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## EduPlant: A design thinking-developed educational kit for plant classification to enhance junior high school students' 21<sup>st</sup> century skills

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### ABSTRACT

This study aims to develop and evaluate EduPlant, a design thinking-based educational kit designed to foster 21st century skills within the framework of Education for Sustainable Development (ESD) among junior high school students. The EduPlant features Augmented Reality (AR) plant classification for local plant identification, and herbarium practice through both OLABs and hands-on experiments. The research adopted design thinking as the methodological framework to guide the development process. The development followed the five iterative stages: empathize, define, ideate, prototype and test, incorporating five phases of design thinking into the 4D method. The research was involved 30 students and a supervising teacher as the validator from a public school in Malang, East Java. Instruments included media and material validation sheets and a readability test sheet. Data were analysed descriptively using mean percentage scores and Fleiss' Kappa to assess inter-rater reliability. Results showed media validation at 92,36%, material validation at 90,63%, and readability at 84,88%, with a Fleiss' Kappa value of 0,51, indicating good agreement. These findings demonstrate that EduPlant is feasible and practical for use in ESD-based science learning. The EduPlant kit has been validated as highly feasible in terms of media, material, and readability with Fleiss' Kappa, indicating its readiness for use in junior high school science learning to support design thinking-based education integrated with ESD principles.



## INTRODUCTION

The rapid development of science and technology in the 21st century demands transformation in the education system, especially in the development of learning media that not only convey content but also train essential life skills (Sukmayadi & Yahya, 2020). Technology provides various conveniences in the field of education, but there are still problems in its application. One of them is the gap in access to technology that affects the quality of learning (Sari et al, 2024). Not all learners or educational institutions have adequate facilities to utilize technology optimally. Some students are still unable to use technology wisely, which may reduce their concentration in the learning process (Mali et al, 2023). Based on observations at a public school in Malang, it shows that all classes have not been able to experience technology facilities optimally due to technology limitations and the laboratory. In this context, it is important to balance the use of technology to support learning in accordance with the development in the 21st century (Ramaila & Molwele, 2022).

Education in the 21st century is oriented to train interpersonal, collaborative, and learner-centered skills. 21st century learning is structured to improve knowledge competencies (creative thinking, critical thinking, and problem solving), interpersonal competencies (collaboration, communication, and coordination), and intrapersonal competencies (self-management, cooperation, and the ability to maintain emotional relationships with others) (Lyndgaard & Kanfer, 2024). In addition, the results of in-depth interviews at a public school in Malang reveal that science learning outcomes remain suboptimal due to student passivity and a preference for individual study over collaborative work. These 21st century competencies or skills are one of the keys to realizing the 17 Sustainable Development Goals (SDGs) (Herlinawati et al, 2024). One of the efforts in realizing the SDGs with education is through Education for Sustainable Development (ESD).

Education for Sustainable Development is an important approach to face global challenges in achieving sustainable development (UNESCO, 2017). ESD is expected to realize a generation that has a sustainable mindset by exploring several crucial issues, one of which is biodiversity. In its implementation, ESD can be integrated into the curriculum at all levels and fields of study, one of which is junior high school science material on plant classification (Lei & Tang, 2025). After learning the material, students are expected to be able to actively contribute to efforts to conserve biodiversity through the introduction, identification, and classification of plants around them (Fiel'ardh et al, 2023).

Students are guided not only to observe and identify plant characteristics but also to classify them based on their taxonomy. This classification process allows students to analyze similarities and differences among plant species and understand their ecological roles. Research indicates that integrating "plant thinking" into ESD can encourage plant conservation behavior (Amprazis & Papadopoulou, 2025; Wang & Wang, 2024; Stagg & Dillon, 2023) as well as increase teachers' ecological awareness of plants (Yüksel, 2025). In addition, the STEAM and ESD project in grade 7 has been proven to improve students' awareness and actions toward biodiversity (Hariyono et al, 2024). In response to these technological gaps and the inherent complexity of the subject matter, the development of an AR-integrated educational kit is essential to facilitate a more intuitive understanding of plant diversity. By employing a design thinking approach, this kit is specifically tailored to meet students' cognitive needs in navigating the complexities of plant taxonomy.

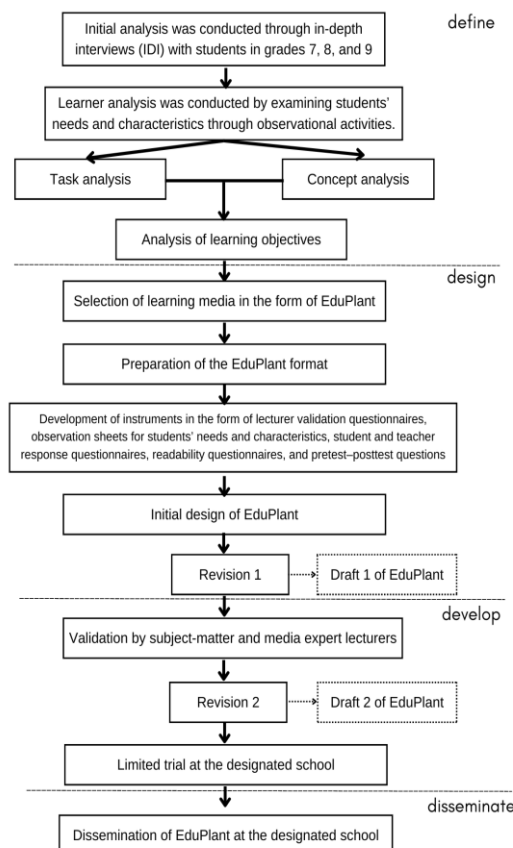
In previous literature, the design thinking approach is considered an effective tool to enhance the teaching and learning process, particularly in developing students' 21st century skills (Razali et al, 2022; Lin et al, 2020). Design thinking-understanding the human needs related to a problem, reframing the problem in human-centric ways, creating many ideas in brainstorming sessions and adopting a hands-on approach to prototyping and testing (Foster, 2021). However, despite its potential, challenges still exist in its implementation by both educators and learners. Therefore, the present study adopts the design thinking framework to guide the development of an educational kit aimed at addressing these challenges. This model is widely applied in STEM

education at the K-12 level and has been shown to enhance collaboration, problem solving, communication, and reflective assessment among students (Hung & Pan, 2025; Li & Zhan, 2022). This kit is a science laboratory equipment packaged in a modular form of a simple integrated instrument box which is versatile and easy to use anytime and anywhere (Yulianti et al, 2021).

In response to this gap, the present study aims to develop an educational kit based on the design thinking approach, integrated with Education for Sustainable Development (ESD) principles. This research proposes EduPlant, an educational kit designed to facilitate plant classification learning while simultaneously cultivating 21st-century skills among lower secondary school students. This development focuses on creating a hands-on learning experience that encourages students to identify environmental and social issues through empathic and iterative problem-solving lenses.

## METHODS

The methodology used in this study is the 4D model (Define, Design, Develop, and Disseminate) developed by (Thiagarajan, 1974). This model consists of systematic stages to produce a learning product that is ready for use. In this study, the 4D model is combined with a design thinking approach. The process of developing an educational kit using the design thinking approach follows the sequence: *empathize* (identifying needs and problems), *define* (formulating the problem), *ideate* (generating creative solutions), *prototype*, and *test* (Thomason & Hsu, 2025). Thus, the use of this research methodology maintains the core characteristics of design thinking while being situated within a structured research and development framework. The methodology research flow is illustrated in Figure 1.



**Figure 1.** The 4D model diagram with a design thinking approach

This study is a development research study conducted at a public school in Malang city. The target participants are 30 students. This study employs design thinking as a human-centered approach and paradigm. This approach ensures that the development process is not only systematic following the stages of empathize, define, ideate, prototype, and test, but also deeply aligned with the actual needs and experiences of the students (Indaryanti et al, 2025). The instruments are the media and material validation sheet and the readability sheet. An expert teacher uses the validation sheet to evaluate the suitability of both media and content. Meanwhile, the readability sheet is used by the 30 students to rate the readability of the materials. The validation results are reported as an average percentage. The readability data are assessed via average percentage and the Fleiss' kappa coefficient to establish the degree of agreement among students (Fleiss et al, 2003).

The prototype was validated and tested using two main instruments: a media and material validation sheet completed by two supervising teachers, and a readability sheet completed by the 30 students to assess the readability and understandability of the materials. The validity of the educational kit was analysed descriptively based on expert evaluations (science teacher) using a Likert scale. The resulting values were interpreted according to the validity categories as shown in Table 1.

**Table 1.** Interpretation validity media and material

No.	Percentage (%)	Category
1	0-20	Very infeasible
2	21-40	Infeasible
3	41-60	Quite feasible
4	61-80	Feasible
5	81-100	Very feasible

The readability data obtained from students were analysed quantitatively using the Fleiss Kappa coefficient to measure the level of agreement among raters. Fleiss Kappa is used to determine the consistency of categorical assessments made by three or more raters. Similarly, the Kappa coefficient is a statistical measure used to evaluate the extent of agreement between two independent raters or more on a categorical variable in the case of a test-retest reliability analysis. Furthermore, the Kappa statistic is employed to measure inter-rater reliability for qualitative data or categorical items (Madadzadeh et al, 2023). The interpretation of Fleiss Kappa values refers to the criteria that Kappa values below 0,40 indicate poor agreement, values between 0,40 and 0,75 reflect good agreement, and values exceeding 0,75 demonstrate excellent reliability (Wang & Yusof, 2025). In general, both classifications suggest that Fleiss Kappa values can be interpreted on a continuum from poor to excellent agreement. Values below 0,40 indicate low or poor reliability, values between approximately 0,40 and 0,75 reflect moderate to good agreement, and values above 0,75 show high or excellent reliability. Meanwhile, Kappa values are classified into six levels of agreement (Table 2).

**Table 2.** Interpretation of Fleiss Kappa (K)

No.	Score	Interpretation
1	< 0,00	No agreement
2	0,01-0,20	Slightly agreement
3	0,21-0,40	Fair agreement
4	0,41-0,60	Moderate agreement
5	0,61-0,80	Substantial agreement
6	0,81-1,00	Almost perfect agreement

(Madadzadeh et al, 2023)

## RESULTS AND DISCUSSION

### Define

The define stage aims to formulate the conceptual and empirical foundation that serves as the basis for the development of EduPlant learning media. This stage integrates the design thinking approach, particularly in the empathize and define phases, which focus on a deep understanding of user needs and the systematic and directed formulation of learning problems. At this stage, a series of analysis activities are carried out, including initial analysis, learner characteristic analysis, task analysis, concept analysis, and learning objectives analysis as a reference in designing relevant and contextual learning media.

The empathy stage was carried out using In-Depth Interview (IDI) techniques to identify and analyze students' needs. The analysis results showed that students still experience limitations in actively participating during the learning process, and the development of higher-order thinking skills in science learning, particularly related to plant classification, is not yet optimal.



**Figure 2.** Result of In-Depth Interview (IDI)

Based on the image above, the results of the interviews using the In-Depth Interview (IDI) technique show that the empathize phase plays an important role in authentically identifying students' learning difficulties and needs, enabling the development of learning media that are more contextual and solution-oriented. This aligns with the design thinking approach, which emphasizes empathy as the foundation for understanding users' real needs through observation and interviews, thereby enabling the development of genuinely user-centered solutions (Albay & Eisma, 2025).

At the define stage, the results indicate that the findings obtained through the In-Depth Interview (IDI) technique during the empathize phase contribute to the formulation of learning objectives based on design thinking. The formulation of these objectives can guide the development of learning media systematically and focused on solving the learning problems experienced by students, thus finding appropriate solutions according to user needs. We found that abstract nature of plant taxonomy and the use of complex Latin nomenclature create significant cognitive barriers in mastering classification materials. Furthermore, students expressed a lack of engagement with existing conventional resources, highlighting an urgent need for interactive learning media.

### Design

The design stage aims to create the EduPlant learning media that integrate into ideate and prototype phase. In the ideate phase, the conceptual framework of EduPlant was systematically aligned with the principles of ESD to foster environmental stewardship alongside botanical mastery. This stage involved brainstorming innovative features that integrate plant classification

with real-world ecological issues, ensuring that the digital content emphasizes the vital role of biodiversity in ecosystem stability. The researcher generated ideas for an educational kit integrated with ESD and design thinking principles for the plant classification topic in science learning as shown in Figure 3. By centering the development on ESD, the learning media does not merely function as a technical aid but as a transformative pedagogical tool designed to cultivate students' sense of responsibility toward a sustainable future into digital learning environments (Huang et al, 2024).

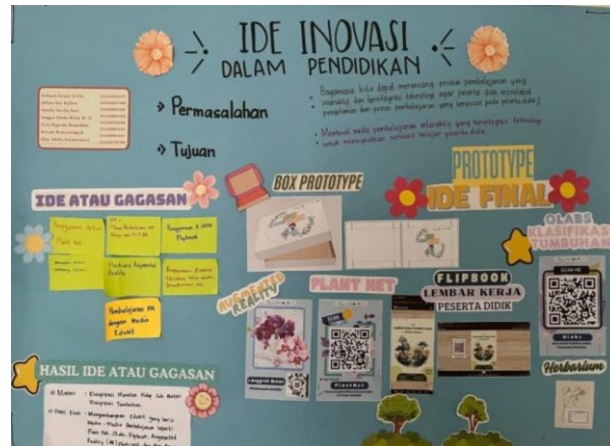


Figure 3. The ideate for an education kit integrated with ESD

A prototype of the educational kit was developed, integrating content on plant classification, sustainable development, and collaborative tasks. The kit is designed to encourage students to explore and conserve plant biodiversity through interactive and hands-on activities. The EduPlant consists of several components: 1) Plant classification cards, 2) Plant identification activity, 3) Herbarium practice which provides both virtual and real experiences, and 4) Experiment guidelines and observation sheets that guide students in classifying plants based on observable characteristics.



Figure 4. The design of the augmented reality plant flashcard

Plant classification cards, each containing a plant photo and QR codes that can be scanned to access additional information about the characteristics of the plant (Figure 4). The first component of the EduPlant features a set of plant classification cards, each displaying a high-resolution photograph alongside a dedicated QR code for enhanced interactivity. These QR codes serve as digital gateways, allowing students to access comprehensive information regarding the specific morphological and biological characteristics of each plant species. By integrating this

technology, the cards facilitate a multi-sensory learning experience that bridges the gap between physical observation and detailed botanical data. This systematic approach encourages students to engage in independent inquiry as they analyze the unique traits necessary for accurate taxonomic grouping. Ultimately, these tools empower learners to develop a more nuanced understanding of plant biodiversity through a seamless blend of visual and digital resources.



**Figure 5.** The design of the Olabs, PlantNet, and Flipbook LKPD flashcard

The second component involves a plant identification activity where students utilize the EduKIT application to identify various flora within their immediate environment (Figure 5). This activity transforms the surrounding ecosystem into a living laboratory, prompting students to engage in active environmental exploration while honing their digital literacy skills. By integrating mobile identification technology, learners can accurately bridge the gap between field observations and scientific nomenclature. This process not only validates their findings in real-time but also cultivates a deeper sense of environmental stewardship through direct interaction with local biodiversity.

Herbarium practice which provides both virtual and real experiences (Figure 6). Students first conduct the herbarium activity virtually using the Olabs, then continue with direct specimen drying and labelling using real materials. This hybrid approach allows students to internalize the systematic procedures of botanical preservation in a controlled digital setting before applying them to tangible biological samples. By integrating these two modes of learning, the activity ensures that students not only master the technical skills required for plant documentation but also appreciate the scientific rigor involved in maintaining long-term biodiversity records.



**Figure 6.** The example of the herbarium for real experience

Experiment guidelines and observation sheets that guide students in classifying plants based on observable characteristics (Figure 7). These structured documents serve as a pedagogical scaffold, ensuring that students follow a systematic inquiry process while documenting their findings accurately. By recording specific traits such as leaf venation, root systems, and floral structures, learners are encouraged to develop sharp analytical skills through comparative observation. Ultimately, this reflective practice reinforces their ability to draw evidence-based conclusions, which is a fundamental competency in scientific literacy.



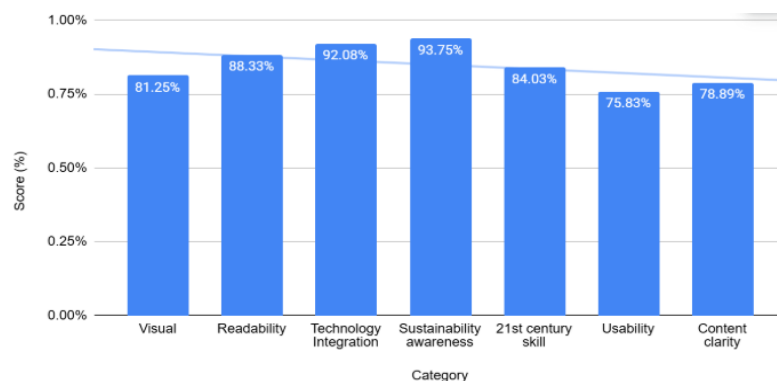
**Figure 7.** The manual book for experiment guidelines and observation

This EduPlant enables students to learn through observation, experimentation, and digital exploration, aligning with 21st century learning principles and ESD. The prototype was then validated by teachers and tested with students to measure its readability and effectiveness. The prototype was validated and tested using two main instruments: a media and material validation sheet completed by two supervising teachers, and a readability sheet completed by the 30 students to assess the readability and understandability of the materials.

### Development

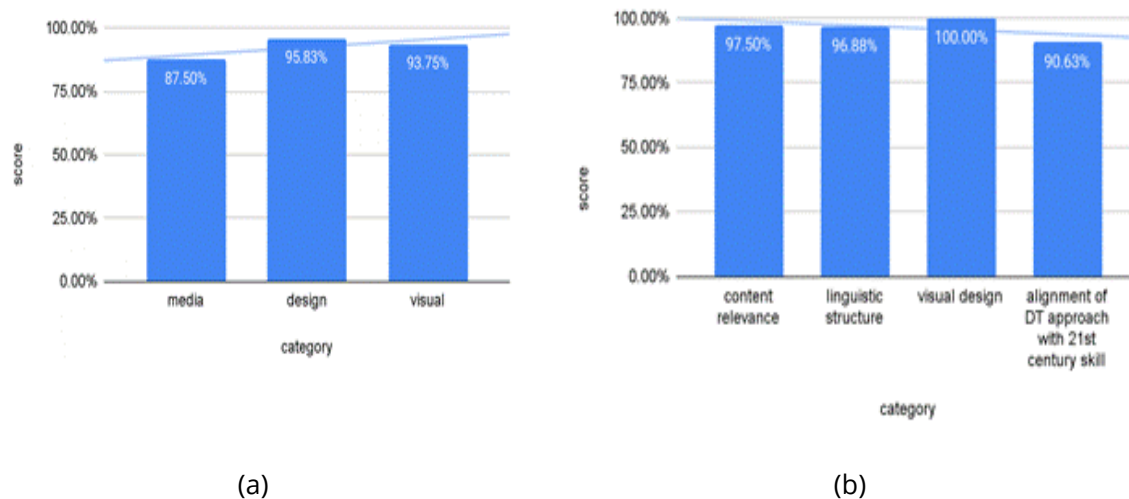
The development stage represents the testing phase of the design thinking approach within the 4D development model. This stage is the product development stage aimed at producing EduPlant that is accurate and systematic according to learning needs. At this stage, the development process is carried out through two main steps, namely validation by expert lecturers in the form of media and material validation, and readability testing on students using Fleiss' Kappa.

The readability test involved 30 lower secondary students using a readability questionnaire. The analysis resulted in an average score of 84,88%, indicating that the EduPlant is categorized as very readable. As shown in Figure 9, the highest score was found in the ESD category (93,75%), followed by technology integration (92,08%) and language (88,33%). Meanwhile, the independence aspect obtained the lowest score (75,83%), suggesting that students may still require teacher guidance when using the kit independently.



**Figure 9.** Result of readability test

The readability data were also analysed using Fleiss' Kappa to measure interrater agreement. The coefficient obtained was 0,51, which, according to the interpretation by Wang & Yusof (2025), indicates a good level of agreement between raters ( $0,40 < K < 0,75 = \text{good}$ ). Media validation was conducted by two expert validators using a media validation sheet that assessed media function, design, and visual presentation. The average score reached 95,14%, categorized as very valid (Figure 2). The design aspect obtained the highest percentage (95,83%), followed by visual (93,75%), and media aspects (87,50%). This suggests that the EduPlant kit design meets the visual and functional standards for interactive learning media.



**Figure 10.** a) Result of media validation, b) Result of material validation

The validation results of the EduPlant media indicate a very high level of feasibility in terms of visual appearance, clarity of content, and ease of use thus confirming that this media is suitable for use in the learning process (Figure 10a). These findings are consistent with the study conducted by Saputri *et al* (2025), which states that interactive learning media with clear visuals and a high level of usability demonstrate strong validity and are able to enhance student engagement and learning efficiency. This alignment suggests that the principles of interactive media development, such as integration of informative visual elements, user friendly navigation, and systematic content presentation, have also been optimally implemented in the EduPlant media. Therefore, EduPlant has the potential to positively impact the quality of learning, particularly in improving 21st century skills.

Material validation was conducted by two science teachers to assess content relevance, linguistic structure, visual design, and alignment of the design thinking approach with 21st century skills. The total average reached 90,63%, indicating that the content is highly valid (Figure 10b). The highest score was achieved in content relevance and visual design (100%), showing that the learning materials are accurate, up to date, and visually supportive of conceptual understanding. The alignment of the design thinking approach scored 92,36% reflecting that the media successfully integrates problem-solving and creativity aspects into the learning process. The final feasibility level shows a validity score of 90,63% with a very feasible category, indicating that development of Eduplant has been aligned with the design thinking stages and is effective in testing 21st century skills. This is in line with Henriksen *et al.* (2020) findings, that systematically designed interactive learning media can enhance active students' engagement. Thus, Eduplant not only meets the criteria for media feasibility but also serves to develop 21st century skills through a design thinking approach.

EduPlant effectively addresses student passivity by transforming traditional science learning into an active, challenge-based experience through the design thinking framework. This approach facilitates a shift from individualistic learning to collaborative exploration, as evidenced by the kit's success in integrating collaborative tasks. Such transformation aligns with Razali *et al* (2022), argue that design thinking is a powerful tool for enhancing learning engagement and nurturing essential 21st century skills. Consequently, the use of this kit not only improves conceptual understanding but also prepares students for sustainable global challenges.

Therefore, based on the results of readability (84.88%), media validation (92.36%), and material validation (90.63%), the EduPlant kit is highly feasible for junior high school science learning. These quantitative results are a direct outcome of the iterative design thinking stages. In the empathize and define stages, the kit was tailored to address the specific passivity and individualistic tendencies observed at a public school in Malang. The ideate stage facilitated the

integration of AR technology to simplify the complex concept of plant classification, which contributed to the high material validation score. Furthermore, during the prototype and test stages, the high readability score (84.88%) and a Fleiss' Kappa value of 0.51 (Good Agreement) confirmed that students could easily interact with the media, effectively shifting their learning from passive to active collaborative. These findings confirm that integrating AR technology within a design thinking framework not only enhances engagement and conceptual understanding but also fosters the collaboration skills necessary for sustainability awareness.

### Disseminate

At the disseminate stage, the EduPlant was disseminated to postgraduate students and several junior high school students in Malang. This dissemination process is essential to ensure the broader adoption and sustainability of educational innovations, as emphasized by (Zatrahadi et al, 2025), who state that knowledge dissemination activities strengthen the scalability, continuity, and long-term integration of educational innovations across educational contexts. Moreover, (Timotheou et al, 2023) argue that the dissemination and integration of technology-integrated learning media contribute to reducing educational disparities and improving instructional quality, particularly in science education.

## CONCLUSION

In conclusion, the EduPlant that developed in this study has demonstrated strong feasibility for implementation in junior high school science learning. The media validation produced an average score of 92,36%, and the material validation yielded 90,63%, indicating that both the media design and the content are highly valid, aligned with pedagogical and technological requirements. Although detailed percentage breakdowns for the readability test were not available, the inter-rater reliability of the readability instrument, expressed by Fleiss' Kappa value of 0,51, falls within the good agreement category ( $0,40 < K < 0,75$ ), confirming that student ratings of readability were consistent and reliable. Together, these findings suggest that the kit is not only visible as valid but also meets the practical requirement of being readable and user-friendly for students. Future research might build on these results by collecting more detailed readability percentage data and exploring the kit's effectiveness in improving learning outcomes and 21st century skills over time.

## REFERENCES

- Albay, E. M., & Eisma, D. V. (2025). Using design thinking for developing pre-service teachers' creativity in designing teaching plans to promote interactive learning in mathematics. *Learning and Instruction*, 96, 102070. <https://doi.org/10.1016/j.learninstruc.2024.102070>
- Amprazis, A., & Papadopoulou, P. (2025). Key competencies in education for sustainable development: A valuable framework for enhancing plant awareness. *Plants People Planet*, 7(4), 1195–1211. <https://doi.org/10.1002/ppp3.10625>
- Fiel'ardh, K., Fardhani, I., & Fujii, H. (2023). Integrating perspectives from education for sustainable development to foster plant awareness among trainee science teachers: A mixed methods study. *Sustainability*, 15(9). <https://doi.org/10.3390/su15097395>
- Fleiss, J. L., Levin, B., & Paik, M. C. (2003). *Statistical methods for rates and proportions* (3rd ed.). Hoboken, NJ: Wiley.
- Foster, M. K. (2021). Design thinking: A creative approach to problem solving. *Management Teaching Review*, 6(2), 123–140. <https://doi.org/10.1177/2379298119871468>
- Hariyono, E., Setiawan, B., Perwitasari, S. I., Susantini, E., Kaniawati, I., & Ishak, A. (2024). The sustainability awareness of students on ecological and biodiversity learning with STEAM project integrated ESD. *AIP Conference Proceedings*, 3116(1). <https://doi.org/10.1063/5.0210455>

- Henriksen, D., Gretter, S., & Richardson, C. (2020). Design thinking and the practicing teacher: addressing problems of practice in teacher education. *Teaching Education*, 31(2), 209–229. <https://doi.org/10.1080/10476210.2018.1531841>
- Herlinawati, H., Suryana, A., & Rahayu, S. (2024). The integration of 21st century skills in the curriculum: A systematic review. *Heliyon*, 10(1), e111796. <https://doi.org/10.1016/j.heliyon.2024.e111796>
- Huang, R., Tlili, A., Chang, T.-W., Zhang, X., Nascimbeni, F., Burgos, D., & Yang, J. (2024). Digital pedagogy for sustainable education transformation. *Frontiers of Digital Education*, 1, 31. <https://doi.org/10.1007/s44366-024-0031-x>
- Hung, L. C., & Pan, H. J. (2025). Innovative approach to ESD integration into school-based curriculum development modules for elementary schools. *Sustainability (Switzerland)*, 17(4), 1–26. <https://doi.org/10.3390/su17041427>
- Indaryanti, R. B., Murtiyasa, B., & Soemardjoko, B. (2025). 4D research and development model: Trends, challenges, and opportunities review. *Jurnal Kajian Ilmiah*, 25(1), 1410–9794. <http://ejurnal.ubharajaya.ac.id/index.php/JKI>
- Lei, CU., & Tang, S. An analysis of Hong Kong high school curriculum with implications for United Nations sustainable development goals. *Smart Learning Environments* 10, 47 (2023). <https://doi.org/10.1186/s40561-023-00267-5>
- Li, T., & Zhan, Z. (2022). A systematic review on design thinking integrated learning in K-12 education. *Applied Sciences*, 12(16), 1–34. <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 instruction of traditional subjects to cultivate students' 21st century skills. *Computers & Education*, 146, 103732. <https://doi.org/10.1016/j.compedu.2019.103732>
- Lyndgaard, S. F., & Kanfer, R. (2024). Interpersonal, intrapersonal, and cognitive tactics: A thematic analysis of adults' 21st century learning management. *Journal of the Learning Sciences*, 33(1), 175–211. <https://doi.org/10.1080/10508406.2024.2303777>
- Madadzadeh, F., Ghafari, H., & Bahariniya, S. (2023). The open public health journal kappa statistics: A method of measuring agreement in dental examinations. *The Open Public Health Journal*, 16, 1–6. <https://openpublichealthjournal.com/VOLUME/16/ELOCATOR/e18749445259818/FULLTEXT/>
- Mali, Y. C. G., Kurniawan, D., Januardi, J. I., Swara, S. J., Lokollo, N. C. E., Picauly, I. A., Paramitha, N. G., Tanore, J. A., Dewani, M. S., & Pakiding, R. W. (2023). Issues and challenges of technology use in Indonesian schools: Implications for teaching and learning. *IJJET (International Journal of Indonesian Education and Teaching)*, 7(2), 221–233. <https://doi.org/10.24071/ijjet.v7i2.6310>
- Rahman, R., Zaki, A., & Pratama, Y. A. (2025). The effect of project-based learning on 21st century skills in middle school students Indonesia. *Lingeduca: Journal of Language and Education Studies*, 4 (1), 17-23. <https://doi.org/10.70177/lingeduca.v4i1.2125>
- Ramaila, S., & Molwele, A. J. (2022). The role of technology integration in the development of 21st century skills and competencies in life sciences teaching and learning. *International Journal of Higher Education*, 11(5), 9. <https://doi.org/10.5430/ijhe.v11n5p9>
- Razali, N. H., Ali, N. N. N., Safiyuddin, S. K., & Khalid, F. (2022). Design thinking approaches in education and their challenges: A systematic literature review. *Creative Education*, 13(07), 2289–2299. <https://doi.org/10.4236/ce.2022.137145>
- Saputri, R. P., Suryadi, A., & Hidayat, A. (2025). Impact of interactive media utilization on enhancing learning outcomes: Meta-analysis. *Jurnal Penelitian Pendidikan IPA*, 11(3), 40–49. <https://doi.org/10.29303/jppipa.v11i3.10438>
- Sari, G. I., Winasis, S., Pratiwi, I., Wildan Nuryanto, U., & Basrowi. (2024). Strengthening digital literacy in Indonesia: Collaboration, innovation, and sustainability education. *Social Sciences & Humanities Open*, 10, 101100. <https://doi.org/10.1016/j.ssaho.2024.101100>

- Stagg, B. C., & Dillon, J. (2023). Plants, education and sustainability: Rethinking the teaching of botany in school science. *Journal of Biological Education*, 57(5), 941–943. <https://doi.org/10.1080/00219266.2023.2264617>
- Sukmayadi, V., & Yahya, A. H. (2020). Indonesian education landscape and the 21 st century challenges. *Journal of Social Studies Education Research Sosial Bilgiler Eğitimi Araştırmaları Dergisi*, 2020(4), 219–234. [www.jsser.org](http://www.jsser.org)
- Thiagarajan, S. (1974). *Instructional Development for Training Teachers of Exceptional Children: A Sourcebook*. Indiana University.
- Thomason, D., & Hsu, P. L. (2025). The effect of a STEM integrated curriculum on design thinking dispositions in middle school students. *International Journal of Technology and Design Education*, 35(1), 83–121. <https://doi.org/10.1007/s10798-024-09894-6>
- Timotheou, S., Miliou, O., Dimitriadis, Y., Sobrino, S. V., Giannoutsou, N., Cachia, R., Monés, A. M., & Ioannou, A. (2023). Impacts of digital technologies on education and factors influencing schools' digital capacity and transformation: A literature review. *Education and Information Technologies*, 28(6), 6695–6726. <https://doi.org/10.1007/s10639-022-11431-8>
- UNESCO. (2017). Education for Sustainable Development Goals: learning objectives. In *Education for Sustainable Development Goals: learning objectives*. <https://doi.org/10.54675/cgba9153>
- Wang, H. H., & Wang, C. H. A. (2024). Teaching design students machine learning to enhance motivation for learning computational thinking skills. *Acta Psychologica*, 251, 104619. <https://doi.org/10.1016/j.actpsy.2024.104619>
- Wang, Y., & Yusof, I. J. (2025). Expert consensus and reliability validation of the portfolio assessment guideline for Chinese practical writing: An empirical study based on fleiss' kappa. *BenchCouncil Transactions on Benchmarks, Standards and Evaluations*, 100248. <https://doi.org/10.1016/j.tbench.2025.100248>
- Yüksel, A. O. (2025). Design-based STEM activities in teacher education and its effect on pre-service science teachers' design thinking skills. *Journal of Science Education and Technology*, 34(4), 904–918. <https://doi.org/10.1007/s10956-025-10215-2>
- Yulianti, E., Maharani, D. W., & Hamimi, E. (2021). Integrated science education mobile application: Edukit for 21st century students. *SEJ (Science Education Journal)*, 5(1). <https://doi.org/10.21070/sej.v5i1.1091>
- Zatrahadi, M. F., Bah, Y. M., Istiqomah, I., Gassama, S., Magistarina, E., Aden, E. bin, Juwara, K., Emovwodo, S. O., & Badjie, H. (2025). Mapping educational innovation and knowledge dissemination: a global bibliometric study. *JPPI (Jurnal Penelitian Pendidikan Indonesia)*, 11(1), 1–14. <https://doi.org/10.29210/020255620>

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### Authors' Note

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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