influences fifth-grade students' understanding of plane geometry concepts. This is demonstrated by the marked improvement in students' comprehension after participating in learning activities utilizing the 360-degree Virtual Tour through the Theasys platform. The enhancement is further supported by the results of the hypothesis testing. A t-test analysis produced a significance value of $0.000 < 0.05$ (Table 2), indicating a statistically significant difference after the application of deep learning integrated with the 360-degree Virtual Tour of the Senapelan Grand Mosque. These outcomes confirm that the intervention contributed meaningfully to students' mastery of the material.

The improvement in student learning outcomes stems from the fact that instruction is no longer merely the delivery of content, but provides students with the opportunity to engage directly through the use of 360° Virtual Tours. With this tool, students can view and observe objects in a more realistic way, making concepts that initially felt abstract easier to understand. Additionally, the learning environment becomes more dynamic due to interactions among students and with the teacher, which encourages them to ask questions and participate in discussions more freely. The role of the 360° Virtual Tour here is quite significant, as it helps connect lesson content with real-world conditions that students can explore. As a result, student activities become more active; they do not merely listen but also strive to understand, explore, and discover concepts on their own. This aligns with the findings of (Bahar & Suyato, 2020), which indicate that the use of virtual reality-based media can enhance both students' understanding and their engagement in the learning process.

This improvement can be seen as one of the key advantages of interactive learning that utilizes 360° Virtual Tours. During lessons, the classroom atmosphere feels more lively because students are not just listening to explanations but are also directly engaged through visual displays they explore on their own. This makes them more enthusiastic and less likely to get bored. Additionally, the 360° Virtual Tour helps students grasp mathematical concepts more easily because they can visualize shapes related to the material more concretely, rather than merely imagining them. As a result, students grasp the intended meaning of the taught material more quickly. These findings align with the research by (Anisa et al., 2020), which shows that the use of virtual media can increase student engagement while helping them understand concepts better. Similar results were also reported by (Tarmizi et al., 2020), who noted that virtual reality-based media makes learning more engaging and encourages students to be more active. Furthermore, according to (Sari &

Priatna, 2020), the use of such technology also brings learning closer to students' real lives, making it easier for them to connect the material to their daily experiences.

CONCLUSION

This study shows that deep learning supported by 360-degree Virtual Tours has a positive impact on students' understanding, fosters their interest in learning, and creates an enjoyable learning experience. The implementation of deep learning supported by 360-degree Virtual Tours helps students gain a deep understanding of the concept of the perimeter of two-dimensional shapes. Analysis results indicate a significant improvement in student learning outcomes. Thus, deep learning supported by 360-degree Virtual Tours can support a more effective and interactive learning process and enhance students' understanding of mathematical concepts.

REFERENCES

- Afsari, S., Safitri, I., Harahap, S. K., & Munthe, L. S. (2021). Systematic Literature Review: Efektivitas Pendekatan Pendidikan Matematika Realistik pada Pembelajaran Matematika. *IJI Publication: Indonesia Journal of Intellectual Publication*, 1(3), 189–197.
- Alim, S. F., Prayitno, H. J., Mu'ti, A., Sutopo, A., & Hastuti, W. (2025). Fundamental Concepts of Deep Learning: Principles in Advancing Holistic Education Practices. *Journal of Deep Learning*, 1(2), 81–94.
- Andayanie, L. M., Adhantoro, M. S., Purnomo, E., & Kurniaji, G. T. (2025). Implementation of Deep Learning in Education: Towards Mindful, Meaningful, and Joyful Learning Experiences. *Journal of Deep Learning*, 1(1), 47–56.
- Anisa, M. K., P, N. D. P., & Nova, T. L. (2020). Penggunaan Simulasi Virtual pada Pembelajaran Fisika untuk Meningkatkan Higher Order Thinking Skills (HOTS) Siswa: Meta-Analisis. *Jurnal Kumpanan Fisika*, 3(2), 163–170.
- Argyriou, L., Economou, D., & Bouki, V. (2020). Design Methodology for 360 ° Immersive Video Applications: the Case Study of A Cultural Heritage Virtual Tour. *Personal and Ubiquitous Computing*, 24(6), 843–859.
- Asokawati, I., Harun, L., & Nursyahidah, F. (2024). Desain Pembelajaran Kerucut Menggunakan Pendekatan Pendidikan Matematika Realistik Indonesia (PMRI) Berkonteks Tradisi Mitoni. *Jurnal Riset Pembelajaran Matematika*, 6(1), 21–30.
- Bahar, R. A., & Suyato. (2020). Efektifitas Media Pembelajaran Virtual Reality terhadap Peningkatan Pemahaman Peserta Didik pada Mata Pelajaran Pendidikan Kewarganegaraan. *Jurnal Pendidikan Kewarganegaraan Dan Hukum Volume*, 9(7), 366–374.
- Bogar, N. (2023). *Pengelolaan Masjid Raya Pekanbaru Pacsa Covid-19*. UIN SUSKA RIAU.
- Cardona, H., Lara-alvarez, C., Parra-gonzález, E. F., & Villalba-Condori, K. (2023). Virtual Tours to Facilities for Educational Purposes : A Review. *TEM Journal: Technology, Education, Management, Informatics Journal*, 12(3), 1725–1731. <https://doi.org/10.18421/TEM123>
- Chen, J., & Singh, C. K. S. (2024). A Systematic Review on Deep Learning in Education : Concepts, Factors, Models and Measurements. *Journal of Education and Educational Research*, 7(1), 125–129.
- Cheris, R., & Repi. (2017). Faktor-Faktor Memudarnya Citra Kampung Bandar Senapelan (Tinjauan Terhadap Nilai Sejarah dan Arsitektur Tradisional Sebagai Identitas Kota Pekanbaru). *Jurnal Arsitektur Melayu Dan Lingkungan*, 4(2), 1–12.
- Fiqri, C. I. A., Cholil, Y. M., Syaifuddin, M., & Effendi, M. M. (2025). Virtual Reality and Artificial Intelligence: Challenges and Opportunities in its Implementation in Mathematics Learning. *Jurnal Riset Pendidikan Matematika*, 12(2), 214–234.

- Fitrah, M., Sofroniou, A., Yarmanetti, N., Ismail, I. H., Anggraini, H., Nissa, I. C., Widyaningrum, B., Khotijah, I., Kurniawan, P. D., & Setiawan, D. (2025). Are Teachers Ready to Adopt Deep Learning Pedagogy? The Role of Technology and 21st-Century Competencies Amid Educational Policy Reform. *Education Science*, 15(10), 1–19.
- Gafar, I. A., Arif, Z., & Syefudin. (2022). Systematic Literature Review: Virtual Tour 360 Degree Panorama. *International Journal of Engineering Business and Social Science*, 1(01), 1–10.
- Garcia, M. B., Nadelson, L. S., & Yeh, A. (2023). “We’re going on a virtual trip!”: a switching-replications experiment of 360-degree videos as a physical field trip alternative in primary education. *International Journal of Child Care and Education Policy*, 17(4), 1–16. <https://doi.org/10.1186/s40723-023-00110-x>
- Harahap, A. A., Siregar, I. A., Sartimah, S., Hsb, N. R., Pulungan, S., & Amir, A. (2025). Model Pembelajaran Matematika di Tingkat SD: Pendekatan Studi Literatur. *Didaktik: Jurnal Ilmiah PGSD STKIP Subang*, 10(2), 250–265.
- Hayati, M., & Jannah, M. (2024). Pentingnya Kemampuan Literasi Matematika dalam Pembelajaran Matematika. *Griya Journal of Mathematics Education and Application*, 4(1), 40–54.
- Indrayani, S. E., Sulistyaningsih, D., & Aziz, A. (2025). Pengembangan E-Modul dengan Pendekatan Inkuiri Berbasis Virtual Reality Tour terhadap Kemampuan Berpikir Kritis Matematis. *JIIP (Jurnal Ilmiah Ilmu Pendidikan)*, 8(6), 6458–6464.
- Iqbal, K., Mokoena, O. P., Tesema, A. K., & Waham, J. J. (2025). Virtual Reality in Education: Immersive Learning for Deeper Understanding. *EDUJAVARE: International Journal of Educational Research Questions*, 3(1), 23–33.
- Isnayanti, A. N., Putriwanti, Kasmawati, & Rahmita. (2025). Integrasi Pembelajaran Mendalam (Deep Learning) dalam Kurikulum Sekolah Dasar: Tantangan dan Peluang. *CJPE: Cokroaminoto Juornal of Primary Education*, 8(2), 911–920.
- Li, S., Say, W., & Rao, S. (2024). Development of Virtual Tours for Understanding the Built Environment of an Educational Building. *Buildings*, 14(5), 1–15.
- Liu, Y., & Zhu, C. (2025). The Use of Deep Learning and Artificial Intelligence-Based Digital Technologies in Art Education. *Scientific Reports*, 15(128559), 1–14.
- Lubis, A., Azhari, I., & Tanjung, S. (2025). Development Of Virtual Tour Media Using Local History To Improve Learning Outcomes. *Inovasi Kurikulum*, 22(4), 2241–2254.
- Maharani, L., Riyadi, A. R., & Maulida, N. (2025). Deep Learning dalam Pembelajaran Matematika di SD. *Pendas : Jurnal Ilmiah Pendidikan Dasar*, 10(2), 125–133.
- Makransky, G., & Mayer, R. E. (2022). Benefits of Taking a Virtual Field Trip in Immersive Virtual Reality: Evidence for the Immersion Principle in Multimedia Learning. *Educational Psychology Review*, 34(3), 1771–1798. <https://doi.org/10.1007/s10648-022-09675-4>
- Misqa, L., Oviana, W., Hayati, Z., & Jannah, M. (2024). Improving Student Learning Outcomes in Mathematics Learning through a Contextual Teaching and Learning Approach in Elementary Schools. *Journal of Indonesian Primary School*, 1(2), 19–26.
- Mutmainnah, N., Adrias, A., & Zulkarnaini, A. P. (2025). Implementasi Pendekatan Deep Learning Terhadap Pembelajaran Matematika Di Sekolah Dasar. *Pendas : Jurnal Ilmiah Pendidikan Dasar*, 10(01), 858–871.
- Purnamatati, A. M., & Madani, F. (2023). Analisis Asesmen Autentik Pembelajaran Matematika Sekolah Dasar. *Jurnal Elementaria Edukasia*, 6(2), 778–788. <https://doi.org/10.31949/jee.v6i2.5659>
- Ramadhani, A. S., Isjoni, & Fikri, A. (2021). Perubahan Status Cagar Budaya Masjid Raya Senapelan Pekanbaru (2009-2017). *Jurnal Pendidikan Tambusai*, 5(11), 7993–8001.

- Rosendahl, P., & Wagner, I. (2024). 360° Videos in Education – A Systematic Literature Review on Application Areas and Future Potentials. *Education and Information Technologies*, 29(2), 1319–1355. <https://doi.org/10.1007/s10639-022-11549-9>
- Sani, F. A., Riswari, L. A., & Amaliyah, F. (2025). Penerapan Model Pembelajaran STAD Berbantuan Media Panram terhadap Pemahaman Konsep Matematika Siswa SD. *MES: Journal of Mathematics Education and Science*, 11(1), 18–28.
- Sari, R. M. M., & Priatna, N. (2020). Model-Model Pembelajaran di Era Revolusi Industri 4.0 (E-Learning, M-Learning, AR-Learning dan VR-Learning). *Biormatika : Jurnal Ilmiah Fakultas Keguruan Dan Ilmu Pendidikan*, 6(1), 107–115.
- Surya, A. (2018). Learning Trajectory pada Pembelajaran Matematika Sekolah Dasar (SD). *Jurnal Pendidikan Ilmiah*, 4(2), 22–26.
- Taqiyya, W., Utami, R. D., Samsuri, M., & Siswanto, H. (2025). Strategies of Deep Learning to Foster Meaningful and Sustainable Education in the 21st Century. *Journal of Deep Learning*, 1(2), 127–138.
- Tarmizi, A. K., Hasbiyati, H., & Hakim, M. (2020). Pengembangan Media Pembelajaran berbasis Virtual Reality pada Mata Kuliah Anatomi dan Fisiologi Manusia pada Mahasiswa Semester VI Pendidikan Biologi. *Jurnal Bioshell*, 9(2), 37–40.
- Utomo, M. T. (2022). *Pengembangan dan Pelestarian Cagar Budaya Masjid Raya Pekanbaru sebagai Objek Wisata Sejarah*. Universitas Islam Riau.
- Yanto, Y. (2017). Pengelolaan Objek Wisata Masjid Raya Pekanbaru Sebagai Destinasi Wisata Kota Pekanbaru. *JOM FISIP*, 4(1), 1–13.
- Yulianti. (2024). Peran Teknologi Dalam Pembelajaran Matematika Sekolah Dasar. *Indonesian Journal of Islamic Elementary Education*, 4(1), 45–53.
- Zebua, N. (2025). Education Transformation: Implementation of Deep Learning in 21st-Century Learning. *Harmoni Pendidikan: Jurnal Ilmu Pendidikan*, 2(2), 146–152.
- Zhao, X., Ren, Y., & Cheah, K. S. L. (2023). Leading Virtual Reality (VR) and Augmented Reality (AR) in Education: Bibliometric and Content Analysis From the Web of Science (2018-2022). *Sage Journals*, 13(3), 1–23. <https://doi.org/10.1177/21582440231190821>