Solo International Collaboration and Publication of Social Sciences and Humanities
E-ISSN: 2988-3512
Vol.3, No.3, 2025, pp. 515-528
DOI: https://doi.org/10.61455/sicopus.v3i03.365

21st Century Competency Analysis of Geography Education Students as an Effort to Support the Implementation of Deep Learning

Pratidina Izza Rahmasyah[1], ***Muhammad Al-Farisy***[2], ***Khoirul Anam***[3]

[1,3]Departemen Pendidikan Geografi, Universitas Negeri Yogyakarta, Indonesia
[2]Departemen Pendidikan Geografi, Universitas Syiah Kuala, Indonesia
[1]pratidinaizzarahmasyah@uny.ac.id, [2]alfarisy.geography@usk.ac.id,
[3]khoirulanam.2023@student.uny.ac.id

Received January 05, 2025; Revised May 30, 2025; Accepted June 28, 2025

Abstract

Objective: 21st century competencies, such as critical thinking, creativity, communication, and collaboration, are the main needs in today's world of education. This study aims to analyze these competencies in Geography Education students and their relationship with readiness to support the implementation of deep learning. **Theoretical framework:** This study uses an interdisciplinary approach that combines the theories of 21st century skills, constructivist learning, deep learning pedagogy, and geographic education. This approach strengthens the understanding of how essential competencies such as critical thinking, creativity, collaboration, and digital literacy can be developed through meaningful learning processes rooted in constructivist principles. **Literature review:** The literature review emphasizes the integration of geospatial technologies, project and challenge-based learning approaches, and the role of Deep Learning in fostering conceptual understanding and higher-order thinking skills. **Methods:** The research method used was a descriptive quantitative approach with the distribution of questionnaires to 100 students. **Results:** The findings reveal that students' competencies are generally in the high category, with critical thinking (mean score = 4.3) and collaboration (4.21) as the most prominent, while technological literacy remains moderate (3.82). A low standard deviation (0.167) indicates a consistent level of competency across indicators. **Implications:** The findings highlight the need for strategic curriculum transformation and cross-sector collaboration to develop 21st century competencies through deep learning in geography education. **Novelty:** The novelty of this study lies in its combined approach of quantitative assessment and critical reflection on the institutional and pedagogical challenges of implementing Deep Learning in higher geography education, offering contextual and actionable strategies for transformative change.

Keywords: 21st century competency, geography education, student analysis, deep learning, education innovation.

INTRODUCTION

The rapid development of information technology and globalization demands fundamental changes in the world of education, especially in the development of competencies relevant to the 21st century. These competencies include critical thinking skills, creativity, collaboration, communication, technological literacy, and the ability to continue learning throughout life [1]. Today's world of work no longer demands only basic cognitive abilities, but also complex skills

that can help individuals adapt to the dynamics of social, economic, and technological change. Geography education as a branch of social sciences is also faced with the same challenge to prepare students who are adaptive to changing times. This is important because contemporary geography issues such as climate change, urbanization, spatial inequality, and environmental sustainability demand an understanding that is not only theoretical, but also analytical and solution-based.

Hasnah emphasized that 21st century geography education must foster creative and innovative thinking, critical thinking, communication, and collaboration skills through a scientific approach that encourages students to be actively involved in the process of discovery and deep understanding [2]. This learning process applies 5M activities, namely observing, questioning, formulating hypotheses, exploring, and concluding, so that students can develop a deep understanding of the concepts learned. In addition, geography learning must focus on participants who grew up with teachers as facilitators, oriented towards the development of geographical knowledge, attitudes, and skills, and ICT-based and rich in learning resources. The use of technology in problem-based learning is an effective strategy to develop 21st century competencies.

Geography education students are expected not only to understand spatial and environmental concepts, but also to be able to solve complex problems, think systematically, and integrate technology in the process of geographic analysis [3]. They must be able to conduct spatial data-based studies, use technologies such as GIS (Geographic Information System), remote sensing, and utilize digital devices in presenting and analyzing geosphere phenomena. In addition, students are also required to have the ability to work in a team, communicate effectively, and be able to make evidence-based decisions. In this context, conventional learning approaches become less relevant if they are not able to develop students' potential as a whole. Along with this increasing need, the application of Deep Learning-based learning methods is one of the approaches that is considered effective in supporting active, deep, and continuous learning [4][5].

Furthermore, Epuri emphasized that the evolution and implementation of artificial intelligence in Geographic Information Systems (GIS) has had a significant impact, not only in improving the efficiency of spatial analysis but also in enriching students' learning experiences. Through the integration of big data, machine learning, and advanced mapping technology, students not only learn theory, but can also conduct simulations and spatial analysis directly with high accuracy. This directly improves the quality of education and competitiveness of graduates, who are now better equipped to face the challenges and demands of the rapidly evolving and complex professional landscape in the digital age [6].

Deep Learning in the context of education refers not only to artificial intelligence technologies, but also to efforts to build deep conceptual understanding, high-level thinking skills, and the development of students' metacognition [7]. This approach emphasizes the importance of developing students' capacity to think reflectively, understand the relationships between concepts in depth, and be able to evaluate and reflect on their own learning process. In deep learning, students do not just absorb information, but actively build knowledge through complex thinking processes and meaningful discussions. Therefore, it is important to analyze the extent to which geography education students have 21st century competencies that can support the implementation of deep learning. This competency is not only an indicator of individual readiness, but also reflects the effectiveness of educational institutions in developing a curriculum that is responsive to future challenges.

Deep learning not only emphasizes mastery of content, but also includes an effective process of knowledge transfer, where students can apply concepts they have learned in a variety of new contexts [8]. This process enhances conceptual understanding while honing critical thinking skills that are essential for dealing with the complex challenges of the 21st century. In the context of geography education, it is emphasized that the development of 21st-century competencies in students cannot be excluded from a learning approach that emphasizes critical thinking skills,

E-ISSN: 2988-3512

creativity, collaboration, and communication that are thoroughly integrated in every stage of the deep learning process.

Previous studies have shown that Challenge-Based Learning and Project-Based Learning models are effective in shaping 21st century skills in students and students [9]. Both approaches encourage students to be actively involved in complex real-world problem-solving processes, collaborate in cross-disciplinary teams, and design creative and applicative solutions. In the context of geography education, this model is very relevant because it is able to provide a contextual learning experience based on the surrounding environment. The use of project-based and challenge-based approaches can improve spatial analysis skills, technology-based geographic data processing, and scientific communication skills [10]. Students don't just learn through lectures or readings, but through hands-on experience that requires critical thinking, data evaluation, and strategic decision-making.

However, there are still various obstacles in the implementation of deep learning in the higher education environment, such as the limitations of technological infrastructure, the lack of lecturer training related to 21st century pedagogy, and the lack of optimal readiness of students to adapt to this more complex learning method [11]. Some campuses still experience limited access to the latest technology that can support digital-based learning and spatial analysis. In addition, most teachers have not fully mastered the pedagogical approach that demands participatory and project-based learning. On the other hand, many students are still used to passive methods and do not have time management, effective communication, and decision-making skills in teams. These barriers show that learning transformation does not only depend on changing methods, but also needs to be accompanied by adequate human resource readiness and support systems.

The limitations of educational technology infrastructure, such as computer hardware, stable internet connectivity, and AI-based software, pose significant challenges to the implementation of deep learning, particularly in regions with large digital divides. It is also emphasized that inequality of access to technology is still the main obstacle in the process of diffusion of educational innovation [12]. The lack of training and digital literacy among lecturers and educators hinders the effectiveness of the implementation of this teaching method [13]. In addition, the issue of privacy and security of student data in the use of digital learning technology is a crucial concern that needs to be addressed to ensure desire and trust in the learning process [14]. These constraints show that learning transformation does not only rely on changes in methodology but also requires adequate human resource readiness and systemic support [15]. These factors affirm the importance of this study to identify and analyze the competencies of 21st century geography education students in order to support the optimal implementation of deep learning.

The fast progression of computerized innovation, globalization, and the rise of the Fourth and Fifth Mechanical Insurgencies have altogether changed the scene of higher instruction. These shifts have required a redefinition of graduate profiles, emphasizing 21st-century competencies such as basic considering, inventiveness, communication, collaboration, advanced education, and long lasting learning. Within the setting of geology instruction, these competencies are progressively crucial due to the multifaceted nature of modern spatial issues, counting climate alter, urbanization, fiasco dangers, and territorial imbalance. Topography understudies are presently anticipated not as it were to ace hypothetical concepts but too to apply innovative apparatuses in analyzing and understanding real-world spatial issues.

In spite of developing intrigued in both 21st-century competencies and Profound Learning, most existing ponders treat these spaces freely. There's a need of experimental inquire about that expressly analyzes how understudy competencies either empower or oblige the execution of Deep Learning models especially within the teach of geology instruction. This constitutes a noteworthy inquire about hole, especially in Indonesia, where the pace of educational modules change and computerized integration remains uneven over teach.

E-ISSN: 2988-3512

To address these gaps, this study employs a descriptive quantitative approach aimed at assessing the extent to which Geography Education students possess core 21st-century competencies. The evaluation focuses on six key dimensions: critical thinking, creativity, collaboration, communication, digital literacy, and lifelong learning**,** as conceptualized by the P21 Framework. The data collection instrument was rigorously validated through expert judgment and confirmatory factor analysis (CFA)**,** ensuring both construct validity and reliability, with a Cronbach's Alpha score of 0.87 indicating high internal consistency. In addition to the quantitative survey, semi-structured interviews were conducted with selected students to explore qualitative insights into their experiences with project-based and digital learning environments.

This research is expected to contribute to curriculum development, learning design, and training strategies that are able to facilitate the achievement of graduate profiles that are in accordance with the demands of the 21st century and the Industrial Revolution 5.0 [16][17]. By understanding the extent of 21st century competencies already possessed by geography education students, educational institutions can design programs that are more targeted and future-oriented. It is hoped that geography education graduates will not only become capable teachers, but also agents of change who are able to utilize geography to solve real problems in an innovative and sustainable manner.

LITERATURE REVIEW

The competence of the 21st century in education shows that the world of education today faces great challenges in preparing students who are not only academically capable, but also have adaptive abilities to global technological, social, and economic changes. 21st Century learning competencies are structured with the 4C concept, namely *Communication*, *Collaboration*, *Critical Thinking and Promblem Solving*and *Creativity and Innovation* [18]. These competencies are an important framework in developing an education system that is relevant to the demands of the times. In the context of higher education, *Deep learning* It is not just knowledge transfer, but includes the formation of deep conceptual understanding, high-level thinking skills, and strengthening students' metacognitive capacity.

In the context of higher education, especially in the field of geography education, the challenge of 21st century competencies becomes particularly relevant because this discipline is closely related to complex spatial and environmental issues. The integration of technologies such as GIS and remote sensing is able to significantly improve the spatial understanding and digital literacy of geography students [19]. The development of science and technology can be a new challenge in the integration of geography [20]. Along with these needs, various learning approaches and models have been developed to encourage the birth of these competencies, one of which is *Project-Based Learning (PjBL)*. The learning model that often receives attention is the PjBL model which encourages an active and collaborative learning process [21].

Geography education in higher education has a very important role for the development of the learning process. The results of the research that discussed the increase of discourse through the Earthcomm model showed that this model succeeded in improving the ability to think spatially and sparked students' activeness in conducting scientific investigations which was proven to be able to stimulate students' awareness to know basic problems about the condition and geographical location of an area [22]. The important position of education students in the learning process is related to the process of solving problems related to the lag and limitations in terms of learning, especially in the learning process from many educational institutions [23]. In the 21st Century, prospective geography educators need to be equipped with competencies and skills in the learning process, both skills in the use of technology and skills in the preparation of e-modules that can trigger the learning process *Deep Learning* [24].

Global Demands Encourage a shift in the learning paradigm from traditional learning to a more modern one, this is done so that the learning process is able to empower students to be more effective than traditional learning [25]. In the 21st Century, technological developments,

E-ISSN: 2988-3512

globalization and rapid changes in the world of work create new challenges as well as opportunities for students, but the skills currently possessed by students are still not enough for this fairly stiff competition, therefore students need to master critical thinking skills, creativity, effective communication, cooperation, digital literacy, and interpersonal skills [26].

In the context of education, deep learning is applied in various forms, such as AI-based learning systems, chatbots for tutoring, and automated assessment systems that can provide direct feedback to students [27]. In addition to increasing effectiveness during the learning process, deep learning can also open up opportunities for the development of more inclusive educational technology, data analysis to recognize learning difficulties, and the use of deep learning as a virtual tutor that can provide additional hours of flexible and independent learning [28].

One example of the implementation of deep learning in the deep learning process is in the process. The application of deep learning by combining four main dimensions, namely thinking, ethics, feeling, and physical, can potentially produce an education system that is more reflective, sustainable, context-based, flexible, and ready to face the challenges of the 21st century [29]. Behind the solutions offered by deep learning, in fact, are inseparable from challenges, such as limited technology infrastructure, lack of understanding and skills of teachers in the use of AI-based technology, and the need for quality data to train deep learning models [30]. One of the must-have skills in the 21st century is the ability to collaborate to solve problems. Improving collaborative ability to solve problems can be leveled using the deep learning process combined with Project-Based Learning, as it often involves group projects that teach students how to work together to achieve common goals [31].

METHODOLOGY

This study uses a descriptive quantitative approach with a survey method. The main objective of this approach is to describe the 21st century competencies of Geography Education students and their relevance in supporting Deep Learning-based learning. The research was carried out at the Geography Education Study Program, Yogyakarta State University in Indonesia, from January to March 2025. The research population is active students of the Geography Education study program at Yogyakarta State University. The sampling technique uses purposive sampling with the criteria of active students in semesters 2, 4, and 6 who have experience participating in project-based or problem-based learning, and are willing to participate. The number of respondents was 120 people [32-33].

Table 1. Sample Breakdown by Semester

Semester	Number of Students	Percentage (%)
2	39	32,5%
4	44	36,7%
6	37	30,8%
Total	120	100%

Data collection was carried out through a closed-ended questionnaire in the form of a Likert scale of 1–5, a literature study to support secondary data, and semi-structured interviews conducted on 10 respondents to deepen the findings. The instrument is based on the 21st century competency theory of the P21 Framework and has been validated by three experts in the fields of education and geography.

E-ISSN: 2988-3512

Table 2. Blueprint of the 21st Century Competency Questionnaire Instrument

Yes	Indicators	Sub Indicators	Number of Items
1	Critical Thinking	Problem solving, reasoning, decision making	5
2	Creativity	Innovation, generating ideas	5
3	Collaboration	Teamwork, interpersonal skills	4
4	Communication	Oral, written, and digital communication	4
5	Digital Literacy	ICT Use, Media Literacy	5
6	Lifelong Learning	Self-regulation, adaptability	4
	Total		27

The validity test was carried out using Confirmatory Factor Analysis (CFA). All instrument loading factors are above 0.5, indicating that the instrument is valid. The reliability test was conducted using Cronbach's Alpha, with a result of 0.87 indicating excellent internal consistency. Descriptive statistical analysis was carried out using SPSS 26, with the following categories of average score interpretation:

Table 3. Interpretation of Average Score

Average Score	Interpretation
4,21–5,00	Very High
3,41–4,20	Tall
2,61–3,40	Keep
1,81–2,60	Low
1,00–1,80	Very Low

RESULTS AND DISCUSSION

Results

Based on the results of data collection from 120 students of the Geography Education study program, an overview of the competencies of the 21st century students in supporting the implementation of Deep Learning was obtained. The following are the results of the recapitulation of the average scores of the main indicators:

Table 4. Results of the Recapitulation of the Average Score of the Main Indicators

Yes	Competence 21st Century	Average Score (0-100)	Average Score (1-5)	Category
1	Critical Thinking and Problem Solving	82.5	4.3	Excellent
2	Creativity and Innovation	78.4	4.1	Good
3	Communication	75.3	4.01	Good
4	Collaboration	80.2	4.21	Excellent
5	Technology Literacy	70.5	3.82	Enough
6	Independence in Learning	77.8	4.11	Good

E-ISSN: 2988-3512

After calculating the average scores for each indicator, the next step of the analysis involved computing the standard deviation. This aims to determine the degree of dispersion or variation of the data from the mean. The standard deviation provides an overview of the consistency or diversity in the achievement levels of each indicator among the respondents involved. The calculations of the mean and standard deviation are as follows:

Mean Score (Scale 1–5)

$$\chi = \frac{4.3+4.1+4.01+4.21+3.82+4.11}{6} = \frac{24.55}{6} = 4.092$$

Standart Deviation

$$S = \sqrt{\frac{\sum(xi - \bar{x})^2}{n}}$$

$$(4.3-4.092)^2 = 0.0433$$
$$(4.1-4.092)^2 = 0.000064$$
$$(4.01-4.092)^2 = 0.0067$$
$$(4.21-4.092)^2 = 0.0139$$
$$(3.82-4.092)^2 = 0.0740$$
$$(4.11-4.092)^2 = 0.000324$$

The sum of squared deviations= 0.1383

$$S = \sqrt{\frac{0.1383}{5}} = \sqrt{0.0277} = 0.1665$$

Based on the quantitative statistical analysis of the six 21st-century competency indicators among Geography Education students, the average competency score (mean) was 4.09 (on a scale of 1 to 5), with a standard deviation of 0.167. The standard deviation reflects the degree of dispersion of the indicator scores from the mean. The statistical results indicate that the distribution of competency scores across indicators falls within a relatively narrow range. Students' perceptions and mastery of competencies across the indicators tend to be uniform, showing no significant variation. The low standard deviation signifies a high level of homogeneity in competency mastery and suggests that the learning process within the study program has comprehensively implemented all aspects of 21st-century competencies.

Among the six indicators assessed, critical thinking and collaboration recorded the highest scores, at 4.30 and 4.21 respectively. Meanwhile, technological literacy received the lowest score, at 3.82. The gap between the highest and lowest scores remains within an acceptable range and does not significantly affect the overall distribution. These findings are further supported by interview results, which indicate that students have demonstrated strong proficiency in reflective thinking and teamwork, although they continue to face challenges in technical aspects related to the use of geospatial technologies and digital learning tools [34-36].

The low standard deviation reinforces the conclusion that educational processes within the study program have been implemented consistently and comprehensively in fostering students' 21st-century competencies. Nevertheless, improvement efforts should be focused on the area of technological literacy, given the critical role of this skill in supporting the successful implementation of deep learning approaches, which require the integration of digital technologies and spatial data analysis capabilities. Therefore, the standard deviation not only represents the spread of the data but also serves as a quantitative indicator of the equity in

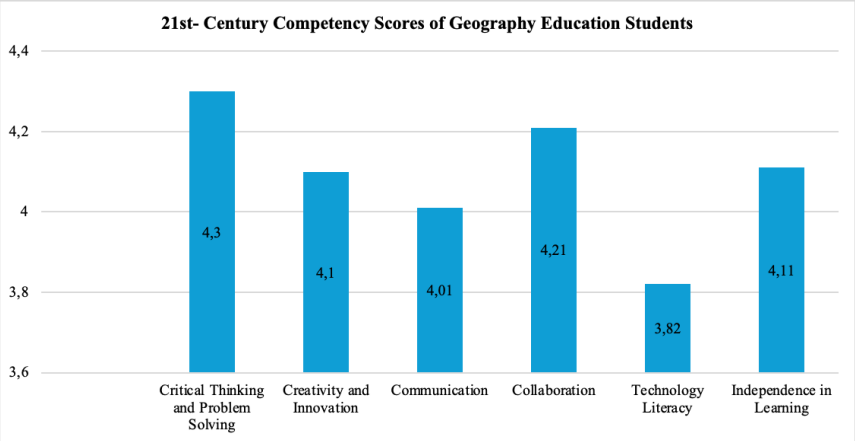
E-ISSN: 2988-3512

students' competency acquisition. Curriculum development and instructional strategies should be more targeted toward strengthening the relatively weaker competencies, so that all 21st-century competency indicators can be optimally and evenly enhanced.

In addition, the results of semi-structured interviews with 10 student representatives strengthened the quantitative findings, especially related to the challenges of using Deep Learning-based technology in project-based learning. The findings suggest that critical thinking and collaboration skills have been key strengths of students, which supports the effectiveness of problem-solving and teamwork-based learning in geography classrooms. Students can identify spatial issues, analyze data from various sources, and construct rational and evidence-based arguments [37-38].

The following bar chart presents the latest scores for the six indicators of 21st-century competencies among Geography Education students. This visualization highlights the relatively even distribution of scores across the indicators, with digital literacy emerging as the area that requires further improvement.

Picture 1. 21st- Century Competency Scores of Geography Education Students



Their good communication competence is reflected in the delivery of digital presentations, group discussions, and mini-project publications carried out during the learning process. Creativity is also growing, reflected in a variety of innovative products such as regional design, disaster simulation, and GIS-based data visualization. However, the aspect of technology literacy is the main challenge. An average score that is classified as adequate indicates a limitation of skills in the use of advanced technology, such as the integration of spatial data with modeling systems or the use of artificial intelligence in geographic analysis. This barrier was also identified in interviews, where students revealed a lack of practical training and access to certain software. Overall, this data shows that while the foundations of 21st century competencies have been well established, systemic efforts are still needed to optimize digital capabilities and the use of cutting-edge technologies to comprehensively support deep learning [39-40].

Discussion

The findings of the study show that Geography Education students at Yogyakarta State University have sufficient competencies in the aspects of critical thinking, collaboration, and creativity, which are important elements in supporting Deep Learning-based learning. High critical thinking competencies reflect students' ability to analyze complex geographical problems in depth, which is an important foundation in the context of *Problem-Based Learning*. Students are able to identify geographical problems, evaluate information from various sources, and formulate logical arguments based on available data. This demonstrates a strong conceptual understanding and ability to make reflective assessments of spatial and environmental issues occurring in various regions.

E-ISSN: 2988-3512

In the aspect of collaboration, students are able to work effectively in groups, share tasks and responsibilities, and demonstrate the ability to achieve common goals. Group projects carried out in field-based courses and geospatial practicum show that students can build good interpersonal communication and bring together various points of view to produce joint solutions. This ability reflects the values of teamwork that are essential in the face of the challenges of a complex and interconnected world of work. Meanwhile, the creativity aspect is reflected in the students' ability to develop new ideas, design innovative solutions to geographical problems, and produce works such as thematic maps, land use design, and software-based disaster simulations. This ability is also seen in multimedia presentation-based projects and the use of digital media as a means of delivering more interesting and easy-to-understand geographic information [41].

This is in line with Prayogi arguing that 21st century competence involves the development of critical, creative, communicative, and collaborative thinking skills as the main foundation for success in a technology and information-based world. These four pillars not only strengthen students' readiness to face global challenges, but also form the character of lifelong learners who are adaptive to change. However, students' technology literacy scores are quite sufficient, with an average score of 70.5. This shows that there are still obstacles in optimizing the use of technology-based devices such as *Geographic Information System* (GIS), spatial modeling, and AI-based data analysis software. Some students have difficulty operating advanced features in GIS, understanding the working principles of spatial modeling, or integrating spatial data with *machine learning* algorithms for predictive analysis. These limitations show the need to strengthen the curriculum and intensive training in the field of geospatial information technology.

In addition, there is still a gap between students' theoretical knowledge of geospatial technology and their practical skills in utilizing the technology effectively to complete geography case studies. This can hinder the effective implementation of *Deep Learning* in modern geography learning that demands the integration of knowledge, technological skills, and complex problem-solving. Therefore, it is important for educational institutions to expand access to technological resources, provide ongoing technical guidance, and encourage students to actively explore various digital applications in a geographical context.

Based on the findings regarding the limited digital literacy among university students, it is crucial to design and implement systematic and sustainable strategies to overcome barriers in the adoption of deep learning-based education at the higher education level. One viable strategy involves curriculum development initiatives, particularly those grounded in information and communication technology. Such efforts should not only include the introduction of basic technological tools but also the integration of digital geospatial tools, such as Geographic Information Systems (GIS) and AI-based spatial analysis, into all stages of the learning process. This curriculum would enable students not only to grasp theoretical concepts but also to develop practical skills that are aligned with current global demands.

Collaboration between educational institutions and the geospatial industry can also serve as a crucial strategy. The involvement of practitioners in the learning process through guest lectures, seminars, student internship programs, and collaborative projects can strengthen the connection between academic theory and real-world professional practice. The effective utilization of learning platforms such as Google Classroom and ArcGIS Online should be optimized to support a learning process that is flexible, adaptive, and collaborative. Technology-integrated learning models are also expected to expand opportunities for both independent and collaborative learning, while fostering a culture of technological exploration among students. By implementing these strategies, higher education institutions can more effectively develop 21st-century competencies. Furthermore, this approach enhances the preparedness of the education system in responding to the demands of the Fifth Industrial Revolution, which emphasizes the synergy between artificial intelligence and human intelligence in the learning process.

E-ISSN: 2988-3512

Implementation of Deep Learning in Geography Education

Deep Learning in the context of education emphasizes more on the achievement of meaningful learning, where students are able to relate new concepts to previous knowledge in depth. In practice, *Deep Learning* requires students' active involvement in the learning process, critical reflection on the material, and the ability to apply knowledge in a real context. This creates an understanding that is not only memorized, but also integrated and applicative. With high critical and collaborative thinking skills, students tend to be more able to adapt learning models such as *Project-Based Learning* and *Inquiry-Based Learning* which are based on *Deep Learning* principles. In *Project-Based Learning*, students are invited to complete a real geographical project, such as regional spatial analysis, disaster potential assessment, or spatial data-based regional planning. This process involves searching for information, formulating problems, collecting field data, and presenting solutions based on geospatial technology, which combines cognitive, affective, and psychomotor aspects in a balanced manner.

Meanwhile, in the *Inquiry-Based Learning* approach, students are challenged to formulate their own research questions, explore data independently, and draw conclusions based on the results of observation and analysis. This encourages them to develop scientific curiosity, problem-solving skills, and reflective thinking in understanding complex geographical phenomena. Thus, *Deep Learning* allows students to become active learners who are independent and able to generate new knowledge through a deep and meaningful learning process. Through the integration of 21st century competencies with *the Deep Learning* approach, geography learning not only focuses on knowledge transfer, but also on developing students' character and life skills in the digital era. This makes a significant contribution in forming Geography Education graduates who are not only proficient in academics, but also ready to face the dynamics of the world of work that demands high adaptability, innovation, and strong technological literacy.

Project-Based Learning (PjBL) and Inquiry-Based Learning (IBL) have a strategic role in developing key 21st-century skills, such as critical thinking, teamwork, and problem-solving. These approaches are essential for promoting deep learning in geography education. Both methods encourage students to take an active role in the learning process through contextual, exploratory, and reflective experiences. For instance, in PjBL, students might work on real-world geography projects, such as assessing regional disaster vulnerability or creating spatial planning proposals using geospatial data. In IBL, students are challenged to identify problems, investigate information independently, and draw conclusions based on data and observation. These approaches support the core goals of deep learning by fostering meaningful engagement and deeper understanding of geographic concepts.

The implementation of deep learning approaches through Project-Based Learning (PjBL) models must be consistently considered in higher education, as it inevitably faces several significant challenges. Technological infrastructure limitations such as access to mapping software like GIS and reliable internet connectivity remain major obstacles in many educational institutions, especially those in regions with pronounced digital divides. Additionally, the readiness of educators presents a critical issue. Not all lecturers possess adequate pedagogical skills to design and facilitate complex project- or inquiry-based learning. This problem is exacerbated by the lack of ongoing training in digital literacy and 21st-century pedagogy. From the student perspective, while critical thinking and collaboration skills have generally improved, there are still notable deficiencies in digital literacy and autonomous learning. Many students are unaccustomed to learning methods that demand high levels of initiative, time management skills, and responsibility within collaborative environments.

The implementation of Project-Based Learning (PjBL) and Inquiry-Based Learning within the context of Deep Learning represents more than a mere shift in pedagogical methods; it demands a comprehensive transformation. This includes enhancing the capacity of educators, improving supporting infrastructure, developing a flexible curriculum, and ensuring institutional policies that prioritize innovation and collaboration. Without a critical reflection on these

E-ISSN: 2988-3512

multifaceted challenges, the gap between the intended pedagogical ideals and the practical realities of implementation is likely to remain substantial. Therefore, the strategic implementation of Deep Learning in higher education must be contextually grounded, sustainable, and responsive to local dynamics as well as the readiness of educational stakeholders.

CONCLUSION

This study concludes that the competence of 21st century geography education students in general is in the high category, with collaboration and communication being the most prominent competencies. However, there are challenges in the aspect of digital literacy that need special attention to support the optimal implementation of deep learning-based learning. Efforts to improve digital competence, strengthen critical thinking and lifelong learning, and integrate technology in the learning process are key in preparing geography education graduates who are adaptive to the challenges of the 21st century and the Industrial Revolution 5.0. Further research is recommended to examine more deeply the relationship between 21st century competency dimensions to the effectiveness of Deep Learning implementation in a variety of different educational geographical and cultural contexts. These findings show that geography education has succeeded in developing soft skills that are essential for 21st century learning, but still have structural challenges related to technological proficiency. Therefore, it is important for educational institutions to expand access to training, improve infrastructure support, and design curricula that emphasize mastery of geospatial applications as well as other digital technologies. Improving digital literacy and lifelong learning skills must be prioritized in designing an education system that produces adaptive and solution-oriented graduates in the Society 5.0 era. Support for the integration of technology in education must be accompanied by digital pedagogical training for educators and a learning environment that encourages exploration and collaboration. In addition, an ongoing evaluation of the approach to the effectiveness of Deep Learning in the context of geography education needs to be conducted, taking into account local characteristics, institutional readiness, and policy support. With an effective strategy, students can be empowered as agents of change who not only have the knowledge, but also the skills to face global challenges creatively and critically.

Acknowledgments

We extend our heartfelt gratitude to the Universitas Negeri Yogyakarta, Indonesia, and Universitas Syiah Kuala, Indonesia for the invaluable support and resources provided throughout this research journey. Your esteemed institution has not only facilitated our academic pursuits but has also offered an environment that encouraged innovation and critical thinking. This accomplishment would not have been possible without the dedication and assistance of the faculty and staff, whose guidance proved instrumental. We are profoundly grateful for the University's commitment to advancing knowledge and fostering academic excellence, and we look forward to contributing to this esteemed institution's legacy.

Author Contribution

All authors contribute equally to the publication of this paper, all authors read and agree to this paper, and all authors declare no conflict of interest.

Conflicts of Interest

All authors declare no conflict of interest.

REFERENCES

[1] S. Syarifuddin, I. Iriani, and L. A. Akbar, "Characteristics, Approaches, and Competency Learning Processes of Students in The 21st Century," *12 Sherb*, vol. 9, no. 1, Art. no. 1, Jul. 2023, doi: https://doi.org/10.47655/12025.v9i1.91.

[2] N. Hasnah, "21st Century Skills Development in Geography Learning," *By J. S. Scott. Cendikia*, vol. 2, no. 3, Art. no. 3, Jun. 2023, Accessed: Jun. 03, 2025. [Online]. Available: https://jurnal.penerbitdaarulhuda.my.id/index.php/NJPC/article/view/275

[3] "Technology for Achieving Learning Objectives Through a System-Activity Approach and the Development of Critical Thinking in Geography Studies | Journal of Ecohumanism." Accessed: Jun. 03, 2025. [Online]. Available: https://ecohumanism.co.uk/joe/ecohumanism/article/view/5797

[4] S. Siswanto, M. U. Dewi, S. Kholifah, G. Widhiati, and W. Aryani, "The Use of Deep Learning Models to Improve Efficiency in Machine Learning Applications," *J. Researcher. Sist. Inf. JPSI*, vol. 1, no. 4, pp. 215–238, Nov. 2023, doi: https://doi.org/10.54066/jpsi.v1i4.1619.

[5] B. Pfülb, "Continual Learning with Deep Learning Methods in an Application-Oriented Context," Jul. 12, 2022, *arXiv*: arXiv:2207.06233. doi: https://doi.org/10.48550/arXiv.2207.06233.

[6] Researcher, "The Evolution And Impact Of Ai In Geographic Information Systems," *Int. J. Comput. Eng. Technol. IJCET*, vol. 15, no. 5, pp. 794–802, Oct. 2024, doi: https://doi.org/10.5281/zenodo.13912537.

[7] M. Elbashbishy and Eman, "Deep Learning in Education," *Sustain. Educ. Globe*, vol. 2, no. 1, pp. 15–21, Jul. 2024, doi: https://doi.org/10.21608/sec.2024.269380.1000.

[8] J. A. C. Hattie and G. M. Donoghue, "Learning strategies: a synthesis and conceptual model," *Npj Sci. Learn.*, vol. 1, no. 1, pp. 1–13, Aug. 2016, doi: https://doi.org/10.1038/npjscilearn.2016.13.

[9] "The Effect of the Problem-Based Learning Model on 21st Century Student Skills: A Meta-Analysis | The Indonesian Journal of Computer Science." Accessed: Jun. 03, 2025. [Online]. Available: http://ijcs.net/ijcs/index.php/ijcs/article/view/3849

[10] "GIS, Geospatial Technology, and Spatial Thinking in Geography Education," obo. Accessed: Jun. 03, 2025. [Online]. Available: https://www.oxfordbibliographies.com/display/document/obo-9780199874002/obo-9780199874002-0276.xml

[11] P. R. M. K. Fernando, K. Wijayaratne, R. Ragel, and R. Mudiyanse, "Readiness for Smart Learning: Reflection on Challenges Faced by Students and Academics in Higher Education Institutions," in *Smart Learning for A Sustainable Society*, C. Anutariya, D. Liu, Kinshuk, A. Tlili, J. Yang, and M. Chang, Eds., Singapore: Springer Nature, 2023, pp. 254–257. doi: https://doi.org/10.1007/978-981-99-5961-7_34.

[12] S. M. Sinambela *et al.*, "The Digital Divide in the World of Education Present and Future: A Case Study at SMP N 35 Medan," *J. Educator Star. Indonesian.*, vol. 2, no. 3, Art. no. 3, May 2024, doi: https://doi.org/10.55606/jubpi.v2i3.3003.

[13] T. M. Adriansyah and T. E. Rahmayati, "Analysis of the Influence of Digital Literacy Level on Work Productivity in Lecturers in Facing Society 5.0 Era Education in Medan City," *J. Science and Technology.*, vol. 5, no. 1, pp. 360–365, Sep. 2023, Accessed: Jun. 03, 2025. [Online]. Available: https://ejournal.sisfokomtek.org/index.php/saintek/article/view/1645

[14] K. R. A. Suari and I. M. Sarjana, "Maintaining Privacy in the Digital Era: Personal Data Protection in Indonesia," *J. Anal. Huk.*, vol. 6, no. 1, Art. no. 1, Apr. 2023, doi: https://doi.org/10.38043/jah.v6i1.4484.

[15] C. F. B. Hartanto, S. Octavianus, and A. M. Paduppai, "Readiness of Educational Human Resources in the Diffusion of Information Technology Innovation in Educational Institutions," *Pros. Ind. Res. Workshop Natl. Semin.*, vol. 13, no. 01, pp. 1412–1418, Aug. 2022, doi: https://doi.org/10.35313/irwns.v13i01.4300.

[16] K. A. Boluk, "Integrated Curriculum Design: An Empowering and Engaging Pedagogical Approach Preparing 21st Graduates," *Sch. J. Leis. Stud. Recreat. Educ.*, vol. 38, no. 3, pp. 224–229, Sep. 2023, doi: https://doi.org/10.1080/1937156X.2022.2099326.

[17] J. S. Barrot, "Curriculum 5.0 for the Twenty-First Century Higher Education: A Way to Move Forward," in *International Handbook on Education Development in Asia-Pacific*, Springer, Singapore, 2023, pp. 1–15. doi: https://doi.org/10.1007/978-981-16-2327-1_134-1.

[18] R. D. Prayogi, "21st Century Proficiency: The Digital Competence of Future Educators," *Manaj. Educators.*, vol. 14, no. 2, Art. no. 2, Jan. 2020, doi: https://doi.org/10.23917/jmp.v14i2.9486.

E-ISSN: 2988-3512

[19] R. Dixit and A. Dixit, "The role of geography in environmental education and sustainability," *Int. J. Soc. Sci. Educ. Res.*, vol. 6, no. 1, pp. 101–104, 2024, doi: https://doi.org/10.33545/26649845.2024.v6.i1b.89.

[20] S. Budiharto and D. Fitriana, "Analysis of Students' Process Skills in Geography Subjects Using Google Earth-Assisted Project Based Learning Model".

[21] N. A. Damayanti, "The Role of Teachers in Determining Project-Based Learning Models (PjBL) in Low Classes Efforts to Increase Students' Learning Interest in Schools," *J. Educator. School Teacher. Basis*, vol. 1, no. 2, pp. 14–14, 2024, doi: https://doi.org/10.47134/pgsd.v1i2.177.

[22] K. Nisa, H. Soekamto, S. Wagistina, and Y. Suharto, "EarthComm Learning Model in Geography Subjects: Its Influence on the Spatial Thinking Ability of High School Students," *J. Ilm. Educators. Teacher Profession*, vol. 4, no. 3, pp. 500–510, Dec. 2021, doi: https://doi.org/10.23887/jippg.v4i3.40031.

[23] N. Sarah *et al.*, "The Role of Students in the Learning Process as a Form of Community Service in West Labuhbaru Village, Pekanbaru City," *J. Servant. Multidisciplinary*, vol. 2, no. 3, Art. no. 3, Nov. 2022, doi: https://doi.org/10.51214/japamul.v2i3.360.

[24] E. Hariyadi, Y. A. Safitri, A. Iskandar, S. Kamur, and S. Awal, "Efforts To Improve The Skills Of Prospective Geography Teachers In The Creation Of Professional Flip Pdf-Based Learning E-Modules In Non-Classical Learning," *Community Dev. J. J. Pengabdi. Mass.*, vol. 5, no. 2, Art. no. 2, Mar. 2024, doi: https://doi.org/10.31004/cdj.v5i2.26532.

[25] F. Almeida and J. Simoes, "The Role of Serious Games, Gamification and Industry 4.0 Tools in the Education 4.0 Paradigm," *Contempt. Educ. Technol.*, vol. 10, no. 2, Art. no. 2, Apr. 2019, doi: https://doi.org/10.30935/cet.554469.

[26] "21st Century Skills-Based Curriculum Development: Perspectives and Challenges | Ikra-Ith Humanities: Journal of Social and Humanities." Accessed: June 11, 2025. [Online]. Available: https://journals.upi-yai.ac.id/index.php/ikraith-humaniora/article/view/4469

[27] A. Turmuzi, "Deep Learning Approaches to Creating Meaningful Learning Experiences," *J. Sci. Mandalika JSM E-ISSN 2745-5955 P-ISSN 2809-0543*, vol. 6, no. 7, Art. no. 7, Apr. 2025, doi: https://doi.org/10.36312/10.36312/vol6iss7pp1711-1719.

[28] "AI Chatbots in Education: Challenges and Opportunities." Accessed: June 11, 2025. [Online]. Available: https://www.mdpi.com/2078-2489/16/3/235

[29] N. Zebua, "Education Transformation: Implementation of Deep Learning in 21st-Century Learning," *Harmony of Educators. J. Educator Science.*, vol. 2, no. 2, pp. 146–152, Mar. 2025, doi: https://doi.org/10.62383/hardik.v2i2.1405.

[30] A. W. Sari and D. J. Arta, "Implementation of Deep Learning: An Educational Innovation," vol. 13, no. 01, 2025.

[31] E. C. Miller and J. S. Krajcik, "Promoting deep learning through project-based learning: a design problem," *Discip. Interdisciplinary. Sci. Educ. Res.*, vol. 1, no. 1, p. 7, Nov. 2019, doi: https://doi.org/10.1186/s43031-019-0009-6.

[32] Y. Utami, M. N. Shabrina, and ..., "Literature-Based Education Figure Islam as an Effort to Develop Islamic Character in Children in The 4.0 Era," *Indones. J. Early …*, vol. 12, no. 1, pp. 29–36, 2023, https://doi.org/10.15294/ijeces.v12i1.67614.

[33] M. Muhtar Arifin Sholeh, Waston, A. Nirwana AN, and S. Hidayat, "Good Character, Good Deeds and Good Speech for Developing Multicultural Islamic Education: An Islamic Concept," *Multicult. Islam. Educ. Rev.*, vol. 1, no. 2, pp. 180–195, 2023, https://doi.org/10.23917/mier.v1i2.3427.

[34] I. Wahono, Lukman, and B. Parmadi, "Analisis Pembentukan Karakter Tanggung Jawab dalam Kegiatan Ekstrakurikuler Pendidikan Kepramukaan Bagi Siswa Sekolah Dasar," *JURIDIKDAS J. Ris. Pendidik. Dasar*, vol. 6, no. 1, pp. 126–132, 2023, https://doi.org/10.33369/juridikdas.v6i1.28658.

[35] F. Farida and R. Rohani, "Pengaruh Partisipasi Siswa dalam Kegiatan Ekstrakurikuler terhadap Karakter Tanggung Jawab di SMA Koperasi Pontianak," *J. Pendidik. Kewarganegaraan*, vol. 5, no. 1, pp. 109–122, 2021, https://doi.org/10.31571/pkn.v5i1.2795.

[36] H. J. Prayitno *et al.*, "Prophetic educational values in the Indonesian language textbook: pillars of positive politeness and character education," *Heliyon*, vol. 8, no. 8, p. e10016, 2022, https://doi.org/10.1016/j.heliyon.2022.e10016.

[37] F. Muharom, "Analysis of the Value of Religious Moderation in Learning Module of Islamic Religious Education and Character," *Profetika J. Stud. Islam*, vol. 24, no. 01, pp. 159–170, 2023, https://doi.org/10.23917/profetika.v24i01.1787.

[38] A. Sulhan and L. Hakim, "Emancipating Islamic Education Management through Good-Quality Santri Character Cultures: Insights from Indonesia," *Eurasian J. Educ. Res.*, vol. 2023, no. 103, pp. 197–214, 2023, https://doi.org/10.14689/ejer.2023.103.012.

[39] I. Ilmi, S. Wanayati, A. Hasanah, and B. S. Arifin, "Islamic Educational Values as the Core of Character Education," *EDUTEC J. Educ. Technol.*, vol. 7, no. 2, pp. 406–471, 2023, https://doi.org/10.29062/edu.v7i2.633.

[40] M. Taufik, "Strategic Role of Islamic Religious Education in Strengthening Character Education in the Era of Industrial Revolution 4.0," *J. Ilm. Islam Futur.*, vol. 20, no. 1, pp. 86–104, 2020, https://doi.org/10.22373/jiif.v20i1.5797.

[41] N. L. Inayati, T. A. Mustofa, A. F. Rohmani, F. N. Anggraini, and Muthoifin, "Development of Religious Education in Junior High Schools for Sustainable Development Goals (SDGs): a Study in Surakarta," *J. Lifestyle SDG'S Rev.*, vol. 5, no. 2, 2025, https://doi.org/10.47172/2965-730X.SDGsReview.v5.n02.pe04411.