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The Implementation of Deep Learning Based Experiential Learning in Developing Metacognitive and Critical Thinking Skills of High School Students: A Systematic Literature Review

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Abstract: This study explores the application of experiential learning to improve high school students' metacognitive and critical thinking skills in understanding electrical and non-electrical concepts. Using a Systematic Literature Review (SLR) method, this study identified and analyzed research on the integration of immersive learning in chemistry education. The abstract nature of electrolyte and non-electrolyte topics often hinders students' conceptual understanding and requires higher-level skills. The findings suggest that experiential learning fosters individualized, flexible, and reflective learning. Students participate in role-playing, modeling, and problem-solving exercises that encourage exploration, analysis, and self-development. This approach enhances students' conceptual understanding and metacognitive skills by helping them understand, remember, and evaluate their learning process. The results of the study indicate that experiential learning methods based on classroom instruction significantly increase students' ability to connect concepts, engage in critical thinking, and refine their learning. Even though it is effective, there are still issues including teacher competency gaps, inadequate technology infrastructure, and the need for curriculum adaptation. Overall, this study offers a synthetic perspective on how learning activities that are specific to experiential learning can increase metacognitive and critical thinking skills. This study offers cost-effective assistance to educators and policy makers in developing technology-based kimia education strategies that encourage understanding and analytical skills in learning complex concepts such as electrical and non-electrical.

Keywords: Deep learning, Experiential learning, Metacognitive skills, Critical thinking, Chemistry education

Introduction

The integration of experience-based learning based on deep learning has become a crucial area of focus for educational innovation in order to increase students' metacognitive and critical thinking skills in chemistry education. Electrolytes and non-electrolytes are examples of abstract, conceptual chemical problems that need students to use analytical and reflective thinking skills in order to understand the underlying principles (Yao, 2023). The emphasis on memorization in traditional education often hinders students' ability to connect theory with verbal expression.

According to recent research, the in-depth model of education that is used in conjunction with learning experiences enables flexible and adaptable learning for students who encourage self-reflection, introspection, and problem-solving (Qi et al., 2024). Students can actively learn about the chemistry process through modeling, simulation, and project-based assignments that increase conceptual understanding and high levels (Ijirana et al.,2022). Furthermore, the use of immersive learning facilitates an individualized feedback system that enhances metacognitive awareness, allowing students to track and assess their own learning progress.

Dessie et al. (2023) claim that students' metacognition, conceptual understanding, and critical reasoning improve significantly when the learning design combines hands-on and experiential approaches.

One of the higher-order thinking abilities required to acquire 21st-century talents is critical thinking. Thinking skills are seen as a crucial asset in education, which aims to enlighten the country (Adhitya Rahardhian, 2021). To determine what to believe and what to do, critical thinking entails careful and logical consideration (Brookhart, 2010). Students' conceptual comprehension and the process of developing critical thinking are inextricably linked. Students need to grasp a specific notion in order to think critically. Students' critical thinking abilities are significantly influenced by their conceptual comprehension. According to I Kadek Budiartawan et al. (2013), students' critical thinking abilities are positively correlated with their comprehension of an idea. Everyone needs to be able to think critically. As a result, the development of students' critical thinking should be the main goal of the learning process at all educational levels, but teachers frequently fail to do so in their role as facilitators (Intan Rizqia Fajariah, 2015). In order to develop critical thinking abilities, this scenario necessitates improving the learning process through the use of an appropriate teaching technique. Pupils who possess strong critical thinking skills will learn more effectively and be able to filter out information so that not all of it is taken at face value. Therefore, it is crucial to have instructional strategies that foster critical thinking in pupils (Hamdani et al., 2019).

According to Liliasari, who cites Facione, the foundation of critical thinking is a thorough explanation of a number of connected traits, such as analysis, inference, explanation, evaluation, self-control, and interpretation. The Deep Learning technique, which shall henceforth be referred to as Pembelajaran Mendalam (PM), is one of the learning ways that require stronger and more innovative efforts to accelerate the impact of education (Suyanto, et al., 2025). The Deep Learning technique promotes critical thinking, creativity, and problem-solving abilities by emphasizing deep, contextual, and meaningful learning. As PM puts students at the center of the learning process by fostering a thoughtful, meaningful, and joyful learning environment, deep learning entails comprehending and relating conceptual and procedural knowledge as well as the capacity to apply conceptual knowledge in novel contexts (Hattie & Donoghue, 2016; Parker et al., 2011; Winch, 2017). Two Deep Learning principles can be found in the literature. First, deep learning refers to machine learning that has been developed through research since the 1940s, ranging from early cybernetics to artificial intelligence (Peters, 2018) and brain neural networks (Gillon et al., 2019; Richards et al., 2019).

The second idea is the use of deep learning in Norwegian education, which is different from the computer science idea (Braten & Skeie, 2020). A Deep Learning technique is required in order to increase pupils' critical thinking capabilities. This can be achieved by changing the educational paradigm from a teacher-centered to a student-centered approach. This change aims to improve the quality of education, both in terms of process and outcomes, through the implementation of creative and innovative teaching methods (Miftianah, Andari Puji Astuti, Fitria Faticahtul Hidayah, 2017). According to Zhou, Huang, and Tian (2013), chemistry is a subject that helps students build critical thinking skills in all of its subjects. Electrolytes and non-electrolytes are one subject covered in chemistry classes. Because the subject of electrolytes and non-electrolytes is contextual, it is simple to relate to and use in daily life. Electrolyte-related phenomena are frequently experienced in daily life, such as the body's requirement for electrolyte solutions and the use of automobile batteries. In order to comprehend these ideas, these phenomena can help pupils develop their critical thinking abilities. Additionally, studying electrochemistry (voltaic cells and electrolysis) requires an understanding of electrolytes (Sri Rejeki Dwi Astuti et al., 2022). Adoption of these technology-driven pedagogies is still hampered by issues including curricular alignment, digital infrastructure, and teacher preparation (Yao, 2023). With an emphasis on fostering metacognitive and critical thinking abilities in high school students studying electrolytes and non-electrolytes, this Systematic Literature Review (SLR) attempts to summarize recent research on the application of deep learning-based experiential learning in chemistry education.Through the research data collected, the researcher formulated several relevant questions as follows:

1. How can high school students' metacognitive and critical thinking abilities be improved when learning electrolyte and non-electrolyte issues through the use of deep learning-based experiential learning?
2. Which deep learning-based experiential learning models or types work best to enhance students' comprehension of these subjects and help them build their metacognitive and critical thinking skills?
3. How might the results of earlier research on experiential learning and deep learning aid in the creation of practical methods for enhancing metacognitive and critical thinking abilities in chemistry education, especially with regard to electrolyte and non-electrolyte concepts?
4. What obstacles and restrictions arise when incorporating experiential learning based on deep learning into chemistry education, and what remedies have been suggested to deal with these problems?

Research Method

Systematic Literature Review

A Systematic Literature Review (SLR) is the technique employed. A survey-based quantitative descriptive method is used in the study (Littell, Corcoran, & Pillai, 2008). This approach is to thoroughly examine and evaluate numerous pertinent research about the use of deep learning to improve critical thinking abilities, especially in the context of teaching chemistry and learning about electrolyte and non-electrolyte solutions. In order to give a clear picture of the connection between deep learning and the growth of critical thinking abilities, the survey is carried out in three stages using secondary data from primary research on the application of deep learning approaches: data collection, data analysis, and drawing conclusions from the findings found in the published literature. Indexed electronic databases including Google Scholar, Garuda Portal, Doaj, Research Gate, and direct journal URLs are used in data collection. Every article that has been extracted will move on to the analysis phase.

Inclusion Criteria

The criteria for selecting the data used the inclusion criteria. Inclusion criteria are criteria for research subjects to represent research samples that qualify as samples (Notoatmodjo, 2012). The inclusion criteria that have been determined are as follows:

Table 1. Criteria for inclusion and exclusion

Category	Inclusion Criteria	Exclusion Criteria
Type of Study	SLR studies, experimental, quasi-experimental, and empirical research articles that address the use of experiential learning and deep learning in chemistry education.	Editorials, opinion pieces, conceptual papers, and non-empirical research devoid of quantitative or qualitative data.
Research Topic	Research on electrolyte and non-electrolyte problems that focuses on helping high school pupils build metacognitive and critical thinking abilities.	Studies that don't deal with electrolyte and non-electrolyte issues or that have nothing to do with the development of higher-order cognitive skills.
Educational Context	Studies carried out at the senior high school level (ages 15–18) or its equivalent.	Studies in the non-formal, university, or elementary school levels.
Learning Approach	Employs experiential learning strategies based on deep learning, such as problem-based learning, project-based learning, and digital simulations.	Use conventional techniques (lectures, memorization) devoid of deep learning or experience components.
Publication Period	Articles released between 2019 and 2025 to guarantee their applicability to the most recent developments in educational technology.	Articles that were not available in full text or that were published prior to 2019.
Language of Publication	Articles that are accessible online and authored in either Indonesian or English	Articles without easily accessible translations that are authored in other languages.

Research Instrument

Selected journal articles that satisfy particular inclusion criteria make up the research tool in this Systematic Literature Review (SLR) titled "The Implementation of Deep Learning-Based Experiential Learning in Developing Metacognitive and Critical Thinking Skills of High School Students on Electrolyte and Non-Electrolyte Topics." The examined works, which were published between 2019 and 2025, concentrated on the incorporation of experiential learning based on deep learning in chemistry education, namely in electrolyte and non-electrolyte issues. Keywords like deep learning, experiential learning, metacognitive skills, and critical thinking were used to find articles. There were only full-text, peer-reviewed papers in Indonesian or English. In order to assess the efficacy of deep learning methodologies in improving students' metacognitive and critical thinking abilities, as well as to uncover obstacles and implications for future chemistry teaching practices, each piece was subjected to content analysis.

Population and Sample

All research articles that discuss how deep learning-based experiential learning can help high school students develop metacognitive and critical thinking skills specifically on electrolyte and non-electrolyte topics make up the population of this Systematic Literature Review (SLR). Ten pertinent papers that satisfied the predetermined inclusion criteria were found from the literature search carried out between 2019 and 2025. These papers were chosen because they emphasize the integration of experiential learning and deep learning methodologies in chemistry education, with the goal of improving students' cognitive and metacognitive skills using creative, technologically assisted teaching methods.

Data Collection Technique

In this Systematic Literature Review (SLR) titled "The Implementation of Deep Learning-Based Experiential Learning in Developing Metacognitive and Critical Thinking Skills of High School Students on Electrolyte and Non-Electrolyte Topics," pertinent journal articles that were in line with the study's goals were gathered and examined. Google Scholar and other scholarly resources were used in a methodical search to gather data. The keywords "Deep Learning," "Experiential Learning," "Metacognitive Skills," "Critical Thinking," "Electrolyte and Non-Electrolyte," and "Chemistry Education" were first used to find 300 articles. Three primary steps comprised the screening process: (1) selecting studies that met the inclusion requirements; (2) assessing content relevance to the study objectives and the deep learning-based experiential learning strategy; and (3) identifying pertinent articles based on titles and abstracts. Ten studies that directly addressed the function of deep learning-based experiential learning in improving metacognitive and critical thinking skills among high school students in chemistry learning were selected for in-depth study after these steps were applied. The mechanism for obtaining data that meets the inclusion criteria in this SLR study is presented in Figure 1.

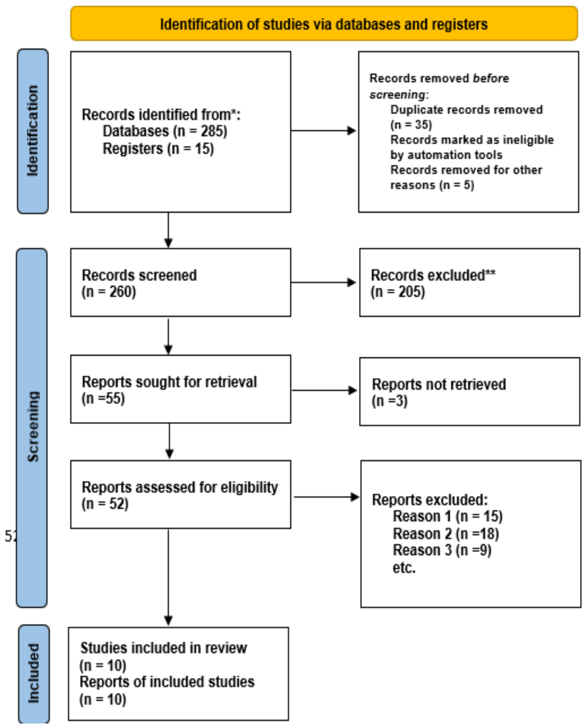

Figure1. Data collection process diagram

Results and Discussion

Description of Findings

Ten carefully chosen articles that satisfied the inclusion criteria were thoroughly examined for this Systematic Literature Review (SLR), "The Implementation of Deep Learning-Based Experiential Learning in Developing Metacognitive and Critical Thinking Skills of High School Students on Electrolyte and Non-Electrolyte Topics." The impact of deep learning-based experiential learning on students' metacognitive growth and critical thinking abilities was highlighted in these research, which investigated different applications of this approach in chemistry education. The examined research shows that experiential learning enhances students' capacity to reflect, analyze, and assess difficult chemical ideas when combined with deep learning frameworks such problem-based learning, project-based learning, simulations, and adaptive digital modules. Additionally, the results show that these methods improve students' ability to learn on their own, enabling them to better organize, track, and evaluate their comprehension. Experiential learning settings based on practical chemical applications have been shown in numerous studies to improve comprehension and cognitive engagement by bridging the gap between abstract theory and practice. However, issues with instructors' preparedness to incorporate technology, the requirement for adequate infrastructure, and the modification of assessment instruments to gauge metacognitive development were noted.Overall, the synthesis shows that deep learning-based experiential learning offers a potent framework for helping high school students develop critical and metacognitive thinking, especially when it comes to electrolyte and non-electrolyte topics that require higher-order cognitive processing. The examined articles' main research findings, learning models, and applicable deep learning techniques are summarized in Table 1.

Table 1. Characteristics of the analyzed articles

No	Article Title	Publication Year	Deep Learning Method Used	Main Focus
1	Deep Learning dan Penerapannya dalam Pembelajaran	2022	Convolutional neural networks (CNN)	Critical Thingking skills
2	Implementation of Deep Learning Methods in Predicting Student Performance.	2021	Convolutional neural networks (CNN) Recurrent neural network (RNN)	Improvement of critical thinking skills
3	Peningkatan Kemampuan Berfikir Kritis Siswa Melalui Pembelajaran Eksperimen pada Materi Larutan Elektrolit dan Non Elektrolit	2019	Recurrent neural network (RNN)	Understanding of electrolyte and non-electrolyte solution concepts
4	Analisis kemampuan berpikir kritis siswa melalui model pembelajaran advance organizer pada materi larutan elektrolit dan nonelektrolit	2018	Convolutional neural networks (CNN)	Critical Thingking skills
5	Deep Learning in Chemistry	2019	Deep Neural networks (DNN)	Chemistry learning
6	Deep learning in analytical chemistry	2021	Deep neural networks (DNNs), convolutional neural networks (CNNs), recurrent neural networks (RNNs), and auto-encoders (AEs)	analytical chemistry
7	Deep learning and generative methods in cheminformatics and chemical biology: navigating small molecule space intelligently	2020	Convolutional neural networks (CNNs, ConvNets)	Chemistry learning
8	Kemampuan Berpikir Kritis Siswa Model Problem Based Learning dengan Asesmen Dinamis Berpendekatan Pembelajaran Berdiferensiasi Ditinjau dari 4emandirian Belajar	2024	Convolutional neural networks (CNN)	Critical Thingking skills
9	Analisis Tingkat Keterampilan Berpikir Kritis Siswa SMA	2020	Convolutional neural networks (CNN)	Critical Thingking skills
10	Peningkatan Kemampuan Berfikir Kritis Siswa Melalui Pembelajaran Eksperimen pada Materi Larutan Elektrolit dan Non Elektrolit	2019	Recurrent neural network (RNN)	Critical Thingking skills, Understanding of electrolyte and non-electrolyte solution concepts

Deep Learning Techniques That Work for Chemistry Concepts

When experiential learning techniques like problem-based, simulation-based, and project-oriented learning are used in conjunction with deep learning, it becomes more effective. Agustian, Finne, and Jørgensen (2022) discovered that laboratory-based experiential learning, with a focus on reflection and metacognitive regulation, improved conceptual and procedural comprehension. These results are consistent with those of Raman et al. (2024), who emphasize that learning models that incorporate real-world problem-solving can greatly boost students' analytical engagement with chemistry content.

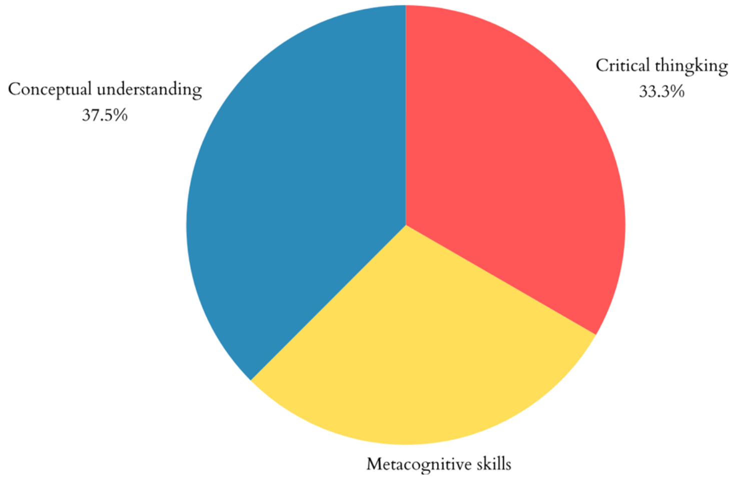

Figure 2. Relationship between learning approaches and skill improvement

Based on the results shown in Figure 2, the use of Deep Learning Based Experiential Learning in both electrical and non-electric learning topics has a significant impact on the development of various student skills. Accordingly, the greatest increase occurred in conceptual understanding (37.5%), which was followed by critical thinking (33.3%) and metacognition (29.2%). The results indicate that deep learning-based learning approaches not only improve students' conceptual understanding of the material, but also foster critical thinking skills and self-reflection (metacognitive awareness). This is in line with research findings conducted by Kolb (2014) and Hmelo-Silver et al. (2017). It states that experiential learning encourages students to actively develop their knowledge through language learning. In addition, Hmelo-Silver et al. (2017) state that an experience-based approach can facilitate the development of conceptual understanding that deepens and strengthens high-level abilities. In the context of chemistry education, Dori et al. (2018) also state that integrating project-based learning with deep learning can improve students' reflective and analytical skills in understanding both electrical and non-electric concepts. Because of this, this approach is effective in developing the metacognitive skills and critical thinking of high school students with complex chemical materials.

The Role of Deep Learning in Developing Critical Thinking Skills

The use of deep learning approaches has been shown to be successful in improving students' critical thinking abilities in the examined publications. Learning models that help students analyze chemical information, especially on electrolyte and non-electrolyte topics, were created using techniques like Convolutional Neural Networks (CNN) and Recurrent Neural Networks (RNN). The use of deep learning in this setting gives students the chance to hone their critical thinking abilities in areas like chemical data processing and resolving challenging issues that frequently arise in electrolyte and non-electrolyte studies. Simulations offered by deep learning models assist students in developing more interactive and in-depth knowledge.

a) CNN: Used to identify patterns in chemical data and assist students in comprehending the connections between chemical topics, such as how molecular structures and chemical reactions can explain the characteristics of electrolytes and non-electrolytes.
b) RNN: Students can gain a greater comprehension of the dynamics of chemical reactions taking place in non-electrolyte topics or the changes in ion concentrations in electrolytes over time by using this technique to assist sequence-based learning.

The effectiveness of various deep learning approaches, the circumstances in which these techniques are implemented, and the quantifiable outcomes connected to critical thinking are some of the aspects from which the function of deep learning in improving critical thinking abilities can be investigated.

Improving the Ability to Solve Problems

Teaching tools that foster problem-solving skills can be created using deep learning techniques like Convolutional Neural Networks (CNNs) and Recurrent Neural Networks (RNNs). With the help of these strategies, students may better understand data patterns, find connections, and resolve challenging issues. Deep learning helps students analyze many options, take into account different points of view, and make well-reasoned conclusions in a critical thinking setting.

Offering Customized Educational Experiences

Customized learning experiences that are suited to each student's needs can be made with the aid of deep learning. Deep learning algorithms can modify curriculum and tests to accommodate various learning styles and speeds by examining student performance data. By giving pupils challenges that test their cognitive capacities, this flexibility promotes critical thinking and active learning.

Encouraging Conceptual Knowledge

Deep learning can help students better envision and comprehend abstract ideas like electrolyte and non-electrolyte behavior, which can be complicated in courses like chemistry. For example, deep learning can be used to build models or simulations that show how ions behave in solutions, giving students a more engaging and clear approach to understand complex ideas. Students get the ability to critically assess and interpret scientific findings through this approach.

Promoting Decision-Making Based on Data

Large datasets can be analyzed using deep learning to find patterns, correlations, and trends. By teaching students how to decipher and make sense of complex material, this data-driven method improves critical thinking. Instead of depending on presumptions or rote memorization, this enables students to draw conclusions in the framework of science education based on real data and evidence.

Enhancing Cooperation and Communication

By offering interactive platforms where students can collaborate to solve issues or evaluate data, deep learning techniques can help promote student collaboration. These settings promote idea exchange, critical discussion, and group problem-solving—all essential elements of critical thinking.

Encouraging Metacognitive Capabilities

By giving students immediate feedback on their learning progress, deep learning can help them build metacognitive skills. With the use of this feedback, students can examine how they think, pinpoint any areas in which they might be having difficulty, and modify their approaches accordingly. Consequently, this reflective exercise strengthens critical thinking skills and fosters the growth of higher-order thinking abilities.

The Impact of Deep Learning on Understanding Electrolyte and Non-Electrolyte Concepts

The majority of the examined publications demonstrate how deep learning can improve students' comprehension of both electrolyte and non-electrolyte subjects. For instance, the ion dissociation process in electrolytes, which was previously challenging for students to comprehend using traditional approaches, was visualized in a number of studies using deep learning models. Table 2 demonstrates how deep learning approaches enhance comprehension of electrolyte and non-electrolyte ideas, especially in areas that are frequently challenging for students to understand, including molecular interactions in electrolytes or changes in chemical reactions.

Table 2. The impact of deep learning on understanding electrolyte and non-electrolyte concepts

No.	Deep Learning Method	Impact on Understanding	Related Topics
1	Convolutional Neural Networks (CNN)	Enhances understanding of electrolyte molecular structure	Electrolytes
2	Recurrent Neural Networks (RNN)	Clarifies the dynamics of ion concentration changes	Electrolytes
3	Deep Neural Networks (DNN)	Improves understanding of non-electrolyte chemical reactions	Non-electrolytes

Successes and Challenges in the Application of Deep Learning

As part of the discussion, this study also identifies several successes and challenges that arise in the application of deep learning for teaching electrolyte and non-electrolyte topics.

Successes:
a) Enhanced student involvement: Through direct data analysis and simulations, deep learning models increase students' involvement in the learning process.
b) Better data analysis abilities: Students can improve their analytical abilities, especially when it comes to recognizing patterns and trends in chemical experiments involving electrolytes and non-electrolytes.

Challenges:
a) Technological constraints: Some schools lack the infrastructure needed to successfully integrate deep learning in the classroom. Technologies that are necessary, such specialized software and hardware, could become obstacles.
b) Curriculum implementation challenges: It can be difficult to incorporate deep learning into current curricula, particularly when it comes to preparing instructors who need to be knowledgeable about these methods and capable of teaching them.

Practical Implications

Practically speaking, the results of this study may help create a chemistry education program that is technologically advanced and participatory. Teachers can give children richer learning experiences an help them develop the critical thinking abilities required in science and math by incorporating deep learning.

Conclusion

The integration of deep learning with experiential learning approaches greatly improves students' higher-order thinking skills, according to the systematic literature review on The Implementation of Deep Learning Based Experiential Learning in Developing Metacognitive and Critical Thinking Skills of High School Students on Electrolyte and Non-Electrolyte Topics. The results show that this hybrid approach enhances students' metacognitive awareness by encouraging reflection on their learning processes in addition to fostering critical thinking through active involvement and problem-solving. When used in educational settings, deep learning techniques like Convolutional Neural Networks (CNN) and Recurrent Neural Networks (RNN) offer interactive, data-driven experiences that make abstract chemistry concepts like ion dissociation and electrolyte conductivity more concrete and understandable. Additionally, students can immediately relate theoretical knowledge to actual chemical occurrences through experiential learning components, which promotes greater conceptual understanding and long-lasting motivation to learn. The combination of these two methods helps students build information on their own while strengthening their analytical and evaluative thinking abilities. Despite these advantages, challenges remain in terms of infrastructure readiness, teacher competence in applying advanced AI based methods, and curriculum adaptation. Future studies should therefore focus on developing scalable frameworks and digital tools that facilitate the implementation of deep learning-based experiential learning across diverse educational settings.

Additionally, students can immediately relate theoretical knowledge to actual chemical occurrences through experiential learning components, which promotes greater conceptual understanding and long-lasting motivation to learn. The combination of these two methods helps students build information on their own while strengthening their analytical and evaluative thinking abilities. Despite these advantages, challenges remain in terms of infrastructure readiness, teacher competence in applying advanced AI based methods, and curriculum adaptation. Future studies should therefore focus on developing scalable frameworks and digital tools that facilitate the implementation of deep learning-based experiential learning across diverse educational settings.

Recommendations

Based on the findings, several recommendations for future research include:

1) Several suggestions for further study are made in light of the findings, including: The use of deep learning to chemistry subjects other than electrolytes and non-electrolytes, like acid-base chemistry or redox reactions, could be investigated in future studies
2) Creating courses that more thoroughly include deep learning technologies and educating educators to use these tools in the classroom

Scientific Ethics Declaration

* The authors declare that the scientific ethical and legal responsibility of this article published in EPESS journal belongs to the authors.

Conflict of Interest

* The authors declare that they have no conflicts of interest.

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References

Akour, M., Al Sghaier, H., & Al Qasem, O. (2020). The effectiveness of using deep learning algorithms in predicting students' achievements. *Indonesian Journal of Electrical Engineering and Computer Science*, *19*(1), 387–393.

Azzahra, S. F. (2019). Peningkatan kemampuan berfikir kritis siswa melalui pembelajaran eksperimen pada materi larutan elektrolit dan non elektrolit. *EduMatSains: Jurnal Pendidikan Matematika dan Sains*, *4*(1), 77–88.

Bendangnuksung, & Prabu, D. (2018). Students' performance prediction using deep neural network. *International Journal of Applied Engineering Research*, *13*(2), 1171–1176.

Bråten, O. M. H., & Skeie, G. (2020). "Deep learning" in studies of religion and worldviews in Norwegian schools? The implications of the national curriculum renewal in 2020. *Religions*, *11*(11), 579.

Brookhart, S. M. (2010). *How to assess higher-order thinking skills in your classroom*. ASCD.

Debus, B., Bonaccurso, E., Menges, F., Marquardt, M., & Tomaschweski, D. (2021). Deep learning in analytical chemistry. *TrAC Trends in Analytical Chemistry*, *143*, 116402.

Diponegoro, M. H., Prasetyo, H., Hermawan, D., & Sutopo, W. (2021). Implementation of deep learning methods in predicting student performance: A systematic literature review. *Jurnal Nasional Teknik Elektro dan Teknologi Informasi*, *10*(2), 193–202.

Dori, Y. J., Mevarech, Z. R., & Baker, D. R. (2018). Cognition, metacognition, and chemistry education. *Journal of Science Education and Technology*, *27*(3), 194–203.

Gillon, C. J., Lillicrap, T. P., Beaudoin, P., Bengio, Y., Bogacz, R., Christensen, A., & Kording, K. P. (2019). A deep learning framework for neuroscience. *Nature Neuroscience*, *22*(11), 1761–1770.

Hattie, J. A., & Donoghue, G. M. (2016). Learning strategies: A synthesis and conceptual model. *Science of Learning*, *1*(1), 1–13.

Karlık, M., & Karlık, B. (2020). Prediction of student performance with deep neural networks. *International Journal of Artificial Intelligence and Expert Systems*, *9*(2), 39–47.

Kim, B.-H. (2019). Deep learning to predict student outcomes. In *ICLR AI for Social Good Workshop* (pp. 1–5).

Littell, J. H., Corcoran, J., & Pillai, V. (2008). *Systematic review and meta-analysis*. Oxford University Press.

Maulida Zammalatul Azka. (2024). Kemampuan berpikir kritis siswa: Model Problem Based Learning dengan asesmen dinamis berpendekatan pembelajaran berdiferensiasi ditinjau dari kemandirian belajar. *Jurnal Cendekia*, *8*(1), 3255

Mater, A. C., & Coote, M. L. (2019). Deep learning in chemistry. *Journal of Chemical Information and Modeling*, *59*(6), 2545–2559.

Notoatmodjo, S. (2012). *Metodologi penelitian kesehatan*. Rineka Cipta.

Raup, A., Ridwan, W., Khoeriyah, Y., Supiana, S., & Zaqiah, Q. Y. (2022). Deep learning dan penerapannya dalam pembelajaran. *JIIP: Jurnal Ilmiah Ilmu Pendidikan*, *5*(9), 3258–3267.

Rejeki Dwi Astuti, S., Puspita Sari, A. R., Nor Amelia, R., & Karlinda. (2022). Instrumen penilaian terintegrasi: Pengukuran kemampuan berpikir kritis dan keterampilan sains siswa pada materi larutan elektrolit dan nonelektrolit. *Jurnal Tarbiyah*, *29*(1), 1–12.

Sitompul, I., Juana, N. A., Susilawati, & Sitompul, N. H. (2024). Penerapan model deep learning untuk meningkatkan kemampuan konseptual siswa dalam pembelajaran matematika siswa kelas V SDN 014628. *Edu Society: Jurnal Pendidikan, Ilmu Sosial dan Pengabdian pada Masyarakat*, *5*(2), 112–120.

Sultana, J., Rani, M. U., & Farquad, M. A. H. (2019). Student performance prediction using deep learning and data mining methods. *International Journal of Recent Technology and Engineering*, *8*(1S4), 1018–1021.

Susilawati, E., Nuraina, L., & Putri, R. (2020). Analisis tingkat keterampilan berpikir kritis siswa SMA. *Jurnal Pendidikan Fisika dan Teknologi*, *6*(1), 11–21.

Zhou, Q., Huang, Q., & Tian, H. (2013). Developing students' critical thinking skills by task-based learning in chemistry experiment teaching. *Creative Education*, *4*(12A), 40–45

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