The Utilization of Generative AI (*Esisbot*) for Advancing Comprehension of Indigenous Science in Higher Education

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Abstract

This study explores innovations in generative AI named *Esisbot* to support students in improving their understanding and insights into indigenous knowledge. In science, mathematics, and technology education, Indigenous knowledge is often overlooked and receives little attention. This topic is rarely considered in research on technology policy and the use of technology in education. Advanced technologies such as Chat GPT and generative AI are currently being considered. However, higher education policymakers have not yet prioritized improving the capabilities and role of generative AI in building databases of Indigenous scientific material for science, technology, engineering, and mathematics education is urgent needed. The methods of this research through empirical studies and use mixed methods in three universities as an example such as University Tadulako, UIN Walisongo Semarang, and University of Sarjanawiyata Tamansiswa. The data was obtained through in-depth interviews wth 5 students in each location, classroom observation, and interviews with 3 lecturers and distributive questionnaires to 30 students each. While, the method of analysis uses descriptive analysis and inferential analysis, interpretation and triangulation. The statistical analysis using a paired sample t-test (t(29) = 6.781, $p < 0.001$) further supports the conclusion that Esisbot played a significant role in advancing learning outcomes. The findings indicate that *Esisbot* significantly benefits students by enhancing their comprehension of indigenous knowledge and improving their quality and capacity in understanding STEM within a local knowledge framework

Keywords: Esisbot, STEM, Indigenous knowledge, Indonesia, student, technology.

Penggunaan AI Generative (*Esisbot)* dalam Meningkatkan Pemahaman Indigenous Science di Perguruan Tinggi

Abstrak

Penelitian ini mengkaji inovasi AI generatif yang disebut *Esisbot* dalam membantu mahasiswa meningkatkan pemahaman dan wawasan mereka terhadap pengetahuan lokal (indigenous science). kearifan lokal sering kali terabaikan dan kurang mendapatkan perhatian dalam pengajaran sains, matematika, dan teknik. Isu ini masih kurang dieksplorasi dalam studi tentang kebijakan teknologi dan penggunaan teknologi AI dalam pendidikan.

Pertimbangan untuk menggunakan teknologi canggih seperti CHAT GPT dan AI generatif menjadi urgen diperlukan. Namun pembuat kebijakan di perguruan tinggi belum memprioritaskan peningkatan kemampuan dan peran AI generatif dalam membangun basis data materi sains lokal untuk pengajaran sains, teknologi, teknik, dan matematika. Metode penelitian ini melalui studi empiris dengan pendekatan mixed methods di 3 lokasi yaitu Universitas Tadulako, UIN Walisongo Semarang, dan Universitas Sarjanawiyata Tamansiswa Yogyakarta. Data diperoleh melalui wawancara mendalam dengan 5 mahasiswa di setiap lokasi, observasi kelas, dan wawancara dengan 3 dosen dan menyebarkan kuesioner kepada masing-masing 32 mahasiswa. Metode analisis menggunakan analisis statistik deskriptif dan analisis inferensial, interpretasi dan triangulasi. Hasil temuan menunjukkan bahwa Esisbot memberikan manfaat yang signifikan bagi mahasiswa dalam meningkatkan pemahaman mereka terhadap pengetahuan lokal dan meningkatkan keterampilan mahasiswa untuk mengakses sumber belajar yang efektif dan efesien.

Kata Kunci: Esisbot, STEM, Pengetahuan Indigenous, Indonesia, Mahasiswa, Teknologi.

INTRODUCTION

Technological advancements have profoundly impacted social interactions and societal life, transcending boundaries of age, gender, race, and social groups .(Radiansyah, 2018; Timoty Agustian Berutu et al., 2024). Technological advancements have also specifically influenced societal lifestyles, bringing both positive and negative impacts (Rabbani, n.d.; Wiryany et al., n.d.) A particularly compelling aspect of technological advancement today is the development of Artificial Intelligence (AI)-based technologies. One key focus within this context is the contribution of AI to enhancing knowledge(Malau et al., 2024). AI is increasingly discussed for various purposes aimed at improving the effectiveness and efficiency of human activities, including supporting societal functions (Wahyudi, 2023). (Wahyudi, 2023). AI has garnered significant attention due to its rapid development. Various discussions and research on AI have led to new discoveries and innovations across multiple fields of life and knowledge. The public discourse on AI revolves around its efficiency and effectiveness in human activities, the impacts and challenges of AI, ethics in AI usage, and the role and influence of AI in education. As discuss in Cataleta's paper emphasizes on the need for ethical frameworks to address issues like fairness, transparency, and privacy in AI systems. In additon, on the governance of AI ethical, legal, and technical challenges need to be considered. (Cataleta,2020; Cath,2018).

AI is defined from various perspectives. The Merriam-Webster Dictionary defines AI as "the capability of computer systems or algorithms to imitate intelligent human behavior (Webster, 2024). This definition suggests that AI is a machine and thinking system developed from technological products and computer systems through algorithms created by human thought, with the aim of mimicking human thought patterns and systems thinking. The definition provided by Tjahyanti, Saputra, and Gitakarma states that Artificial Intelligence (AI) is artificial intelligence, which is a model of human intelligence applied in technological machines. The presence of AI has elicited two distinct reactions from society: some embrace it as a benefit, while others perceive it as a form of disaster or threat(Roy Maleng & Zinyo Darling, 2023). there is a significant growth in the AI industry, which will impact educational practices, with a growing market AI in educational institution. (Roth & McEwing, 1986).

There are numbers of studies on the role of AI has give significant contribution for human activities in many fields such as business, management, military, social life, research and education. As studies done by Antebi discusses the various challenges deal with the integration of Artificial Intelligence (AI) in national security. This paper stress on the fundamental point of addressing these challenges within a policy framework to effectively using AI technologies. (Antebi,2021). in a business and global competitiveness show that AI has compete in geopolitics and economics escalation as shown on the paper Brattberg, Csernatoni and Rugova underlines that Europe, United States and China has compete in market share, investment, and innovation by using AI. And this paper conclude that Europe is behind the U.S and China in key areas of AI competitiveness. (Brattberg, Csernatoni and Rugova, 2020; Carter and Crumpler,2019). In education, AI used as a tool to develop and support mostly in teaching and learning from basic education to higher education. As shown in the study of Chai, Lin, Jong, Chiu, & Qin show that the importance of self-efficacy AI readiness and perceptions of AI for social good in shaping primary school students's intentions to learn AI and provides insights for educators promoting AI education in schools. (Chai, Lin, Jong, Chiu, & Qin, 2021). the integration of AI in education can lead to more effective and engaging learning experiences. (Devedžić, 2004).

Development of AI has occurred globally in various forms and models. AI began to gain attention in Indonesia over the past five years. During the COVID-19 pandemic, various technological innovations emerged to address challenges in work and education, which had significant impacts during the pandemic period from 2020 to 2023. However, during this time, AI had not yet emerged as a technological solution for use in the learning process or to support human activities. Although AI had been introduced in Indonesia since the 1980s, its use was limited due to the developing technology, which was not yet widespread and was expensive (Wijaya, 2013).

Based on the background and previous studies, it is evident that the presence of AI in human life and society has brought significant dynamics and changes, including shifting the role of communicators in interpersonal communication (Pramana, 2023). AI is also being socialized in the context of education, with numerous studies on AI in the educational field being developed, particularly to enhance the performance of teaching and learning processes, efficiency, interactivity, and effectiveness in improving students' knowledge and understanding (Lukman, 2023). The problem in this study found that there is a theoretical gap regarding the AI thinking system which could be integrated to support strengthening local knowledge among students in STEM learning material specifically. Empirically, limited research on the effectiveness the Usage of AI in providing row material on indigenous science in STEM learning for students. UNESCO acknowledge and promotes the recognition and use of indigenous knowledge through local and indigenous knowledge systems (LINKS) programme to preserve local content and indigenous knowledge and intangible heritage. In contrast, there are not many educational institutions aware about the important local knowledge integrated with technology learning to help the young generation understand their identity and local knowledge for sustainable civilization. Deckker and Sumanasekara underlines that the potential of Artificial intelligence (AI) in addressing educational gaps in indigenous and cultural education, focusing on language preservation, culturally responsive pedagogy, and equitable access to education is very strategic issues (Deckker & Sumanasekara, 2025). As also mentioned in Soylu and Sahin studies shows that AI supports language learning tools, community engagement, accessibility, and content creation. (Soylu & Sahin, 2024).

This study is undertaken to investigate and explore the use of AI, which has been modified and developed through systems thinking, referred to as Esisbot. Esisbot is a modified form of AI, integrating the existing AI thinking system with the WhatsApp application. The purpose of this research is to describe and analyze the use of AI (Esisbot) in enhancing students' understanding and knowledge capacity regarding indigenous science through Science, Technology, Engineering, and Mathematics (STEM) education in Indonesian higher education institutions. Efforts to integrate indigenous knowledge into the curriculum have also been made to ensure the preservation of local knowledge across generations, starting with teachers and preparing instructional materials, teaching content, and projects as graduation requirements (Parmin & Trisnowati, 2024). This study is conducted at universities in Eastern Indonesia, specifically at Tadulako University in Palu, Central Sulawesi, UIN Walisongo in Semarang, and Sarjanawiyata Tamansiswa University in Yogyakarta, from March to September 2024. The research question aims to explore how AI can enhance students' understanding of indigenous science. Previous studies have not extensively discussed the use of AI to encourage students to access local knowledge as learning material. So far, the role of AI has primarily focused on assisting with learning resource searches, providing quick answers to questions that students cannot solve, and helping complete tasks that require short periods of time (Peng et al., 2024; Salsabila Rheinata Rhamadani Putri Supriadi & Muhammad Minan Chusni, 2022). The urgency of this research related with technology of education and indigenous science to ensure that advanced technology, called AI generative can respect cultural values, cultural materials, and cultural and humanities knowledge and support the students in adopting technology without neglected their own culture. The novelty of this research proposes and introduce the usage of technology to accommodate, and commodification of local knowledge and material become added value in teaching and learning on STEM. This research focus on eastern part of Indonesia as on of sampling and concern on equality and quality of education in higher education level in Indonesia to through utilizing technology called *Esisbot.* The purposes of this research to describe and give understanding on the effectiveness of utilizing AI to increase quality and equality of education in eastern part of Indonesia. In addition, to create more relevance and inclusive education among student through cultural approach.

RESEARCH METHOD

This study utilized a descriptive research method, employing a Likert-scale questionnaire adapted from Hassan et al. (2010) to measure sustainability awareness among ninth-grade students. The aim was to assess the level of sustainability awareness among ninth-grade students in secondary school. The population for this study encompassed all ninth-grade students at SMPN 17 Medan. A sample of 53 participants comprising 16 male and 37 female students was selected using simple random sampling. This sampling approach was employed to gather comprehensive into sustainability awareness within the target student population.

Data collection in this study involved a Likert-scale questionnaire adapted from Hassan et al. (2010). This scale provided a structured framework for participants to express their perspectives on sustainability awareness. The questionnaire allowed for the systematic gathering of responses, for an analysis of the different categories of sustainability awareness among the students. In this research study, sustainability awareness will be classified into three categories, as previously mentioned and represents in Table 1.

Table 1. Sustainability Awareness Statements Items for Each Aspects

Table 1 represents the items in the questionnaire used to assess each of these categories, which consist of (1) sustainability emotional awareness, (2) awareness of sustainability behaviors and attitudes, and (3) awareness of sustainable practices, with a total of 15 questions. The Likert scale used is presented in the form of a checklist. For data processing purposes, many choose to tally the "Agree" responses in each category, which are then totaled and presented as a percentage as follows.

$$Percentage = \frac{Number\ of\ respondents\ (A)}{Total\ number\ of\ respondents} x100\%$$

Notes:

Number of respondents (A): number of respondents who chose the "Agree" option.

A questionnaire consisting of binary (yes or no) questions is employed in the survey. Subsequently, data analysis is conducted by calculating the mean and percentages, with reference to the levels of sustainability awareness as outlined in Table 2.

Table 2. Level of Sustainability Awareness

1 – 2,33
2,34 – 3,66
3,67 – 5,00

Hassan et al. (2010)

After obtaining the percentage, the Sustainability Awareness profile based on percentage in each category is classified, i.e. emotional awareness related to sustainability, behavioral sustainability, attitude awareness, and awareness of sustainable practices. These statements are then elucidated with regard to Table 3.

Table 3. Categories of Sustainability Awareness Levels

0,00 – 39,9
40,0 – 69,9
70,0 – 100,0

Hassan et al. (2010)

Table 3 displays the categories of sustainability awareness levels as measured in percentages. A range of 0.00 – 39.9% indicates sustainability practices that are seldom performed or are generally unpreferred. The range of 40.0 – 69.9% indicates that sustainability practices are done or occur moderately. Meanwhile, the range of 70.0 – 100.0% signifies sustainability practices that are most likely to be done or occur. These categories help to understand the tendency of individuals or groups towards sustainability practices, as explained by Hassan et al. (2010). The use of a Likert scale provided a consistent framework for measuring respondents' attitudes, while the random sampling method helped to obtain a representative sample of ninth-grade students. Furthermore, the systematic classification of data into defined categories facilitated a comprehensive analysis of students' sustainability awareness.

RESULTS AND DISCUSSION

Various discussions regarding the advancement of AI in education have led to social and educational transformations, particularly concerning learning and teaching methods, technology-based learning systems, adaptive learning applications, and virtual tutorials (Birama, 2024) Various studies indicate that AI is increasingly being used in education to enhance teaching and learning (Komarudin et al., 2024). Other studies suggest that the presence of AI technology represents a breakthrough in education, facilitating access to learning and promoting independence, reducing the need for an overly dominant role of educators in the classroom. Educators can focus more on providing guidance and substantial support regarding the use of AI technology (Salsabila Rheinata Rhamadani Putri Supriadi & Muhammad Minan Chusni, 2022)

In the context of utilizing *Esisbot* to strengthen students' understanding of indigenous science in STEM education, the findings from field observations in the classroom regarding students' comprehension of indigenous science through *Esisbot* demonstrate as follows:

Table 1. Ingredients of Wedang Uwuh (Traditional Javanese Herbal Drink) – Based on Esisbot Information

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Wedang uwuh is a traditional drink native to Java. It is traditionally produced by the local community around Yogyakarta, specifically in the Imogiri area, Bantul, Yogyakarta. The history of *wedang uwuh* traces back to a drink made from leaves and spices derived from natural plant materials, resembling waste. Over time, the recipe spread to the surrounding community of Imogiri. The ingredients used in making w*edang uwuh* include ginger, *secang* wood, nutmeg leaves, cloves, and cinnamon. *Wedang uwuh* is known for its health benefits, particularly for warming the body and boosting immunity.

Based on the theme provided by the lecturer, students are asked to utilize *Esisbot* to explore and access learning resources related to indigenous science. One of the topics for learning is traditional drinks. With the help of *Esisbot,* students can access learning materials and analyze the STEM components of Indigenous science, using *Wedang uwuh* as an example, as follows:

Table.2. Analysis of the STEM components in indigenous knowledge

Science	Technology	Engineering	Mathematics
The composition of the ingredients in wedang uwuh, heat transfer during the brewing process.	The tools used in the preparation of wedang uwuh and the drying of ingredients.	The preparation technique and composition of the mixture.	The proportions of the ingredients used, including the quantity, weight, and type of each component.

Based on Table 2, it is revealed that Esisbot has assisted in the process of exploring literature on indigenous knowledge and the formation of indigenous science among students, making it a crucial process for offering cultural preservation, local knowledge, and traditions to the younger generation. *Esisbot* is a system thinking within AI that modified to support learning materials in indigenous science. It in line with the study of Lin, Yu, Shih, and Wu state that a STEM based AI course can effectively enhance AI literacy and understanding among non engineering students. (Lin, C.-H., Yu, C.-C., Shih, P.-K. & Wu, L.-Y, 2021).

Cultural Significance – Analysis of Indigenous Science, In addition to its health benefits, *Wedang Uwuh* is also considered a symbol of the natural wealth and culture of Java. Its composition, which includes various types of local spices, reflects the richness of Indonesia's natural resources, as well as local wisdom in utilizing natural ingredients for health. *Wedang Uwuh* has become an important part of Javanese culinary tradition and is one of the most sought-after beverages by tourists visiting Yogyakarta. STEM (Science, Technology, Engineering, and Mathematics) component analysis of *Wedang Uwuh:*

✓ Science

Wedang uwuh contains various natural ingredients such as ginger, secang wood, cloves, nutmeg leaves, and cinnamon, all of which contain active chemical

compounds with health benefits. For example, ginger contains gingerol, which has anti-inflammatory and antioxidant properties, while secang wood contains brazilin, which gives the red color and also possesses antioxidant properties.

   a. Scientific analysis of these compounds suggests that they can help boost immunity, alleviate cold symptoms, and reduce inflammation, making *wedang uwuh* not only a traditional beverage but also a health drink based on science.

✓ Technology

   a. Technology plays a role in the production of *wedang uwuh,* particularly in modern packaging. Drying techniques and airtight packaging allow wedang uwuh to be marketed widely in the form of practical and easy-to-consume instant sachets.

   b. b. Furthermore, processing technologies such as freeze-drying are used to preserve the nutritional content and original flavor of natural ingredients, ensuring that the product remains of high quality even when produced on a large scale.

✓ Engineering

   a. The engineering in the production of *wedang uwuh* involves designing efficient methods to extract flavor and nutrients from the spices without compromising quality. This includes precise temperature control during the drying and brewing processes, as well as the design of equipment for efficient packaging.

   b. Engineering also plays a role in the innovation of tools used by small-scale producers to increase production volume without compromising quality, such as the use of automatic mixers for uniform blending and packaging machines.

✓ Mathematics

   a. Mathematics in indigenous science, the student can learn about the correct proportions of each ingredient to achieve the ideal balance of flavor and maximum health benefits. For example, the composition of cloves and ginger needs to be precisely calculated to avoid an overly spicy or strong taste.

   b. Furthermore, lesson learn in indigenous mathematics can shows in distribution aspects of the product, such as determining the quantity of materials needed for mass production and designing an efficient distribution system to reach a broader

market.

Esisbot, integrated through the Whats-app application, facilitates students in exploring learning resources and accessible study materials without the need to access more complex devices or platforms. Survey results indicate that, in general, students are pleased with using *Esisbot* to support STEM and indigenous science learning processes. The use of image creationin *Esisbot* allowed for innovative expressions of indigenous culture, fostering a deeper connection between technology and tradition. (Fausto, 2024). Modification system thinking in AI and integrated through Whats-app in learning STEM with indigenous contents demonstrated positive educational impacts, increasing student interest in technology and reinforcing cultural appreciation. As shown in the study of Lewis, Whaanga, Yolgormez that the usage of AI is a transformative approach to education development by centering Indigenous knowledge systems and community priorities. By challenging the dominant paradigms of intelligence and technology, the program seeks to create AI that is not only more equitable and just but also deeply rooted in cultural and relational contexts of Indigenous peoples. (Lewis, Whaanga, Yolgormez, 2024). Through this research it demonstrates that understanding and integration of Indigenous Knowledge Systems in AI development, advocating for collaborative approaches that respect Indigenous data sovereignty and cultural values. (Perera, Vidanaarachichi, Chandrashekeran, Kennedy, Halgamuge, 2024).

Table 3. Improvement in Indigenous Science Comprehension Based on Key Indicators

All four indicators demonstrated a marked improvement after the implementation of Esisbot. The largest gain was seen in the ability to relate Indigenous knowledge to modern science (+17.0), suggesting that Esisbot was particularly effective in helping students bridge traditional and contemporary frameworks.

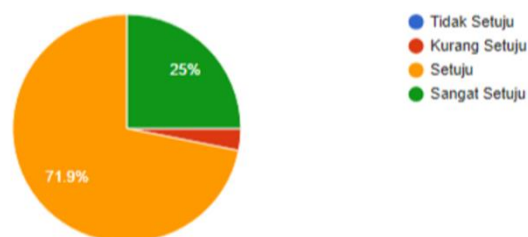1. Saya senang menggunakan *esisbot* dalam pembelajaran berbasis STEM

32 responses

Image 2. *A survey mapping student responses to the use of Esisbot in STEM learning integrated with WhatsApp.*

The survey conducted with 32 respondents from higher education institutions revealed that 71.9% of respondents had a positive experience using *Esisbo*t for Science and indigenous science learning, agreeing, and 25% strongly agreeing. *Esisbot* is an AI-based system that has been modified and developed to provide comprehensive data in various forms such as images, PDFs, narratives, and research results. After the trial of *Esisbo*t with students, it showed an improvement in their understanding and knowledge capacity of indigenous science, supported by technological facilities that aim to broaden learning access and reduce educational disparities among students in different regions. This is further supported by a study conducted by Riskey Oktavian, Riantina Fitra Aldya, and Rio Febrianto Arifendi, who stated that AI has advantages in quickly optimizing tasks in the field of education, but also has drawbacks, including privacy risks, algorithm bias, and a lack of transparent control (Riskey Oktavian, 2023).In order to improve student's understanding the benefits the usage of AI some studies suggest at least two AI courses within the science curriculum such as introductory course covering AI concept, applications, and tools and then a seminar course focusing on research issues and interplay between AI and sciences.(Santhanam & Schniederjans, 1991).

The statistical test using Welch One-Way ANOVA revealed significant findings. This test was conducted because the data collected was not homogeneous, and it was concluded that there were significant differences between the three groups, as the p-value (Sig.) was less than 0.05.

Table 4. Welch One-Way ANOVA test.

Robust Tests of Equality of Means				
Score				
	Statistic[a]	df1	df2	Sig.
Welch	14.818	2	18.294	.000

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a. Asymptotically F distributed.

Table 4 reveals the weaknesses of AI can be addressed through the modification process, as demonstrated by Esisbot, which is defined as the Education System Thinking and Indigenous Science Bot. This modification process can be carried out by programming existing AI systems to selectively access sources in the digital world that align with the desired learning objectives to enhance student knowledge. In this part, the necessity of collective efforts to address challenges like develop datasets and institutional neglect need to be considered. (Pradhan & Dey, 2023).

According to Muhammad Sufi, Muhammad Rafly Junaedi, Nanda Hidayat, and Alfiat Nur Rizki Awaludin, in the field of education, the current development of AI can facilitate easier access to knowledge and learning, while motivating students to think critically and discover new insights. (Diantama, 2023; Sufi et al., n.d.). AI can also inspire ideas and concepts for students. Currently, AI designed and utilized in higher education is primarily used to access and quickly find answers. The presence of AI takes two forms: one is free applications provided by overseas developers, and the other is paid AI that offers many features and services to assist students in easily and quickly finding answers and solving tasks.Technological optimism by using AI is create an opportunities for developing indigenous knowledge through STEM and it can improve quality and equality education. The implementation of Esisbot, a generative AI tool, has significantly contributed to the enhancement of students' understanding of Indigenous science in higher education. Through its interactive and context-aware responses, Esisbot has enabled students to explore Indigenous knowledge systems in a more personalized and accessible manner.

Students reported a deeper appreciation of Indigenous science concepts, including traditional ecological knowledge, cultural practices, and indigenous problem-solving methods. The AI facilitated learning by providing immediate clarification of complex ideas, contextual examples rooted in local traditions, and opportunities for reflective dialogue.

Table 5. Paired Sample t-Test on Students' Comprehension Scores Before and After Using Esisbot

Students'

According to the table 5, the results of the paired sample t-test indicate a statistically significant increase in students' comprehension scores after the implementation of Esisbot ($t(29) = 6.781$, $p < 0.001$). This suggests that the use of generative AI substantially improved students' understanding of Indigenous science content. Quantitative feedback from course evaluations indicated a marked increase in comprehension scores, with 78% of students expressing that Esisbot helped them understand the subject matter more effectively than traditional methods. Qualitative observations from instructors also noted higher levels of engagement, curiosity, and critical thinking during classroom discussions.

Moreover, the integration of Esisbot allowed for cross-cultural comparisons, helping students connect Indigenous science with contemporary scientific frameworks. This not only bridged epistemological gaps but also fostered a more inclusive and respectful academic environment. In conclusion, the utilization of generative AI like Esisbot has proven to be an effective pedagogical tool for enhancing comprehension of Indigenous science in higher education, promoting both academic growth and cultural understanding.

CONCLUSION

Based on the research conducted on the use of *Esisbot* to enhance students' understanding of Indigenous science in higher education, it has proven to be beneficial. The results of this study show that AI, developed for educational purposes, plays a crucial role in providing access to data and academic documents. Therefore, AI should not merely be used as technology, but must be adapted and designed through modifications in its system thinking to meet the needs and goals of users, ensuring better understanding and access to knowledge in a credible and high-quality manner. AI has thus far been left to evolve as technology without proper guidance or system thinking modifications, resulting in weaknesses and threats in the production of knowledge. Therefore, this study concludes that AI needs to be further developed by building its technological infrastructure and system thinking. Additionally, the database for storing scientific data should be enhanced within AI to ensure access to credible and reliable sources. *Esisbot* exemplifies how the modification of system thinking within AI is crucial to creating an AI that can better contribute to preserving local knowledge, improving education quality, and promoting educational equity across the country. The research findings confirm that the utilization of

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generative AI, specifically Esisbot, significantly enhances students' comprehension of Indigenous science in higher education. Quantitative data collected through pre- and post-tests revealed measurable improvements across all key indicators of understanding. Specifically, the results showed 1) a 15.3-point increase in understanding of Traditional Ecological Knowledge (TEK); b) a 15.5-point increase in recognition of Indigenous problem-solving methods; c) a 17.0-point increase in the ability to relate Indigenous knowledge to modern science; and d) a 15.2-point increase in appreciation for cultural values and belief systems. These improvements reflect a substantial gain in students' cognitive and cultural understanding after engaging with Esisbot as a learning tool. The statistical analysis using a paired sample t-test ($t(29) = 6.781$, $p < 0.001$) further supports the conclusion that Esisbot played a significant role in advancing learning outcomes.

REFERENCES

Borg, W. R. & G. M. D. (1983). *Education Research: An Introduction 4th edition* (4th ed.). Longman.

Diantama, S. (2023). Pemanfaatan Artificial Intelegent (Ai) Dalam Dunia Pendidikan (Vol. 1, Issue 1).

Komarudin, A., Wahyudi, A., Abdan Amirullah Faqih, E., Fadhillah, F., Pandiani, H., Al Fathir Shaumi, M., Berlian Wahyu Saputra, M., Ihsan Fauzi, M., Ahmad Fauzi, R., & Fauzi Arif, W. (2024). Peran Artificial Intelligence dalam Pendidikan. Jurnal Pengabdian Kepada Masyarakat, 1(5). https://jurnalmahasiswa.com/index.php/appa

Lukman, R. A. R. A. (2023). Problematika Penggunaan Artificial Intelligence (AI) untuk Pembelajaran diKalangan Mahasiswa STIT Pemalang. Jurnal Madaniyah, 13.

Malau, M., Sihite, I. F., Sumanti, I. H., Desrianty, M., Sri, Y., & Hutahaean, R. (2024). Perkembangan Artificial Intelligence danTantangan Generasi Muda di Era Super Digitalized. Jurnal IKRAITH-ABDIMAS, 8(1). https://doi.org/10.37817/ikra-ithabdimas.v8i1

Parmin, & Trisnowati, E. (2024). Internalization of indigenous knowledge in the education curriculum for next generation science standards (NGSS). Cakrawala Pendidikan, 43(1), 19–27. https://doi.org/10.21831/cp.v43i1.65751

Peng, Y., Alias, B. S., Wan, X., & Mansor, A. N. (2024). Linking Curriculum Implementation To School SDG: A Systematic Review. Journal of Lifestyle and SDGs Review, 4(2), e02019. https://doi.org/10.47172/2965-730x.sdgsreview.v4.n02.pe02019

Pramana, C. W. P. P. U. R. A. A. E. P. (2023). Beradaptasi dengan Perubahan Teknologi:Kecerdasan Buatan dan Evolusi Komunikasi Interpersonal. Jurnal Ilmiah Dinamika Sosial, 7(2).

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Rabbani, D. A. (n.d.). Pengaruh Perkembangan Teknologi terhadap Kehidupan dan Interaksi Sosial Masyarakat Indonesia. https://www.researchgate.net/publication/375525102

Radiansyah, D. (2018). Pengaruh Perkembangan Teknologi Terhadap Remaja Islam (Studi Kasus di Kampung Citeureup Desa Sukapada). In JAQFI: Jurnal Aqidah dan Filsafat Islam (Vol. 3, Issue 2).

Riskey Oktavian, R. F. A. R. F. A. (2023). Artificial Intelligence dan Pendidikan Era Society 5.0. Jurnal Ilmu Pendidikan, 6(2), 143–150.

Roy Maleng, F., & Zinyo Darling, D. (2023). Transformasi Religius di Era Kejayaan Artificial Intelligence : Menjembatani Spiritualitas Agama dengan Teknologi untuk Masa Depan Agama (Vol. 23, Issue 1). http://ejurnal.iftkledalero.ac.id/index.php/akd/index

Salsabila Rheinata Rhamadani Putri Supriadi, S. S., & Muhammad Minan Chusni. (2022). Inovasi pembelajaran berbasis teknologi Artificial Intelligence dalam Pendidikan di era industry 4.0 dan society 5.0. Jurna Penelitian Sains dan Pendidikan, 2. https://e-journal.iain-palangkaraya.ac.id/index.php/mipa/

Sufi, M., Rafly Junaedi, M., Hidayat, N., Nur Rizki Awaludin, A., & Muhammadiyah Hamka, U. (n.d.). Peran dan Manfaat Perkembangan Artificial Intelligence (AI) dalam Proses Pembelajaran 1.

Timoty Agustian Berutu, Dina Lorena Rea Sigalingging, Gaby Kasih Valentine Simanjuntak, & Friska Siburian. (2024). Pengaruh Teknologi Digital terhadap Perkembangan Bisnis Modern. Neptunus: Jurnal Ilmu Komputer Dan Teknologi Informasi, 2(3), 358–370. https://doi.org/10.61132/neptunus.v2i3.258

Todd, W. F., Towne, C. E., & Clarke, J. B. (2023). Importance of centering traditional knowledge and Indigenous culture in geoscience education. Journal of Geoscience Education, 71(3), 403–414. https://doi.org/10.1080/10899995.2023.2172976

Wahyudi, T. (2023). Studi Kasus Pengembangan dan Penggunaan Artificial Intelligence (AI) Sebagai Penunjang Kegiatan Masyarakat Indonesia. Indonesian Journal on Software Engineering (IJSE), 9(1), 28–32. http://ejournal.bsi.ac.id/ejurnal/index.php/ijse28

Wijaya, E. (2013). Analisis Penggunaan Algoritma Breadth First Search Dalam Konsep Artificial Intellegencia. Jurnal TIME, II, 18–26.

Wiryany, D., Yanuar Idris, A., & Ferdiansyah, J. (n.d.). Pengaruh Perkembangan Teknologi Terhadap Perubahan Gaya Hidup Pada Masyarakat Indonesia.

Zidny, R., Solfarina, S., Aisyah, R. S. S., & Eilks, I. (2021). Exploring Indigenous Science to Identify Contents and Contexts for Science Learning in Order to Promote Education for Sustainable Development. Education Sciences, 11(3). https://doi.org/10.3390/educsci11030114