JPPS (Jurnal Penelitian Pendidikan Sains)
Homepage : https://journal.unesa.ac.id/index.php/jpps
Email : jpps@unesa.ac.id

p-ISSN : 2089-1776 **; e-ISSN :** 2549-1597
JPPS, Vol. 15, No. 1, November 2025 : 17-34

(Jurnal Penelitian Pendidikan Sains)

Development of the BASA (Bamboo Acoustic STEM Approach) Booklet with Gamification Design Understanding of Open-Pipe Resonance

Ali Khasan Al Farishi[1], Binar Kurnia Prahani[1*], Mita Anggaryani[1], Muhammed Akif Kurtulus[2]
[1]Universitas Negeri Surabaya, Surabaya, Indonesia
[2]Alanya Alaaddin Keykubat University, Antalya, Turkey

DOI : https://doi.org/10.26740/jpps.v15n1.p16-33

Sections Info
Article history:
Submitted: February 5, 2026
Final Revised: April 1, 2026
Accepted: April 2, 2026
Published: May 30, 2026

Keywords:
Digital Learning
Ethnophysics
Gamification
Physics
STEM

ABSTRACT

Objective: *Physics learning on sound wave topics, particularly open-pipe organ systems, is often perceived as abstract due to the limited availability of contextual and meaningful learning media. This study aims to develop and evaluate the feasibility of the BASA Booklet (Bamboo Acoustic STEM Approach) as a physics learning medium that integrates the STEM approach, gamification, and ethnophysics through the local wisdom context of bamboo flute instruments.* ***Method:*** *This study employed a Research and Development (R&D) approach using a modified Borg and Gall development model, implemented up to the main field-testing stage. The research subjects consisted of physics teachers and pre-service physics teachers as potential users of the developed media. Data were collected using feasibility questionnaires that assessed media design, learning content, and gamification aspects, and were analyzed descriptively.* ***Results:*** *The results of the main field testing indicate that the BASA Booklet received positive responses across all evaluated aspects, demonstrating that the developed media is conceptually and pedagogically feasible. Respondents perceived the booklet as visually engaging, easy to use, and supportive of independent and structured learning, particularly for abstract physics concepts related to sound waves and open-pipe organ principles.* ***Novelty:*** *The novelty of this study lies in the development of a culture-based, gamified STEM booklet grounded in ethnophysics, which integrates local cultural contexts into physics learning. This model offers an alternative approach to making abstract physics concepts more contextual, meaningful, and relevant. Nevertheless, further studies are required to examine the classroom implementation and effectiveness of the BASA Booklet.*

INTRODUCTION

Physics learning in the 21st century requires students not only to understand concepts theoretically but also to be able to connect such knowledge with real-world phenomena in their surrounding environment. However, learning practices in schools still tend to focus on problem-solving activities and classroom discussions without providing contextual and meaningful learning experiences (Saleem et al., 2024). This condition has resulted in low levels of students' conceptual understanding, especially in sound wave topics. Open-pipe organ systems are often perceived as abstract because the concepts involve invisible phenomena such as air vibrations, standing waves, and resonance patterns that cannot be directly observed (Al-Ansi et al., 2023; Dhamayanti, 2022). Without appropriate contextual learning media, students tend to rely on memorizing formulas rather than constructing conceptual understanding, which may lead to misconceptions regarding the relationship between air column length and frequency (Susanti et al., 2020). Contextual

media that visualize resonance phenomena and relate them to real-life objects can support students in connecting theoretical representations with observable experiences, thereby promoting deeper conceptual understanding (Kotsis, 2025; ŞAHİN, 2026).

The Science, Technology, Engineering, and Mathematics (STEM) approach is a learning approach that effectively connects physics concepts with real-life applications (Bacovic et al., 2022; Wang et al., 2022). STEM guides students to understand scientific phenomena through the integration of technology, engineering analysis, and mathematics-based problem solving. In the context of sound wave learning, the STEM approach is particularly relevant because concepts such as resonance and frequency can be explored through the engineering design of musical instruments, technological representation of sound phenomena, and mathematical relationships between air column length and frequency (Nurpratiwi et al., 2025). Numerous studies have demonstrated that STEM-based learning can enhance conceptual understanding, motivation, attention, and problem-solving skills (Sırakaya & Alsancak Sırakaya, 2022; Xu & Ouyang, 2022). However, the integration of STEM in physics learning remains suboptimal when it is implemented in a purely theoretical manner without representative learning media that promote students' active engagement (Ouyang & Xu, 2024; Permanasari et al., 2021). In many cases, STEM learning activities focus primarily on abstract problem-solving tasks without sufficiently connecting scientific concepts to students' cultural experiences or familiar real-world phenomena (Abideen & Jabeen, 2025; Dare et al., 2021; Sata, 2024).

In recent years, gamification has increasingly been incorporated into educational media to enhance learning motivation and student engagement. Gamification provides enjoyable learning experiences through elements such as challenges, points, levels, missions, and rewards, thereby fostering students' autonomy and active participation during the learning process (Krishnamurthy et al., 2022). Beyond enhancing motivation, gamification can also function as a pedagogical structure that supports higher-order thinking skills (Rahim & Mohammed, 2025). Elements such as levels, challenges, and missions can be aligned with inquiry-based learning processes in physics, encouraging students to formulate hypotheses, examine relationships between variables, test conceptual predictions, and draw evidence-based conclusions. Through structured challenges, gamification encourages students not only to complete tasks but also to engage in analytical reasoning, logical thinking, and the progressive development of scientific understanding (Takwin et al., 2023). These pedagogically structured gamification elements can become more meaningful and contextual when integrated with local wisdom, as learning activities are connected with cultural phenomena that are familiar to students' real-life experiences (Kadoi, 2026).

Conventional gamified learning media are often designed in generic digital formats that emphasize rewards, points, and competition, but they do not always connect learning experiences with students' socio-cultural environments (Zhang et al., 2022). As a result, the learning process may remain procedurally engaging but conceptually detached from students' real-life experiences. In contrast, culturally grounded gamified learning media integrate game elements with local cultural contexts, enabling students to explore scientific concepts through familiar phenomena (Lopes et al., 2024). This integration allows gamification to function not only as a motivational tool but also as a contextual bridge that connects abstract physics concepts with meaningful cultural experiences, thereby strengthening the novelty of the proposed approach (Hou, 2023).

Local wisdom is positioned as a constructive identity of a community that is transmitted across generations and functions as a social, cultural, and moral guideline in societal life (Jumriani et al., 2021). In the educational context, local wisdom plays an important role as an authentic learning resource because it is able to connect scientific concepts with students' real-life experiences, thereby making learning more meaningful, contextual, and culturally relevant (Krualunteerayut et al., 2024; Tohri et al., 2022). The integration of local wisdom into physics learning not only situates scientific concepts within culturally familiar contexts but also supports students in connecting abstract principles with observable phenomena (Fiskawarni et al., 2025). Cultural objects such as bamboo flute instruments allow students to directly relate the length of the air column to variations in pitch, providing tangible experiences that illustrate the relationship between vibration, frequency, and resonance. Through these representations, students can more easily interpret theoretical explanations of sound waves, as the concepts are linked to phenomena that can be experienced in everyday life (Firmansyah et al., 2025). One physics topic that can be integrated with local wisdom is sound waves through the study of traditional flute musical instruments. Therefore, integrating local wisdom into science education has the potential to create learning experiences that are more relatable and meaningful for students.

The results of the needs assessment conducted with Grade XI senior high school students indicate that many students experience difficulties in understanding physics concepts when learning relies primarily on lectures, and they show strong interest in the use of interactive and technology-supported learning media. The needs assessment was conducted through a questionnaire administered to 35 students to identify their perceptions of current learning practices and expectations toward more engaging instructional media. The findings also show that students expect learning resources equipped with example problems, practice exercises, and accessible formats that support independent learning. However, previous studies rarely integrate STEM principles, gamification elements, and local wisdom within a single physics learning medium, particularly for abstract topics such as sound wave resonance. This gap indicates the importance of developing more contextual learning experiences that help students relate abstract physics concepts to phenomena encountered in their daily lives, including learning contexts that are relevant to their socio-cultural environment.

Based on this identified gap, this study aims to develop and examine the feasibility of a culturally integrated gamified STEM learning medium in the form of the BASA Booklet (Bamboo Acoustic STEM Approach). The novelty of this study lies in the integration of STEM principles, gamification elements, and ethnophysics by bamboo flute instruments as meaningful representations of open-pipe resonance concepts. Unlike many existing gamified learning media that predominantly emphasize digital environments, the BASA Booklet offers a learning experience that connects abstract physics concepts with students' real-life and socio-cultural contexts. Through this approach, the study proposes a learning media model that is not only visually engaging but also pedagogically meaningful, thereby supporting students in developing a more comprehensive understanding of acoustic resonance phenomena in authentic contexts.

RESEARCH METHOD

Research Design

This study uses a Research and Development (R&D) approach with the Borg and Gall development model modified to suit the educational research context (Borg & Gall, 1983; Gustiani, 2019). The Borg and Gall model was chosen because it provides systematic stages that emphasize gradual product development and iterative improvement through empirical feedback obtained from field testing, which are important for assessing the feasibility of learning media. Compared with other learning design models, Borg and Gall has a clearer focus on product development and gradual improvement based on empirical feedback, making it more suitable for the development of gamification-based STEM learning media. Accordingly, this study is positioned as a design-oriented formative development study that focuses on evaluating the feasibility of the developed learning media rather than examining its effectiveness through large-scale classroom implementation. The scope of this research is therefore limited to the preliminary and main field-testing stages as deliberate methodological boundaries. The research flow is illustrated in Figure 1.

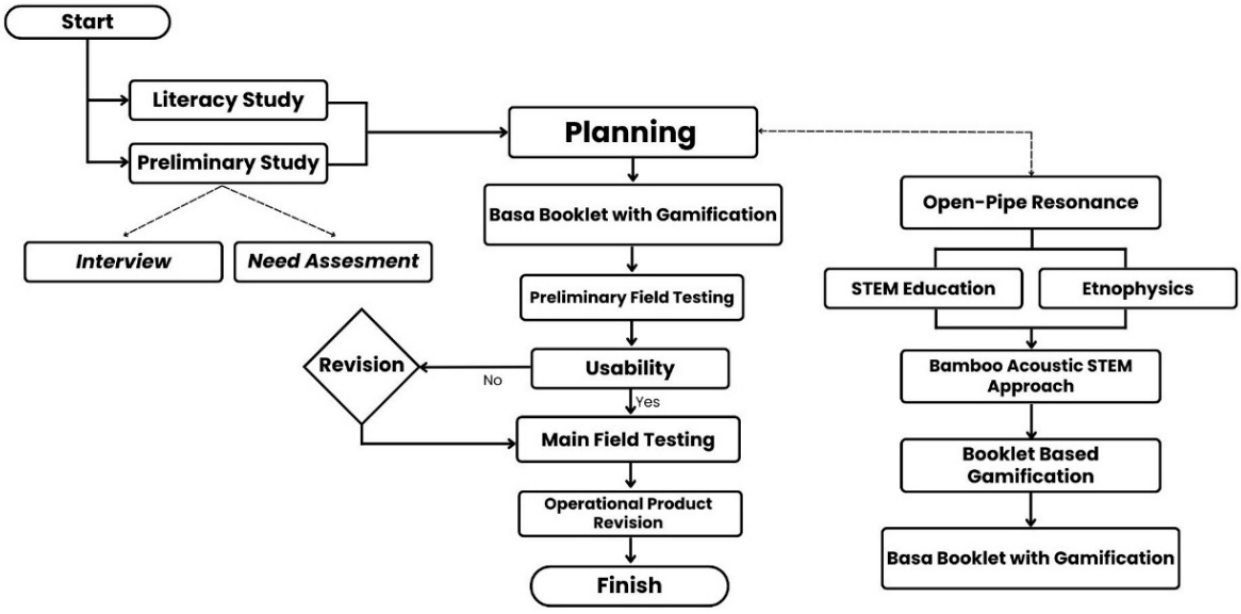

Figure 1. Research and development approach based on Borg and Gall

Research Sample

The research subjects varied across the development stages in accordance with the modified Borg and Gall model. At the needs assessment stage, the participants consisted of 35 Grade XI senior high school students from the science track (IPA), who represented the target users of the developed learning media. The students had previously studied sound wave concepts as part of the physics curriculum, enabling them to provide relevant input regarding their learning experiences and media needs. The participants involved in the product feasibility evaluation consisted of pre-service physics teachers. The preliminary field testing involved 6 pre-service physics teachers, while the main field testing involved 14 pre-service physics teachers. These participants were considered to have sufficient content knowledge and pedagogical understanding to evaluate the appropriateness of the developed learning media. Participants were selected using a

convenience sampling technique based on accessibility and willingness to take part in the study. Although this sampling approach may limit the generalizability of the findings, it is considered appropriate for design-oriented research that focuses on obtaining initial feedback for product development and refinement.

Data Collection

The data in this study consisted of primary and secondary data collected according to the modified Borg and Gall development model up to the main field-testing stage. Primary data were obtained through questionnaires administered sequentially across three stages: needs assessment, preliminary field testing, and main field testing. The questionnaire consisted of several items organized into three main aspects: learning content, media design, and gamification elements. The instrument was developed based on relevant literature on STEM learning media and gamification principles to ensure that each indicator represents an essential component of effective learning media.

The needs assessment involved 35 Grade XI senior high school students from the science track who had previously studied sound wave concepts. This stage aimed to identify students' learning difficulties, preferences toward instructional media, and expectations regarding more contextual learning resources. Preliminary field testing was conducted with 6 pre-service physics teachers to obtain initial feedback on the learning content, media presentation, and gamification structure. The results of this stage were used as the basis for revising and improving the developed BASA Booklet. Subsequently, the main field testing was carried out with 14 pre-service physics teachers using response questionnaires to evaluate the feasibility of the booklet in terms of content quality, media design, and gamification aspects. The collected data were analyzed descriptively to determine the feasibility level of the developed learning media. Secondary data were obtained from relevant books and journal articles to support the theoretical foundation and development process.

Data Analysis

The analysis was limited to descriptive statistics intended to determine the feasibility level of the developed learning media, as the primary objective of this stage was formative evaluation and initial product refinement rather than hypothesis testing or measurement of instrument reliability. Data obtained from the questionnaires were analyzed to determine the feasibility level of the developed learning media. Each response was rated using a four-point Likert scale ranging from 1 to 4 (Joshi et al., 2015; Sugiyono, 2017) as shown in Table 1.

Table 1. Likert scale ranging and category

Scale	Category
1	Strongly Disagree (SD)
2	Disagree (D)
3	Agree (A)
4	Strongly Agree (SA)

A forced-choice scale without a neutral option was intentionally employed to encourage respondents to provide more definitive evaluative judgments regarding the feasibility of the developed media. Previous methodological studies suggest that the

absence of a midpoint can reduce central tendency bias and generate clearer response patterns in evaluative research contexts.

The aggregated scores were then transformed into percentage values to allow comparability across indicators. These percentage results were subsequently used to classify the feasibility level of the BASA Booklet based on predefined interpretation ranges, providing a descriptive overview of the media's quality in terms of learning content, media presentation, and gamification components (Table 2). This analysis approach enabled the identification of general trends in respondents' evaluations and supported decision-making regarding product revision and refinement. The use of percentage-based interpretation also facilitates clearer communication of evaluation results by summarizing multiple indicators into an easily interpretable format. Consequently, the analysis provides a systematic basis for determining whether the developed learning media meet acceptable feasibility criteria for instructional use.

Table 2. Interpretation of percentage responses (Akbar, 2013).

Percentage (%)	Interpretation	Description
$x \leq 25\%$	Very Poor (VP)	The media/content/model is not feasible for use.
$25\% < x \leq 50\%$	Poor (P)	The media/content/model is less effective and needs major revision.
$50\% < x \leq 75\%$	Good (G)	The media/content/model is appropriate and effective, with minor improvements needed.
$75\% < x \leq 100\%$	Very Good (VG)	The media/content/model is excellent and highly effective.

RESULTS AND DISCUSSION

Results

Need Assessment

The results are presented descriptively to illustrate respondents' evaluations of the developed learning media, as this study focuses on the feasibility and formative refinement stages of product development. Data on media needs were collected through the distribution of questionnaires to Grade XI senior high school students. The questionnaire consisted of indicators related to the need for innovative learning media, students' interest in innovative media, and the practicality of media use. These indicators reflect students' expectations for learning media that are more engaging, interactive, and supportive of independent learning, which align with the design principles of contextual learning and the incorporation of structured challenges in the developed BASA Booklet. The results of the needs analysis indicated that most students required new learning media that are engaging and contextual, which can facilitate their understanding of the learning materials. The results of the needs analysis are presented in Table 3.

Table 3. Need assessment from learning media result

No.	Indicators	Percentage
1	Learning in the classroom has been engaging so far.	46.43%
2	Students often experience difficulty understanding the material when it is explained only through lectures.	78.57%
3	The learning media used by teachers are sometimes unclear or boring.	49.29%

No.	Indicators	Percentage
4	There is a need for learning media that support independent study at home.	68.57%
5	Learning materials are easier to understand when teachers use learning media.	81.43%
6	Students are interested in learning when technology-based media are used.	80.00%
7	Students enjoy learning when instructional materials are complemented with interactive media.	77.14%
8	Learning media should be equipped with example problems and practice exercises.	76.43%
9	There is an expectation for new learning media that make learning easier and more enjoyable.	85.71%
10	There is a desire for learning media that can be accessed via mobile phones or laptops.	79.29%

The analysis results indicate that students show a high level of interest in the use of gamified learning media and a strong preference for linking physics learning with elements of local culture. In addition, students identified resonance as one of the topics that is relatively difficult to understand without visual media and experiment-based activities.

Research and Literature Study

The research and literature review stages were conducted to identify theoretical foundations and cultural contexts that informed the design of the BASA Booklet (Bamboo Acoustic STEM Approach). The development of this learning media is grounded in the ethnophysics perspective, which emphasizes the integration of local cultural knowledge as a meaningful context for understanding scientific concepts. In the context of sound waves, traditional bamboo flute instruments represent observable applications of physical principles related to vibration, resonance, and frequency formation. The use of culturally familiar objects enables abstract physics concepts to relate to students' daily experiences, thereby supporting more contextual and meaningful learning processes.

Sound resonance is a fundamental phenomenon in acoustics that occurs when the frequency of a sound source matches the natural frequency of an air column, resulting in the amplification of sound waves. As illustrated in Figure 2, resonance in an air column can be observed when sound waves propagate through a medium and are reflected at the boundary of the tube, forming standing wave patterns consisting of nodes and antinodes. This phenomenon provides a scientific basis for understanding how sound intensity can increase under specific physical conditions. An understanding of resonance is essential for explaining sound production mechanisms in various musical instruments that rely on vibrating air columns.

The open-pipe organ model represents a system in which both ends of the air column are open, allowing standing waves to form with antinodes at each end of the pipe. Under this condition, resonance produces a fundamental frequency and higher harmonics, as presented in Figure 3.

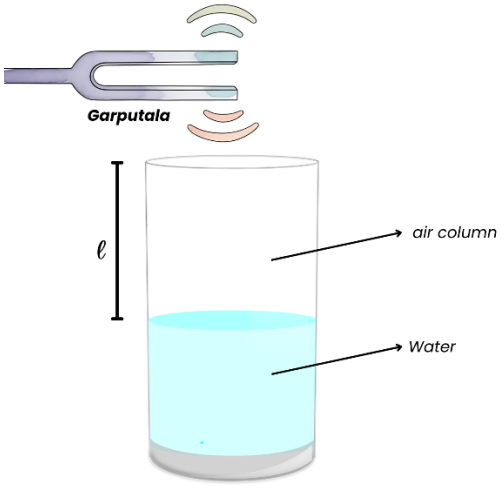

Figure 2. Resonance in the Air Column

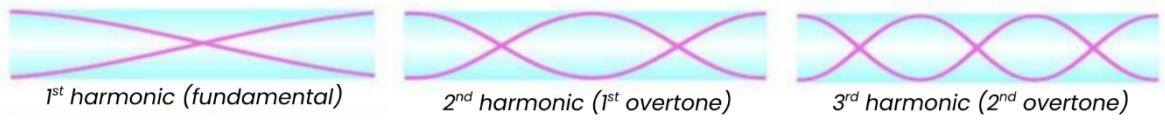

Figure 3. Frequency of notes on an organ pipe

The resonant frequency of an open pipe is inversely proportional to the effective length of the air column, meaning that shorter air columns produce higher frequencies, while longer air columns produce lower frequencies. This principle explains how variations in air column length influence pitch differences in wind instruments. The working mechanism of the bamboo flute corresponds to the open-pipe resonance principle, in which pitch variations are produced by adjusting the effective length of the vibrating air column through the opening and closing of finger holes. These structural characteristics make the bamboo flute relevant as a contextual representation for explaining the relationship between air column length, wavelength, and frequency. From an ethnophysics perspective, traditional musical instruments provide authentic examples of how scientific principles are embedded in cultural practices developed by communities. How the flute works is presented in Figure 4.

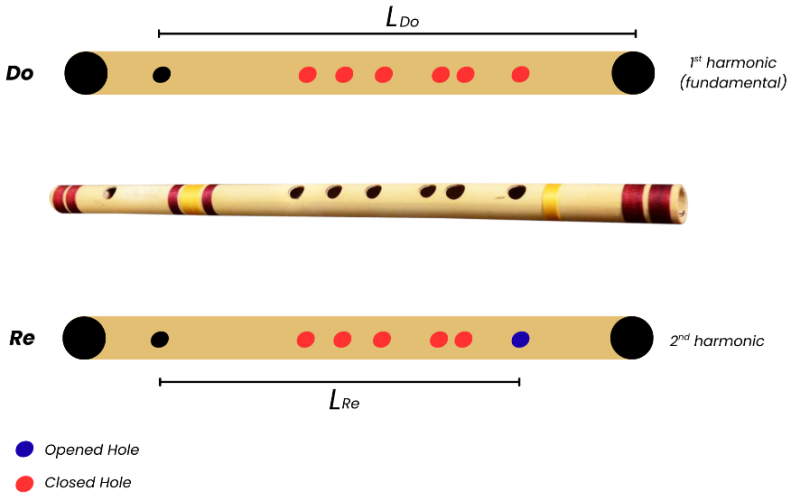

Figure 4. Notes on the flute

The flute is a wind musical instrument that operates based on the principle of an open-pipe organ, in which both ends of the air column are open. Sound in a flute is produced when the blown airflow passes over the embouchure, creating turbulence that subsequently triggers resonance within the air column inside the bamboo tube. Changes in pitch are achieved by opening and closing the finger holes, which function to alter the effective length of the air column and, consequently, the resulting resonant frequency. As more holes are opened, the effective length of the air column becomes shorter, producing a higher pitch. These characteristics indicate that the working mechanism of the flute corresponds to the open-pipe organ model in physics, making this instrument relevant as a contextual representation for explaining resonance concepts and the relationship between air column length and sound frequency.

Ethnophysics views physics concepts as phenomena that can be identified and learned through cultural practices and local wisdom that develop within communities. In the context of sound waves, various traditional musical instruments represent the natural application of physical principles such as vibration, resonance, and frequency formation. Wind instruments, including the flute, demonstrate how sound wave phenomena are empirically utilized by communities through the regulation of air column length to produce variations in pitch. The ethnophysics approach allows concepts of sound and resonance to be understood not only theoretically but also interpreted through cultural experiences that are closely related to students' daily lives. Therefore, local culture serves as an authentic context that bridges abstract physics concepts into more concrete and meaningful learning experiences.

Planning

Based on the results of the needs assessment, the BASA Booklet (Bamboo Acoustic STEM Approach) was designed by integrating four main elements: (a) the cultural context of the bamboo flute, (b) the STEM approach, (c) gamification elements, and (d) challenge-based learning activities. The planned structure of the booklet development is presented in Figure 5.

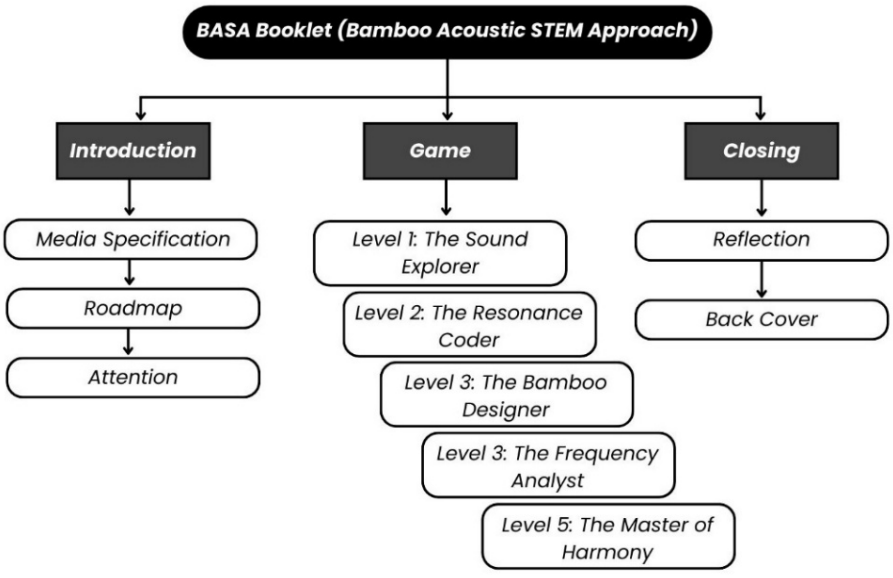

Figure 5. Structure of BASA booklet with gamification

The BASA Booklet (Bamboo Acoustic STEM Approach), which is based on local wisdom, provides gamified features consisting of five progressive levels that can be utilized in learning activities (Figure 6).

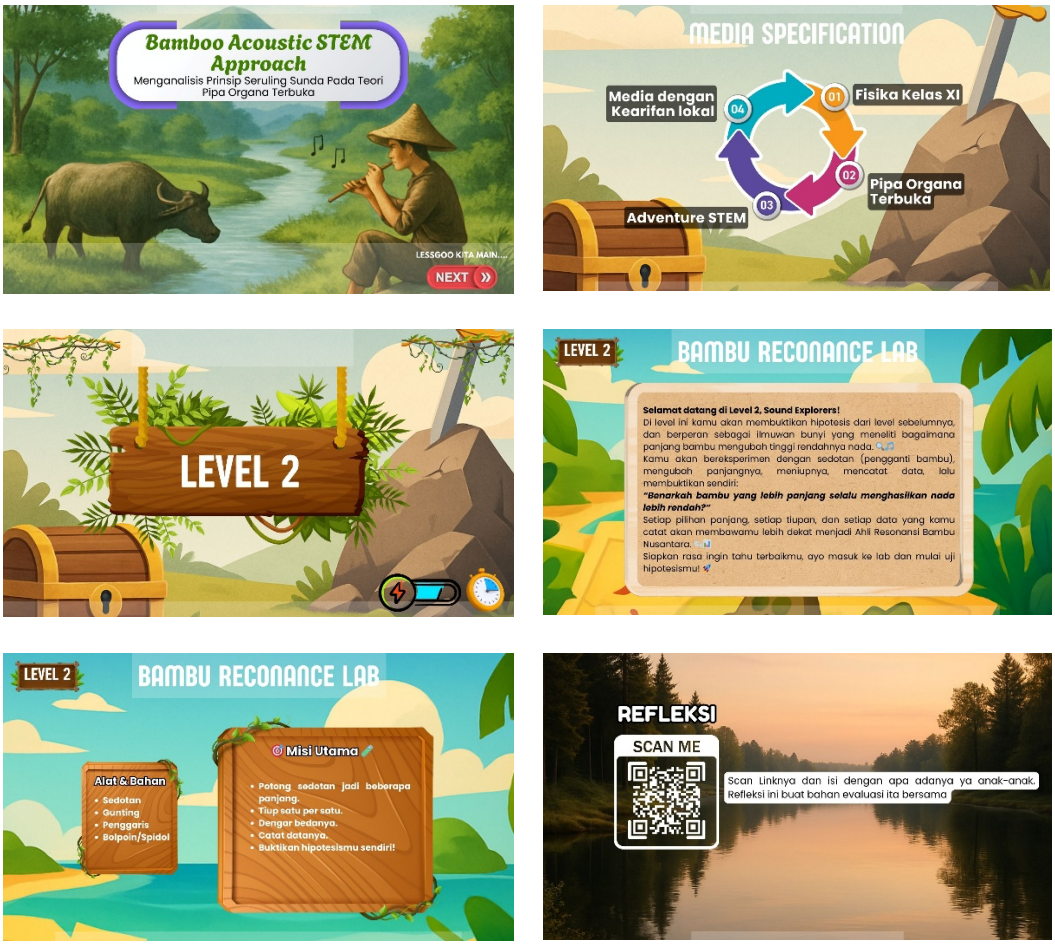

Figure 6. BASA Booklet display with gamification in the context of local wisdom

Preliminary Field Testing

At this stage, six respondents were intentionally involved to use the booklet and provide feedback through a questionnaire using a four-point Likert scale (1–4). In accordance with the Borg and Gall development framework, preliminary field testing is specifically designed to employ a small number of participants to obtain focused formative feedback for identifying design weaknesses and improving product quality. Therefore, the limited sample size at this stage represents a deliberate methodological choice aimed at supporting iterative product refinement rather than statistical generalization. The results of the preliminary study are presented in Table 4.

Table 4. Preliminary field-testing result

Usability Aspect	Mean Score	Percentage (%)	Interpretation
Media	33.09	87%	Very Good (VG)
Content	3.25	81.25%	Very Good (VG)
Gamification	3.11	79%	Very Good (VG)

Main Field Testing

The field testing of the learning media was conducted to examine how the BASA Booklet was directly evaluated by pre-service teachers or in-service teachers, to obtain an overview of the media's practicality, functionality, and attractiveness in the learning process. The assessed aspects included media design, content quality, and gamification. Data obtained during the main field-testing stage served as the basis for evaluating the stability of the product's quality and for identifying aspects that still required adjustment at the operational product revision stage. The results of the evaluation for the media aspect are presented in Figure 7.

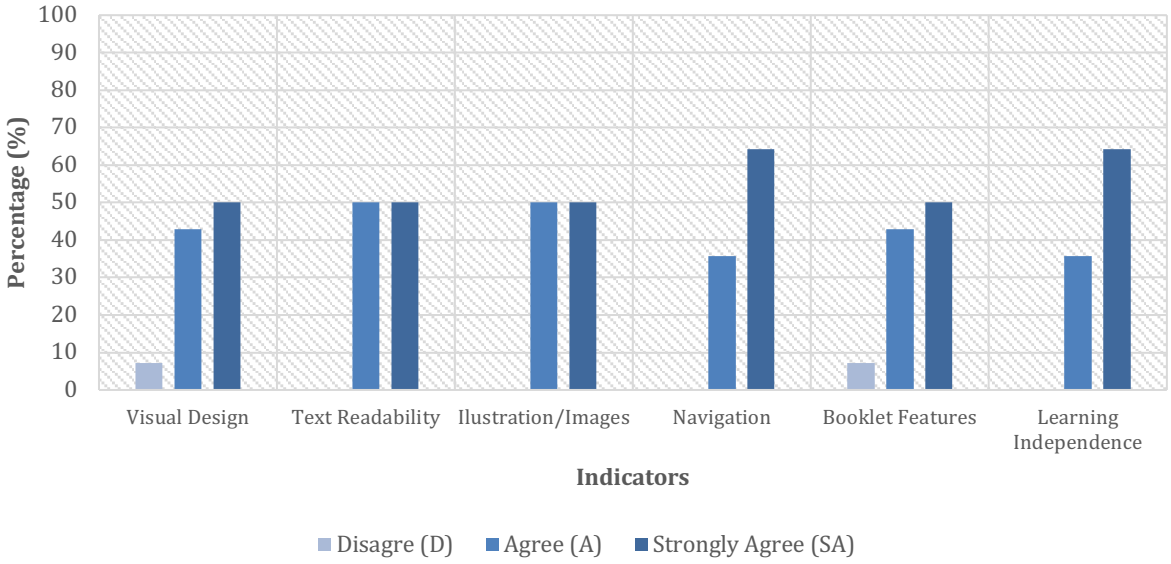

Figure 6. Learning media responses of BASA booklet

Based on the data presented in Figure 7, educators' or pre-service teachers' responses to the BASA Booklet were generally positive, as indicated by the dominance of Agree and Strongly Agree responses across all measured indicators. The indicators of navigation and learning autonomy showed the highest proportion of Strongly Agree responses compared to the other indicators, while indicators related to visual design, text readability, and illustrations/images also received positive responses without the dominance of negative responses. Overall, these findings suggest that the developed media was well received in terms of appearance, ease of use, features, and support for independent learning.

Based on the data presented in Figure 8, educators' or pre-service teachers' responses to the learning content of the BASA Booklet were generally positive, as indicated by the dominance of Agree and Strongly Agree responses across all indicators. The indicator related to relevance to real-life contexts showed a relatively high proportion of Strongly Agree responses, while indicators concerning content presentation, learning activities, language use, and activity instructions were predominantly rated as Agree. Overall, these results indicate that the learning content of the BASA Booklet was well accepted by the respondents.

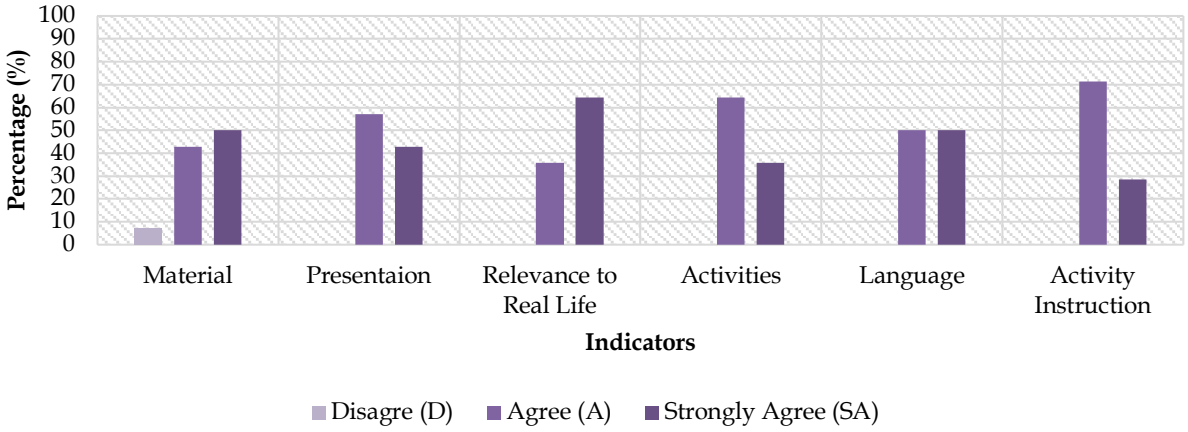

Figure 7. Learning content responses of the BASA booklet

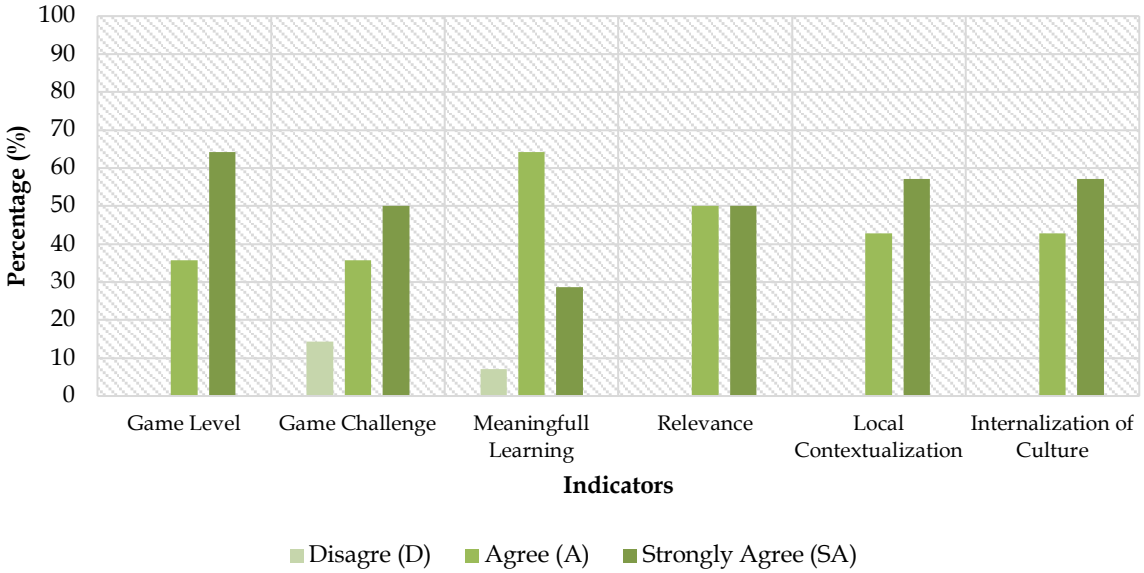

Figure 8. Gamification responses of BASA booklet

Based on the data presented in Figure 9, educators' or pre-service teachers' responses to the gamification aspects of the BASA Booklet showed a positive tendency, as reflected by the dominance of Agree and Strongly Agree responses across all indicators. The indicators related to game levels, local contextualization, and cultural internalization exhibited relatively high proportions of Strongly Agree responses, while indicators concerning game challenges, meaningful learning, and relevance were dominated by positive responses. Overall, these findings indicate that the gamification elements of the BASA Booklet were well received by the respondents.

Discussion

The results of the main field testing indicate that the BASA Booklet received positive responses from physics teachers and pre-service physics teachers across the aspects of media design, learning content, and gamification. Within the Borg and Gall development framework, these findings indicate that the developed BASA Booklet has reached the field-tested product stage, which refers to a product that has undergone main field testing and demonstrated preliminary feasibility prior to proceeding to the operational field-

testing stage. The positive responses from teachers as potential users demonstrate that the media structure, the flow of content presentation, and the designed learning activities are considered appropriate for the characteristics of senior high school physics learning, particularly for abstract topics such as sound waves and open-pipe organ systems. The media was perceived not merely as a supplementary learning resource, but as an instructional tool that can assist teachers in organizing the learning process in a more systematic and structured manner (Arlinwibowo et al., 2023; Asyiqin et al., 2025; Fazrin et al., 2025; Gumilar et al., 2025). These findings are consistent with previous studies indicating that gamification can enhance learning engagement and support structured learning processes (Arlinwibowo et al., 2023; Hou, 2023; Lopes et al., 2024; Rahim & Mohammed, 2025; Zeybek & Saygı, 2024). However, this study extends prior research by integrating ethnophysics-based local wisdom into a gamified STEM learning medium, thereby providing a culturally contextualized approach for representing abstract physics concepts such as open-pipe resonance.

From a pedagogical perspective, the acceptance of the BASA Booklet indicates that the integration of the STEM approach and gamification is perceived as relevant in supporting physics learning. The STEM approach embedded in the booklet enables scientific concepts to be connected with aspects of technology, engineering, and mathematics in an integrated manner, thereby making learning experiences more structured and analytical (Arifin, 2020; Khasanah et al., 2024; Sulistyawati et al., 2021). Meanwhile, gamification elements such as levels, challenges, and missions are regarded as instructional mechanisms that assist teachers in managing the learning flow in a gradual and systematic way (Ariani, 2020; Manzano-le et al., 2021; Mislia et al., 2025; Oliveira et al., 2023). Gamification is not viewed merely as an entertainment element, but rather as a pedagogical strategy with the potential to enhance learning engagement and sustain learning activities, particularly for topics that require strong conceptual understanding and the integration of interrelated physics variables (Dinihari et al., 2025; Martdana & Atno Atno, 2025).

Furthermore, the integration of local wisdom through the context of the bamboo flute as a representation of the open-pipe organ strengthens the ethnophysics dimension of the developed media. From the teachers' perspective, the use of local cultural objects as learning contexts provides opportunities to connect physics concepts with students' experiences and cultural identities, thereby making learning more contextual and meaningful (Pilendia, 2024). This approach positions physics not as knowledge detached from everyday life, but as an integral part of cultural practices that can be scientifically analyzed (Sasmi et al., 2025; Zaini et al., 2024). However, it should be noted that the findings regarding the cultural relevance of the BASA Booklet are based on respondents' perceptions, as the product has not yet been implemented directly in classroom learning. Therefore, further research involving classroom implementation is necessary to examine how the integration of ethnophysics-based local wisdom influences students' conceptual understanding and learning engagement in real instructional contexts. Therefore, further studies are recommended to conduct experimental or quasi-experimental research designs to evaluate the effectiveness of the developed media in improving students' learning outcomes, conceptual understanding, and higher-order thinking skills. Additionally, future research may examine students' cognitive gains and engagement levels when interacting with the gamified learning environment in order to provide stronger evidence of its pedagogical impact.

CONCLUSION

Fundamental Finding: The development of the BASA Booklet demonstrates that integrating STEM, gamification, and ethnophysics within a physics learning medium is a relevant strategy for addressing the need for contextual learning in sound wave topics. Conceptually, this study highlights that local wisdom, when positioned as an object of ethnophysics, can serve as a meaningful foundation for developing structured learning media that help bridge abstract physics concepts with real-world contexts. **Implication:** The developed BASA Booklet contributes an alternative model of culture-based learning media that conceptually supports the teaching of abstract physics topics through a structured and contextual design. **Limitation:** This study is limited to the development and feasibility evaluation stages based on responses from pre-service physics teachers, without classroom implementation. **Future Research:** Future research should involve experimental or quasi-experimental studies to evaluate the effectiveness of the media in improving learning outcomes, conceptual understanding, and students' cognitive gains.

REFERENCES

Abideen, Z. ul, & Jabeen, S. (2025). The role of context in problem-solving in STEM education: bridging informal and formal learning: A systematized literature review. *2025 ASEE Annual Conference & Exposition*. https://doi.org/10.18260/1-2--57256

Akbar, S. (2013). *Instrumen perangkat pembelajaran*. PT Remaja Rosdakarya.

Al-Ansi, A. M., Jaboob, M., Garad, A., & Al-Ansi, A. (2023). Analyzing augmented reality (AR) and virtual reality (VR) recent development in education. *Social Sciences and Humanities Open*, *8*(1), 100532. https://doi.org/10.1016/j.ssaho.2023.100532

Ariani, D. (2020). Gamifiksi untuk pembelajaran. *Jurnal Pembelajaran Inovatif*, *03*(02), 144–149. https://doi.org/10.21009/JPI.032.09

Arifin, A. M. (2020). Pengembangan media pembelajaran STEM dengan augmented reality untuk meningkatkan kemampuan spasial matematis siswa. *Jurnal Riset Pendidikan Matematika*, *7*(1), 59–73. https://doi.org/10.21831/jrpm.v7i1.32135

Arlinwibowo, J., Ishartono, N., Linguistika, Y., Purwoko, D., & Suprapto. (2023). Gamification in the STEM domain subject: The prospective method to strengthen teaching and learning. *Jurnal Pendidikan IPA Indonesia*, *12*(4), 564–574. https://doi.org/10.15294/jpii.v12i4.48388

Asyiqin, A. D., Mudhofar, M., & Wijaya, B. H. (2025). Development and implementation of system information management " Labsains 1 . 0 " for supporting practicum activities in FTIK Laboratory at IAIN Ponorogo. *Integrative Science Education and Teaching Activity Journal*, *6*(1), 75–86. https://doi.org/https://doi.org/10.21154/insecta.v6i1.10857

Bacovic, M., Andrijasevic, Z., & Pejovic, B. (2022). STEM education and growth in europe. *Journal of the Knowledge Economy*, *13*(3), 2348–2371. https://doi.org/10.1007/s13132-021-00817-7

Borg, W. R., & Gall, M. D. (1983). *Educational Research: An Introduction* (4th ed.). Longman.

Dare, E. A., Keratithamkul, K., & Hiwatig, B. M. (2021). Beyond content: The role of STEM disciplines, real-world problems, 21st century skills, and STEM careers within science teachers' conceptions of integrated STEM education. *Education Sciences*, *111*. https://doi.org/10.3390/educsci11110737

Dhamayanti, P. V. (2022). Systematic literature review: Pengaruh strategi pembelajaran.

Indonesian Journal of Educational Development, *3*(2), 209–219. https://doi.org/10.51878/science.v5i2.5162

Dinihari, Y., Rafli, Z., & Boeriswati, E. (2025). *Inovasi bahan ajar literasi: Pendekatan gamifikasi dan pedagogi modern*. Edupedia Publisher.

Fazrin, A. I., Agnafia, D. N., & Mashuri, A. (2025). Development of augmented reality (AR) media to improve learning outcomes on earth structure for eighth grade students. *Integrated Science Education Journal*, *6*(2). https://doi.org/10.37251/isej.v6i2.1762

Firmansyah, H., Ramadhan, I., & Wiyono, H. (2025). Enhancing historical understanding through local wisdom based learning : A case study in senior high schools. *Diakronika*, *25* (2025), 20–32. https://doi.org/10.24036/diakronika/vol25-iss1/477

Fiskawarni, T. H., Kurniawan, E., & Andriani, A. A. (2025). Integrating local wisdom into physics education through traditional games : A qualitative ethnoscience mapping of congklak. *Journal of Local Wisdom in Education*, *1*(2), 161–179. https://doi.org/https://doi.org/10.65508/7hrtt727

Gumilar, G., Wulandari, M. D., & Widyasari, C. (2025). Effectiveness of digital media-based contextual learning on critical and creative thinking skills in photosynthesis for elementary students. *Science Education Journal (SEJ)*, *9*(2), 135–156. https://doi.org/10.21070/sej.v9i2.1713

Gustiani, S. (2019). Research and development (R&D) method as a model design in educational research and its alternatives. *Holistics Journal*, *11*(2), 12–22.

Hou, H. (2023). Learning science through cloud gamification : A framework for remote gamified science learning activities integrating cloud tool sets and three-dimensional scaffolding. *Information*, *14*. https://doi.org/10.3390/info14030165

Joshi, A., Kale, S., Chandel, S., & Pal, D. K. (2015). Likert scale: Explored and explained. *British Journal of Applied Science & Technology*, *7*(4), 396–403. https://doi.org/10.9734/BJAST/2015/14975

Jumriani, J., Mutiani, M., Putra, M. A. H., Syaharuddin, S., & Abbas, E. W. (2021). The Urgency of local wisdom content in social studies learning: Literature review. *The Innovation of Social Studies Journal*, *2*(2), 103. https://doi.org/10.20527/iis.v2i2.3076

Kadoi, M. J. (2026). Culturally-Embedded Gamification : Integrating Behoa Valley local wisdom to enhance elementary science learning outcomes. *Journal of Innovation and Research in Primary Education*, *5*(1), 1108–1120. https://doi.org/10.56916/jirpe.v5i1.2968

Khasanah, A. N., Rosana, D., Wilujeng, I., & Siswanto, I. (2024). The effectiveness of nutrition booklet based on the local potential of Surakarta through STEM learning to optimize students ' healthy lifestyle attitude. *Proceedings of the 6th International Conference on Current Issues in Education*, 119–129. https://doi.org/10.2991/978-2-38476-245-3_14

Kotsis, K. T. (2025). From theory to practice : Exploring students ' everyday use of physics knowledge. *European Journal of Contemporary Education and E-Learning*, *3*(5), 59–76. https://doi.org/10.59324/ejceel.2025.3(5).05

Krishnamurthy, K., Selvaraj, N., Gupta, P., Cyriac, B., Dhurairaj, P., Abdullah, A., Krishnapillai, A., Lugova, H., Haque, M., Xie, S., & Ang, E. T. (2022). Benefits of

gamification in medical education. *Clinical Anatomy*, *35*(6), 795–807. https://doi.org/10.1002/ca.23916

Krualunteerayut, P., Meethaisong, T., & Phanchan, C. (2024). The integration of local wisdom with learning innovations in the 'Buddhism' course for lower secondary school students in Thailand's educational opportunity expansion schools. *Journal of Education and Learning*, *13*(5), 48. https://doi.org/10.5539/jel.v13n5p48

Lopes, L., Schreurs, S., Licour, C., & Soares, S. (2024). Developing competencies through flow, gamification and cultural integration : An analysis of the potential of games in teaching/learning. *Radiation Effects & Defects in Solids*, *179*(1–2), 3–13. https://doi.org/10.1080/10420150.2024.2318700

Manzano-le, A., Camacho-lazarraga, P., Guerrero, M. A., Guerrero-puerta, L., Aguilar-parra, J. M., & Alias, A. (2021). Between level up and game over : A systematic literature review of gamification in education. *Sustainability*, *13*(2247), 1–14. https://doi.org/ 10.3390/su13042247

Martdana, R. A., & Atno Atno. (2025). Gamifikasi dalam pembelajaran sejarah: Analisis literatur terhadap dampaknya pada motivasi dan keterlibatan belajar siswa. *Edukasiana: Jurnal Inovasi Pendidikan*, *4*(2), 327–335. https://doi.org/10.56916/ejip.v4i2.1148

Mislia, Riatmaja, D. S., Rukhmana, T., Ikhlas, A., Widoyo, H., & Nurcahyo, N. (2025). Implementasi gamifikasi dalam pembelajaran untuk meningkatkan motivasi siswa. *Indonesian Institute for Corporate Learning and Studies (IICLS)*, *6*(1), 461–470. https://doi.org/10.47827/jer.v6i1.547

Nurpratiwi, F., Prima, E. C., & Septiyanto, A. (2025). Measurement of sound speed using a frequency generator-assisted resonance tube for STEM-based learning. *Jurnal Pendidikan Matematika dan Sains*, *13*(2), 284–295. https://doi.org/10.21831/jpms.v13i2.86

Oliveira, W., Hamari, J., Shi, L., Toda, A. M., Rodrigues, L., Palomino, P. T., & Isotani, S. (2023). Tailored gamification in education : A literature review and future agenda. *Education and Information Technologies*, *28*(1), 373–406. https://doi.org/10.1007/s10639-022-11122-4

Ouyang, F., & Xu, W. (2024). The effects of educational robotics in STEM education: a multilevel meta-analysis. *International Journal of STEM Education*, *11*(1). https://doi.org/10.1186/s40594-024-00469-4

Permanasari, A., Rubini, B., & Nugroho, O. F. (2021). STEM education in indonesia: science teachers and students perspectives. *Journal of Innovation in Educational and Cultural Research*, *2*(1), 7–16. https://doi.org/10.46843/jiecr.v2i1.24

Pilendia, D. (2024). Kajian filsafat ilmu : integrasi multimedia interaktif dan kearifan lokal dalam pembelajaran fisika. *JPSS: Jurnal Pendidikan Sang Surya*, *10*(2), 474–481. https://doi.org/10.61132/jupenkifb.v1i4.527

Rahim, M., & Mohammed, L. A. (2025). Impact of gamification based formative assessment tasks on higher order thinking skills and motivation in the subject of mathematics among primary school students. *Journal of Asian Development Studies*, *14*(1), 1863–1894. https://doi.org/10.62345/jads.2025.14.1.148

ŞAHİN, M. (2026). Digital story-based science concept teaching and reflective thinking skills for early childhood education. *Journal of Theoretical Educational Sciences*, *19*(1), 216–231. https://doi.org/10.30831/akukeg.1795707

Saleem, S., Dhuey, E., White, L., & Perlman, M. (2024). Understanding 21st century skills

needed in response to industry 4.0: Exploring scholarly insights using bibliometric analysis. *Telematics and Informatics Reports*, *13*(February), 100124. https://doi.org/10.1016/j.teler.2024.100124

Sasmi, R. R., Shiha, S. N., Saregar, A., & Deta, U. A. (2025). Perspektif siswa SMA terhadap kearifan lokal, literasi sains, dan motivasi belajar dalam pembelajaran fisika. *Reog: Journal of Ecoethnoscience Education*, *01*(01), 32–39. https://doi.org/10.58706/reog.v1n1.p32-39

Sata, S. K. (2024). Advancing analytical and problem-solving skills for STEM-Related challenges : Exploring innovative educational strategies and practical applications. *World Journal of Arts, Education and Literature*, *1*(2), 32–38. https://doi.org/doi.10/10/2024

Sırakaya, M., & Alsancak Sırakaya, D. (2022). Augmented reality in STEM education: a systematic review. *Interactive Learning Environments*, *30*(8), 1556–1569. https://doi.org/10.1080/10494820.2020.1722713

Sugiyono. (2017). *Statistik untuk Penelitian* (29th ed.). Alfabeta.

Sulistyawati, E., Faizah, L., Nisa, I., & Putra, I. G. (2021). Pengembangan media pembelajaran berbasis STEM respon siswa terhadap matematika. *Focus Action of Research Mathematic*, *3*(2), 125–138. https://doi.org/10.30762/factor-m.v3i2.2611

Susanti, N., Yennita, & Azhar. (2020). Development of contextual based electronic global warming modules using flipbook applications as physics learning media in high schools. *Journal of Educational Sciences*, *4*(3), 541–559. https://doi.org/10.31258/jes.4.3.p.541-559

Takwin, M., Suchat, M., & Charuni, W. (2023). Constructivist gamification environment model designing framework to improve ill - structured problem solving in learning sciences. *Educational Technology Research and Development*, *71*(6), 2413–2429. https://doi.org/10.1007/s11423-023-10279-0

Tohri, A., Rasyad, A., Sururuddin, M., & Istiqlal, L. M. (2022). The urgency of Sasak local wisdom-based character education for elementary school in East Lombok, Indonesia. *International Journal of Evaluation and Research in Education*, *11*(1), 333–344. https://doi.org/10.11591/ijere.v11i1.21869

Wang, C., Shen, J., & Chao, J. (2022). Integrating computational thinking in STEM education: A literature review. *International Journal of Science and Mathematics Education*, *20*(8), 1949–1972. https://doi.org/10.1007/s10763-021-10227-5

Xu, W., & Ouyang, F. (2022). The application of AI technologies in STEM education: a systematic review from 2011 to 2021. *International Journal of STEM Education*, *9*(1). https://doi.org/10.1186/s40594-022-00377-5

Zaini, M., Kafrawi, M., & Musanni. (2024). Ethnophysics and technology : Physics e-module integrated with local wisdom based on an Android application. *Jurnal Pendidikan Fisika dan Teknologi (JPFT)*, *10*(2), 283–297. https://doi.org/10.29303/jpft.v10i2.7240

Zeybek, N., & Saygı, E. (2024). Gamification in education: why, where, when, and how?—A systematic review. *Games and Culture*, *19*(2), 237–264. https://doi.org/10.1177/15554120231158625

Zhang, B., Goodman, L., & Gu, X. (2022). Novel 3D contextual interactive games on a gamified virtual environment support cultural learning through collaboration among intercultural students. *Sage Publication*, *3663*(1), 1-16. https://doi.org/10.1177/21582440221096141

Ali Khasan Al Farishi
Department of Physics Education, Faculty of Mathematics and Natural Science,
Universitas Negeri Surabaya,
Jl. Ketintang, Surabaya, East Java, 60231, Indonesia.
Email: 25031635002@mhs.unesa.ac.id

***Dr. Binar Kurnia Prahani (Corresponding Author)**
Department of Physics Education, Faculty of Mathematics and Natural Science,
Universitas Negeri Surabaya,
Jl. Ketintang, Surabaya, East Java, 60231, Indonesia.
Email: binarprahani@unesa.ac.id

Mita Anggaryani, Ph.D.
Department of Physics Education, Faculty of Mathematics and Natural Science,
Universitas Negeri Surabaya,
Jl. Ketintang, Surabaya, East Java, 60231, Indonesia.
Email: mitaanggaryani@unesa.ac.id

Muhammed Akif Kurtulus, Ph.D.
Alanya Alaaddin Keykubat University, Turkey,
Kestel Neighbourhood University Street No: 80 Alanya, Antalya, Turkey.
Email: muhammed.kurtulus@alanya