Jurnal Ilmiah Profesi Pendidikan
Volume 9, Nomor 4, November 2024
ISSN (Print): 2502-7069; ISSN (*Online*): 2620-8326

STEM Module Validation: Enhancing Physics Knowledge in Prospective Teacher Education

Ibrahim[1]*, Bahtiar[2], Maimun[2], Asri Fauzi[1]
[1]Universitas Mataram, Indonesia
[2]Universitas Islam Negeri Mataram, Indonesia
*Corresponding Author: ibrahim14@unram.ac.id

Article History
Received : September 06th, 2024
Revised : Oktober 17th, 2024
Accepted : November 15th, 2024

Abstract: This research aims to develop and evaluate the validity of a STEM-based learning module designed to improve understanding of physics concepts for prospective teachers. This module includes various physics materials that are integrated with the STEM (Science, Technology, Engineering and Mathematics) approach and is designed to be implemented in the classroom learning process. Module validation was carried out by five experts who assessed four main aspects: accuracy of material, clarity of presentation, integration of STEM approaches, and suitability to learning objectives. The results of the analysis using Aiken's V show that this module has good validity, with the accuracy of the material getting the highest score of 0.85, followed by clarity of presentation and integration of the STEM approach which each got a score of 0.75, and suitability with learning objectives which got a score of 0.7. Based on these results, it can be concluded that this module is ready to be implemented in learning and has the potential to effectively improve prospective teachers' understanding of physics concepts.

Keywords: conceptual understanding; Learning modules; STEM; teacher candidate

INTRODUCTION

Physics education is one of the main pillars in the development of science and technology, which has an important role in preparing future generations to face global challenges (Nowotny et al., 2018; Jauhariyah et al, 2021). However, a deep understanding of physics concepts is often a challenge, especially for prospective teachers who are expected to be able to teach this material effectively in schools (Purvis et al., 2019; Radzi et al., 2022; Bahtiar et al., 2022). Facts in the field show that many prospective physics teachers still face difficulties in understanding basic physics concepts, which can have an impact on the quality of their teaching in the future (Alemu et al., 2021; Fidan, M., & Tuncel, 2019; Kulgemeyer, C., & Riese, 2018).

Conventional physics learning methods often focus on memorizing theory without providing applicable learning experiences (Marcinauskas et al., 2024; Cai et al., 2021). As a result, prospective teachers are less able to link theory with practice, so that the understanding they form tends to be shallow (Boe et al., 20218). This condition creates an urgent need to find learning methods that are more effective and relevant in increasing understanding of physics concepts (Hofer et al., 2o18; Rosales et al., 2020; Maimun & Bahtiar, 2022).

Data obtained from various studies shows that the current learning modules do not fully support optimal understanding of physics concepts. These modules tend to be theoretical in nature and do not integrate practical elements that are relevant to everyday life. This causes difficulties for prospective teachers in connecting physics theory with its application in the real world (Xu et al., 2020; Strxys et al., 2018).

One approach that is considered capable of overcoming this problem is STEM (Science, Technology, Engineering, and Mathematics) based learning (Sagala et al., 20219; Sari et al., 2020; Dare et al., 2018; Bahtiar et al., 2023). Observations in various educational institutions show that the STEM approach has a positive impact in understanding physics concepts (Struyf et al, 2019; Adhelacahya et al., 2023). This approach combines various scientific disciplines, so students can see how physics concepts are applied in a broader and more real context, making learning more meaningful and interesting (Altmeyer et al., 2020; Thibaut et al., 2018).

Although there has been a lot of research examining the use of STEM approaches in learning, there is still a gap in research regarding the validity of STEM-based modules specifically designed to improve understanding of physics concepts for prospective teachers (Wahono & Chang, 2020; Acar et al., 2018). Most research focuses on developing modules without testing their validity in depth in the context of physics learning. This shows the need to conduct more specific research in validating STEM-based learning modules.

This research aims to offer novelty through validation of STEM-based learning modules specifically designed to increase understanding of physics concepts for prospective teachers. Validation of this module is important to ensure that the module not only meets academic standards, but is also relevant and effective in the context of physics learning (Wati et al., 2020; Hardeli et al., 2022). With validated modules, it is hoped that prospective physics teachers will have a better understanding and be ready to apply physics concepts in the classroom learning process (Barquilla & Cabili, 2021; Kasim & Ahmad, 2018).

The validity of the learning module is a crucial aspect that determines success in the learning process (Suastrawan et al., 2021; Irdawati et al., 2023). A valid module must be able to bridge theory with practice and suit the needs of students (Astuti et al., 2018). Therefore, this research places module validation as an important step before implementing the module widely (Yevira, 2023).

It is hoped that the results of this research can make a significant contribution to the development of better physics learning modules in the future. With validated modules, it is hoped that prospective physics teachers will have a deeper understanding of the concepts and be ready to teach them effectively. This research is specifically aimed at prospective physics teachers, who are key actors in science education. Through this research, it is hoped that a STEM-based learning model can be found that is not only valid but also practical and applicable, so as to improve the overall quality of physics education.

METHODS

This research uses a research and development approach (Research and Development, R&D) which aims to develop and validate STEM-based learning modules to increase understanding of physics concepts in prospective teachers. This research was limited to the validation stage, which was carried out through expert validation without involving student subjects. This validation is carried out to ensure that the module developed meets academic standards and is relevant for use in physics learning.

The research procedure began with the development of a STEM-based learning module designed to increase understanding of physics concepts by referring to Thiagaran's 4D development steps (Gasong et al., 2021), namely define, design, develop, and disseminate (Farida et al., 2021; Ibrahim et al., 2020). After this module was developed, the validation process was carried out by experts in the fields of physics and media education. Experts were asked to assess the modules in terms of content and construct validity, which includes appropriateness of the material, clarity of presentation, and alignment with STEM approaches.

The data collection instrument used in this research was a module validation sheet, which was filled in by experts. This sheet is designed to measure various aspects of validity, including the accuracy of the material, suitability to the curriculum, and the potential of the module to improve understanding of physics concepts. Experts provide their assessments based on predetermined criteria and provide necessary input for improving the module.

Data obtained from expert validation was analyzed descriptively to determine the level of module validity. This analysis involves calculating the average validation scores from experts, as well as reviewing qualitative input to identify aspects that need improvement. The results of this analysis will be used to make final revisions to the module, ensuring that the module developed meets the expected standards before it can be implemented further in the learning context. Apart from descriptive analysis, expert validation data was also analyzed to determine the level of validity using the Aiken's V formula. Validity level determined based on the following table.

Table 1. Validity Level

Value Range	Category
$v \leq 0.4$	Weak validity
$0.4 > V < 0.8$	Validity is moderate
$V \geq 0.8$	high validity

FINDINGS AND DISCUSSION

Findings The product resulting from this research is a STEM-based learning module specifically designed to increase understanding of physics concepts for prospective teachers. This module consists of several main parts, namely an introduction that explains the learning objectives and relevance of the material, chapters that discuss physics concepts in depth using a STEM approach, as well as exercises and evaluations to measure prospective teachers' understanding. Each part of this module is designed with attention to the integration between science, technology, engineering and mathematics, which is expected to provide a comprehensive and applicable learning experience (Eom, 2019).

This module is also equipped with relevant illustrations and examples, which aim to facilitate prospective teachers' understanding of the physics concepts being taught. The illustrations used are not just pictures, but also simulations and diagrams that can help them to visualize abstract concepts into more concrete ones. In addition, the examples included in this module are taken from everyday life and real world situations, so that prospective teachers can see a direct connection between the theory they learn and its application in the real world (Chen, 2018).

As part of the STEM approach, this module also emphasizes the use of technology in the learning process. Prospective teachers are invited to use digital devices such as computers or tablets to access additional materials, interactive simulations, and learning videos that support their understanding. This approach is in line with the demands of the digital era, where the ability to use technology effectively is one of the important competencies that prospective teachers must have. The use of this technology is also expected to increase their motivation and involvement in the learning process (Puspitarini & Hanif, 2019; Ahmadi, 2018)).

To ensure that this module is effective in achieving learning objectives, evaluations and exercises are included at the end of each chapter. The exercises provided include questions with varying levels of difficulty designed to measure prospective teachers' overall understanding. Apart from that, evaluations in the form of formative and summative tests are also designed to provide feedback to them and teachers regarding the progress that has been achieved. The results of this evaluation can be used as a basis for improving or adjusting learning strategies in the classroom (Cheng et al., 2019).\

The learning modules that have been developed are then validated by experts. The validity of this module is measured based on assessments by five experts in the field of education, with a focus on aspects of material accuracy, clarity of presentation, integration of STEM approaches, and suitability to learning objectives. The expert validity results are presented in the following table.

Table 2. Results of Expert Validity Analysis

Validation Aspect	Indicator	Average Score	Aiken's V	Category
Accuracy of Material	Accuracy of scientific information	4.4	0.85	High Validity
	Compatibility with the curriculum	4.2	0.80	High Validity
	Conformity with the latest references	4.6	0.90	High Validity
Clarity of Presentation	Logical module structure	4.2	0.75	Medium Validity
	Readability and ease of understanding	4.4	0.85	High Validity
	Quality examples and illustrations	4.4	0.85	High Validity
Integration of STEM Approaches	Connectedness to technology	4.1	0.75	Medium Validity

	Integration of mathematical elements	4.3	0.80	High Validity
	Real world application	4.2	0.80	High Validity
Suitability to Learning Objectives	Achievement of learning objectives	4.0	0.70	Medium Validity
	Competency achievement	4.1	0.75	Medium Validity
	Assessment of learning outcomes	4.2	0.80	High Validity

Based on Table 2 above, it is known that under the Material Accuracy aspect, the indicators assessed include the accuracy of scientific information, conformity with the curriculum, and conformity with the latest references. The average score for accuracy of scientific information was 4.4 with an Aiken's V of 0.85, indicating that experts strongly agreed that the material presented in the module was accurate and relevant. This is consistent with the theory that learning materials must be based on the latest scientific knowledge to ensure educational quality (Darling-Hammond et al., 2020). The indicator of conformity with the curriculum obtained an average score of 4.2 and Aiken's V of 0.80, indicating the suitability of the module with the applicable curriculum. In accordance with the principle that teaching materials must meet curriculum standards for learning effectiveness (Gess-Newsome et al., 2019). Conformity with the latest references received the highest score, namely 4.6 with Aiken's V 0.90, indicating that the module utilizes the latest and relevant sources, supporting the concept that learning must always be updated in accordance with scientific developments (Valverde-Berrocoso et al., 2020).

For the Clarity of Presentation aspect, the indicators assessed include logical module structure, readability and ease of understanding, as well as the quality of examples and illustrations. The logical module structure received a mean score of 4.2 with an Aiken's V of 0.75, indicating that most experts consider the module structure to be adequate, although there is still room for improvement. Good structure is important in learning to facilitate an effective learning process (Bozkurt, 2019). Readability and ease of understanding received a score of 4.4 and Aiken's V 0.85, indicating that the module is easy to understand and access by students. This is important because clarity of presentation contributes to better understanding and retention of material (Cheng et al., 2018). The quality of examples and illustrations also received a score of 4.4 with Aiken's V 0.85, indicating that the examples and illustrations in the module really support understanding of concepts, in accordance with the theory that good illustrations can improve student understanding (Shepard et al., 2018).

The Integration Aspect of the STEM Approach assesses connectedness to technology, integration of mathematical elements, and real-world applications. Connectedness with technology obtained an average score of 4.1 with an Aiken's V of 0.75, indicating that there are efforts to link physics concepts with technology, but it needs to be further improved. The integration of technology in STEM education is key to preparing students to face the challenges of the modern world (Kalogiannakis et al., 2021). Integration of mathematical elements received a score of 4.3 with an Aiken's V of 0.80, indicating that the module links mathematical concepts with physics effectively, in accordance with guidelines that integration of scientific disciplines can deepen understanding (Kwangmuang et al., 2021). The real world application also received a score of 4.2 with an Aiken's V of 0.80, indicating that the module connects physics concepts with practical applications, which is in accordance with the theory that real applications can increase the relevance and motivation of learning (Kaufman, 2018).

Table 2 also shows that in the aspect of Conformity to Learning Objectives, indicators include achievement of learning objectives, achievement of competencies, and assessment of learning outcomes. Achievement of learning objectives received an average score of 4.0 with an Aiken's V of 0.70, indicating that the module almost fully meets the stated objectives. Clear and measurable learning objectives are important for achieving desired learning outcomes (Huang, B., & Hew, 2018). Competency achievement obtained a score of 4.1 with Aiken's V 0.75, indicating that the module supports the expected competencies. This is in accordance with the principle that teaching materials must support the achievement of desired competencies (Lavrentieva et al., 2019; Bahtiar et al., 2023). The assessment of learning outcomes received a score of 4.2 with Aiken's V 0.80, indicating that the module includes an effective evaluation mechanism to assess the achievement of learning outcomes, which supports the importance of continuous evaluation in the learning process (Rodrigues et al., 2019; Bahtiar, 2023). Specifically, the results of the expert validation analysis are presented in Figure 1 below.

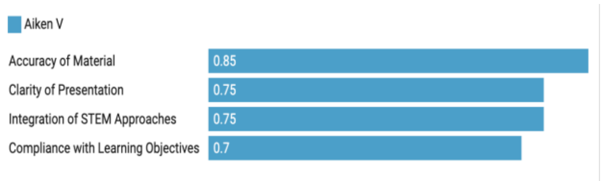

Figure 1. Results of Expert Validity Analysis

The figure shows the results of expert validation analysis of STEM-based learning modules, which are represented by Aiken's V scores for four main aspects: accuracy of material, clarity of presentation, integration of STEM approaches, and suitability to learning objectives. With an Aiken's V value of 0.85, the Accuracy of Material aspect it has the highest validity among all aspects assessed. This shows that the experts strongly agree that the material in this module is accurate and in accordance with applicable physics concepts. According to learning evaluation theory, material accuracy is key in ensuring that students (or in this context, prospective teachers) obtain correct and reliable information, which is the foundation of effective learning.

The Clarity of Presentation aspect received an Aiken's V value of 0.75, which indicates good validity, although there is little room for improvement. Clarity of presentation is an important element in learning design, where information must be conveyed in a way that is easy for prospective teachers to understand. This is in line with cognitive theory in education which emphasizes the importance of presenting clear and structured information to support the process of understanding and retaining material.

For the Integration of STEM Approaches aspect): also obtained an Aiken's V value of 0.75, indicating that this module effectively integrates elements from science, technology, engineering and mathematics. STEM education theory emphasizes the importance of this integration to create relevant and applicable learning, where prospective teachers can see the interrelationships between scientific disciplines and apply the concepts learned in learning.

With an Aiken's V value of 0.7, the Compliance with Learning Objectives aspect has a fairly good validity value, but slightly lower than other aspects. Suitability to learning objectives is important to ensure that this module can actually achieve the expected competencies. The instructional design concept emphasizes that each element in the module must support the achievement of specific learning objectives, so that learning outcomes can be measured and evaluated effectively.

Overall, the Aiken's V value obtained for each aspect shows that this module has a good level of validity, with the accuracy of the material as the strongest aspect. However, there are still several aspects that could be improved to ensure that this module is not only accurate, but also presented in the most effective way and in accordance with the intended STEM approach. The following presents the results of the analysis using the Rasch model.

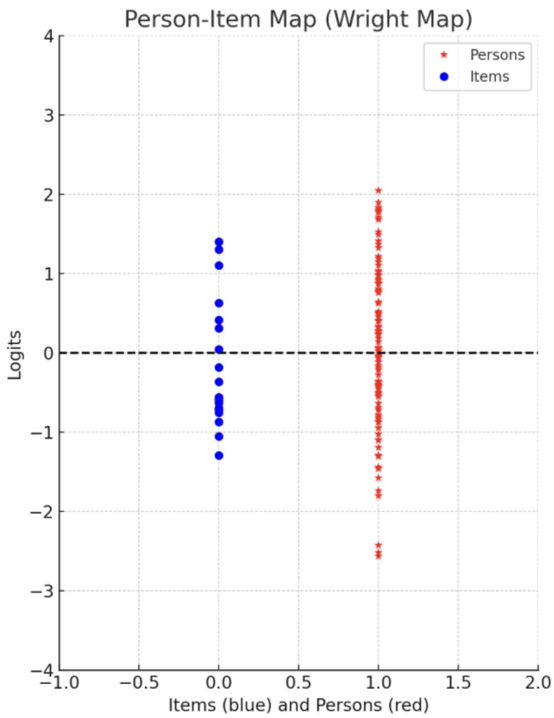

Figure 2. Person-Item Map (Wright Map)

The Wright Map or Person-Item Map image above shows the distribution of the abilities of the experts involved in the validation of the STEM-based learning module and the difficulty level of the items or indicators being assessed. On this map, the red marks represent the experts, while the blue marks represent the items being assessed. Both components are displayed on the same logit scale, allowing for a direct comparison between the abilities of the experts and the difficulty level of the items.

The horizontal line on the logit scale 0 represents the average difficulty of the items. Items above this line are more difficult than average, while items below it are easier. The red dots scattered along the vertical axis indicate variation in the abilities of the experts, with higher points indicating greater ability. Conversely, the scattered blue dots indicate variation in the difficulty level of the items, with more difficult items located higher on this scale.

Through this Wright Map, it can be seen whether the distribution of expert abilities is in line with the difficulty level of the items. When expert abilities (red dots) cluster around the difficulty level of the item (blue dots), this indicates that the item is at the right level of difficulty to be measured by the experts involved. If there is an imbalance, such as many highly skilled experts without corresponding items, or many difficult items without experts who are able to rate them, then this indicates that the instrument may need to be adjusted to reflect balanced abilities. Overall, the Wright Map provides an important visual representation in assessing the fit between expert ability and item difficulty in a validation instrument.

CONCLUSION

Based on the results of research and expert validation, it can be concluded that the STEM-based learning module developed to improve understanding of physics concepts for prospective teachers has good validity, especially in the aspect of material accuracy which received the highest score. Although aspects of clarity of presentation, integration of STEM approaches, and suitability to learning objectives are also considered valid, there is room for further improvement to achieve module perfection. Overall, this module has met the standards required to be implemented in the learning process and has great potential to become an effective tool in supporting the development of prospective physics teacher competencies in accordance with the demands of 21st century education.

ACKNOWLEDGMENT

This section displays authors appreciation to sponsors, fund donors, resource persons, or parties who have an important role in conducting research.

REFERENCES

Acar, D., Tertemiz, N., & Taşdemir, A. (2018). The effects of STEM training on the academic achievement of 4th graders in science and mathematics and their views on STEM training. *International electronic journal of elementary education*, *10*(4), 505-513.

Adhelacahya, K., Sukarmin, S., & Sarwanto, S. (2023). The impact of problem-based learning electronics module integrated with STEM on students' critical thinking skills. *Jurnal Penelitian Pendidikan IPA*, *9*(7), 4869-4878.

Ahmadi, D. M. R. (2018). The use of technology in English language learning: A literature review. *International journal of research in English education*, *3*(2), 115-125.

Altmeyer, K., Kapp, S., Thees, M., Malone, S., Kuhn, J., & Brünken, R. (2020). The use of augmented reality to foster conceptual knowledge acquisition in STEM laboratory courses—Theoretical background and empirical results. *British Journal of Educational Technology*, *51*(3), 611-628.

Astuti, I. A. D., Putra, I. Y., & Bhakti, Y. B. (2018). Developing Practicum Module of Particle Dynamics Based on Scientific Methods to Improve Students' Science Process Skills. *Scientiae Educatia: Jurnal Pendidikan Sains*, *7*(2), 183-196.

Bahtiar, B. (2023). The effect of self-efficacy on organizational citizenship behavior (OCB) of science teacher candidates in technology-based learning. *Jurnal Penelitian Pendidikan IPA*, *9*(1), 390-401.

Bahtiar, B., Ibrahim, I., & Maimun, M. (2022). Profile of student problem solving skills using discovery learning model with cognitive conflict approach. *Jurnal Penelitian Pendidikan IPA*, *8*(3), 1340-1349.

Bahtiar, B., Maimun, M., & Ibrahim, I. (2023). Analysis of collaboration, communication, critical thinking, and creative thinking ability of students in solving science problems in terms of gender. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education)*, *11*(2), 379-400.

Bahtiar, B., Yusuf, Y., Doyan, A., & Ibrahim, I. (2023). The trend of technology pedagogical content knowledge (TPACK) research in 2012-2022: Contribution to science learning of 21st century. *Jurnal Penelitian Pendidikan IPA*, *9*(5), 39-47.

Barquilla, M. B., & Cabili, M. T. (2021, March). Forging 21st century skills development through enhancement of K to 12 gas laws module: a step towards STEM Education. In *Journal of Physics: Conference Series* (Vol. 1835, No. 1, p. 012003). IOP Publishing.

Bøe, M. V., Henriksen, E. K., & Angell, C. (2018). Actual versus implied physics students: How students from traditional physics classrooms related to an innovative approach to quantum physics. *Science Education*, *102*(4), 649-667.

Bozkurt, A. (2019). From distance education to open and distance learning: A holistic evaluation of history, definitions, and theories. In *Handbook of Research on Learning in the Age of Transhumanism* (pp. 252-273). IGI Global.

Cai, S., Liu, C., Wang, T., Liu, E., & Liang, J. C. (2021). Effects of learning physics using Augmented Reality on students' self-efficacy and conceptions of learning. *British Journal of Educational Technology*, *52*(1), 235-251.

Chen, J., Wang, M., Kirschner, P. A., & Tsai, C. C. (2018). The role of collaboration, computer use, learning environments, and supporting strategies in CSCL: A meta-analysis. *Review of Educational Research*, *88*(6), 799-843.

Cheng, A., Nadkarni, V. M., Mancini, M. B., Hunt, E. A., Sinz, E. H., Merchant, R. M., ... & Bhanji, F. (2018). Resuscitation education science: educational strategies to improve outcomes from cardiac arrest: a scientific statement from the American Heart Association. *Circulation*, *138*(6), e82-e122.

Cheng, L., Ritzhaupt, A. D., & Antonenko, P. (2019). Effects of the flipped classroom instructional strategy on students' learning outcomes: A meta-analysis. *Educational Technology Research and Development*, *67*, 793-824.

Dare, E. A., Ellis, J. A., & Roehrig, G. H. (2018). Understanding science teachers' implementations of integrated STEM curricular units through a phenomenological multiple case study. *International journal of STEM education*, *5*, 1-19.

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied developmental science*, *24*(2), 97-140.

Eom, S. (2019). The effects of student motivation and self-regulated learning strategies on student's perceived e-learning outcomes and satisfaction. *Journal of Higher Education Theory and Practice*, *19*(7).

Farida, F., Hanum, F., & Rahim, A. (2021). Adobe Flash CS6 to Develop Mathematics Learning Media for Plane Geometry. *Jurnal Didaktik Matematika*, *8*(2), 175-189.

Gasong, B. I., Rufi'i, R., & Hartono, H. (2021). Development of augmented reality code application on 3d animation in learning procedure at school. *Edcomtech J. Kajian Teknol. Pendidik*, *6*, 79-88.

Gess-Newsome, J., Taylor, J. A., Carlson, J., Gardner, A. L., Wilson, C. D., & Stuhlsatz, M. A. (2019). Teacher pedagogical content knowledge, practice, and student achievement. *International Journal of Science Education*, *41*(7), 944-963.

Hardeli, H., Yusmaita, E., Mulyani, S., & Alora, B. S. (2022). Validation of Discovery Learning E-Module based on Video Demonstration on Chemical Equilibrium for High School Student. *Jurnal Penelitian Pendidikan IPA*, *8*(2), 718-726.

Hofer, S. I., Schumacher, R., Rubin, H., & Stern, E. (2018). Enhancing physics learning with cognitively activating instruction: A quasi-experimental classroom intervention study. *Journal of Educational Psychology*, *110*(8), 1175.

Huang, B., & Hew, K. F. (2018). Implementing a theory-driven gamification model in higher education flipped courses: Effects on out-of-class activity completion and quality of artifacts. *Computers & Education*, *125*, 254-272.

Ibrahim, I., Gunawan, G., & Kosim, K. (2020). Validitas perangkat pembelajaran fisika berbasis model discovery dengan pendekatan konflik kognitif. *Jurnal Pijar Mipa*, *15*(3), 214-218.

Irdawati, I., Chatri, M., Wulansari, K., Razak, A., & Fajrina, S. (2023). Development of stem-based biology e-module to improve student learning outcomes. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 6694-6700.

Kalogiannakis, M., Papadakis, S., & Zourmpakis, A. I. (2021). Gamification in science education. A systematic review of the literature. *Education sciences*, *11*(1), 22.

Kasim, N. H., & Ahmad, C. N. C. (2018). PRO-STEM module: The development and validation. *International Journal of Academic Research in Business and Social Sciences*, *8*(1), 728-739.

Kaufman, D. M. (2018). Teaching and learning in medical education: how theory can inform practice. *Understanding medical education: evidence, theory, and practice*, 37-69.

Kwangmuang, P., Jarutkamolpong, S., Sangboonraung, W., & Daungtod, S. (2021). The development of learning innovation to enhance higher order thinking skills for students in Thailand junior high schools. *Heliyon*, *7*(6).

Lavrentieva, O. O., Rybalko, L. M., Tsys, O. O., & Uchitel, A. D. (2019). Theoretical and methodical aspects of the organization of students' independent study activities together with the use of ICT and tools. In *Proceedings of the 6th Workshop on Cloud Technologies in Education (CTE 2018), Kryvyi Rih, Ukraine, December 21, 2018* (No. 2433, pp. 102-125). CEUR Workshop Proceedings.

Maimun, M., & Bahtiar, B. (2022). The effect of search, solve, create, and share (SSCS) learning models assisted multimedia interactive to improve creative thinking ability and student learning outcomes. *Jurnal Penelitian Pendidikan IPA*, *8*(4), 1834-1840.

Marcinauskas, L., Iljinas, A., Čyvienė, J., & Stankus, V. (2024). Problem-based learning versus traditional learning in physics education for engineering program students. *Education Sciences*, *14*(2), 154.

Puspitarini, Y. D., & Hanif, M. (2019). Using Learning Media to Increase Learning Motivation in Elementary School. *Anatolian Journal of Education*, *4*(2), 53-60.

Rodrigues, H., Almeida, F., Figueiredo, V., & Lopes, S. L. (2019). Tracking e-learning through published papers: A systematic review. *Computers & education*, *136*, 87-98.

Rosales, J., Sulaiman, F., & Juan Jr, J. R. (2020). The development of integrated STEM-PBL physics module for learning classical mechanics in secondary education. *Solid State Technology*, *63*(6), 19410-19433.

Sagala, R., Umam, R., Thahir, A., Saregar, A., & Wardani, I. (2019). The effectiveness of stem-based on gender differences: The impact of physics concept understanding. *European Journal of Educational Research*, *8*(3), 753-761.

Sarı, U., Duygu, E., Şen, Ö. F., & Kırındı, T. (2020). The Effects of STEM education on scientific process skills and STEM awareness in simulation based ınquiry learning environment. *Journal of Turkish Science Education*, *17*(3), 387-405.

Shepard, L. A., Penuel, W. R., & Pellegrino, J. W. (2018). Using learning and motivation theories to coherently link formative assessment, grading practices, and large-scale assessment. *Educational measurement: issues and practice*, *37*(1), 21-34.

Struyf, A., De Loof, H., Boeve-de Pauw, J., & Van Petegem, P. (2019). Students' engagement in different STEM learning environments: Integrated STEM education as promising practice?. *International Journal of Science Education*, *41*(10), 1387-1407.

Struyf, A., De Loof, H., Boeve-de Pauw, J., & Van Petegem, P. (2019). Students' engagement in different STEM learning environments: Integrated STEM education as promising practice?. *International Journal of Science Education*, *41*(10), 1387-1407.

Strzys, M. P., Kapp, S., Thees, M., Klein, P., Lukowicz, P., Knierim, P., ... & Kuhn, J. (2018). Physics holo. lab learning experience: using smartglasses for augmented reality labwork to foster the concepts of heat conduction. *European Journal of Physics*, *39*(3), 035703.

Suastrawan, K. E., Suardana, I. N., & Sudiatmika, A. A. I. A. R. (2021). The effectiveness of science e-modules for class VII junior high schools based on socioscientific issues to improve students' critical thinking skills. *Journal of Science Education Research*, *5*(2), 1-9.

Thibaut, L., Knipprath, H., Dehaene, W., & Depaepe, F. (2018). The influence of teachers' attitudes and school context on instructional practices in integrated STEM education. *Teaching and teacher education*, *71*, 190-205.

Valverde-Berrocoso, J., Garrido-Arroyo, M. D. C., Burgos-Videla, C., & Morales-Cevallos, M. B. (2020). Trends in educational research about e-learning: A systematic literature review (2009–2018). *Sustainability*, *12*(12), 5153.

Wahono, B., Lin, P. L., & Chang, C. Y. (2020). Evidence of STEM enactment effectiveness in Asian student learning outcomes. *International Journal of STEM Education*, *7*(1), 36.

Wati, M., Putri, M. R., Misbah, M., Hartini, S., & Mahtari, S. (2020). The development of physics modules based on madihin culture to train kayuh baimbai character. In *Journal of Physics: Conference Series* (Vol. 1422, No. 1, p. 012008). IOP Publishing.

Xu, W., Liu, Q., Koenig, K., Fritchman, J., Han, J., Pan, S., & Bao, L. (2020). Assessment of knowledge integration in student learning of momentum. *Physical Review Physics Education Research*, *16*(1), 010130.

Yevira, R. (2023). Development of SETS (Science Environment Technology and Society) Based E-Modules on Environmental Pollution Materials to Increase Learning Interest and Critical Thinking Ability. *Jurnal Penelitian Pendidikan IPA*, *9*(8), 6306-6313.