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Exploring The Impact of Deep Learning Approaches on Geography Education: Student Perceptions and Educational Implications

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Abstract: This study addresses the gap in understanding the effectiveness of deep learning approaches in geography education, particularly in higher education contexts where such methods are not yet fully integrated. The aim of this study was to explore students' perceptions of deep learning in geography courses, focusing on its impact on their understanding of the subject, critical thinking, student engagement, and the role of technology. A quantitative descriptive research design was employed, utilizing a structured questionnaire administered to 100 geography students from a university in Indonesia. The questionnaire explored five key areas: understanding of deep learning, deep learning-based instructional processes, student engagement, the use of technology, and the development of higher-order thinking skills. The results showed that students perceived deep learning as effective in enhancing their understanding of geography, improving critical thinking skills, and increasing engagement in the learning process. Students also recognized the importance of integrating technology, such as digital tools and geospatial data, in fostering deeper learning experiences. However, while students expressed positive perceptions, the study highlighted the need for further professional development for educators in applying deep learning strategies effectively. In conclusion, deep learning has the potential to significantly enhance geography education by fostering deeper engagement, critical thinking, and the use of technology. It is recommended that higher education institutions invest in training faculty members to integrate deep learning methods into their teaching practices and that future research explore the long-term effects of deep learning on academic performance and real-world applications in geography.

Keywords: Deep learning; Educational implications; Geography education; Student perceptions

Introduction

In the rapidly evolving landscape of global education, the demand for transformative pedagogical approaches has intensified, particularly those that foster critical thinking, creativity, collaboration, and lifelong learning (Rahimi & Oh, 2024). Traditional didactic teaching methods, which emphasize passive reception of facts, are no longer sufficient to meet the complex needs of 21st-century learners (Aguilera & Perales-Palacios, 2020). These conventional approaches often fail to promote the deep conceptual understanding and transferable skills required in a knowledge-based society (Aparicio et al., 2023; Rahimi & Oh, 2024). Students are expected to not only recall information but also to analyze, synthesize, and apply it in diverse, often

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unfamiliar, contexts. As a result, educators are increasingly turning to student-centered and inquiry-based approaches (Bacak & Byker, 2021). One such promising approach is deep learning, which aligns closely with constructivist theories of learning and emphasizes active engagement, critical reflection, and real-world problem-solving (Dutta et al., 2024; Mathew et al., 2021; Vaghela & Parsana, 2024). Within this paradigm, learning is not merely the accumulation of knowledge, but a process of meaning-making that transforms both cognitive and emotional understanding (Ferreira, 2021).

Deep learning, as introduced by Marton and Säljö (1976), involves the active engagement of learners in connecting new information with prior knowledge, analyzing underlying principles, and applying knowledge in varied contexts (Ge et al., 2024; Hu et al., 2021; Orozco et al., 2023; Wang et al., 2020). It goes beyond surface learning, which is characterized by memorization without understanding, to foster meaningful comprehension and long-term retention (Murphy et al., 2023). Deep learning encourages students to think critically, evaluate evidence, challenge assumptions, and construct their own understanding of the subject matter (Vaiid et al., 2024). This pedagogical orientation is especially relevant in the teaching of geography, a subject that deals with complex, interconnected systems such as climate change, population dynamics, urbanization, and natural resource management (Koupatsiaris & Drinia, 2024). Geography inherently demands analytical and spatial thinking, which deep learning approaches can effectively nurture (Bendl et al., 2024; Chen et al., 2023; Deng et al., 2021; Johnson et al., 2020; Liu & Biljecki, 2022; Mubita et al., 2023; Singh & Nayyar, 2024). Moreover, deep learning empowers students to appreciate the relevance of geography to real-world challenges, thereby increasing motivation and engagement in the classroom.

The integration of technology into deep learning environments further amplifies its educational benefits (Alam & Mohanty, 2023; Singh & Nayyar, 2024). particularly in geography (Han et al., 2023; Raihan, 2023; Yeo et al., 2021). Modern digital tools such as Geographic Information Systems (GIS), remote sensing applications, interactive digital globes, and 3D virtual modelling enhance students' spatial awareness and enable them to explore geographical phenomena in immersive ways (Annoni et al., 2023; Bharambe et al., 2024; Pasquaré Mariotto et al., 2023). These tools also support the development of geospatial literacy, which is increasingly recognized as a vital 21st-century competency (Sulaiman et al., 2023). When used effectively, technology can transform geography education from passive textbook learning to an interactive, inquiry-driven experience that mirrors the investigative nature of geographical research (Sulaiman et al., 2023). For example, students can analyze real-time satellite imagery to study environmental change, or use spatial data to propose solutions to urban planning issues. Additionally, technology facilitates collaborative learning, allowing students to engage in virtual fieldwork, share data across regions, and work on global case studies, thus expanding the boundaries of the classroom.

In the context of Education for Sustainable Development (ESD), deep learning plays a critical role in equipping students with the competencies necessary for addressing global challenges (Sihombing et al., 2024; Yu et al., 2024). Corres (2020) emphasizes that education must go beyond knowledge transmission and enable learners to develop values, skills, and attitudes for sustainable living. Deep learning approaches foster these capabilities by encouraging learners to reflect on the implications of their actions, consider multiple perspectives, and envision alternative futures. Geography, as a subject deeply intertwined with issues of sustainability, serves as a natural platform for ESD. Through deep learning, students can investigate issues such as deforestation, migration, water scarcity, and climate resilience, not only at a theoretical level but also in terms of practical solutions. This alignment of deep learning with sustainability goals underscores its importance in shaping responsible and informed global citizens.

Despite the theoretical appeal and policy-level endorsements of deep learning, its implementation in classroom practice, especially in developing countries, remains inconsistent and under-researched. Many educators lack the training, resources, or institutional support necessary to shift from traditional methods to deep learning approaches. There is often a gap between curriculum intentions and actual pedagogical practices. Moreover, cultural, technological, and infrastructural constraints may hinder the adoption of student-centered learning models. Therefore, empirical research is needed to explore how geography educators perceive, apply, and evaluate deep learning strategies in their specific contexts. Such research can illuminate the enablers and barriers to effective implementation and provide a roadmap for professional development and curriculum innovation (Nolan & Guo, 2022).

This study aims to examine the understanding, application, and impact of deep learning in geography education from the perspective of educators. It explores multiple dimensions: educators' conceptual understanding of deep learning, the strategies they use to incorporate it into their teaching, its role in student motivation and engagement, the integration of technology, and its effects on students' higher-order thinking and environmental awareness. By analyzing survey responses and qualitative reflections, this study seeks to uncover patterns, challenges, and best practices in deep learning implementation. Ultimately, the findings are expected to inform policy, pedagogy, and teacher training programs, thereby enhancing the quality and relevance of geography education in the 21st century.

Method

This study employed a quantitative descriptive research design to explore geography lecturers' and students' perceptions of deep learning practices in higher education. The purpose of this method was to obtain a general overview of how deep learning is understood, implemented, and perceived in geography education. Quantitative descriptive research is suitable for measuring attitudes, behaviors, and experiences using numerical data and statistical interpretation (Chen & Cheng, 2021). This method allows researchers to systematically collect, analyze, and interpret data related to the various components of deep learning in geography instruction, such as understanding, instructional strategies, student involvement, technology use, higher-order thinking skills, and the perceived impact on learning outcomes.

Participants

The participants in this study were university students majoring in geography at a higher education institution in Indonesia. A total of 100 students participated, consisting of both male and female students from different semesters to ensure diverse representation. Participants were selected through purposive sampling, a method that allows researchers to choose respondents who have relevant knowledge and experience with the subject matter being investigated (Ali et al., 2024). The inclusion criteria required participants to have taken at least one course that used deep learning approaches in geography, ensuring they had sufficient experience to respond meaningfully to the survey.

Instrument

The primary instrument used for data collection was a structured questionnaire, which was developed based on key themes from the literature on deep learning in education. The questionnaire consisted of 30 items divided into six sub-sections: Understanding of Deep Learning; Deep Learning-Based Instructional Process; Student Engagement; Use of Technology Higher-Order Thinking Skills (HOTS); and Impact on Student Learning. Each item was rated using a 4-point Likert scale, where 1 = Strongly Disagree, 2 = Disagree, 3 = Agree, and 4 = Strongly Agree. The use of a 4-point Likert scale eliminates neutral answers and encourages participants to express a more definitive stance on each statement (Nguyen, 2024).

The questionnaire items were validated through expert judgment by three senior geography education lecturers with experience in deep learning pedagogies. Their feedback ensured that the items were relevant, clearly worded, and covered all aspects of the deep learning framework. The instrument was also pilot-tested with 15 students not included in the final sample, and minor adjustments were made to enhance clarity and reliability.

Data Collection

Data collection was conducted over a two-week period during the academic semester. The questionnaire was administered online via Google Forms to ensure ease of access and wide reach. Participation was voluntary, and students were informed that their responses would remain anonymous and be used strictly for research purposes. Ethical approval was obtained from the university's research ethics committee prior to data collection. All participants provided informed consent before beginning the questionnaire.

Data Analysis

The collected data were analyzed using descriptive statistics, including frequencies and percentages for each response category. This analysis helped identify trends in student responses related to their understanding and experience with deep learning in geography. Each of the six domains of the questionnaire was analyzed individually to gain insight into specific aspects of the learning process. The data were then summarized and visualized using tables and bar graphs for ease of interpretation. Additionally, the findings were interpreted in the context of existing literature to draw meaningful conclusions and identify areas for pedagogical improvement.

Result and Discussion

Understanding of Deep Learning in Geography Education

The data indicates that most respondents have a solid understanding of deep learning and acknowledge its importance in geography education. A significant majority (70–80%) agree that they comprehend the concept of deep learning and are capable of integrating its strategies into their teaching practices. Furthermore, 75% of participants believe that deep learning enables students to grasp geographical concepts more thoroughly. There is also a strong belief (60–65%) that deep learning is more effective than traditional teaching methods and is highly relevant to the demands of modern education. These results suggest that educators are not only familiar with deep learning but also view it as a meaningful and applicable approach to enhance student learning outcomes in geography.

Deep Learning-Based Learning Process

The results demonstrate a positive perception of the deep learning process in geography education. A majority of respondents (70%) agree that deep learning motivates students to explore geographical content in more depth. Over half (55–60%) report that this method encourages students to think critically and engage creatively in solving geographic problems. Additionally, 70% believe that deep learning effectively integrates technology into the learning process, while 60% confirm that it helps students understand cause-effect relationships in geographic phenomena. These findings reflect that educators see deep learning as a powerful instructional approach that deepens understanding, fosters inquiry, and promotes a more interactive and meaningful learning environment.

Student Engagement

In terms of student engagement, deep learning is seen as an effective approach to foster active learning. The data shows that 65–70% of educators observe that students are more actively involved and motivated to learn independently when deep learning strategies are applied. Moreover, 55–60% believe students can identify solutions to global environmental issues and apply geographical concepts to real-life situations. A significant 70% agree that deep learning encourages students to engage directly with complex geographical issues. Overall, this indicates that deep learning not only increases student participation but also supports the development of autonomy and real-world application of knowledge.

Utilization of Technology in Deep Learning

The utilization of technology in deep learning is highly supported by the respondents. A strong majority (65–75%) agree that the integration of digital tools and geospatial data enhances students’ understanding of geographical concepts. A notable 80% believe that incorporating digital applications or 3D modelling is essential for effective geography education. Additionally, 65% of respondents affirm that interactive digital maps are helpful in identifying both local and global geographic issues. These results highlight the crucial role of technology in implementing deep learning, providing students with practical and engaging tools to deepen their geographical knowledge.

Higher-Order Thinking Skills (HOTS)

The data reveals that educators perceive deep learning as instrumental in fostering higher-order thinking skills among students. A large portion (75%) agree that students are capable of constructing logical arguments related to geographical phenomena through deep learning approaches. Moreover, 65–70% observe improvements in students' ability to analyze, synthesize, and evaluate information, as well as in their understanding of human-environment interactions. The ability to identify the effects of global environmental changes is also noted by 75% of respondents. These findings suggest that deep learning significantly contributes to the development of students' critical and analytical thinking capabilities in geography.

Impact of Deep Learning on Students

The overall impact of deep learning on student development in geography is reported as highly positive. A majority of educators (70%) agree that deep learning enhances students’ research skills and supports their understanding of cross-disciplinary geographic concepts. The same percentage observe increased environmental literacy among students exposed to deep learning methods. Additionally, 65–70% of respondents note improvements in students’ critical thinking abilities and their capacity to connect local phenomena to global geographic trends. These results indicate that deep learning not only improves academic competencies but also prepares students to engage with real-world geographic issues more effectively.

Discussion

The findings of this study reveal a strong and consistent understanding of deep learning among geography educators, indicating a positive shift toward more student-centered and conceptually rich pedagogical approaches. A significant number of respondents acknowledged their ability to grasp and apply the core principles of deep learning in their teaching practices. This suggests that educators are not only familiar with the theoretical foundations of deep learning but also see its relevance and applicability in the context of geography education. Deep learning, as defined by Mayer (2024), involves the learner engaging meaningfully with content, seeking to understand and relate ideas. Rui (2024) further emphasized that deep learning encourages reflective thinking and the ability to transfer knowledge across contexts. This trend also reflects broader educational reforms that prioritize higher-order thinking skills, lifelong learning, and competency-based education (Quang et al., 2025).

In terms of instructional process, deep learning was perceived as an effective strategy to promote active exploration, critical thinking, and independent problem-solving in geography classrooms. Respondents reported that students were not only motivated to investigate topics more thoroughly but also encouraged to connect classroom content to real-world issues. This is particularly important in geography, where content is closely linked with spatial reasoning, global systems, and human-environment interactions. According to Marougkas (2023), deep learning environments support knowledge construction by encouraging learners to draw upon prior knowledge and engage with complex problems. In line with constructivist theories, the process of inquiry and discovery enables learners to build their own understanding and make meaning from geographical phenomena (Du et al., 2024). Furthermore, Tannous (2020) identified deep learning strategies, such as self-questioning and elaboration, as having a high effect size on student achievement.

Student engagement also emerged as a significant theme, with most educators observing higher levels of participation and independent learning among students engaged in deep learning-based instruction. When learners are actively involved and feel ownership of their learning process, their motivation and academic achievement tend to increase (Leggett & Harrington, 2021). The findings indicate that deep learning enables students to immerse themselves in complex geographical issues, develop their own inquiries, and pursue knowledge beyond textbook explanations. Furthermore, the ability of students to identify and propose solutions to local and global environmental issues demonstrates the empowering effect of deep learning on student agency and civic responsibility. These observations are consistent with the goals of geography education to develop informed, critical, and engaged citizens (Miao & Nduneseokwu, 2025). As Hayati et al. (2024) noted, meaningful learning occurs when students see relevance and purpose in what they are learning, especially when it relates to real-life problems.

The integration of technology into deep learning practices was highly regarded by respondents, who emphasized its role in enhancing students' understanding and analytical capabilities. The widespread use of geospatial data, interactive digital maps, and modelling tools like 3D simulations provides students with hands-on, immersive experiences that mirror real-world scenarios. Jiang (2022) TPACK framework supports this integration, stressing the importance of technological knowledge intertwined with pedagogical and content knowledge. Additionally, digital tools such as GIS (Geographic Information Systems) have been shown to improve spatial thinking and data literacy in geography education (Shakhislam et al., 2024). The use of such tools aligns with the digital literacy demands outlined in 21st-century education frameworks (Zhang & Wu, 2024), suggesting that technology not only supports deep learning but also prepares students for future academic and career pathways.

Regarding higher-order thinking skills (HOTS), the results show that deep learning significantly contributes to students' cognitive development, particularly in analysis, synthesis, and evaluation. Teachers observed that students were able to formulate logical arguments, understand complex interactions between human and environmental systems, and draw well-reasoned conclusions based on evidence. These skills align with the top tiers of Bloom's revised taxonomy—analyzing, evaluating, and creating—which are essential for meaningful learning (Killian, 2024). Geography education, by its nature, lends itself to developing HOTS through tasks such as evaluating environmental policies, analyzing spatial data, and predicting future scenarios (Martindale et al., 2023). Moreover, Faravani & Zohoorian (2022) argue that developing higher-order thinking requires instructional strategies that promote questioning, problem-solving, and decision-making—all of which are embedded in deep learning pedagogies.

Finally, the impact of deep learning on students' broader academic growth and environmental literacy was evident throughout the findings. Teachers reported that students showed improved research skills, interdisciplinary thinking, and the ability to relate local phenomena to global trends—key indicators of a comprehensive geography education. According to Lam (2020), sustainability education requires learners to connect different knowledge systems, engage in systems thinking, and understand the interconnectedness of local and global processes. The emphasis on real-world relevance and problem-solving allows students to apply theoretical knowledge to practical contexts. Furthermore, increased environmental awareness and the ability to formulate solutions to geographic conflicts suggest that deep learning can cultivate responsible global citizens, a goal outlined in Education for Sustainable Development (ESD) initiatives (Yu et al., 2024). In this way, deep learning not only supports curriculum objectives but also contributes to transformative learning outcomes.

In conclusion, the study underscores the transformative potential of deep learning in geography education. It reveals that educators are not only prepared to implement this approach but are also witnessing its positive effects on student engagement, critical thinking, and technological competence. These findings suggest the need for continued investment in teacher training, curriculum design, and educational technologies to support and sustain deep learning practices. Future research could explore longitudinal effects of deep learning, identify challenges in implementation, and examine the perspectives of students to gain a more holistic understanding of its impact. With appropriate support, deep learning can be a cornerstone in developing geographically literate, critically aware, and socially responsible learners equipped to address the challenges of the modern world.

Conclusion

The study concluded that deep learning significantly enhances geography education by improving students' understanding of complex geographical concepts, promoting higher-order thinking skills, and fostering greater engagement in the learning process. Students expressed positive perceptions of deep learning practices, emphasizing how these approaches allowed them to explore geography in greater depth, think critically about geographical issues, and apply their learning to real-world contexts. The integration of technology, such as digital tools and resources, was particularly beneficial, enabling students to interact with geographical data in innovative ways and visualize abstract concepts more clearly. This aligns with previous research that highlights the importance of technology in facilitating active learning and deeper engagement with course content. Moreover, the findings underscore the significance of deep learning in encouraging student independence, as it motivates learners to take responsibility for their learning and think critically about the material they encounter. However, while the students' perceptions were largely positive, the study also revealed that there is a need for more professional development for educators in effectively integrating deep learning strategies into geography teaching. Teachers must be adequately trained to utilize deep learning techniques and technologies to fully leverage their potential in the classroom. Furthermore, while this study focused on student perceptions, future research should explore the long-term impact of deep learning on academic performance and its ability to prepare students for real-world geographical challenges. In conclusion, the integration of deep learning into geography education holds great promise, but its full potential can only be realized through continuous support, professional development, and further investigation into its long-term effects.

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