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Transformation of Junior High School Mathematics Learning: Integration of Interactive Student Worksheet and Virtual Reality Based on Deep Learning Approach

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ABSTRACT

Mathematics learning in junior high schools still faces challenges in building active student engagement, deep conceptual understanding, and the application of technology during the learning process. This study aims to describe the transformation of the implementation of mathematics learning in junior high schools through the integration of interactive Student Worksheets (LKPD) and Virtual Reality (VR) based on the Deep Learning approach. The research employed a qualitative descriptive method, with data collected through classroom observations and interviews involving four classes of grade VII students and interviews with four grade VII mathematics teachers from four different junior high schools. Before implementation, all research instruments including the interactive LKPD, VR media assisted by Artsteps, observation sheets, and interview guidelines were validated by three experts in mathematics education and educational technology, and the results were categorized as very valid. Data were analyzed using the Miles and Huberman model, consisting of four stages: data collection, data reduction, data presentation, and conclusion drawing. The result of this study is that the application of the Deep Learning approach supported by interactive LKPD and VR media received a positive response from teachers and students. Interactive LKPD and VR Media effectively support the Deep Learning stages, namely (1) Introduction of material with context, (2) In-depth presentation of material, (3) Project-based assignments, (4) Discussion and collaboration, (5) In-depth reflection, (6) Provision of constructive feedback, (7) Competency-based assessment (8) Use of technology in learning, (9) Independent learning and self-regulation, (10) Evaluation and development on an ongoing basis. The implementation of learning is in line with the principles of Deep Learning, namely knowledge connectedness, active involvement, critical and reflective thinking, problem-based learning, collaboration, and intrinsic motivation; and also in line with the Deep Learning learning experience, namely understanding, applying and reflecting. These results show that the integration of interactive LKPD and VR media can be an effective strategy to transform mathematics learning at the junior high school level.

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A. INTRODUCTION

Mathematical skills Mathematical skills are critical competencies for students' daily lives including calculating savings, discerning profit, and loss, and estimating household costs like utilities (Kaya & Demirci, 2022; Sigus & Mädamürk, 2024). Improving mathematical skills can

be achieved through learning mathematics in elementary and secondary schools, as mathematical learning is deeply connected to human life (Kaya & Keşan, 2023; Pasani & Amelia, 2025). Mathematics trains humans to think systematically, think rationally and logically. So that basic mathematical skills are one of the basic abilities that humans must have. However, mathematics is still considered difficult by junior high school students, as evidenced by the decline in national scores in PISA (The Programme for International Student Assessment) in 2022. Based on PISA results, Indonesia's overall ranking decreased in 2022 compared to 2018. Where the PISA report found that the mathematics ability of students in 2015 was an average of 379, and in 2022 was an average of 366. Since 2015, Indonesia's mathematical ability has declined (The State of Learning and Equity in Education, 2023).

Science and reading ability can be important factors in mathematics, and reading ability and mathematics are also important in scientific performance, as well as mathematics and science are also good factors in reading ability. Because of this, reading, mathematics and science skills are the items that will be tested by PISA (Nieto-Isidro & Martínez-Abad, 2024).This interrelationship indicates that the three domains mutually reinforce each other. Reading literacy supports students' ability to comprehend mathematical statements, word problems, and contextualized tasks, while science literacy strengthens the application of mathematical concepts in real-life phenomena and experimental reasoning. Therefore, improving reading and science literacy indirectly enhances students' logical, analytical, and reflective thinking in mathematics. Based on this, the aspects assessed by PISA are reading literacy, mathematical literacy, and science literacy cognitive domains that educational systems consistently and systematically target (Arastaman et al., 2024; X. S. Wang et al., 2023). The evaluation of these literacies provides a comprehensive overview of how education systems cultivate students' critical thinking, problem-solving, and scientific reasoning abilities relevant to daily life.

The stimulus for developing students' cognitive thinking skills can initially take the form of theoretical guidance, followed by practical, hands-on application within classroom learning (Blyznyuk & Kachak, 2024; Harris & Bacon, 2019). Therefore, a learning approach is needed that can include theoretical and practical thinking. The Deep Learning learning approach is one of the learning approaches that prioritises theory and practice. Deep Learning is a learning approach that focuses on deep understanding and connections between concepts and their application in the real world (Ramadan et al., 2025).

Meaningful and deep learning not only focuses students on memorisation, but students are also asked to understand and apply this knowledge in their daily lives. Deep learning emphasizes meaningful learning by enabling students to explore, analyze, and connect mathematical concepts through engaging, student centered activities (Li, 2024; Suglo, 2024). The Deep Learning learning approach has three main components (Suyanto et al., 2025), namely meaningful, mindful, and joyful learning. The first component is Meaningful Learning to make a learning that will be understood deeply and comprehensively. The learning carried out enables students to have a network between material concepts that are connected to new and old phenomena, so that students can develop a deeper understanding. The second component is Mindful Learning. In the learning process, students are expected to develop awareness and active involvement during the teaching process. With the involvement of

students in the teaching and learning process, it will develop students' self-management to achieve academic and personal results. The third component is Joyful Learning, characterized by a teaching and learning process that is enjoyable and creates a sense of security boosting students' motivation to engage enthusiastically with academic challenges (Adeyinka-Ojo et al., 2025).

To encourage learning transformation towards meaningful and deep learning, it is necessary to integrate innovative approaches with interactive learning media. One of them is the use of interactive LKPD that not only guides student learning activities but also facilitates independent and reflective exploration of concepts according to the principles of Deep Learning. The use of interactive e-worksheets in mathematics has been shown to enhance student motivation and comprehension (Sari et al., 2024). Interactive LKPD is a form of learning tool innovation designed to increase the effectiveness of the teaching and learning process. The interactive LKPD developed in mathematics subjects can significantly improve students' problem-solving skills and learning independence. This is in line with the principle of the Deep Learning approach, where students are required to build connections between concepts and reflect on their knowledge through active, meaningful, and fun learning activities.

The use of technology in mathematics learning can also strengthen the learning process by providing a new learning experience using a deep learning approach (Nugroho et al., 2025). Technology that can be used as a learning support with a Deep Learning approach is Virtual Reality. With the use of virtual reality in the learning process, virtual learning materials can be displayed in real time on the device in use (Liu et al., 2025). The use of VR technology in mathematics learning can provide an in-depth, interactive, focused, and imaginative learning experience to increase students' mathematical creativity (Hidajat, 2024). The use of Virtual Reality (VR) technology has received positive student responses because VR can render dynamic virtual environments in real time immersing learners in engaging pseudo-worlds that make education more interesting (Hsu et al., 2025; Lin et al., 2024).

One of the topics of mathematics learning in junior high school is development. Geometry is one of the fields of mathematical material that is large enough to be studied, which contains points, lines, and planes (Pujiastuti & Haryadi, 2024). Learning about the topic of regeneration is one of the mathematics learning topics that, at first glance, is easy, but in its implementation, there are still students who have not been able to solve the problem of regeneration properly. The cause of students who do not master the curriculum material is due to the use of inappropriate methods. Often, teachers only refer to memorising formulas and override the understanding of basic concepts from wholeness (Hussein & Csíkos, 2023; Östergren et al., 2024).

Previous research has identified several factors that hinder students' mathematical learning: insufficient thoroughness in reading and understanding problem statements, limited spatial reasoning abilities, and an overreliance on worked examples, all of which impede genuine conceptual comprehension (Douglas et al., 2025; Duffy et al., 2024). This is in line with the results of observations and interviews with mathematics teachers regarding the implementation of mathematics learning in one of the junior high schools, where it was found that students experienced difficulties in building materials. Students have difficulty in imagining the form of coexistence and understanding the basic concept of coexistence; there

has not been a significant transformation in the implementation of mathematics learning in the classroom. The results of interviews with students found that the implementation of learning was also boring because teachers only lectured during learning, and the lack of use of learning media that supported the delivery of material about learning material.

Based on the difficulties experienced by students, it is necessary to develop innovations in learning, especially in the topic of regeneration in junior high school students. This innovation can be realised through learning transformation that integrates cutting-edge approaches and interactive learning media. One form of transformation is the use of an ethnomathematical approach through virtual reality (VR) technology to teach cooperative living in junior high school (Bertrand et al., 2024). VR has become one of the keywords among educators over the past few years, because the tools used every year are becoming more affordable and the quality is getting better (Alizadeh, 2019). In addition, learning transformation can also be strengthened using interactive LKPD that is contextually designed and encourages independent exploration and student activity. Several studies have tested the use of learning media using technology and separate learning approaches. However, there has been no research that integrates Deep Learning approaches, technology-based media such as VR, and interactive LKPD in mathematics learning.

The novelty of this research lies in the focus on the application of deep learning approaches and the use of VR technology in mathematics learning, especially on the topic of development, which is combined with interactive LKPD as the main supporting media for junior high school students. This study describes how mathematics learning on the topic of awakening uses a Deep Learning approach and is collaborated with the use of interactive LKPD and Virtual reality (VR) learning media assisted by the Artsteps application, which makes learning as if it is in the real world through virtual simulation.

B. METHODS

This research is a qualitative descriptive research. Qualitative research is research taken from natural language to understand individual experiences specifically and meaningfully (Sevilla-Liu, 2023). This study describes the application of the Deep Learning approach and the use of interactive LKPD and Virtual Reality-based learning media on the topic of awakening. This qualitative descriptive method presents the results of the research by describing the results of measurement tools in the form of written tests and interviews.

The subject of this study is junior high school grade VII students with a total of 4 classes. Each class consists of approximately 20 to 30 students. Data collection techniques use observation and interviews. Prior to data collection, the research instruments including the interactive LKPD, VR media assisted by Artsteps, observation sheets, and interview guidelines were validated by three experts in mathematics education and educational technology. The validators assessed the instruments in terms of content accuracy, construct relevance, language clarity, and usability. Each instrument was rated using a four-point likert scale, and the average validity score was categorized as very valid, indicating that the instruments were suitable for data collection. The observations were conducted using a non-structured participatory approach, in which the researcher was directly involved in classroom activities to observe the implementation of interactive LKPD and VR media. The interviews were semi-structured,

allowing the researcher to explore teachers' and students' perspectives when learning mathematics using a deep learning approach by integrating interactive LKPD and Virtual Reality (VR). The data analysis used in this study is the Miles and Huberman model. There are four stages of data analysis, namely data collection, data reduction, data presentation, and conclusion drawing (Hendrawan et al., 2022). The following is a flowchart of the data analysis stage, as shown in Figure 1.

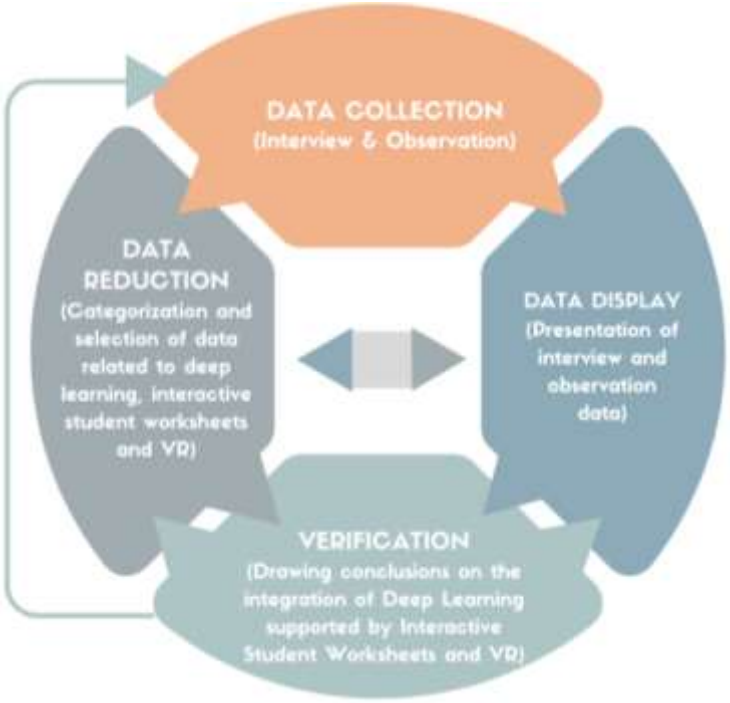

Figure 1. Flowchart of data analysis stages according to Miles and Huberman

C. RESULT AND DISCUSSION

In this study, we discuss the picture of mathematics learning with a Deep Learning approach assisted by interactive LKPD and Virtual Reality (VR)-based learning media. Before the learning was carried out, the researcher conducted interviews with 4 grade VII mathematics teachers from 4 different schools. Grade VII mathematics teachers always make learning tools before learning; this is in line with what teacher A said.

"*A teacher, before teaching, must indeed prepare learning tools which are usually compiled together in the meeting forum for the preparation of learning tools at the beginning of the semester, because indeed teachers must lower Learning Outcomes to Learning Objectives to know the achievement of learning*".

This is also supported by teacher C, who said:

"*Ideally, learning tools are arranged at the beginning of the semester, but there are indeed some that are arranged precisely when learning takes place*".

In the preparation of learning tools, especially the Teaching Module, of course, teachers have prepared an overview of the learning that will be carried out by considering strategies that are in accordance with learning, starting from methods, models, approaches, assessments,

or media that will be used. Through the preparation of learning plans, teachers become proficient in identifying the needs of students and optimising learning (Acquah et al., 2024). The activity of a teacher in preparing a lesson plan by paying attention to several aspects and building students' ideas is very important (Yan & Goh, 2023).

The existence of PISA in the world of education makes it urgent for literacy in reading, mathematics, and science. In optimising these abilities, the provision of theoretical, practical, and in-depth learning can be carried out by teaching staff. Therefore, as an educator, it is expected to be able to adjust the learning carried out using an approach that makes learning more theoretical, practical, and in-depth, such as the Deep Learning approach. This Deep Learning approach is still less popular among educators. Therefore, before learning with the Deep Learning approach. So, teachers should understand Deep Learning. The following statement from Teacher B:

"*Learning with the Deep Learning approach that I know is deep learning, as the name implies, for the stages I don't know in detail*"

This is supported by the statement from Teacher D, namely:
"*All I know is an approach that provides in-depth learning to students*"

Based on this, teachers already know about the Deep Learning approach, even though it is only the basic concept. To support the implementation of the Deep Learning approach, teachers can also use interactive LKPD and learning media that are in accordance with the Deep Learning approach that provide theoretical, practical, and in-depth learning, such as Virtual Reality (VR). However, Teacher D said that the use of LKPD so far is not LKPD, which contains steps in the learning process that are scaffolding for students, but LKPD, which only contains practice questions. Interactive LKPD is integrated into the learning process and used to help students master the material and achieve certain learning goals (Olena et al., 2022). The use of technological media in the form of VR has also never been done in mathematics learning, precisely in the same material by Teacher D. in recent years, VR technology has emerged as a promising technology in changes in the field of education (Liu et al., 2025).

The use of Virtual Reality (VR) technology in mathematics learning, especially the topic of awakening, uses the Artsteps application. Because Artsteps is an application that can make the virtual world like an exhibition in the real world. This interactive LKPD and Virtual Reality (VR)-based learning media contains all learning stages that are adjusted to the Deep Learning approach on the topic of class VII rejuvenation. Before the LKPD and learning media were implemented, the researcher provided an opportunity for teachers to give their opinions regarding LKPD and Virtual Reality (VR)-based learning media in mathematics learning, with the topic of cohesion. Based on the opinions expressed by Teachers A-D, they gave a positive response regarding interactive LKPD and VR-based learning media. For them, interactive LKPD integrated with the use of VR in learning provides a new learning experience for students. However, the content presented can be further developed. The interactive LKPD and its learning media are also at the Deep Learning stage.

The deep learning approach has 3 principles, namely prioritising mindful, meaningful and joyful in line with the implementation of the Independent Curriculum (Fatihah & Wiji, 2025).

The mindful principle emphasises that students have awareness of the importance of the material to be discussed. The principle of meaningful learning makes students apply learning materials to the phenomena of life around the student body. Meanwhile, the joyful principle makes the learning atmosphere fun and provides a sense of pleasure so that students can understand, remember, and apply the learning material well.

The principle of Deep Learning will be able to honour teachers, students, and other stakeholders and provide 3 learning experiences, namely understanding, applying, and reflecting (Suyanto et al., 2025). This learning experience is contained in order in the interactive LKPD. At the understanding stage, students are asked to be active in understanding knowledge in depth on concepts and materials from various sources. The second stage is to apply; at this stage, students can apply their knowledge in a real life context. The final stage is reflection, during which students evaluate and interpret both the process and outcomes of their real-world mathematical practices (Hoffman et al., 2024). In this study, the application of deep learning learning is carried out using deep learning principles and experiences supported by interactive LKPD and the use of VR in it. The following is a flowchart of the learning material that is carried out using the principles and experiences of Deep Learning learning, as shown in Figure 2.

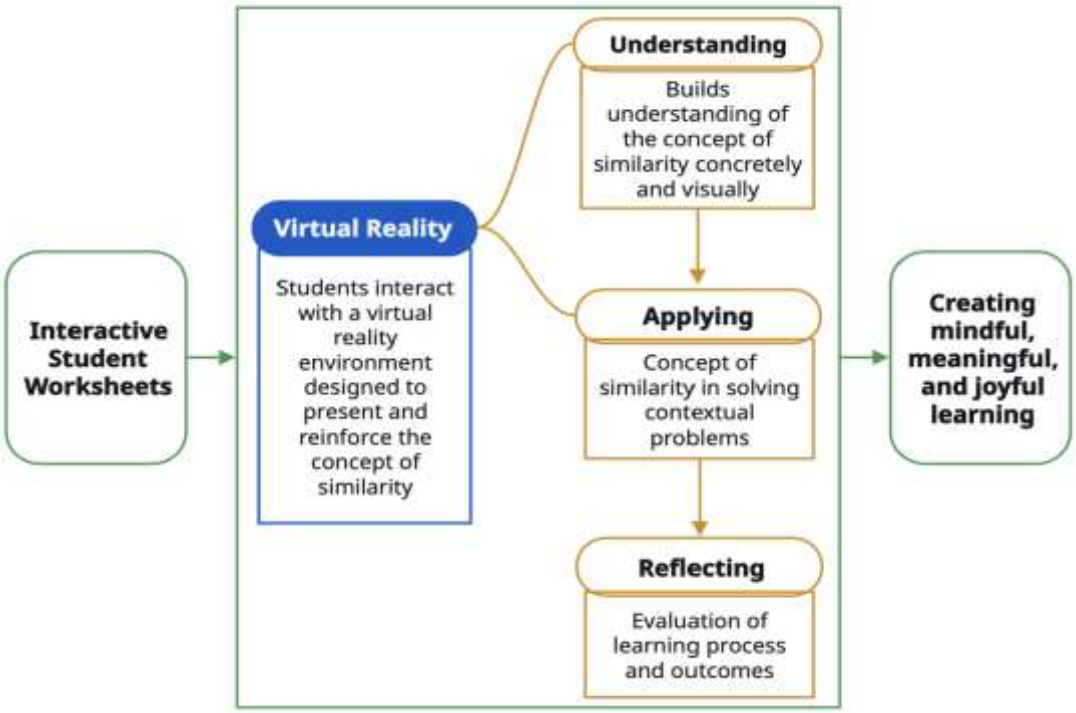

Figure 2. Flowchart of Deep Learning Stages with the Help of Interactive LKPD and VR

Based on the flowchart in Figure 2 describes the learning flow based on a deep learning approach through the integration of interactive LKPD and VR in understanding the concept of togetherness in junior high school. Learning with a Deep Learning approach assisted by interactive LKPD and VR-based learning media began with the opening of learning as usual, using greetings, prayers, and the delivery of learning objectives. Teachers provide interactive LKPD that not only presents practice questions, but also in the form of a series of activities that guide students to explore, apply, and reflect on their understanding. This interactive LKPD

plays an important role in building active involvement and critical thinking of students through structured and contextual activities (Harahap et al., 2022). In exploring, understanding, and applying the concept of development, assisted by the existence of VR media. Starter questions are often used by teachers to direct students to the material to be studied.

The core activity includes three learning experiences from the deep learning approach, namely understanding, applying, and reflecting. The first learning experience is to understand. This stage of understanding builds students' understanding of the concept of coexistence in a concrete and visual way. This is in accordance with one of the principles of deep learning, namely mindfulness. The learning carried out makes students understand deeply. Teachers can open learning by asking students about their experiences related to similar forms, such as shadows, miniatures, and enlarged photos. The delivery of the concept of development, in addition to using verbal methods, can also use visuals to better build a representation of the information that will be conveyed (Zhang et al., 2025). The use of visual aids such as pictures can improve the understanding of text material better than just verbal explanations (Emirmustafaoğlu & Gökmen, 2015).

The use of VR at this stage is carried out by inviting students to explore the virtual world, which displays various flat buildings and spaces in the form of recreation through Artsteps software. By using VR, students can rotate objects, measure sides, and compare angles to see the development. The use of Artsteps allows users to create custom VR spaces and acquire hyperlinks, the ability to chat with other users and share content on social media (Vital et al., 2023). By using VR, a 3D representation becomes a complete representation of the real world or objects within it (Farshid et al., 2018). Artsteps presents VR in the form of a virtual exhibition that can be used as a learning tool (Sylaiou et al., 2024). In this learning experience, students are asked to discuss in groups the characteristics of waking up based on their experience in VR. This stage divides students into several groups.

The next learning experience is to apply; it is hoped that students will be able to use the concept of coexistence to solve problems. Activities that can be carried out are case studies and project-based assignments. In the case study, students were asked to enter a VR scenario by measuring the height of the building based on the shadow of a tree whose height is known. In project-based assignments, students are asked to present how the concept of coexistence is applied in the real world. This is by the principle of deep learning, namely mindful, that is, the learning created must provide experiences to students that emphasise the importance of the material given. Project-based learning engages learners in tasks that concern implementation in life (Chen & Yang, 2019). Thus, it can be said that project-based learning is a solution to solve problems in the real world (Kłeczek et al., 2020). Using project assignments can encourage learners in soft skills such as problem-solving, critical thinking, and cooperation (Wu et al., 2025). So that learning does not seem boring, students are given several supporting impressions in the form of videos to explore the project. This is in accordance with one of the principles of deep learning, namely joyful learning. Where the implementation of learning creates a sense of security and calm.

The last learning experience is reflecting, students are expected to evaluate the learning process and outcomes to deepen their understanding. The activity carried out was that students were asked to write down their understanding of development. To conduct an evaluation

related to learning, students are asked to make short videos about awakening in daily life. Followed by the provision of constructive feedback by teachers as motivation and encouragement to improve the results that have been obtained. Do not forget that teachers make assessments related to the competencies of students' practical skills through the psychomotor rubik's cube. At the stage of independent learning and self-regulation, teachers give project assignments independently to encourage students in learning independently. The last stage is evaluation in the form of independent quizzes, and for continuous development in the form of reflection on learning that has been carried out with satisfaction surveys and digital teacher performance evaluations.

Based on observations made on the implementation of learning with a Deep Learning approach by integrating interactive LKPD and VR-based learning media, students responded well to learning with a Deep Learning approach assisted by interactive LKPD and VR technology. This is as expressed by the grade VII mathematics teacher that students show an enthusiastic attitude when participating in learning, and students also actively participate in the learning. Group cooperation also went well, and of course, in addition to theoretical learning, in practice, students were also taught about the use of media. Interactive LKPD-assisted learning and Virtual Reality also provide students get a new learning experience, and the content presented is interesting, so that students follow learning comfortably and carefully.

The implementation of learning is by the principles of deep learning learning, namely knowledge connectivity, active engagement, critical and reflective thinking, problem-based learning, collaboration, and intrinsic motivation (Ramadan et al., 2025). Knowledge connectivity is characterised by the relationship between knowledge about coexistence and previous material, such as algebraic forms and integers, that can be used in calculating angles in coexistence. The active involvement of students is indicated by the participation of grade VII students in the activeness of students in learning in responding to learning, and the activeness of participants in following the teacher's direction. There is currently an increase in the demand for mathematics teachers to foster student-centred learning (Avishai et al., 2025).

Advanced learning is needed to develop students' competencies, such as in-depth mastery of challenging content, critical thinking, complex problem-solving, communication and collaboration (Darling-Hammond et al., 2017). By learning in the 21st century focuses on creativity, innovation, critical thinking, problem-solving, communication and collaboration (Keiler, 2018). The achievement of 21st-century skills is essential, so teachers are expected to create activities that match those skills (Sjølie et al., 2021).

Collaboration between students in discussing various ideas is an important aspect of mathematics learning (Kooloos et al., 2023). Collaborative learning is a valuable educational approach that is often used to promote such collaborative skills (Sjølie et al., 2021). Critical thinking skills in learning are aimed at when student’s complete projects given by teachers related to solving problems of building materials. Students who have critical thinking skills can complete reasonable assessments and evaluations (Zhang et al., 2025). With the development of existing technology, it triggers students to think more critically in analysing knowledge (Abbasi-Sosfadi et al., 2025).

Besides critical thinking, the principle of deep learning is problem-based learning. In this case, students are presented with a problem at the time of making the project. Problem-solving

skills in problem-solving are one of the important skills in higher-level thinking (Koçoğlu & Kanadlı, 2025). Students' motivation in participating in problem-solving tasks is driven by students' confidence to succeed in a task (Pan et al., 2025). So that better project completion ideas are obtained due to the high motivation of students (Pucher & Lehner, 2011).

The next principle is intrinsic motivation, as an educators, teachers can build students' motivation in participating in learning. Intrinsic motivation can be said to be the learners have their intrinsic tendency to learn new things (Fidan & Oztürk, 2015). Intrinsic motivation itself can be useful in improving speech accuracy by creating a positive learning environment, increasing student efficacy, and encouraging practice in communicating (W. Wang et al., 2024). In this study, teachers build student motivation by using the use of technology that students have never used in learning, namely VR. As has been researched by the Ukrainian government, the use of virtual simulation technology is practical and effective in increasing the creativity and motivation of students (Rizki et al., 2025) .

Based on the researcher's observations of students in grades A-D, that students followed learning from beginning to end with enthusiasm. This is shown by students actively participating in learning, and all stages of learning are well followed. When using interactive LKPD and Virtual Reality (VR) learning media, students are curious because their use is still new among students, especially when it is used in mathematics learning. This is supported by statements from students that they often find Virtual Reality (VR) technology in games, but currently the use of virtual reality can be used in learning. Moreover, in mathematics learning, many students find it difficult and boring. Students also revealed that they usually complete LKPD, whose content is questions that they must work on; now they feel happy with the interactive LKPD that helps them in guiding the learning process from start to finish. With the integration of interactive LKPD and Virtual Reality (VR) technology media in learning, the learning is made more interesting and engaging.

The statement is in accordance with research conducted by Alhazzaa & Yan (2025) on the use of interactive LKPD, AR and VR technology to increase student involvement and understanding in the teaching and learning process and be more effective for communication and visuals. And the involvement of VR and AR technology can be a solution in optimising learning outcomes. In line with that, VR is a viable tool, and it provides a safe, engaging, and controlled environment for learners. Learners can apply theoretical knowledge to real-world scenarios and think critically (Gårdling et al., 2025). This is also supported by Zhan et al. (2024) that the use of VR improves student learning performance and makes the classroom more student-centred, students become active, innovative, and interactive to achieve deeper learning. This is by the application of the Deep Learning learning approach. Deep learning can improve attention, concentration levels, and academic effort (Zhao, 2022).For the success of the use of technology in the world of education, moreover, the use of VR in learning is still not popular among teachers. The importance of equipping educators with the knowledge and skills in utilising VR in improving learning (Elhambakhsh et al., 2024).

D. CONCLUSION AND SUGGESTIONS

Based on research conducted related to the application of the Deep Learning approach by integrating interactive LKPD and Virtual Reality (VR) learning media, it was found that: (1) The application of the Deep Learning approach to mathematics learning, especially the regenerative material, received a positive response from both teachers and students, as seen from the results of observations and interviews with teachers and students; (2) The integration of interactive LKPD and Virtual Reality (VR) technology-based learning media can make students more active, independent and enthusiastic through learning experiences ranging from understanding, applying and reflecting; (3) The integration of interactive LKPD and Virtual Reality-based learning media is also adjusted to the learning stages with a Deep Learning approach and Deep Learning learning principles, namely mindful, meaningful and joyful learning; and (4) Further research related to this research is expected to be able to describe the learning process in more detail using the Deep Learning approach.

In theoretical terms, this research reinforces the concept of deep learning within mathematics education by demonstrating that the approach can be effectively implemented through the combination of digital media and interactive worksheets. In practical terms, the findings provide guidance for teachers in designing learning activities that foster active engagement, reflective thinking, and conceptual understanding through the integration of VR media and interactive LKPD. This approach also supports the implementation of the Indonesian Merdeka Curriculum, which emphasizes meaningful, project-based, and student-centered learning aligned with 21st-century competencies.

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