Lensa : Jurnal Kependidikan Fisika
Penerbit: Program Studi Pendidikan Fisika IKIP Mataram
e-mail: lensafisika@gmail.com
url: https://e-journal.undikma.ac.id/index.php/Lensa

Dec. 2023. Vol. 11, No. 2
e-ISSN: 2686-0937
p-ISSN: 2338-4417
pp. 89-96

Analysis of Students' Design Thinking in Information Technology Innovation

[a*] Indriaturrahmi, [b] Saiful Prayogi, [b] Muhammad Asy'ari, [c] Taufik Samsuri
[a]Information Technology Education Department; [b]Department of Physics Education; Biology Education Department, Universitas Pendidikan Mandalika, Jl. Pemuda No. 59A Mataram 83125, Indonesia

*Corresponding email: indriaturrahmi@undikma.ac.id

Received: November 2023, Accepted: December 2023, Published: December 2023

Abstract

This study delves into the design thinking characteristics among students in the field of information technology innovation, examining their competencies within the context of the Information Technology Education program at Mandalika University of Education - Indonesia. Employing an exploratory descriptive research design, the research focuses on 30 students, utilizing the Design Thinking Scale to assess six crucial dimensions: comfort with uncertainty and risks, human-centeredness, mindfulness of the process and impacts on others, collaborative work with diversity, orientation to learning by making and testing, and confidence and optimism to use creativity. The findings reveal a comprehensive understanding of the nuanced aspects of students' design thinking capabilities, indicating areas for improvement. Notably, students exhibit discomfort with uncertainty and risks, signaling a need for interventions to enhance resilience and adaptability. Human-centeredness, collaborative work with diversity, and mindfulness to the process receive "Poor" and "Fair" ratings, emphasizing the importance of fostering user-centric approaches and enhancing collaborative competencies. While students demonstrate a moderate level of competency in practical learning and creative application, there is room for improvement in orientation to learning by making and testing and confidence and optimism to use creativity. The overall "Poor" rating for the average design thinking score suggests a collective need for targeted interventions and educational strategies. This study contributes to the ongoing discourse on design thinking in IT education. It offers insights that can inform tailored pedagogical approaches and interventions to enhance students' design thinking capabilities in preparation for the dynamic challenges of the evolving information technology landscape.

Keywords: Design thinking, analysis, information technology, innovation

How to cite: Indriaturrahmi, I., Prayogi, S., Asy'ari, M., & Samsuri, T. (2023). Analysis of Students' Design Thinking in Information Technology Innovation. *Lensa: Jurnal Kependidikan Fisika, 11*(2), 89-96. doi:https://doi.org/10.33394/j-lkf.v11i2.10493

INTRODUCTION

The concept of design thinking has garnered significant attention from both professionals and scholars due to its profound impact on fostering innovation (Kimbell, 2011; Micheli et al., 2019). This approach holds a crucial role in propelling society towards modernization (Li & Zhan, 2022). In the realm of design, design thinking revolves around comprehending design expertise to facilitate the development of students' skills, enabling them to emerge as skilled and exceptional designers (Cross, 2004). Expert designers are renowned for their adeptness in creative problem-solving, serving as valuable sources of innovative insights (Kimbell, 2011).

Design thinking is a way that involves identifying human needs and generating innovative solutions using design principles. Scholars argue that design thinking can be taught and adopted by individuals in various design fields (Micheli et al., 2019), leading to a growing interest in expanding design education (Brenner et al., 2016). Previous research has explored the integration of design thinking in education, highlighting its role in promoting abductive reasoning and its potential as a competitive advantage (Li & Zhan, 2022). Design thinking is recognized as a valuable skill applicable to different domains, including information technology (IT) (Dorst, 2011).

Within the realm of IT education, design thinking has a significant impact on students' ability to create innovative digital products (Chang et al., 2022). Another study (Lin et al., 2020) emphasizes the importance of design thinking in IT courses, demonstrating its effectiveness in achieving curriculum objectives, developing information skills, and enhancing the value of students' digital creations. The development of students' thinking abilities relies on interventions during the learning process (Prayogi et al., 2018; Verawati et al., 2021), such as providing a supportive and motivating learning environment (Papadakis et al., 2020) that is engaging and

interactive (Suhirman & Prayogi, 2023), along with relevant digital resources relevan (Bilad et al., 2022; Verawati et al., 2022). Moreover, presenting students as autonomous learners and employing a digital learning framework through an online system can be a practical solution (Ou et al., 2023; Zhao, 2023).

Design thinking, with its emphasis on human-centric problem-solving, has become integral to innovation across various industries. Its impact on education is particularly noteworthy, as it transforms traditional learning paradigms, encouraging a mindset that seeks to understand and address user needs (Kimbell, 2011). This shift is crucial in preparing students for the complex challenges of the modern world, where adaptability and creative thinking are highly prized skills. As scholars delve into the pedagogical aspects of design thinking, there is a consensus that it can be taught and cultivated, making it an essential component of design education (Micheli et al., 2019). This recognition has led to a surge of interest in expanding design education programs to incorporate design thinking principles, ensuring that future designers are well-equipped to navigate a rapidly evolving landscape (Brenner et al., 2016).

In the realm of information technology (IT) education, the impact of design thinking is palpable. It goes beyond theoretical understanding, influencing students' practical ability to create innovative digital products (Chang et al., 2022). The fusion of design thinking into IT courses has been explored extensively, demonstrating its efficacy in achieving educational objectives and enhancing students' digital creation skills (Lin et al., 2020). This integration is not without its challenges, and the development of students' thinking abilities necessitates strategic interventions during the learning process (Prayogi et al., 2018; Verawati et al., 2021). Creating a supportive and motivating learning environment is paramount, fostering engagement and interaction among students (Papadakis et al., 2020; Suhirman & Prayogi, 2023).

In this dynamic educational landscape, digital resources play a pivotal role. Relevant materials contribute to the effectiveness of design thinking by providing students with the necessary tools and insights (Bilad et al., 2022; Verawati et al., 2022). Additionally, recognizing students as autonomous learners becomes crucial, empowering them to take ownership of their educational journey. Employing a digital learning framework through online systems is identified as a practical solution in this regard, offering flexibility and accessibility (Ou et al., 2023; Zhao, 2023). As the educational community continues to explore the multifaceted implications of design thinking, its integration into IT education stands as a testament to its transformative potential in shaping the skillsets and perspectives of the next generation of professionals.

In the dynamic landscape of IT education, students are not merely consumers of information but active participants who express their imaginative prowess through the creation of digital artifacts, thereby contributing to the cultivation of creative product designs. A robust body of research underscores the positive nexus between the ability to conceive creative designs and the proficiency in design thinking among students (Liu & Li, 2023). Recent scholarly inquiries have delved into the intricate web of factors influencing students' digital creativity within the framework of online courses. The identified determinants, including digital openness, honed digital skills, self-directed learning, and conducive learning environments, collectively serve as catalysts, fostering a positive impact on students' digital creativity (Nguyen et al., 2023). Notably, these factors provide valuable insights into the multifaceted nature of online learning environments and underscore the need for tailored pedagogical approaches that account for the intricacies of the digital realm.

Despite the wealth of research on digital creativity, a noticeable gap exists in the current scholarly discourse, particularly regarding the exploration of design thinking characteristics among information technology students enrolled in online courses focused on creative designs and their subsequent influence on innovation. This void in understanding presents a compelling avenue for further investigation, as it directly pertains to the development of a nuanced understanding of how design thinking unfolds in the context of IT education. To truly nurture design thinking in students, it becomes imperative to establish a pedagogical scaffold that not only facilitates the acquisition of technical knowledge but also empowers students to refine their cognitive skills and actively engage in the iterative process of creating innovative solutions. This study, therefore, seeks to fill this void by rigorously examining the design thinking characteristics exhibited by students in information technology innovation, paving the way for a more comprehensive comprehension of the factors shaping creative outputs in the digital realm.

METHODS

This research employs an exploratory descriptive research design to delve into the intricate landscape of design thinking characteristics among students enrolled in the Information Technology Education study program at Mandalika University of Education - Indonesia. The chosen research design is well-suited for this study as it facilitates a thorough examination of the participants' design thinking competencies within the context of information technology innovation. The participants in this study consist of 30 students, ensuring a diverse and representative sample from the Information Technology Education program. The demographic profile of the participants reveals an age range of approximately 18-19 years, with an equal gender distribution, contributing to a balanced representation of the student population.

To systematically evaluate the students' design thinking competence, this study employs the Design Thinking Scale, a self-perception questionnaire crafted by Ladachart et al. (2022). The scale incorporates six dimensions, each meticulously designed to measure specific aspects of design thinking. These dimensions include (1) comfort with uncertainty and risks, (2) human-centeredness, (3) mindfulness to the process and impacts on others, (4) collaborative work with diversity, (5) orientation to learning by making and testing, and (6) confidence and optimism to use creativity. The questionnaire, comprising thirty items, utilizes a five-point Likert scale for participants to express their perceptions. To ensure the reliability of the scale, Cronbach's α is applied, yielding a commendable value of 0.927. This surpasses the generally accepted threshold of 0.9, underscoring the trustworthiness and consistency of the scale in evaluating the students' design thinking capabilities.

The research data, collected through the Design Thinking Scale, undergoes a meticulous descriptive analysis employing the average score parameter. This analytical approach provides a comprehensive understanding of the nuanced aspects of design thinking exhibited by the participants. The design thinking scores obtained are further categorized into criteria, namely: very good, good, fair, poor, and very poor. This categorization facilitates a nuanced interpretation of individual competencies within the six dimensions of the Design Thinking Scale, offering valuable insights into the students' strengths and areas for potential improvement.

Throughout the entire research process, ethical considerations are of paramount importance. The study adheres strictly to the ethical guidelines set forth by Mandalika University of Education. These guidelines ensure the ethical treatment of participants, emphasizing key principles such as informed consent, confidentiality, and the protection of participants' rights. Adherence to ethical standards is crucial in maintaining the integrity of the research and ensuring the well-being of the students involved in the study.

RESULTS AND DISCUSSION

The research aimed at dissecting the design thinking characteristics among students in the field of information technology innovation has yielded insightful results, which are meticulously presented in Table 1, and descriptive plots are presented in Figure 1.

Table 1. Results of analysis of student design thinking

Design thinking indicators	N	M	SE	SD	Criteria
(1) comfort with uncertainty and risks	30	2.256	0.109	0.598	Poor
(2) human-centeredness	30	2.975	0.131	0.717	Poor
(3) mindfulness to the process and impacts on others	30	3.156	0.147	0.806	Fair
(4) collaborative work with diversity	30	3.080	0.131	0.717	Fair
(5) orientation to learning by making and testing	30	3.042	0.161	0.883	Fair
(6) confidence and optimism to use creativity	30	3.277	0.144	0.787	Fair
Average	30	2.955	0.086	0.472	Poor

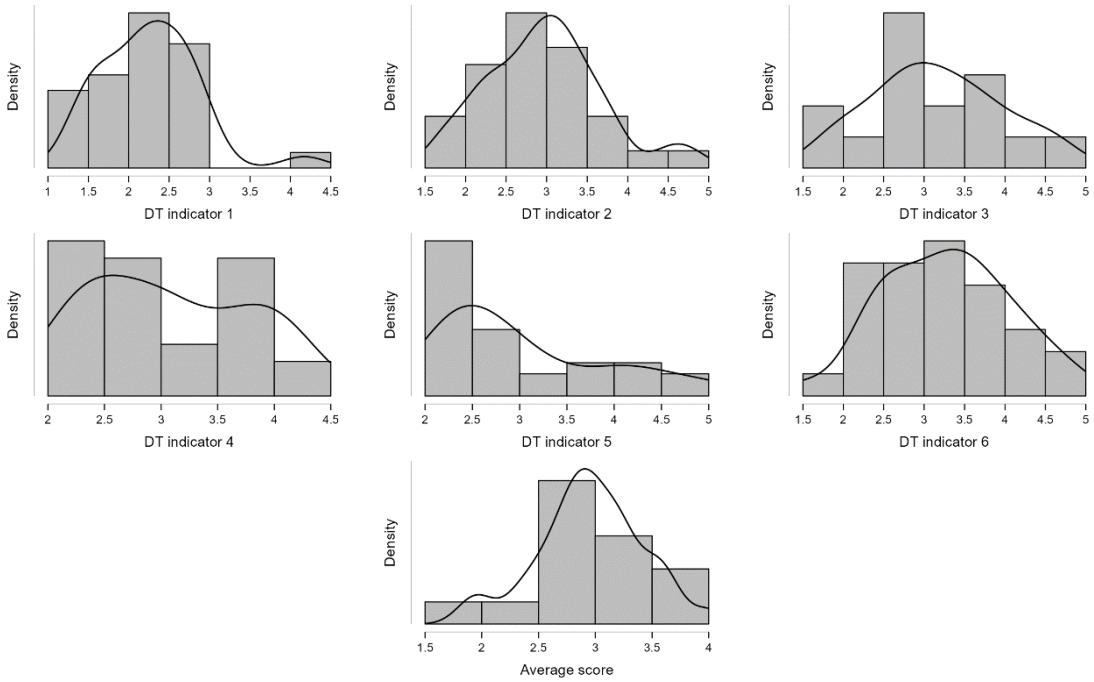

Figure 1. Descriptive plots of students design thinking

The Table 1 encapsulates the outcomes of a descriptive analysis of various design thinking indicators, shedding light on the nuanced dimensions of students' competencies in this critical area. The six design thinking indicators, each addressing distinct facets of the students' abilities, are systematically evaluated across a sample of 30 participants. The first design thinking indicator, focusing on students' comfort with uncertainty and risks, reveals an average score of 2.256. This score categorizes the criterion as "Poor," indicating a notable room for improvement in terms of the participants' ease in dealing with uncertainties and risks. Similarly, the second indicator, human-centeredness, shows an average score of 2.975, placing it in the "Poor" category as well. These findings highlight areas where students may need additional support and development to enhance their comfort with uncertainties and cultivate a more human-centric approach in their design thinking processes.

Moving on to indicators associated with collaborative work and mindfulness to the process, both score in the "Fair" category. Collaborative work with diversity, with an average score of 3.080, suggests a moderate competency level among students in working with diverse teams. The indicator related to mindfulness to the process and impacts on others has an average score of 3.156, also falling within the "Fair" category. This implies that students exhibit a reasonable level of awareness regarding the process and the implications of their design thinking on others, but there is room for improvement. Furthermore, the indicators of orientation to learning by making and testing, as well as confidence and optimism to use creativity, both receive "Fair" ratings with average scores of 3.042 and 3.277, respectively. These findings indicate that while students demonstrate a moderate orientation toward learning through practical application and possess confidence in utilizing creativity, there is still room for improvement in these specific dimensions of design thinking.

The overall average design thinking score, calculated across all indicators, stands at 2.955, classifying the collective performance as "Poor." This comprehensive assessment suggests a need for targeted interventions and educational strategies to enhance students' overall design thinking capabilities in the realm of information technology innovation. The detailed breakdown of scores in Table 1 and Figure 1 provides valuable insights for educators and institutions to tailor their approaches and interventions to address specific areas of improvement among students in the context of design thinking.

The results of this study provide valuable insights into the design thinking characteristics exhibited by students in the field of information technology innovation. The analysis of six design thinking indicators reveals specific areas for improvement and highlights the need for targeted

interventions to enhance students' overall design thinking capabilities. One notable aspect illuminated by the findings is the perceived discomfort with uncertainty and risks among students. This aligns with existing research emphasizing the importance of cultivating resilience and adaptability in dealing with uncertainties, essential for fostering innovation (Kimbell, 2011). Design thinking often involves navigating uncharted territories, making it crucial to address this discomfort to promote a more confident and creative problem-solving approach.

Similarly, the study underscores a potential gap in students' human-centeredness, as reflected in the "Poor" rating for this indicator. This resonates with the literature on design thinking, emphasizing the significance of adopting a user-centric approach (Cross, 2004). To bridge this gap, educators should focus on incorporating pedagogical strategies that promote empathy and user-centric thinking, aligning with the principles of design thinking. The "Fair" ratings for collaborative work with diversity and mindfulness to the process and impacts on others suggest a moderate level of competency among students. This finding aligns with the recognition that collaborative skills are vital in design thinking (Micheli et al., 2019). However, the study emphasizes the need for continued improvement in these areas to enhance the effectiveness of collaborative design thinking processes. The "Fair" ratings for orientation to learning by making and testing and confidence and optimism to use creativity indicate a moderate level of competency in practical learning and creative application. This resonates with the notion that design thinking encourages practical experimentation and creative problem-solving (Dorst, 2011). Targeted interventions in these dimensions can further empower students to apply design thinking principles more robustly in their digital creations.

The overall "Poor" rating for the average design thinking score reinforces the collective need for interventions and educational strategies. This aligns with the consensus in the literature that design thinking can be taught and cultivated, making it an essential component of design education (Micheli et al., 2019). Tailoring educational approaches to address specific areas of improvement in design thinking is crucial for preparing the next generation of IT professionals to navigate the evolving landscape of technology successfully. In conclusion, the research results emphasize the importance of addressing specific aspects of design thinking among information technology students. By drawing on existing literature and related findings, educators and institutions can develop targeted interventions to enhance students' design thinking capabilities. As design thinking remains integral to innovation, addressing these areas of improvement will contribute to better preparing students for the challenges of the rapidly evolving IT landscape (Brenner et al., 2016).

CONCLUSION

In examining students' design thinking within the realm of information technology innovation, this study sheds light on critical areas demanding attention for educational enhancement. The findings underscore a notable discomfort with uncertainty and risks, signaling the need for interventions to foster resilience and adaptability crucial for effective problem-solving and innovation. Furthermore, the identified gap in human-centeredness highlights the importance of incorporating pedagogical strategies that instill empathy and a user-centric approach, aligning with the core tenets of design thinking. While collaborative work and mindfulness to the process show moderate competency, there is room for improvement, emphasizing the ongoing need for effective collaborative design thinking processes. The study advocates for targeted interventions in orientation to learning by making and testing and confidence and optimism to use creativity, aiming to empower students to apply design thinking principles more robustly in their digital creations.

In summary, the overall "Poor" rating for the average design thinking score emphasizes the collective need for interventions and educational strategies. This underscores the teachable nature of design thinking and its crucial role in preparing the next generation of IT professionals. By addressing the identified areas of improvement, educators and institutions can contribute to a more robust integration of design thinking principles in IT education, equipping students with the skills necessary to navigate the rapidly evolving technological landscape successfully.

LIMITATIONS OF THE STUDY

While this study offers valuable insights into students' design thinking characteristics within the realm of information technology innovation, several limitations should be acknowledged. First, the research focused on a specific group of students from the Information Technology Education program at Mandalika University of Education in Indonesia. Generalizing the findings to a broader population may require caution, as the characteristics and experiences of students in different institutions or regions could vary. Second, the study employed a self-perception questionnaire, the Design Thinking Scale, to assess students' design thinking competencies. Self-reported data may be influenced by social desirability bias, where participants provide responses that align with perceived expectations. Additionally, relying solely on self-perception may not capture the holistic nature of design thinking skills, as actual behaviors and outcomes might differ from individual assessments. Third, the study focused on a specific set of design thinking indicators, and while these provided valuable insights, other dimensions of design thinking may exist. Exploring additional facets could contribute to a more comprehensive understanding of students' design thinking abilities.

FUTURE DIRECTIONS

To address the limitations and further advance the understanding of students' design thinking in information technology innovation, future research can adopt a more diverse and expansive approach. Conducting similar studies across various institutions and cultural contexts would enhance the generalizability of findings. Comparative analyses between different educational programs or countries could unveil unique challenges and strengths associated with specific contexts. In terms of methodology, combining self-reported data with objective assessments, such as performance-based tasks or peer evaluations, could provide a more comprehensive and nuanced understanding of students' design thinking abilities. Employing a mixed-methods approach could offer richer insights into the multifaceted nature of design thinking in IT education. Future research endeavors could also explore the longitudinal development of design thinking skills among students, tracking their progression throughout the duration of their academic programs. This longitudinal perspective would offer insights into the effectiveness of educational interventions over time and the enduring impact on students' design thinking capabilities. Lastly, as technology continues to evolve, it would be pertinent to investigate the influence of emerging technologies on design thinking in IT education. Exploring the integration of virtual reality, artificial intelligence, or other cutting-edge tools could provide insights into how technology shapes and interacts with students' design thinking processes, preparing them for the demands of the ever-evolving IT landscape.

ACKNOWLEDGMENT

We sincerely thank Mandalika University of Education - Indonesia for providing the necessary support and resources for this research endeavor. Our appreciation extends to the participating students whose valuable insights and contributions formed the foundation of this study. Additionally, we acknowledge the guidance and expertise of our colleagues and mentors who provided valuable input throughout the research process. This work would not have been possible without the collaborative efforts and commitment of all those involved.

REFERENCES

Bilad, M. R., Anwar, K., & Hayati, S. (2022). Nurturing Prospective STEM Teachers' Critical Thinking Skill through Virtual Simulation-Assisted Remote Inquiry in Fourier Transform Courses. *International Journal of Essential Competencies in Education*, *1*(1), Article 1. https://doi.org/10.36312/ijece.v1i1.728

Brenner, W., Uebernickel, F., & Abrell, T. (2016). Design Thinking as Mindset, Process, and Toolbox. In W. Brenner & F. Uebernickel (Eds.), *Design Thinking for Innovation* (pp. 3–21). Springer International Publishing. https://doi.org/10.1007/978-3-319-26100-3_1

Chang, Y., Kao, J.-Y., & Wang, Y.-Y. (2022). Influences of virtual reality on design creativity and design thinking. *Thinking Skills and Creativity*, *46*, 101127. https://doi.org/10.1016/j.tsc.2022.101127

Cross, N. (2004). Expertise in design: An overview. *Design Studies*, *25*(5), 427–441. https://doi.org/10.1016/j.destud.2004.06.002

Dorst, K. (2011). The core of 'design thinking' and its application. *Design Studies*, *32*(6), 521–532. https://doi.org/10.1016/j.destud.2011.07.006

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to design and evaluate research* (8th ed.). Mc Graw Hill.

Goldman, S., Kabayadondo, Z., Royalty, A., Carroll, M. P., & Roth, B. (2014). Student Teams in Search of Design Thinking. In L. Leifer, H. Plattner, & C. Meinel (Eds.), *Design Thinking Research* (pp. 11–34). Springer International Publishing. https://doi.org/10.1007/978-3-319-01303-9_2

Kimbell, L. (2011). Rethinking Design Thinking: Part I. *Design and Culture*, *3*(3), 285–306. https://doi.org/10.2752/175470811X13071166525216

Ladachart, L., Cholsin, J., Kwanpet, S., Teerapanpong, R., Dessi, A., Phuangsuwan, L., & Phothong, W. (2022). Ninth-grade students' perceptions on the design-thinking mindset in the context of reverse engineering. *International Journal of Technology and Design Education*, *32*(5), 2445–2465. https://doi.org/10.1007/s10798-021-09701-6

Li, T., & Zhan, Z. (2022). A Systematic Review on Design Thinking Integrated Learning in K-12 Education. *Applied Sciences*, *12*(16), 8077. https://doi.org/10.3390/app12168077

Lin, L., Shadiev, R., Hwang, W.-Y., & Shen, S. (2020). From knowledge and skills to digital works: An application of design thinking in the information technology course. *Thinking Skills and Creativity*, *36*, 100646. https://doi.org/10.1016/j.tsc.2020.100646

Liu, S., & Li, C. (2023). Promoting design thinking and creativity by making: A quasi-experiment in the information technology course. *Thinking Skills and Creativity*, *49*, 101335. https://doi.org/10.1016/j.tsc.2023.101335

Micheli, P., Wilner, S. J. S., Bhatti, S. H., Mura, M., & Beverland, M. B. (2019). Doing Design Thinking: Conceptual Review, Synthesis, and Research Agenda: Doing Design Thinking. *Journal of Product Innovation Management*, *36*(2), 124–148. https://doi.org/10.1111/jpim.12466

Nguyen, M.-H., Jin, R., Hoang, G., Nguyen, M.-H. T., Nguyen, P.-L., Le, T.-T., La, V.-P., & Vuong, Q.-H. (2023). Examining contributors to Vietnamese high school students' digital creativity under the serendipity-mindsponge-3D knowledge management framework. *Thinking Skills and Creativity*, *49*, 101350. https://doi.org/10.1016/j.tsc.2023.101350

Noweski, C., Scheer, A., Büttner, N., Von Thienen, J., Erdmann, J., & Meinel, C. (2012). Towards a Paradigm Shift in Education Practice: Developing Twenty-First Century Skills with Design Thinking. In H. Plattner, C. Meinel, & L. Leifer (Eds.), *Design Thinking Research* (pp. 71–94). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-642-31991-4_5

Ou, J., Lin, D., & Zheng, Z. (2023). Comprehensive Evaluation of Online Experimental Teaching Quality in Colleges and Universities Based on Support Vector Machine. *International Journal of Emerging Technologies in Learning (iJET)*, *18*(12), 88–102. https://doi.org/10.3991/ijet.v18i12.39697

Papadakis, S., Trampas, A., Barianos, A., Kalogiannakis, M., & Vidakis, N. (2020). Evaluating the Learning Process: The "ThimelEdu" Educational Game Case Study: *Proceedings of the 12th International Conference on Computer Supported Education*, 290–298. https://doi.org/10.5220/0009379902900298

Prayogi, S., Yuanita, L., & Wasis. (2018). Critical Inquiry Based Learning: A Model of Learning to Promote Critical Thinking Among Prospective Teachers of Physic. *Journal of Turkish Science Education*, *15*(1), Article 1.

Suhirman, & Prayogi, S. (2023). Problem-based learning utilizing assistive virtual simulation in mobile application to improve students' critical thinking skills. *International Journal of Education and Practice*, *11*(3), 351–364. https://doi.org/10.18488/61.v11i3.3380

Tytarenko, I., Pavlenko, I., & Dreval, I. (2023). 3D Modeling of a Virtual Built Environment Using Digital Tools: Kilburun Fortress Case Study. *Applied Sciences*, *13*(3), 1577. https://doi.org/10.3390/app13031577

Verawati, N. N. S. P., Ernita, N., & Prayogi, S. (2022). Enhancing the Reasoning Performance of STEM Students in Modern Physics Courses Using Virtual Simulation in the LMS Platform. *International Journal of Emerging Technologies in Learning (iJET)*, *17*(13), Article 13. https://doi.org/10.3991/ijet.v17i13.31459

Verawati, N. N. S. P., Hikmawati, H., Prayogi, S., & Bilad, M. R. (2021). Reflective Practices in Inquiry Learning: Its Effectiveness in Training Pre-Service Teachers' Critical Thinking Viewed from Cognitive Styles. *Jurnal Pendidikan IPA Indonesia*, *10*(4), Article 4. https://doi.org/10.15294/jpii.v10i4.31814

Verawati, N. N. S. P., Wahyudi, W., & Ayub, S. (2020). Pengaruh Model Pembelajaran Inquiry-Creative-Process (ICP) terhadap Kemampuan Berpikir Kritis Mahasiswa Calon Guru. *Jurnal Penelitian Dan Pengkajian Ilmu Pendidikan: E-Saintika*, *4*(1), 7. https://doi.org/10.36312/e-saintika.v4i1.151

Zhao, L. (2023). Use of a Deep Learning Approach for the Evaluation of Students' Online Learning Cognitive Ability. *International Journal of Emerging Technologies in Learning (iJET)*, *18*(12), 58–74. https://doi.org/10.3991/ijet.v18i12.41093