Integrated Science Education Journal
Vol. 7, No. 3, May 2026, pp. 490~505
ISSN: 2716-3725, DOI: 10.37251/isej.v7i3.3041

Research Article

Development of the PjBL-SSI-Based Soundwise E-Module for Fifth-Grade Elementary Science Learning on Sound and Its Properties

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Article Info

Article history:

Received Feb 28, 2026
Revised Apr 02, 2026
Accepted May 21, 2026
OnlineFirst May 31, 2026

Keywords:

E-module
Digital Learning
Project-Based Learning
Socio-Scientific Issues

ABSTRACT

Purpose of the study: This study aims to develop and validate an e-module based on Project-Based Learning (PjBL) and Socio-Scientific Issues (SSI) for fifth-grade elementary science learning on sound and its properties, and to assess its validity through expert assessments of the material, media, and language aspects.

Methodology: This study employed a Research and Development (R&D) approach, using a modified 4D model comprising the Define, Design, and Development stages. The e-module was created with digital design tools and incorporated Project-Based Learning (PjBL) and Socio-Scientific Issues (SSI) approaches. Data collection involved expert validation sheets and questionnaires, which were analyzed using descriptive quantitative methods and percentage calculations.

Main Findings: The validation results demonstrated that the developed e-module received high validity scores from experts: 97% from material experts, 92% from media experts, and 95% from language experts. These findings suggest that the e-module is highly valid, suitable, and feasible as a learning resource in elementary science education, especially for the topic of sound and its properties.

Novelty/Originality of this study: The novelty of this study lies in the integration of Project-Based Learning and Socio-Scientific Issues within a single interactive e-module design for elementary science learning. This integration provides contextual, inquiry-based learning experiences that connect abstract scientific concepts with real-world issues, thereby enhancing conceptual understanding and supporting meaningful learning in elementary education.

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1. INTRODUCTION

Science learning in elementary schools still faces challenges in increasing student active involvement, especially in abstract materials. Activities that let students observe, try, and relate the material to everyday life can improve understanding of concepts [1], [2]. In this context, science as the basis of science learning is not only oriented towards mastering facts and concepts, but also emphasizes the scientific process and scientific way of thinking as a unit [3]. However, classroom learning is still often dominated by theoretical explanations and

passive learning activities, limiting students' opportunities to construct understanding through meaningful experiences.

Students' active involvement is essential in developing 21st-century skills such as critical thinking, creativity, collaboration, and problem-solving [4], [5]. In science learning, students are expected not only to master concepts but also to develop scientific processes and ways of thinking [6], [7]. Research has shown that contextual and problem-based learning can improve conceptual understanding and critical thinking through meaningful learning experiences [8]. Furthermore, socioscientific discussions encourage students to evaluate information, formulate arguments, and make evidence-based decisions related to real-life scientific phenomena [9], [10]. Based on the distribution of questionnaires to fifth-grade students at Elementary School 016 Samarinda Ulu, a significant gap was identified between the expected implementation of active learning and its actual classroom practice. Although students showed interest in IPAS learning (76.84%), their understanding of sound material and its properties remained moderate (69.73%). This condition was reinforced by students' responses, indicating difficulties in understanding abstract concepts (71%).

The limited availability of digital teaching materials was identified as one of the main contributing factors. Learning activities were still dominated by worksheets (88%) and textbooks (36%), while e-modules accounted for only 6%, even though most students agreed that digital media made learning easier and more engaging (80.78%). In addition, students perceived science learning as overly theoretical (64.57%) and less connected to everyday life contexts (72.89%). Although students expressed interest in Project-Based Learning (70.26%), many considered its implementation difficult and time-consuming. Teachers also reported classroom management and limited instructional time as major obstacles in implementing PjBL and SSI approaches, despite strongly agreeing with their effectiveness (90%).

These findings indicate that existing learning resources have not adequately supported contextual, interactive, and meaningful science learning experiences. Although students showed interest in Project-Based Learning (PjBL), they considered project implementation difficult and time-consuming. Teachers also identified classroom management and limited instructional time as obstacles in implementing PjBL and SSI approaches. Modules as structured teaching materials can support students' independent learning [11]. Along with technological development, digital teaching materials are increasingly needed to facilitate interactive and flexible learning [12], [13]. E-modules supported by multimedia elements such as images, videos, animations, and simulations can increase students' engagement and conceptual understanding [14], [15].

The integration of e-modules with active learning models is essential for fostering flexible and meaningful learning. E-modules support students through the combination of textual explanations and visual elements such as images, animations, and simulations, allowing concepts to be understood more interactively [16]. However, e-modules alone are not sufficient to create meaningful engagement; therefore, integration with the PjBL model is needed to encourage student participation in project-based activities and real problem-solving [17]. In its implementation, PjBL not only requires students to understand concepts but also encourages them to take action to solve problems by creating products or project outcomes. These activities can be strengthened through the SSI approach, which presents everyday-life contexts to make learning more meaningful and reflective [18]. SSI also encourages students to evaluate information, discuss evidence, and develop decision-making skills through authentic socio-scientific problems relevant to daily life [19]. In addition, SSI learning facilitates argumentation and discussion activities that help students consider scientific concepts alongside moral and social perspectives when responding to real-world issues [20].

Various studies have shown that integrating PjBL and SSI can improve science learning. Alya & Purwaningsih [21] found that SSI-based e-modules integrated with projects improved science process skills. Fitriyani et al. [22] reported that integrating PjBL with SSI enhanced elementary students' critical thinking skills more effectively than conventional learning. Syarlisjiswan et al. [23], also showed that PjBL-SSI e-modules increased student engagement with real-world issues. Other studies confirmed that PjBL-based e-modules improved cognitive learning outcomes and critical thinking skills among elementary school students [24], [25].

However, previous studies mostly focused on secondary education and have not specifically explored the integration of PjBL and SSI within digital e-modules designed for elementary school students, particularly in abstract science materials such as sound and its properties. This study, therefore, addresses this gap by developing and validating an integrated e-module for elementary science learning on sound and its properties, integrating PjBL and SSI. This gap highlights the urgency of providing contextual, interactive, and visually supported learning materials that enhance students' conceptual understanding and engagement.

Therefore, this study aims to develop and validate a Soundwise e-module based on Project-Based Learning (PjBL) and Socio-Scientific Issues (SSI) for fifth-grade science learning on sound materials and their properties. Accordingly, this study seeks to answer two main research questions: (1) how is the development process of the PjBL-SSI-based Soundwise e-module for fifth-grade science learning on sound material and its properties, and (2) what is the validity level of the developed Soundwise e-module based on material, media, and language expert assessments?

2. RESEARCH METHOD

This type of research is Research and Development. Research and Development (R&D) is a systematic process of stages focused on developing or improving new products [26]. In line with this, According to [27] emphasize that this approach not only focuses on product outcomes but also encourages innovation that increases student engagement and maintains relevance to learning objectives. This study employs the research and development (R&D) method, adhering to Thiagarajan's 4D model, comprising the Define, Design, Develop, and Disseminate phases [28]. This study is confined to the Development stage, consistent with the stated research objectives and scope. The development procedure is illustrated in Figure 1.

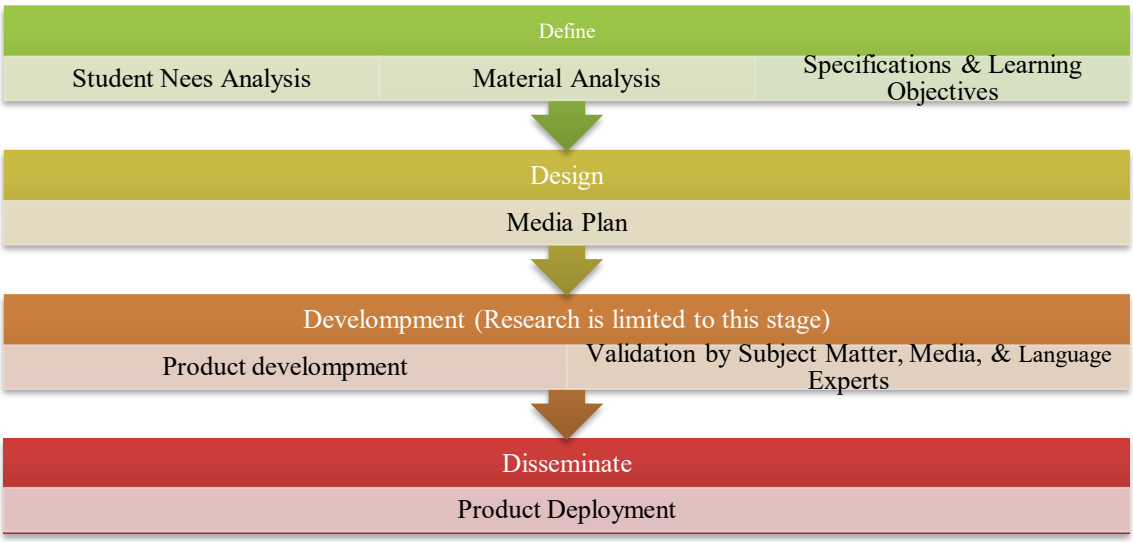


Figure 1. 4D Development Model Research Procedure

The participants in this study consisted of grade V students and teachers at Elementary School 016 Samarinda Ulu who participated in the needs analysis phase. A saturated sampling technique was employed, including all grade V students at Elementary School 016 Samarinda Ulu as research participants. This approach was selected due to the relatively small and accessible population, which enabled inclusion of the entire population without sampling.

The inclusion criteria for participants were as follows: (1) students enrolled in grade V at Elementary School 016 Samarinda Ulu; (2) students who had participated in science learning on the topic of sound; and (3) teachers who actively teach science in grade V. The product's feasibility was evaluated by three material experts, three media experts, and three language experts to ensure comprehensive validation of the developed e-module.

Data were collected using Likert-scale questionnaires. The instruments consisted of: (1) a needs analysis questionnaire was administered to identify students' learning needs, which served as the foundation for developing the Soundwise e-module. (2) a validation questionnaire was used to evaluate the feasibility of the developed e-module. The variables assessed in this study were material feasibility, media feasibility, and language feasibility. The variables were assessed through expert validation utilizing a five-point Likert scale, with values ranging from 1 (very poor) to 5 (excellent).

The validation instruments used in this study were adapted from previously validated studies. The material validation instrument was adapted from [28], the media validation instrument from [28], and the language validation instrument was adapted from [29]. Content validity was ensured through expert judgment from specialists in the fields of materials, media, and language. The instruments were adapted from previously validated instruments, ensuring content validity and relevance to the research context. The adaptation was carried out by maintaining the structure and indicators from the original instruments, while adjusting the wording to fit the context of this study. Therefore, the instruments were considered appropriate for data collection based on their prior validation in prior studies. Each instrument consists of aspects and indicators as presented in Table 1, 2, and 3.

Table 1. Material Expert Validation Instrument

Aspects	Indicator
Content eligibility	Material accuracy with Learning Outcomes
	Material Accuracy
Presentation Eligibility	Serving Techniques
	Presentation Support
Project Based Learning	Compatibility with the PjBL Model Stages
Socio-Scientific Issues	Compatibility with the SSI approach

Table 2. Media Expert Validation Instrument

Aspects	Indicator
Audio Visual	Media Display Clarity
	Cover Design
	Completeness of Layout Elements
	Page Layout
Media Engineering Aspects	Effectiveness and efficiency
	Precision in selecting media
	Reliability of the material used if used for a long time
	Security Use of learning media
	Cost-effectiveness in the long run
Media Usage	Implementation
	Media Flexibility

Table 3. Linguist Validation Instruments

Aspects	Indicator
Accuracy with student development	Precision with the level of emotional development
	Precision with the level of emotional development
Communicative	Students' understanding of the language being delivered
	Accuracy of the illustration of the problem conveyed with the substance of the message
Straightforward	Sentence structure accuracy
	Standardization of terms
Coherence and Cohesion	The Meaning of Meaning in Alenia
	Standardization of terms
Accuracy with the correct Indonesian language rules	Grammatical accuracy
	Spelling linkage

Each response option is assigned a distinct score that indicates the quality of the e-module teaching materials. The scoring for each answer option is shown in Table 4.

Table 4. Scoring Criteria

Score	Category
5	Excellent
4	Good
3	Moderate
2	Poor
1	Very Poor

Data analysis in this study employed descriptive quantitative analysis. The feasibility level of the e-module was determined by calculating percentage scores using the following formula: Based on the score obtained, it can be calculated using the formula from [31] as follows:

$$P = \frac{f}{N} \times 100\% \ldots (1)$$

Description:
P = Percentage numbers and questionnaires
f = Total score obtained
N = Maximum number of scores

Furthermore, to measure the average percentage of each aspect according to the criteria for the e-module, with the calculation formula of [32] as follows:

$$\bar{X} = \frac{\sum x_i}{n} \times 100\% \ldots (2)$$

Description:
$\bar{X}$ = Average
$\sum x_i$ = The number of values of each validator
n = Number of validators

This study employs descriptive quantitative analysis to assess the product's feasibility rather than conducting hypothesis testing. Data obtained from expert validation were analyzed using percentage calculations, comparing the obtained scores with the maximum possible score. The results were then interpreted descriptively to determine the quality and feasibility of the developed e-module against predetermined validity criteria.

The results of the validation questionnaire calculations are categorized based on the validity criteria presented in Table 5.

Table 5. Validity Criteria

Interval Persentase (%)	Criteria
81% - 100%	Highly Valid
61% - 80%	Valid
41% - 60%	Quite Valid
21 – 40%	Invalid
0 – 20%	Highly Invalid

3. RESULTS AND DISCUSSION

The research findings are organized according to three primary stages of the 4D model: define, design, and development. The 4D model was selected due to its clear, systematic, and efficient development procedures. The main focus of this study was to develop a PjBL- and SSI-based Soundwise e-module that meets the standards of material, media, and language validity for sound and its properties materials.

The developed Soundwise e-module integrates PjBL-SSI, and multimedia features to support contextual and interactive science learning. PjBL encourages students' critical thinking, collaboration, creativity, and communication through project activities, while SSI connects scientific concepts with real-life social issues and promotes reasoning and decision-making skills [34], [35]. In addition, multimedia support such as videos, animations, and images helps students understand abstract science concepts more effectively by reducing cognitive burden and improving information processing [36]. Therefore, the integration of PjBL, SSI, and multimedia features within a single digital learning resource represents the novelty of this study, as it was specifically designed for elementary science learning on abstract materials, such as sound and its properties.

Overall, the Soundwise e-module is arranged in several main components, namely the title of the material, instructions for use, learning outcomes, learning objectives, learning materials, learning videos, discussion of socioscientific issues as the context of the problem, group projects, and practice questions, so as to support contextual and independent learning.

3.1. Define Stage

At the definition stage, the researcher defines learning needs by analyzing the questionnaires given to students and teachers. This stage aims to systematically identify learning needs, especially in the implementation of PjBL and SSI. The focus of the analysis at this stage is only on student needs, based on questionnaire data. The analysis was carried out on 56 grade V students and 2 teachers at Elementary School 016 Samarinda Ulu. Based on the questionnaire results, 71% of students agreed that abstract IPAS material was difficult to understand. Although 69.73% of students stated that they understood the material, some students still experienced difficulties in understanding abstract concepts related to sound. A contextual approach through daily activities can make the concept of IPAS easier to understand and potentially reduce misconceptions [37].

In terms of teaching materials, the use of e-modules remains very low at 6%, while learning is still dominated by worksheet (88%) and textbooks (36%). This condition indicates that the use of interactive digital teaching materials in elementary schools is still limited. In fact, e-modules serve as systematic, interactive teaching materials to support independent learning, allowing students to control their learning process according to their individual capacity and pace [38]. This situation reflects the need for digital transformation in instructional media at the elementary school level.

Student interest in PjBL reached 70.26%, showing a positive tendency towards project-based learning. However, 70% of students stated that projects were difficult, and 75% considered projects to take a long time. These findings indicate that although PjBL is in demand, its implementation faces obstacles, making it

suboptimal. Meanwhile, SSI-related skills, such as decision-making (66.57%), delivery of results (66.57%), and understanding of science uncertainty (65.26%), showed progress that was beginning to be seen, but had not reached the optimal level.

These findings indicate that students need contextual, interactive, and digitally supported learning resources that can facilitate the understanding of abstract science concepts while supporting project-based and socioscientific learning activities. Overall, the results of this needs analysis show various weaknesses in science learning, including understanding concepts, using teaching materials, and applying learning methods. Therefore, the findings of the needs analysis served as the basis for developing a contextual and interactive Soundwise e-module integrating PjBL and SSI approaches.

3.2 Design Stage

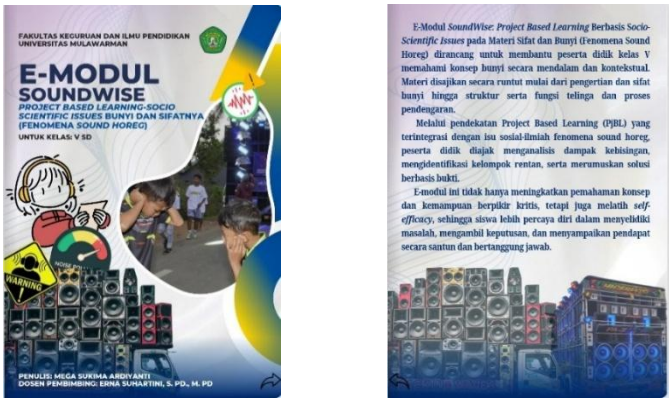
The design stage begins with designing an e-module structure based on learning outcomes (CP) and learning objectives (TP) on nature and sound materials. In this Soundwise e-module, interactive navigation buttons are prepared, namely home to return to the front page, materials to access content properties and sounds, SSI to display sound issues, projects for project-based activity stages, and practice questions for evaluation of student understanding. All components of the module are arranged into a complete form, including front and back covers, table of contents, instructions for use, concept map, introduction, property and sound material, noise pollution, sound phenomenon as part of SSI, IPAS project with PjBL syntax, summary, Wayground-based practice questions, glossary, bibliography, author profile, and interactive navigation.

The design stage continues with the creation of the e-module interface using Canva. The use of Canva enabled the development of an attractive, interactive e-module interface accessible across various devices**.** In this case, Taufan et al. [39] stated that Canva is an online-based graphic design platform that facilitates the creation of interesting and interactive learning media and can be accessed through various devices such as mobile phones, computers, laptops, and tablets, and can be used as an innovative alternative in creating interactive learning media in the digital era that is effective to increase students' interest in learning [40], [41]. Interactive digital media can also increase students' motivation and engagement in elementary learning through game-based and visually attractive activities [42].

The learning content in this Soundwise e-module is designed by integrating the PjBL model and the SSI approach. The implemented Project-Based Learning (PjBL) framework comprises several stages: formulating the essential question, designing a project plan, establishing a schedule, monitoring student and project progress, assessing outcomes, and evaluating the overall experience [43]. Prior studies demonstrate that project-based and contextual learning approaches foster active inquiry, collaboration, and meaningful learning experiences in science education [44].

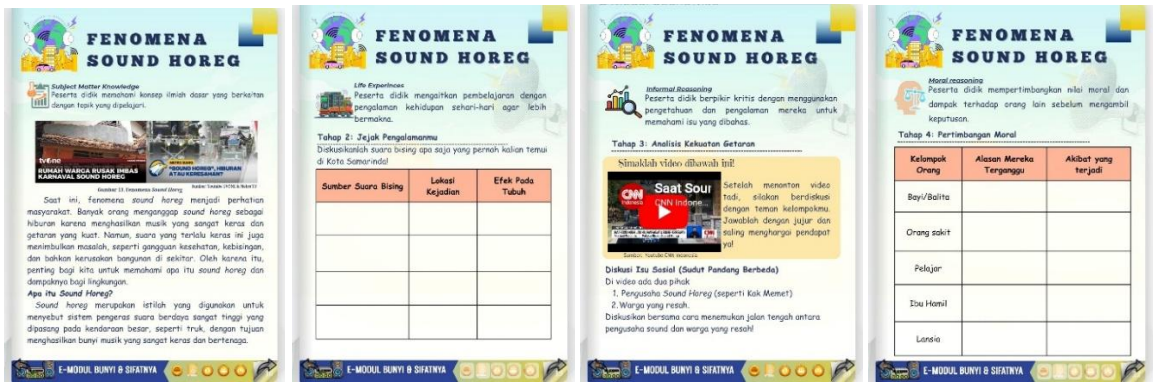
The SSI approach is integrated through the presentation of real issues related to daily life, namely the phenomenon of sound horeg. The integration of SSI was intended to encourage students to relate scientific concepts to real-life social problems through reasoning and decision-making activities. SSI-based learning also encourages students to develop scientific argumentation, communicate ideas, and actively participate in problem-solving discussions related to real-life issues [45]. The inclusion of socio-scientific issues in learning sparks debates that require students to analyze problems in depth; This integration has proven to be effective in improving decision-making competence, although it still faces challenges in forming a flexible attitude towards risk at the primary school level [19], [46]. The SSI stages used in this Soundwise e-module include subject-matter knowledge, informal reasoning, decision-making, character and reflective judgment, argumentation, moral reasoning, and life experiences [47].

Furthermore, the Soundwise e-module was transformed into a flipbook on the Heyzine platform. As a web-based tool, Heyzine converts PDFs into interactive digital books that look and feel like physical books. The flipbook incorporates multimedia elements, including links, videos, and audio, that enhance learner engagement and minimize monotonous instructional delivery [48], [49].



(a) (b)

Figure 2. E-Module Cover a) E-module front cover b) E-module back cover



(a) (b) (c) (d)

(e) (f) (g)

Figure 3. Socio-Scientific Issues (SSI) Stages a) a) Subject matter knowledge, b) Informal reasoning, c) Decision making, d) Character and reflective judgment, e) Argumentation, f) Moral reasoning, g) Life experiences

(a) (b) (c)

(d) (f) (g)

Figure 4. Syntax of PjBL a) Determining fundamental questions b) Designing project planning c) Developing project schedules d) Monitoring project progress e) Testing results f) Evaluation

3.3 Development Stage

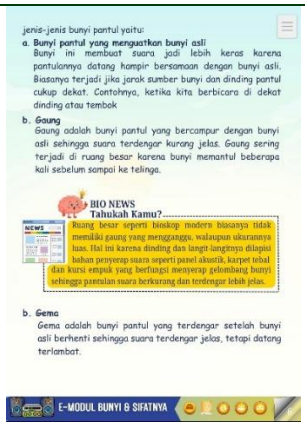
In the development stage, the activity focuses on validating and revising the Soundwise e-module developed in the previous stage. This validation assesses the product's validity in terms of materials, media, and language before it is implemented in learning. The validation process in development research aims to ensure quality and to assess the suitability of the developed products for meeting educational criteria [50], [51].

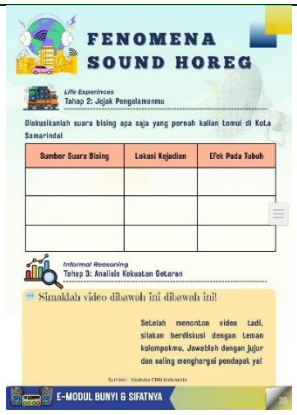
In this study, the validators consisted of three subject matter expert validators (two PGSD lecturers and one teacher of Elementary School 016 Samarinda Ulu), three media expert validators (Computer Education lecturers), and three linguist validators (one PGSD lecturer, one Indonesian Language Education lecturer, and one teacher of Elementary School 016 Samarinda Ulu). Experts are selected based on their academic background and teaching experience [52]. This selection ensures the credibility and validity of the evaluation process.

After validation, the validators provided various suggestions and inputs that served as the basis for product revisions. Revisions are made to address flaws and weaknesses identified during validation [53]. Based on validation results from the material experts, several suggestions to improve the material's feasibility and presentation were identified. The revisions include simplifying paragraphs, adding representative images, grounding the material in a real-world context, and providing more in-depth explanations of concepts. A summary of the revisions from the subject matter expert validators is presented in Table 6.

Table 6. Revision of E-Module Materials

Enter	Before Revision	After Revision
On page 5 the paragraphs are simplified into one to make it more concise.	 Comprised three long, repetitive paragraphs explaining wave propagation theories.	 Merged into a single narrative paragraph that is direct and concise.

Enter	Before Revision	After Revision
On page 6, the use of images is excessive and BioNews is added, which explains that modern large spaces such as cinemas do not experience echoes.		
	Cluttered with four overlapping sound reflection images without structural context.	Reduced to two key images and added a *BioNews* box about cinema soundproofing.
On page 7 add an explanation of the frequency and the difference in the height of the sound		
	Provided only a general definition of sound without distinguishing its core properties.	Added text and diagrams to differentiate between pitch (frequency) and loudness (amplitude).
On page 13, an explanation of the process of denying		
	Ear anatomy functions were presented statically without explaining hearing protection mechanisms.	Added a step-by-step flowchart of hearing and text explaining how materials damp sound waves.

Enter	Before Revision	After Revision
On pages 17-24 An explanation of each stage of SSI is added	 Presented the sound horeg article directly without guiding students through structured analytical steps.	 Integrated explicit sub-headings and discussion prompts for each of the seven SSI stages.

After improvements are made based on the validator's suggestions, the product is reassessed. The results of the reassessment are presented in Table 7.

Table 7. Recapitulation of Subject Matter Experts after Revision

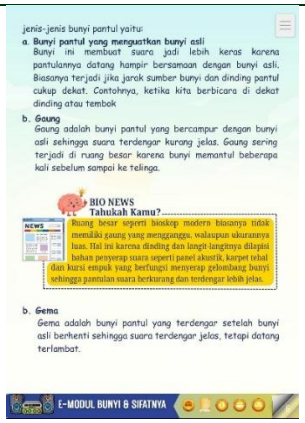
Aspects Assessed	Material Expert Validator			Eligibility Percentage (%)	Categories
	Validator 1	Validator 2	Validator 3		
Content Eligibility	100%	100%	96%	98%	Highly Valid
Presentation Eligibility	96%	96%	100%	97%	Highly Valid
Aspects of Project Based Learning	100%	88%	100%	96%	Highly Valid
Socio-Scientific Issues Approach	100%	100%	95%	98%	Highly Valid
Average Percentage				97%	Highly Valid

The percentage of material expert validation results for the PjBL-SSI-based Soundwise e-module applied in the learning process reached 97% and was included in the "Highly Valid" category. This finding indicates that the developed material, PjBL syntax, and SSI integration were deemed appropriate for elementary school learning objectives.

Based on the validation results from media experts, several inputs on audio-visual aspects, media engineering, and usability were obtained. The revisions included optimizing audio elements, enhancing navigation flexibility, and making typographic adjustments to improve readability. A summary of the revisions from the media expert validators is presented in Table 8.

Table 8. Media Expert Recapitulation after Revision

Enter	Before Revision	After Revision
On page 18 Add audio sound horeg to improve the learning experience of students.	 Featured only static text and photos of trucks, lacking actual auditory perception	 Embedded an interactive audio link of authentic *sound horeg* bass vibrations.

Enter	Before Revision	After Revision
Added a navigation button so that users can directly access the desired part of the material.	 Lacked a shortcut menu, forcing users to flip pages manually one by one.	 Added a navigation menu (Home, Materials, SSI, Project, Quiz) on every page.
Change font types and sizes to make them clearer and improve readability.	 Used a decorative "Rustico" font that was too dense and hard to read on screens.	 Changed to a kid-friendly "Comic Sans" font to optimize readability for elementary students.

After improvements are made based on the validator's suggestions, the learning media are reassessed. The results of the reassessment are presented in Table 9.

Table 9. Recapitulation of Media Expert Validation after Revision

Aspects Assessed	Material Expert Validator			Eligibility Percentage (%)	Categories
	Validator 1	Validator 2	Validator 3		
Audio Visual	90%	91%	97%	93%	Highly Valid
Media Engineering	85%	92%	97%	91%	Highly Valid
Aspects of Project Based Learning	86%	100%	93%	93%	Highly Valid
Average Percentage				92%	Highly Valid

The percentage of media expert validation results for the PjBL-SSI-based Soundwise e-module reached 92% and was included in the Highly Valid category. These results indicate that the developed media meet the standards for functional design, readability, navigation, and multimedia integration in digital learning.

In addition to the material and media aspects, validation of the linguistic aspect is also carried out to ensure that the information in the module can be conveyed effectively. Based on the linguist's validation, several suggestions for improving the accuracy of the term, the effectiveness of the sentences, and the clarity of the context were provided. The revisions include replacing foreign terms with Indonesian equivalents, changing passive sentences to active voice, and adding explanations of technical terms such as sound horeg and earmuff. A summary of revisions from linguist validators is presented in Table 10.

Table 10. Language Expert Revision Summary

Enter	Before Revision	After Revision
On page 1 change the term to the correct Indonesian equivalent.	 Mixed non-standard English phrases into navigation prompts (e.g., "click button home").	 Replaced completely with formal, standard Indonesian terms (e.g., "klik tombol beranda").
On page 12 Omit the first paragraph and directly present the material of the ear parts.	 Opened with a wordy biological narrative about anatomy that drifted from physics concepts.	 Removed the text completely to open directly with the human ear diagram.
On page 17 add the definition of sound horeg so that readers understand the context of the phenomenon.	 Definition of *sound horeg* to clarify the context.Introduced the local cultural term "sound horeg" abruptly in the text without any prior explanation.	 Added a clear operational definition explaining "sound horeg" as a localized high-intensity audio parade phenomenon.

After improvements are made based on the validator's suggestions, the product's linguistic aspects are reassessed. The results of the reassessment are presented in Table 11.

Table 11. Recapitulation of Language Expert Validation after Revision

Aspects Assessed	Material Expert Validator			Eligibility Percentage (%)	Categories
	Validator 1	Validator 2	Validator 3		
Accuracy with Student Development	100%	100%	90%	98%	Highly Valid
Communicative	90%	100%	90%	97%	Highly Valid
Straightforward	100%	100%	100%	96%	Highly Valid
Coherence and Cohesion	100%	100%	90%	98%	Highly Valid
Accuracy with Indonesian Language Rules	90%	90%	100%		
Average Percentage				97%	Highly Valid

The percentage of linguist validation results for the PjBL-SSI-based Soundwise e-module reached 95% and was included in the Highly Valid category. This finding indicates that the language employed in the module was clear, accessible, and suitable for the developmental stage of elementary school students. The validation results demonstrate that the developed Soundwise e-module has high validity and feasibility for implementation in elementary science education.

The results indicate that the Soundwise e-module demonstrates high validity across material, media, and language. This suggests that integrating PjBL, SSI, and multimedia features is suitable for elementary science instruction on sound and its properties. The integration of structured project activities, socioscientific reasoning, and multimedia learning supports contextual science learning for elementary students. The findings support previous studies reporting that integrating PjBL and SSI can improve science learning, critical thinking, science process skills, and student engagement with real-world issues [21]-[23]. Furthermore, PjBL-based e-modules have been shown to enhance cognitive learning outcomes and critical thinking skills among elementary school students [24], [25].

However, previous studies mostly focused on secondary education and did not specifically integrate PjBL and SSI within digital e-modules for elementary science learning on abstract materials such as sound and its properties. Therefore, the novelty of this study lies in the development of an integrated Soundwise e-module that combines PjBL syntax, SSI stages, and multimedia features in one contextual digital learning resource for elementary students.

Practically, the Soundwise e-module can support teachers in implementing interactive, contextual, and technology-based science learning in elementary schools. However, this study was limited to the development and validation stages and did not include classroom implementation or effectiveness testing. Therefore, future research is recommended to examine the practicality and effectiveness of the Soundwise e-module in improving students' learning outcomes, critical thinking, and socioscientific reasoning abilities.

4. CONCLUSION

A Soundwise E-Module was developed utilizing PjBL integrated with the SSI approach for fifth-grade science learning on sound and its properties. Validation results indicated that the e-module met the criteria for a highly valid instructional resource across material, media, and language quality. The contribution of this study lies in the development of an integrated digital learning resource that combines PjBL activities, SSI stages, and multimedia features within a single instructional design for elementary science learning. This study also addresses the gap in previous research, which mostly focused on secondary education and rarely integrated PjBL and SSI within digital e-modules for abstract elementary science materials. Practically, the Soundwise e-module can support interactive, contextual, and technology-based science learning in elementary schools. This study was limited to the validation stage. Consequently, additional research is required to assess the implementation, practicality, and effectiveness of the Soundwise e-module in diverse educational contexts.

ACKNOWLEDGEMENTS

The author would like to thank all parties who have contributed to the completion of this research. Special thanks are expressed to Mrs. Erna Suhartini, S.Pd., M.Pd., as the supervisor, as well as all PGSD FKIP lecturers at Mulawarman University for their guidance, direction, and academic support during this research process. In addition, the author also expressed his appreciation to the Principal and Guardian of Classes 5A and 5B at Elementary School 016 Samarinda Ulu for the permission and support given.

AUTHOR CONTRIBUTIONS

Conceptualization, Methodology, Formal Analysis, Investigation, Resources, Data Curation, Writing-Original Draft Preparation, & Visualization, MSA; Writing Review & Editing, MSA, ES; Supervision & Project Administration, MSA, ES.

CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies.

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