



Validity of an Interactive STEM-Based E-Book on Science Material to Train Students Digital Literacy Skills

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DOI: <https://doi.org/10.29303/goescienceed.v7i3.2545>

Article Info:

Received : May, 28 2026
Revised : June, 16 2026
Accepted : June, 27 2026
Published : July, 17 2026

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Abstract: Digital technology development requires prospective elementary school teachers to possess adequate digital literacy competencies to design twenty-first-century learning effectively. One learning medium that can facilitate this competency is an interactive electronic book integrating Science, Technology, Engineering, and Mathematics (STEM). This study aimed to describe the validity of a STEM-based interactive e-book on science learning designed to foster digital literacy skills among undergraduate students. The study employed a Research and Development (R&D) approach using the Four-D (4D) development model consisting of Define, Design, Develop, and Disseminate stages. This article focuses on the Develop stage, particularly expert validation. Validation data were collected using material and media validation sheets with a four-point rating scale. Data were analyzed descriptively by calculating the average score for each validation aspect. The results indicated that the interactive e-book achieved an average score of 3.89 from the material expert, categorized as very valid, while the media expert evaluation resulted in an average score of 3.44, also categorized as very valid. The highest scores were obtained in material suitability, completeness, and language quality, while the media aspects demonstrated excellent visual design, interactivity, usability, and STEM integration. Therefore, the developed STEM-based interactive e-book is considered feasible for use as a learning medium to foster digital literacy skills among prospective elementary school teachers.

Keywords: Interactive E-Book; STEM; Science Education; Digital Literacy; Validity

Citation: Shiyamsyah, F. S. F., Sabar, & Pradiarti, R. A. (2026). Validity of an Interactive STEM-Based E-Book on Science Material to Train Students Digital Literacy Skills. *Jurnal Pendidikan, Sains, Geologi, Dan Geofisika (GeoScienceEd Journal)*, 7(3), 3756–3760. <https://doi.org/10.29303/goescienceed.v7i3.2545>

Introduction

Digital transformation has shifted the paradigm of higher education from lecturer-centered to student-centered learning by utilizing digital technology as an integral part of the learning process. This shift requires higher education institutions to develop learning innovations that integrate technology, pedagogy, and content so that students acquire twenty-first-century competencies relevant to the needs of the workforce and the digital society (Fernandez-Otoya et al., 2024; Rahmawati et al., 2024).

One important competency that students must possess in the era of digital transformation is digital

literacy. Digital literacy is no longer limited to the ability to operate technological devices, but also includes the ability to access, evaluate, manage, create, and communicate digital information critically, ethically, and responsibly. Bibliometric studies show that research on digital literacy has increased significantly over the past decade and has become one of the main focuses of educational research because it is directly related to learning quality and graduates' readiness to face the digital era (Oktarina et al., 2025; Wu et al., 2025).

Strengthening digital literacy is becoming increasingly important for students in the Elementary School Teacher Education Program because they are

prospective educators who will facilitate technology-based learning in elementary schools. A prospective teacher is not only required to be able to use digital technology, but also to be able to select credible information sources, evaluate the validity of information, develop digital learning media, and utilize technology pedagogically to improve learning quality (Fernandez-Otoya et al., 2024; Rahmawati et al., 2024).

Nevertheless, various studies show that the digital literacy competence of both students and teachers still faces various challenges, particularly in the aspects of evaluating digital information, integrating technology into learning, and developing innovative digital media. This condition indicates that the development of digital literacy needs to be facilitated through authentic learning experiences using interactive and contextual digital learning media (Reddy et al., 2023; Gokdaş et al., 2024).

In science (IPA) learning, the use of digital media is very important because most science concepts are abstract and require good visualization to be easily understood. Presenting material through a combination of text, illustrations, videos, animations, simulations, and interactive activities can help students build conceptual understanding more meaningfully than conventional teaching materials. Therefore, the development of digital teaching materials is one of the strategies widely recommended in twenty-first-century science learning (Shiyamsyah & Yuliani, 2022).

One form of digital teaching material that is developing rapidly is the interactive e-book. Interactive e-books not only present material in text form, but also integrate multimedia, instructional videos, animations, interactive quizzes, hyperlinks, and digital activities that can increase student engagement during the learning process. These characteristics allow students to gain a more active, flexible, and independent learning experience, thereby contributing to increased learning motivation and digital competence (Shiyamsyah & Yuliani, 2022). A study conducted by Shiyamsyah and Yuliani (2022) showed that an interactive e-book on cellular respiration material achieved a very valid category and was able to train students' digital literacy skills through activities of accessing digital information, evaluating information sources, utilizing various digital media, and producing simple digital products.

In addition to the use of digital media, twenty-first-century learning also demands the application of learning approaches capable of integrating various disciplines in solving real problems. One widely recommended approach is Science, Technology, Engineering, and Mathematics (STEM). The STEM approach can improve critical thinking skills, creativity, collaboration, communication, and problem-solving abilities through contextual, project-based learning

(Jones et al., 2025; Nuryadin et al., 2024). Integrating STEM into interactive e-books provides broader opportunities for students to develop digital literacy through activities of digital information exploration, scientific investigation, engineering-design-based problem solving, technology utilization, and reflection on the learning process. Thus, students not only gain an understanding of science concepts, but also develop the ability to use technology effectively in solving various learning problems (Fernandez-Otoya et al., 2024; Ramli & Arsad, 2023).

Based on these conditions, this study developed a STEM-based interactive e-book on science material designed to train the digital literacy skills of PGSD students. The novelty of this study lies in the integration of STEM activities with digital literacy indicators within a single digital learning medium that was systematically developed and validated by experts prior to implementation. Therefore, this study aims to describe the validity of the STEM-based interactive e-book on science material as a learning medium feasible for use in training students' digital literacy skills.

Method

This study is a Research and Development (R&D) study using the Four-D (4D) model developed by Thiagarajan et al. (1974), comprising the define, design, develop, and disseminate stages. This study focuses on the develop stage, namely testing the validity of the STEM-based interactive e-book on science material to train the digital literacy skills of students in the Elementary School Teacher Education Program (PGSD).

Product validation was carried out by two validators, namely one material expert and one media expert. The aspects assessed by the material expert included material suitability, material completeness, STEM integration, digital literacy integration, and language quality. Meanwhile, the media expert assessed the aspects of visual appearance, interactivity, ease of use, language quality, and conformity with the STEM approach. Research data were obtained through validation sheets using a four-level Likert scale, namely 1 (invalid), 2 (fairly valid), 3 (valid), and 4 (very valid). Data were analyzed descriptively and quantitatively by calculating the average score of each aspect using the formula:

$$\bar{X} = \frac{\sum X}{N}$$

where X is the average validity score, $\sum X$ is the total score obtained, and N is the number of assessment indicators. The average score was then interpreted based on validity criteria adapted from Riduwan (2015): 3.26–

4.00 very valid; 2.51–3.25 valid; 1.76–2.50 fairly valid; and 1.00–1.75 invalid.

Result and Discussion

The development (develop) stage produced a STEM-based interactive e-book on science material designed to train the digital literacy skills of PGSD students. Before implementation, the product was validated by a material expert and a media expert to determine its feasibility based on content, presentation, language, appearance, interactivity, and conformity with the STEM approach. Validation was carried out using a four-level Likert rating scale.

Material validation was conducted by assessing five aspects, namely material suitability, material completeness, STEM relevance, digital literacy, and language quality. The validation results are presented in Table 1.

Table 1. Material Expert Validation Results

Aspect	Average	Category
Material suitability	4.00	Very Valid
Material completeness	4.00	Very Valid
STEM relevance	3.75	Very Valid
Digital literacy	3.75	Very Valid
Language quality	4.00	Very Valid
Overall average	3.89	Very Valid

Based on Table 1, the interactive e-book achieved an average score of 3.89, categorized as very valid, and was therefore declared feasible for use without revision. The material suitability aspect achieved the maximum score (4.00). This result indicates that the material presented is aligned with the learning outcomes of the science course, the concepts presented are scientifically accurate, and the examples used are relevant to the learning context of prospective elementary school teachers.

The material completeness aspect also achieved a score of 4.00. The validator assessed that the e-book contained complete learning components, including learning objectives, material description, contextual examples, learning activities, exercises, and summaries. The systematic presentation of material allows students to learn concepts gradually and supports independent learning.

For the STEM relevance aspect, an average score of 3.75 was obtained. This result shows that Science, Technology, Engineering, and Mathematics activities have been well integrated into each learning activity. Students not only learn science concepts but are also

directed to utilize digital technology, solve problems through simple engineering activities, and apply mathematical concepts as part of the scientific thinking process.

The digital literacy aspect obtained an average score of 3.75. This assessment was based on the presence of activities training Access, Analyze, Content Creation, and Reflect abilities. The validator gave a very valid rating to the Content Creation and Reflect indicators, while the Access and Analyze indicators received a valid category.

For the language aspect, all indicators received a very valid category with an average score of 4.00. The language used was assessed as communicative, using scientific terms appropriately, and conforming to proper Indonesian language rules, making it easy for students to understand.

Media validation was carried out on five aspects, namely visual appearance, interactivity, ease of use, language feasibility, and STEM alignment. The validation results are presented in Table 2.

Table 2. Media Expert Validation Results

Aspect	Average	Category
Visual appearance	3.80	Very Valid
Interactivity	3.40	Valid
Ease of use	3.50	Very Valid
Language feasibility	3.00	Valid
STEM alignment	3.00	Valid
Overall average	3.44	Very Valid

The media validation results show that the e-book achieved an average score of 3.44, categorized as very valid. The media was therefore declared feasible for use as a digital learning medium. The visual appearance aspect obtained the highest score, 3.80, indicating that the cover design, layout, color selection, font type, and illustrations met the design principles of learning media.

For the interactivity aspect, a score of 3.40 was obtained, categorized as valid. The hyperlink feature linking to external sources and the use of videos or animations received a very valid category, while the navigation function, interactive quizzes, and feature responsiveness received a valid category.

The ease of use aspect achieved a score of 3.50, categorized as very valid. The validator assessed that the e-book interface was easy to understand, usage instructions were presented clearly, and the medium could be accessed through various digital devices. For the language feasibility and STEM alignment aspects, each obtained a score of 3.00, categorized as valid,

indicating room for strengthening term consistency and enriching engineering-design activities in further development.

The findings show that the STEM-based interactive e-book on science material achieved a very valid category from both the material expert (3.89) and the media expert (3.44). This finding reinforces the results of Shiyamsyah and Yuliani (2022), who similarly demonstrated that an interactive e-book on science material can achieve a very valid category and effectively train students' digital literacy skills through activities of accessing, evaluating, and creating digital products. The consistency of findings across two different learning contexts – high school students and PGSD students – indicates that the interactive e-book is an adaptive learning medium that can be applied across various levels of education to support the strengthening of digital literacy.

The maximum scores on the material suitability and completeness aspects (4.00) indicate that the science content presented in the e-book is aligned with the learning outcomes and free from scientific misconceptions. This is consistent with the view of Rahmawati, Abdullah, and Widiaty (2024), who emphasized that the quality of digital content largely determines the effectiveness of strengthening digital literacy among teachers and prospective teachers. Similarly, Fernandez-Otoya et al. (2024), in their systematic review, concluded that elementary school teachers' digital literacy competence cannot be separated from mastery of credible and well-structured learning content.

The STEM relevance aspect, which obtained a score of 3.75, shows that the integration of Science, Technology, Engineering, and Mathematics in the e-book has worked well, although there remains room to strengthen engineering-design activities. This result is relevant to the findings of Jones et al. (2025), who emphasized that authentic STEM learning needs to provide space for students to design, test, and revise solutions to real problems. Similarly, Nuryadin et al. (2024) found that self-regulated learning is one of the important outcomes in STEM-based learning. Strengthening the engineering element in further development of this e-book aligns with the recommendation of Ramli and Arsad (2023) that technology integration in post-pandemic STEM learning needs to be accompanied by concrete technology-based problem-solving activities.

In the digital literacy aspect, the Content Creation and Reflect indicators achieved a very valid category, while the Access and Analyze indicators achieved a valid category. This finding is consistent with the bibliometric studies of Oktarina et al. (2025) and Wu et al. (2025), which reported that the ability to evaluate and

critically analyze digital information is the digital literacy dimension most frequently identified as still weak across various levels of education. Reddy, Chaudhary, and Hussein (2023) likewise emphasized that the digital literacy skills gap generally lies in the ability to evaluate the credibility and relevance of information, rather than in technical device-operation skills.

The media validation results show that the visual appearance aspect obtained the highest score (3.80), while the language feasibility and STEM alignment aspects obtained the lowest scores (3.00). An attractive visual appearance plays an important role in increasing students' motivation and attention, as emphasized by Reddy et al. (2023), who noted that ergonomic digital media design influences the level of user engagement in digital literacy activities. The slightly lower interactivity score (3.40) is relevant to the findings of Zhang and Zhang (2024), who showed that leveraging intelligent technology, including adaptive features and automated feedback, can enrich the interactivity of digital learning media.

Overall, the validation results from both the material expert and the media expert demonstrate that the STEM-based interactive e-book on science material is feasible for use as a learning medium to train the digital literacy skills of PGSD students. This finding reinforces the urgency of developing digital learning media that explicitly integrate the STEM approach with digital literacy indicators, as recommended by Fernandez-Otoya et al. (2024) and Rahmawati et al. (2024). Thus, this e-book has the potential not only to improve students' understanding of science concepts but also to equip PGSD students with relevant digital literacy competencies to be applied in their future teaching practice in elementary schools.

Conclusion

Based on the research results and discussion, it can be concluded that the STEM-based interactive e-book on science material is categorized as very valid as a learning medium to train the digital literacy skills of PGSD students, with an average material-expert validation score of 3.89 and an average media-expert validation score of 3.44. This feasibility is supported by the suitability and completeness of the material, good STEM integration, facilitation of digital literacy indicators (Access, Analyze, Content Creation, and Reflect), attractive visual appearance, and ease of use of the medium. These results indicate that the STEM-based interactive e-book is feasible for use in science learning to support the strengthening of digital literacy competence among prospective elementary school teachers. Further research is recommended to proceed to the disseminate stage to test the effectiveness and

practicality of the e-book on a wider scale of use, as well as to strengthen engineering-design activities to optimize STEM integration.

Acknowledgements

The authors would like to thank the Elementary School Teacher Education Program, Universitas Sunan Gresik, as well as the material and media expert validators for their input and assessment provided throughout the product validation process of this study.

References

- Bravo, J., Alcázar-Holguin, M. A., & Vilca-Rodríguez, M. (2024). Digital and information literacy in basic-education teachers: A systematic literature review. *Education Sciences*, 14(2), 127. <https://doi.org/10.3390/educsci14020127>
- Jones, M., Geiger, V., Falloon, G., Fraser, S., Beswick, K., Holland-Twining, B., & Hatisaru, V. (2025). Learning contexts and visions for STEM in schools. *International Journal of Science Education*, 47(4), 337–357. <https://doi.org/10.1080/09500693.2024.2323032>
- Nuryadin, A., Lidinillah, D. A. M., Prehanto, A., Maesaroh, S. S., Putri, I. R., & Desmawati, S. A. (2024). Self-regulated learning in STEM education: A bibliometric mapping analysis of research using Scopus database. *International Journal of Education in Mathematics, Science and Technology*, 12(4), 919–941.
- Oktarina, A. D., Hamdi, S., Wijaya, A., Zafrullah, Z., & Rashid, S. (2025). Research trends on the implementation of digital literacy in education: A bibliometric analysis of the Scopus database. *Indonesian Journal on Learning and Advanced Education*, 7(3), 481–502. <https://doi.org/10.23917/ijolae.v7i3.11087>
- Rahmawati, S., Abdullah, A. G., & Widiaty, I. (2024). Teachers' digital literacy overview in secondary school. *International Journal of Evaluation and Research in Education*, 13(1), 1–10. <https://doi.org/10.11591/ijere.v13i1.25747>
- Ramli, F. N. A., & Arsad, N. M. (2023). STEM teacher digital literacy: Relationship between digital literacy and technology integration in teaching and learning post COVID-19. *Journal of Nusantara Studies*, 8(2), 316–333. <https://doi.org/10.24200/jonus.vol8iss2pp316-333>
- Reddy, P., Chaudhary, K., & Hussein, S. (2023). A digital literacy model to narrow the digital literacy skills gap. *Heliyon*, 9(4), e14878. <https://doi.org/10.1016/j.heliyon.2023.e14878>
- Riduwan. (2015). *Skala Pengukuran Variabel-Variabel Penelitian* [Measurement scale of research variables]. Alfabeta.
- Shiyamsyah, F. S. F., & Yuliani. (2022). Pengembangan e-book interaktif pada materi respirasi seluler untuk melatih kemampuan literasi digital siswa SMA kelas XII [Development of an interactive e-book on cellular respiration to train the digital literacy skills of twelfth-grade high school students]. *Berkala Ilmiah Pendidikan Biologi (BioEdu)*, 11(2), 492–501. <https://doi.org/10.26740/bioedu.v11n2.p492-501>
- Thiagarajan, S., Semmel, D. S., & Semmel, M. I. (1974). *Instructional Development for Training Teachers of Exceptional Children: A Sourcebook*. Leadership Training Institute/Special Education, University of Minnesota.
- Wu, D., Sukumaran, S., Zhi, X., Zhou, W., Li, L., & You, H. (2025). Categories, themes and research evolution of the study of digital literacy: A bibliometric analysis. *Education and Information Technologies*, 30(4), 4907–4931. <https://doi.org/10.1007/s10639-024-12955-x>
- Zhang, J., & Zhang, Z. (2024). AI in teacher education: Unlocking new dimensions in teaching support, inclusive learning, and digital literacy. *Journal of Computer Assisted Learning*, 40(4), 1871–1885. <https://doi.org/10.1111/jcal.12988>