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IMPROVING SENIOR HIGH SCHOOL STUDENTS' NUMERACY LITERACY USING DEEP LEARNING AND INTERACTIVE DIGITAL MEDIA

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ABSTRACT

This study investigated the effectiveness of integrating deep learning pedagogical approaches with interactive digital media to improve high school students' numeracy literacy, particularly in exponential and radical domains. This research is based on the persistent underperformance of Indonesian students in international numeracy assessments, emphasizing the urgent need to adopt learning innovations that foster deep conceptual understanding, analytical reasoning, and active student engagement. Using a quantitative methodology with a quasi-group pre- and post-test design, this study involved 35 tenth-grade students from Senior High School (SMA) Negeri 12 Bandar Lampung. Data were obtained through standardized pre- and post-test instruments, supported by analytical rubrics, that assess conceptual comprehension, application fluency, problem-solving efficiency, and strategic reasoning. Statistical analyses, including normality, homogeneity, and paired t-tests, were conducted using SPSS 26.0. The findings show a statistically significant improvement in students' numeracy literacy following the implementation of integrated deep learning and interactive media interventions. The mean score increased from 61.40 to 74.06, with a significance level of 0.001 (<0.05), indicating a significant pedagogical effect. The results show that this integrated approach increases conceptual depth, fosters reflective and analytical thinking, and promotes ongoing student engagement. Interactive media further support learning by providing dynamic, multimodal representations that facilitate understanding of abstract mathematical constructions. The study concludes that combining Deep Learning with interactive media is an effective and transformative strategy to strengthen numeracy literacy in contemporary mathematics education. Future research should include a broader sample, a wider range of mathematical topics, and additional affective or behavioural variables.

Keywords: numeracy literacy, *Deep learning*, interactive media, mathematics learning, digital education.

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INTRODUCTION

Education has always been an important topic because it plays a huge role in shaping one's behaviour to be able to meet the needs of society from physical, intellectual, emotional and moral aspects. The development of information and communication technology has encouraged digitalisation and significant transformation in various sectors, including education. In the era of Society 5.0, numeracy literacy skills are increasingly important as they are needed in everyday life, the world of work, and society, both as part of conventional literacy

and contemporary literacy related to data and technology understanding (Sinaga & Simanjorang, 2024). Since 2020, the Indonesian government has implemented the Merdeka Curriculum as a development of the 2013 Curriculum, with a stronger emphasis on mastering numeracy literacy and critical thinking skills to meet the demands of 21st-century skills (Meliana, Suwindia, & Winangun, 2025).

Numeracy literacy is an essential competency that reflects a student's ability to effectively understand, interpret, apply, and communicate basic mathematical number concepts and symbols. This ability is not only limited to numeracy skills, but also includes the ability to think logically, analytically, and critically in solving a wide range of contextual problems encountered in everyday life. Numeracy literacy allows students to analyse, evaluate, and infer information presented in various forms of representations such as narratives, graphs, tables, and diagrams, so that they can make rational, data-driven decisions that are relevant to real situations (Ambarwati & Kurniasih, 2021).

The development of numeracy literacy skills of Indonesian students can be seen through the results of the *International Student Assessment Programme (PISA).* Based on the 2022 PISA results, Indonesia's math literacy score dropped from 379 to 366, 106 points below the global average, indicating students' poor numerical literacy. This situation shows the need for learning that fosters critical, logical and creative thinking skills through the use of interactive media that is appropriate to their characteristics and needs (Annurwanda, Ellissi, & Maerz, 2024). n an effort to meet the challenges of literacy and numeracy, this activity aims to improve students' abilities through the integration of approaches to *Deep Learning* and interactive learning media that promote an engaging learning atmosphere, foster curiosity, and strengthen analytical skills, problem-solving, and learning freedom. At the same time, it helps teachers effectively map students' abilities to support the continuous improvement of the quality of basic education (Padilah, Turohmah, Syavira, Yatillah, & Suwenti, 2025).

In another study, there are three indicators of achievement that can be seen to assess students' numeracy literacy skills, namely *First* Can use different types of numbers or symbols related to basic mathematics to solve problems in everyday life; *Second* Ability to understand information in various forms; And *Third* Ability to interpret the results of problem analysis to estimate and make decisions (Darmastuti, Meiliasari, & Rahayu, 2024). A student's numeracy literacy skills are a marker of the success of the learning process as measured by *Trial* and *Post Exam,* Before and after integration implementation, *Deep Learning* with interactive media, without any assessment of the attitude, motivation or character of the student (Tsani Inesita, Maghfiroh, Nuril Azizah, Uswah Sadieda, & Hanizar, 2024).

Based on previous research, improving numeracy literacy can be done through the use of contextual and interactive learning models, so that students not only understand mathematical concepts in theory, but also are able to apply them in real-world situations students (Sutrimo, Sajdah, Sinambela, & Bagas, 2024).

Deep learning (Deep Learning) is an approach that focuses on improving students' understanding through thorough exploration and active participation, emphasizing in-depth analysis of concepts, integration of new knowledge with previous experiences, and its application in real-life contexts, so as to develop critical, reflective, and creative thinking skills that not only improve academic outcomes, but also strengthen the intellectual growth, character, and meaning of Students' learning experiences (Rahmandani, Rifqi Hamzah, Handayani, & Wahyu Kurniawan, 2025). In addition to the use of interactive media, numeracy literacy plays an important role in creating meaningful learning as it includes the ability to apply number concepts and computational operations in everyday life, as well as understand and analyse information in the form of numbers or data (Sulistiawati, Putriani, Hamidah, & Kusuma, 2025).

The integration of artificial intelligence (AI) in education is an important innovation that improves the efficiency and effectiveness of learning through the application of technologies such as *machine learning, natural language processing,* And *Big Data Analytics*, which enables the presence of adaptive learning systems, virtual assistants, and automated assessments, so that higher education can create a more personalized, relevant, and tailored learning experience to students' needs (Ratnasari, Zabeta, & Sholeha, 2024). Additionally, the use of AI also promotes a paradigm shift in pedagogy through the provision of more flexible and data-oriented learning, so that educators can design more appropriate and responsive learning strategies. For students, these technologies allow access to interactive learning resources, practical feedback, and personalised learning suggestions based on their individual abilities. This makes the learning process more effective and meaningful as the administrative burden can be reduced and the learning time can be used optimally. However, the implementation of AI in education still requires adequate digital infrastructure support, increased technological literacy of educators, and ethical policies that ensure data security and privacy (Respati, 2024).

In the field of Education, deep learning refers to learning that is not only on the surface but involves deep understanding, critical analysis, and the application of concepts in a variety of real-life situations (Isnayanti, Putriwanti, Kasmawati, & Rahmita, 2025). Model *Deep Learning* Focus on developing a deeper understanding of the subject through a comprehensive learning experience, in which students actively participate emotionally and cognitively in the learning process (Nurhakim, Rojibillah, Harsing, Supiana, & Zakiah, 2025). Deep Learning demands the integration of a fun, caring, and meaningful learning environment so that students are actively engaged, but its implementation in Indonesian primary education is still constrained by limited teacher understanding, a less flexible curriculum, and policies that focus on academic outcomes, creating a gap between ideal concepts and practices (Feri, Ismiati, Al-nur, & Akbar, 2025).

In Approach *Deep Learning* combined with Ki Hajar Dewantara's educational principles, it forms a holistic learning model that not only transfers knowledge, but also nurtures students' personality and morals, thus producing a generation that is intelligent and intellectually dignified, in line with the demands of 21st century education that emphasizes the mastery of high-level thinking skills (HOTS) (Angga & Sari, 2025). This activity aims to integrate the educational values of Ki Hajar Dewantara with deep learning technology to build a holistic, adaptive and character learning model that is effective, personal and able to develop high-level thinking skills (HOTS), so that through the collaboration of humanistic values and technological sophistication, it is hoped that a generation will be born who are intellectually intelligent, have moral dignity, and are ready to face the challenges of future education (Sofia, Syafrudin, & Yulistia, 2023). The use of technology through digital-based games is an innovative approach in developing students' logical-mathematical intelligence. Therefore, teachers need to design learning strategies that support the enhancement of these abilities and have a positive belief in the role of technology in supporting student learning success (Sofia et al., 2023).

Results obtained from previous studies show that *Deep Learning* has not been fully implemented in teaching and learning activities in schools, especially in mathematics subjects. In research on *Deep Learning in* the field of education, using the Literature Research method or also called qualitative research, this method is a research method that focuses on the collection and analysis of data from various written sources such as books, journals, scientific articles and official documents (Isnayanti et al., 2025).

In other studies, the use of integrating *Deep Learning* with interactive media was conducted using Canva's digital platform with the aim of finding out the impact of the approach

of *Deep Learning* and interactive learning media based on Canva's digital platform on extensive measurement materials to improve student learning outcomes (Asmi & Wijayanto, 2025). Meanwhile, in this study, the implementation of integrating *Deep Learning* with interactive media in mathematics learning, especially in Exponential and Root Form materials to improve numeracy literacy skills among students. Accordingly, many previous studies have discussed the use of interactive media in other subjects rather than mathematics. Interactive media can make the learning experience more engaging and enjoyable for students, while boosting their enthusiasm for learning .

Technology-based use of *Deep Learning presents* an adaptive and data-oriented learning approach to improve students' literacy and numeracy skills (Aryanto et al., 2025). Through an in-depth analysis of students' learning patterns, the system is able to tailor personalised teaching materials and strategies, so that educators can design a more effective learning process in fostering logical thinking skills and numerical comprehension. In addition, the application of digital media such as educational games and interactive applications also plays a role in increasing students' motivation and active involvement during the learning process (Khairah & Cem, 2025). Several studies have also confirmed that the application of digital games and technology-based adaptive learning strategies has a positive impact on students' numeracy skills, literacy, mathematical reasoning, and conceptual comprehension. Therefore, the integration of *Deep Learning in* learning, literacy and numeracy represents not only technological innovations, but also pedagogical strategies that emphasise the importance of adaptive and centred learning on the development of students' logical-mathematical intelligence (Gök & İnan, 2021).

Previous research, including the study at SMA 10 Pandeglang, is still limited to mapping students' abilities without involving the application of certain learning models aimed at improving these competencies. The method used is still in the form of routine exercises with simple media, so it does not use technology and in-depth approaches that can strengthen the understanding of concepts. The study was also limited to basic numeracy and did not include more complex materials such as exponents and root shapes, nor did not include statistical analyses to test efficacy. Therefore, experimental research that combines Deep Learning and interactive media is needed to produce a more tangible and measurable increase in numeracy literacy (Pancawardani et al., 2024).

Previous studies using digital media such as Microsoft Sway have focused only on presenting materials and improving basic numeracy in primary schools, without deep learning strategies that encourage high-level reasoning. without deep learning strategies that promote high-level reasoning. Therefore, new research that combines Deep Learning and more adaptive interactive media is needed to strengthen numeracy literacy in complex math materials at the secondary school level (Hidayat & Wijayanto, 2024).

Although the utilization of deep learning technology and interactive digital media in education has developed rapidly, its implementation to improve students' numeracy literacy remains suboptimal. Previous studies have largely focused on the use of deep learning for non-pedagogical purposes such as automated assessment, predictive analysis of learning outcomes, and educational data management, which limits its contribution to enhancing the quality of classroom learning. In addition, studies that integrate deep learning with interactive digital media in mathematics instruction generally emphasize the mastery of basic concepts and procedural skills, while the development of higher-order thinking skills, including quantitative reasoning, context-based problem solving, and understanding complex mathematical representations, has rarely been explored. This gap indicates the need for research that comprehensively examines how the integration of artificial intelligence-based technology can effectively support the development of numeracy literacy, particularly at the senior high school

level, where critical thinking skills and the ability to apply mathematical concepts in real-world contexts are highly required, yet students' numeracy literacy remains low.

The low performance of Indonesian students in numeracy literacy, as reflected in international assessments such as PISA, highlights the urgency of introducing pedagogical innovations that can strengthen higher-order thinking skills and deepen conceptual understanding. Furthermore, the integration of deep learning with interactive digital media has the potential to increase student engagement, enhance conceptual comprehension, and promote the comprehensive development of numeracy literacy. Therefore, this study is important as it can provide empirical evidence regarding the effectiveness of technology-based approaches in developing higher-order thinking skills, which have been scarcely examined in previous literature.

The novelty of this study can be seen in three main aspects. First, it specifically focuses on improving numeracy literacy, including quantitative reasoning, context-based problem solving, and understanding complex mathematical representations, which goes beyond mere mastery of basic concepts and procedural skills. Second, it utilizes interactive digital media that supports adaptive and contextualized learning, enabling students to learn more meaningfully according to their individual needs. Third, it provides empirical evidence at the senior high school level, which is still limited in previous studies, and this not only reinforces prior findings but also offers a technology-based learning model that aligns with the demands of education in the digital era. Consequently, this study is expected to address the existing research gaps while offering a comprehensive learning strategy to significantly enhance students' numeracy literacy.

METHOD

This research was conducted through three main stages, namely the preparation of instruments, the implementation of treatment using the Deep Learning model combined with interactive media and the assessment of numeracy literacy skills before and after the intervention. Each stage is structured to fit the research objectives. During the implementation of the research, the researchers maintained that external factors such as classroom conditions, learning schedules, and the readiness of technological devices were controlled so that they did not affect the research results.

Interactive media is used in each learning session to help students understand the material through visualisations, animations, and exercises that provide hands-on feedback. The use of these media is chosen so that students can actively interact with the material in an active and sustainable manner. Class X-8 was chosen as a sample because it was considered to meet the criteria, both in terms of technological readiness and availability of time, so that the implementation of interventions based on Deep Learning and interactive media could run optimally.

This study uses a quantitative approach with the aim of analysing the influence of integrating *Deep Learning* using interactive media for students' numeracy literacy. The quantitative approach was chosen because it allows researchers to systematically collect and analyse numerical data, as well as test the relationship between independent variables and dependent variables (Waruwu, Pu`at, Utami, Yanti, & Rusydiana, 2025). The research design used is a *Quasi-experimental design* without a control group, where one group is treated and measured through pre-test and post-test (Nasution, Netriwati, & Dewi, 2021). This design was chosen to facilitate implementation in a school environment while still obtaining information about the changes in numeracy literacy due to treatment.This study uses a critical literature review model that examines the integration of deep learning (*Deep Learning*) with interactive media, where *Deep Learning* It is carried out through the in-depth collection and analysis of relevant resources, while interactive media is understood as technology-based media such as

computers or smartphones that not only display teaching materials, but also motivate and respond to student interactions during the learning process (Sijabat, Hutabarat, Sitorus, Salsabilla, & Khairunnisa, 2024). This approach allows for the development of learning strategies that are more adaptive and responsive to the needs of students.

The sampling in this study used a combination *of facility sampling* and *cluster sampling*. *The sampling facility* was chosen because it made it easier for researchers to reach participants who were willing to participate in the research and obtain permission from the school. In this case, class X8 of SMA Negeri 12 Bandar Lampung, with a total of 30 students, was selected as a sample because the classroom conditions allowed for the efficient implementation of pre-test, treatment, and post-test. Meanwhile, *cluster sampling* was used by considering each class as a natural cluster of the class X population, then selecting one cluster (class X8) as the research sample. This approach provides a systematic structure, reduces logistical burdens, and allows all students in the class to receive treatment simultaneously.

The combined use of these two sampling techniques has several advantages. Practically, *facility sampling* ensures that samples are easily accessible, while *cluster sampling* takes into account the natural distribution of the population, so that the study still has an organised and structured sampling framework. This approach is especially relevant for *quasi-experimental designs without* a control group because all members of the class can be treated simultaneously. However, the researchers are aware of the limitations of this method:*facility sampling* is *not a probability,* so not all members of the population have the same opportunity to be selected, and the use of a single cluster limits the overall representation of the class X population. Therefore, the conclusions of this study are more appropriate to be directed to the class studied, rather than the entire population of class X students in the school.

The variables observed in this study consisted of independent variables, i.e. the integration of *Deep Learning* with interactive media, and the dependent variable, i.e. students' numeracy literacy. The research instruments include *pre-tests* conducted before treatment and *post-tests* conducted after treatment, aimed at objectively measuring changes in students' numeracy literacy ability.

To objectively assess numeracy literacy, this study used an assessment rubric arranged based on research questions. The questions cover several aspects: understanding concepts, applying concepts, problem-solving solving and problem-solving strategies/inventions. Each aspect was assessed using a scale of 0–4 (0 = not showing ability, 1 = very weak, 2 = adequate, 3 = good, 4 = excellent), and the total score of all aspects was calculated as the student's numeracy literacy score. This rubric allows for consistent and measurable assessments for pre- and post-examination, while also providing a foundation for quantitative analysis.

The data analysis techniques used include prerequisite tests and hypothesis tests. Prerequisite tests include normality tests using the Shapiro-Wilk and homogeneity tests using the Homogeneity of Variance, while hypothesis testing is conducted using *paired t-tests* to test for significant differences between *pretest* and *posttest* results. All analyses were conducted using *SPSS Statistics 26.0 for Windows* to ensure the validity and reliability of the research results.

This research was conducted at SMA Negeri 12 Bandar Lampung on 6-13 October 2025. Overall, the research design, sampling techniques, instruments, evaluation rubrics, and analytical procedures used allow research to run systematically and efficiently, while remaining transparent about the limitations of representation and generalisation of results. This approach provides a solid foundation for the interpretation of research results and their implications for the development of numeracy literacy through the integration of Deep Learning with interactive media.

RESULT

Prerequısıte Tests

Normality Test

Normality testing is a statistical procedure that aims to verify the validity of data, *Trial* and *Post Exam,* by identifying whether the data is distributed normally or deviates from the normal distribution pattern (Nasar et al., 2024).

Table 1. Normality Test (Shapiro-Wilk)

Category	Statistics	df	Sig.
Trial	0.971	35	0.458
After Testing	0.980	35	0.754

Based on the results of the normality test conducted, a significant value of 0.458 for the pretest and 0.754 for the post-test was obtained. Both values are greater than 0.05, which indicates that the data is distributed normally. So that the data meets the assumptions of normality and can be used in parametric statistical analysis.

Homogeneity Test

The homogeneity test aims to determine whether the data *Trial* And post-exam have a homogeneous variance or not (Izza et al., 2025).

Table 2. Homogeneity Test

Test of Homogeneity of Variances	Levene Statistic	df1	df2	Sig.
Based on Mean	0.049	1	68	0.826
Based on Median	0.042	1	68	0.837
Based on Median and with adjusted df	0.042	1	67.942	0.837
Based on trimmed mean	0.045	1	68	0.832

Based on the results of the homogeneity test, a significance value of 0.826 is obtained, which is greater than the significance of 0.05. This indicates that the data has a uniform or homogeneous variance. Therefore, it can be interpreted that the variation between *pretest* and *posttest scores* is quite similar, so that differences in results that arise are more likely to be due to the treatment or intervention given than differences in initial characteristics between groups.

Hypothesıs Testıng

T-Test Sample Dependent

The t-test is a statistical method used to test the hypothesis of whether or not the difference between two average random samples from the same population is statistically significant (Azhari et al., 2023).

Table 3. Paired Samples Statistics (t-Test)

Paired Samples	Mean	N	Std. Deviation	Std. Error Mean
Pretest	61.40	35	7.543	1.275
Posttest	74.06	35	7.332	1.239

Table 4. Paired Samples t-Test Results

Paired Samples	t	df	Sig. (2-tailed)
Pretest – Posttest	-43.257	34	0.000

Based on the results of the t-test analysis, the average difference between *a pretest score of* 61.40 and *a posttest score of* 74.06 was obtained. A significance value of 0.000, which is below the 0.05 threshold, shows a statistically significant difference. These findings show that

Deep Learning applications integrated with interactive media contribute significantly to improved student learning outcomes. Therefore, it can be concluded that the use of interactive media is effective in improving students' abilities and understanding after the learning process has taken place.

Comparison Of Pre-Test And Post-Test Averages

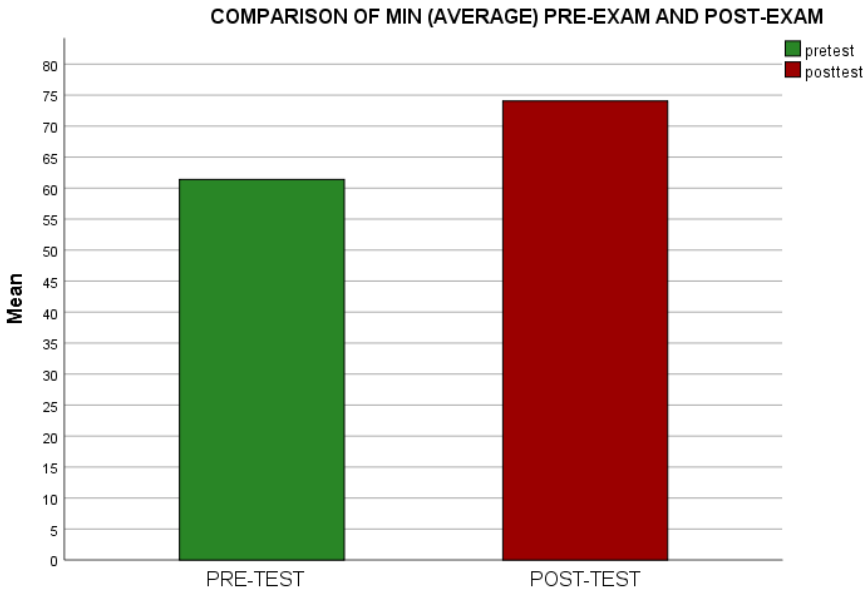

Figure 1. Comparison of Min (Average) Pre-Exam and Post-Exam

Based on the mean comparison graph, the *Pre-test* and post-exam above, showing that there is an improvement in student learning outcomes after being given treatment. Average score *Pre-test* from 61.40 increased to 74.06 at the time *post-exam,* So there is an increase difference of 12.66 points. This increase shows that applied learning has a positive impact on students' understanding, where, after following the learning process, they can obtain better results than before being given the learning. These results provide the idea that the interventions used in this study may improve student learning outcomes in the material being tested.

DISCUSSION

The results of the study show that the application of learning based on Deep Learning with Interactive Media is able to improve the numeracy literacy ability of class X 8 SMA Negeri 12 Bandar Lampung. At the pretest stage, many students still have difficulty understanding concepts and solving problems related to exponents and root shapes. However, after improvements were made through the implementation of more interactive learning strategies and exploration at the post-test level, there was a significant improvement in students' numeracy comprehension and overall literacy skills. The success of improving numeracy literacy skills can be attributed to the principles of learning by integrating Deep Learning with Interactive Media.

Based on the results of the research that has been presented, it can be concluded that Interactive Media has a positive impact on student learning outcomes. This can be seen from the comparison of the average score of 61.40 in the pre-test results and increased to 74.06 in the post-test results after being treated in the form of the use of interactive media. The post-test average showed a greater improvement in learning outcomes compared to pretest results that

did not use media. These findings show that interactive media is able to increase student engagement, clarify material understanding, and create a more effective learning process that which impacts improved learning outcomes.

The application of Deep Learning in mathematics learning plays an important role in developing students' literacy and numeracy skills through an independent and reflective knowledge-building process. Through the application of strategies such as collaborative discussions, open problem-solving, and actual application-based projects, the learning process becomes more contextual and meaningful. This approach not only strengthens conceptual understanding but also increases logical thinking capacity, mathematical literacy, and knowledge transfer ability to a wider range of situations (Nababan et al., 2025). To support this, teachers use a more structured Deep Learning approach through context-based problem-solving, individual reflection activities, and mini-projects that relate exponential concepts to everyday life situations. This activity helps students build a deeper conceptual understanding and not just memorise formulas. In addition, interactive media also strengthens the learning process by providing step-by-step visualisation of materials that are considered difficult, so that students can understand concepts more clearly and systematically.

Learning models that integrate Deep Learning are seen as relevant pedagogical findings to be implemented to strengthen and optimise students' numeracy skills (Idham Khalid et al., 2025). The implementation of Deep Learning in the context of education has been proven to present a more comprehensive, individualistic and meaningful learning paradigm. Several scientific studies have shown that this approach not only contributes to the strengthening of students' conceptual understanding but also plays an important role in the development of literacy and numeracy competencies. In particular, the use of Deep Learning strategies in mathematics teaching can enrich the learning process and significantly improve students' numerical abilities (Hafidzni et al., 2025).

Numeracy literacy is an important element in the field of mathematics that is always related to various learning materials and is always linked to the context of its application in real life (Aini, Ar, Sama', Jamilah, & Armadi, 2024). The use of interactive media in teaching materials can stimulate students to have an engaging, dynamic, and customised learning experience through apps, games, or online resources that contain multimedia elements, such as animations, simulations, videos, and interactive quizzes, to increase learning motivation and strengthen numeracy skills (Kartikasari, Fitriana, & Nurhasanah, 2025).

Different studies have shown that the Deep Learning method can improve students' accuracy and thinking skills, especially in solving mathematical problems that require an understanding of concepts. These findings are in line with the results of this study, which showed a significant improvement in numerical literacy skills after students received a more in-depth and reflective learning experience (Dasar, Amelia, & Maharbid, 2025).

Other research has also shown that the use of digital-based interactive learning media has been shown to be effective in improving students' understanding of literacy and numeracy, although the level of improvement varies according to each student's initial ability. These findings suggest that a learning approach through interactive digital media can be a potential alternative to improve the quality of basic education, especially in madrasah settings.

Previous research revealed that the use of Deep Learning-based learning can significantly improve students' numeracy skills. This model not only contributes to better learning outcomes but also fosters students' active involvement in discussion activities and strengthens their understanding of practical and meaningful numeracy concepts (Numerasi, Kelas, Upt, & Gura, 2025).

In line with that, previous research revealed that the use of the Deep Learning learning model integrated with interactive learning media through Canva has been proven to have a

positive and significant impact on improving student learning outcomes on a wide range of measurement materials at SD Negeri 1 Tlobong (Asmi & Wijayanto, 2025).

Previous studies have concluded that the application of Deep Learning combined with interactive media can improve students' numeracy literacy through a more meaningful, contextual and exploration-based learning process. This approach encourages students to understand numeracy concepts in depth, think critically, and relate mathematics learning to everyday life situations more effectively than traditional methods (Numerasi et al., 2025).

Student learning outcomes obtained and supported by data from the results of the above research, as well as studies conducted by several other researchers, it can be said that learning-based interactive media can improve student learning outcomes, so that this media can be said to be very feasible to be used as a learning medium (Handini, Ermiana, & Oktaviyanti, 2022). While Deep Learning has great potential in education, its implementation still faces various obstacles, such as huge data requirements, limited infrastructure, and a technology gap between urban and rural schools. In addition, the complex and difficult nature of deep learning models is also a challenge for educators in understanding and explaining the results produced by these technologies. The use of interactive learning media, such as *PowerPoint, educational videos, and word walls* Capable of increasing student engagement and learning motivation, its effectiveness is often hampered by the limitations of technological infrastructure, teachers' lack of digital competence, and potential distractions that can reduce students' focus on core materials. Without careful pedagogical planning and adequate technical support, the use of these media risks causing unequal access and reducing the depth of understanding of learning concepts (Salsabila Dwi Karna, Adrias Adrias, & Aissy Putri Zulkarnaini, 2025).

This study shows alignment with various previous research findings that assert that the application of innovative technology-based learning strategies can improve student learning outcomes and numeracy literacy skills. Based on the results of the synthesis of various studies that have been conducted, it is possible to get the idea that the integrationof *Deep Learning* and interactive learning media is an effective approach in creating a meaningful, contextual and oriented learning process oriented towards improving high-level thinking skills. This proves that the results of this study support and reinforce previous findings on the effectiveness of the use of technology and deep learning approaches in mathematics education. The use of digital-based interactive learning media has been shown to have a positive influence on improving students' learning outcomes and numeracy literacy skills. The increase in average scores from pre-test to post-test results reflects the successful use of interactive media in encouraging students' active engagement during the learning process.

The results of these improvements appear because interactive media allows students to understand complex concepts more easily through engaging visualizations, simulations, and technology-based activities, thus increasing motivation and learning effectiveness. Presentations like this make it easier for students to understand abstract concepts such as exponents and root shapes. In addition, the interactive media used is organized systematically and makes it easier for students to understand the material, so that they can be more accurate in solving problems.

In addition, the application of Deep Learning-based learning strategies combined with interactive media plays an important role in developing students' critical, logical, reflective, and creative thinking skills. Through student-centred learning, students are not only required to understand concepts but are also invited to build knowledge through exploratory activities such as collaborative discussions, open-ended problem-solving, and the application of concepts in real-life contexts. This approach makes math learning more meaningful and assists students in transferring knowledge to a wider range of situations.

However, the application of Deep Learning and interactive media in the learning process still faces several challenges, such as limited technology infrastructure, a digital access gap

between schools, and the need to improve teachers' efficiency in the use of learning technologies. For this reason, education policy support, strengthening of facilities and infrastructure, and continuous teacher training are needed so that the implementation of this strategy can run optimally. Overall, the results of this study confirm that the integration of Deep Learning and interactive media is an effective pedagogical innovation to improve students' numeracy literacy skills while strengthening the quality of mathematics learning in the digital era.

CONCLUSION AND SUGGESTIONS

The research conducted at SMA Negeri 12 Bandar Lampung demonstrated that the implementation of Deep Learning-based instruction integrated with interactive media has a significant and positive impact on students' numeracy literacy as well as their overall mathematical performance. This was evidenced by an increase in the average pre-test score from 61.40 to 74.06 ($p = 0.000 < 0.05$), indicating meaningful learning gains and measurable improvements in conceptual understanding. The Deep Learning approach encourages students to actively construct knowledge rather than passively receive information, which strengthens their metacognitive skills and fosters a deeper understanding of mathematical principles. Through activities that emphasize analysis, synthesis, evaluation, and reflection, students are guided to connect procedural fluency with conceptual comprehension, internalizing the logic and relationships within mathematical concepts such as exponents and roots. In addition, the integration of interactive media, including dynamic visualizations, simulations, conceptual animations, and real-time feedback, enhances student engagement, motivation, and concentration, while reducing cognitive overload. Consequently, students develop clearer understanding of abstract concepts, higher-order problem-solving abilities, and more positive attitudes toward mathematics, contributing to meaningful and lasting learning outcomes. These findings suggest that combining cognitive-focused strategies with multimedia resources can create a more effective and stimulating learning environment. Furthermore, the results highlight the potential of technology-enhanced instruction to bridge gaps in students' understanding and to support differentiated learning needs.

The integration of Deep Learning and interactive media also creates an adaptive, contextual, and student-centered learning environment that aligns with the principles of twenty-first-century education. This combination not only improves academic achievement but also nurtures essential higher-order cognitive competencies such as critical thinking, creativity, collaboration, and communication. To ensure the effectiveness and sustainability of this pedagogical approach, institutional support is crucial, including adequate technological infrastructure, stable internet access, and continuous professional development for teachers to enhance their digital pedagogical competence. Collaboration among educators, curriculum developers, and policymakers is likewise necessary to design and implement technology-integrated learning frameworks that promote active learning and digital literacy. Future research should involve larger and more heterogeneous samples and explore additional variables, such as learning motivation, students' perceptions of technology, digital readiness, and mathematical self-efficacy. A comprehensive investigation of these factors will provide a deeper, evidence-based understanding of how Deep Learning and interactive media jointly enhance numeracy literacy, foster cognitive development, and contribute to the continuous improvement of mathematics education in the digital era. Moreover, the findings underline the importance of integrating innovative instructional strategies into regular curricula to ensure long-term benefits. In conclusion, the study emphasizes that the synergy between technology and pedagogy is essential for preparing students to meet the complex challenges of modern education.

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