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Website Development for Environmental Pollution Topics Based on Inquiry Learning Model

Iyan Sopian[1,2], Bibin Rubini(*)[1], Indarini Dwi Pursitasari[1]

[1] Science Education Program, Post Graduate School, Pakuan University
Pakuan Rd. Tegalega, Bogor, West Java, Indonesia, Postcode 16143;
[2] Public State Junior High School of SMP Negeri 1 Cibadak
Siliwangi Rd. No. 123, Cibadak, Sukabumi, West Java, Indonesia, Postcode 34111

***Correponding author:** bibinrubini@unpak.ac.id

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Abstract

Various online media platforms, such as Google Classroom, Zoom, and WhatsApp, have been widely utilized to optimize teaching and learning activities. However, these platforms have not yet integrated inquiry-based learning into the science education process, resulting in limited engagement of students' critical thinking skills. Consequently, there is a need to develop an Inquiry-Based Environmental Pollution Learning Website (WPPLI) as a learning medium to address students' needs for more effective learning. This study aims to determine the feasibility of the WPPLI as an educational tool, and analyze teachers'-students' responses to the WPPLI. This research employs a Research and Development (R&D) methodology, utilizing the ADDIE (Analyze, Design, Develop, Implement, Evaluate) design model. Data were collected through media and content expert validation forms, as well as teacher and student response questionnaires. The results indicate that the WPPLI has been deemed suitable as a learning medium based on validation by media and content experts, with respective scores of 94.02% and 97.77%, both categorized as "Highly Suitable." Field testing of the WPPLI revealed average responses of 96.83% from teachers and 81.55% from students, both falling within the "Excellent" category

Keywords: *Inquiry; Environmental Pollution; Learning Website*

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INTRODUCTION

In the rapidly evolving digital era, education must adapt to technological advancements to provide more interactive and engaging learning experiences. Websites play a crucial role in education and learning due to their multifaceted benefits. These include enhanced information accessibility (Sandrasyifa & Nugraheni, 2024), the provision of interactive learning platforms (Meiliyanthi et al., 2022), and the utilization of digital learning resources (Surani, 2019). Furthermore, websites facilitate independent learning (Yunus et al., 2023), foster innovation in education (Huraerah et al., 2023), enable efficient feedback and evaluation processes (Wulandari et al., 2021), and serve as an inexhaustible source of information (Agustian & Salsabila, 2021). This convergence of digital technology and education through websites offers a promising avenue for enriching the learning experience and improving educational outcomes.

A survey conducted on the presence of school websites among junior high school science teachers in Sukabumi district revealed that 80% of junior high schools in the district have established school websites. However, only 20% of these schools utilize their websites as learning media. This indicates that e-learning capabilities on school websites remain largely underutilized. Currently, most schools primarily rely on traditional teaching methods, such as printed textbooks and lectures, which may be less effective in facilitating optimal teacher-student learning processes.

Website-based learning media can foster discussion-based learning, allowing students to flexibly manage their learning activities in accordance with their daily schedules and activities, provided these media are well-designed and appropriately implemented. Web-based learning media continue to evolve rapidly, keeping pace with technological advancements and increasingly complex educational needs (Shabrina & Diani, 2019; Alo & Origines, 2021; Gunawan et al., 2022; Rahayu et al., 2022). Various online platforms, such as Google Classroom, Zoom, and WhatsApp, are widely used to optimize teaching and learning activities (Nugraheny, 2020). However, these platforms have not yet integrated inquiry-based learning into the science education process (Kamdi et al., 2022), resulting in limited engagement of students' critical thinking skills.

Inquiry-based learning can effectively stimulate students' cognitive processes. This pedagogical approach encourages active student participation in the learning process (Fathurrohman, 2017), fosters critical thinking skills (Suid et al., 2016), and facilitates a deeper understanding of concepts through exploration and discovery (Yeritia et al., 2017). While traditionally implemented in classroom settings, inquiry-based learning can also be effectively integrated into web-based platforms. These websites can provide structured inquiry learning stages, including question formulation, hypothesis development, experimental design, data analysis, and conclusion drawing (Yasin et al., 2021). Moreover, research indicates that web-based technologies support more collaborative inquiry pedagogies in scientific investigations, enhancing students' ability to construct and communicate scientific understanding (Astuti et al., 2020). Additionally, these technologies have been shown to improve 21st-century skills and problem-solving

capabilities (Haseski et al., 2018). Thus, the integration of inquiry-based learning with web-based platforms offers a promising approach to enhancing science education and developing critical skills for the modern era.

Interviews with several science teachers in Sukabumi district revealed that environmental pollution lessons are primarily conducted through lectures and group discussions. However, these methods often fail to generate enthusiasm among students. In group discussions, only the most active students tend to participate effectively, often dominating the class. Meanwhile, students with below-average abilities tend to remain passive. Classroom situations frequently become chaotic, leading to suboptimal learning outcomes. Teachers have not yet implemented inquiry-based learning, resulting in students merely knowing the concepts of environmental pollution's health impacts without understanding their real-world applications. Consequently, students lack training in critical thinking and problem-solving skills.

These findings align with research by Coronado et al., (2020), which demonstrated inadequate progress on Sustainable Development Goals (SDGs) number 3 and 6, concerning health, well-being, clean water, and sanitation. This underscores the need for further improvements in these areas. Clean water and sanitation are intrinsically linked to environmental pollution. The environmental pollution curriculum encompasses the definition of the environment, factors causing environmental pollution, and strategies to mitigate it, equipping individuals with knowledge to preserve the environment. This makes environmental understanding crucial for students across various educational levels (Nesmith et al., 2016; Truelove & Gillis, 2018).

Given the background presented, there is a clear need for the development of an Inquiry-Based Environmental Pollution Learning Website (WPPLI) to serve as an effective learning medium and address students' needs for more efficient learning. This study aims to: (1) determine the feasibility of the WPPLI as an educational tool, and (2) analyze teachers' and students' responses to the WPPLI. This research addresses a significant gap in current educational practices by integrating inquiry-based learning with web-based technology in the context of environmental pollution education. The WPPLI has the potential to enhance student engagement, promote critical thinking, and foster a deeper understanding of environmental issues. By evaluating the feasibility of this tool and assessing stakeholder responses, this study contributes to the growing body of literature on innovative educational technologies and their application in science education. The findings of this research may have important implications for educational policy and practice, particularly in the context of improving science education and environmental awareness among students. Moreover, it aligns with broader educational goals of promoting 21st-century skills and addressing pressing global issues such as environmental pollution.

METHOD

This study employed a Research and Development (R&D) methodology, utilizing the ADDIE (Analyze, Design, Develop, Implementation, Evaluate) model as developed by Branch (2009). The ADDIE model comprises five sequential phases: (1) Analysis (Analyze); (2) Designing (Design); (3) Development (Develop); Implementing (Implementation); and (5) Evaluating (Evaluation). For the purposes of this study, the research and development process was limited to the development phase. A detailed explanation of each ADDIE phase follows,

Analysis Phase

The initial stage of this research comprised a comprehensive preliminary analysis to identify and address current issues with the most appropriate solutions. This phase encompassed three key analytical components: (1) A systematic review of existing literature on web-based learning media was conducted using bibliometric tools, specifically Publish or Perish software and VOSviewer. The Google Scholar database served as the primary source for this analysis; (2) A thorough needs Assessment was performed to ascertain the specific requirements for web-based learning media in science education; and (3) Direct observations were conducted to evaluate the current state of science education practices and the available supporting infrastructure.

Design Phase

The design phase focused on conceptualizing the structure, interface, and navigation of the Inquiry-Based Environmental Pollution Learning Website (WPPLI). This phase encompassed a comprehensive flowchart was created to map out the logical structure and user journey within the WPPLI. Detailed storyboards were developed to visualize the layout, content placement, and interactive elements of each webpage within the WPPLI. The presentation of content within the WPPLI was carefully structured to integrate environmental pollution subject matter with inquiry-based learning approaches. This design aspect focused on creating a seamless blend of theoretical knowledge and practical inquiry skills. This design phase was crucial in translating the insights gained from the analysis phase into a concrete, user-friendly, and pedagogically sound web-based learning platform. By meticulously planning the structure and content of the WPPLI, this phase laid the groundwork for a learning tool that not only delivers content on environmental pollution but also actively engages students in the inquiry process, thereby enhancing their scientific reasoning and investigative skills.

Development Phase

The development phase focused on the actual creation of the Inquiry-Based Environmental Pollution Learning Website (WPPLI) based on the previously established design. This phase encompassed several key development activities, such as, creating a robust database application by using XAMPP. The WPPLI application was deployed on a selected hosting site, enabling web-based access to the platform. A comprehensive validation process was conducted, involving both media and content experts. Based on

the feedback received from the expert validation process, necessary revisions were made to the WPPLI. This iterative refinement process ensured that both the technical aspects and the educational content of the website met high standards of quality and effectiveness.

This development phase was crucial in transforming the conceptual design into a functional, web-based learning tool. By focusing on robust database development, effective web deployment, and rigorous expert validation, this phase ensured the creation of a high-quality, user-friendly, and pedagogically sound learning platform. The iterative nature of the development process, particularly the incorporation of expert feedback, was instrumental in refining the WPPLI to effectively meet its educational objectives in environmental pollution education through an inquiry-based approach.

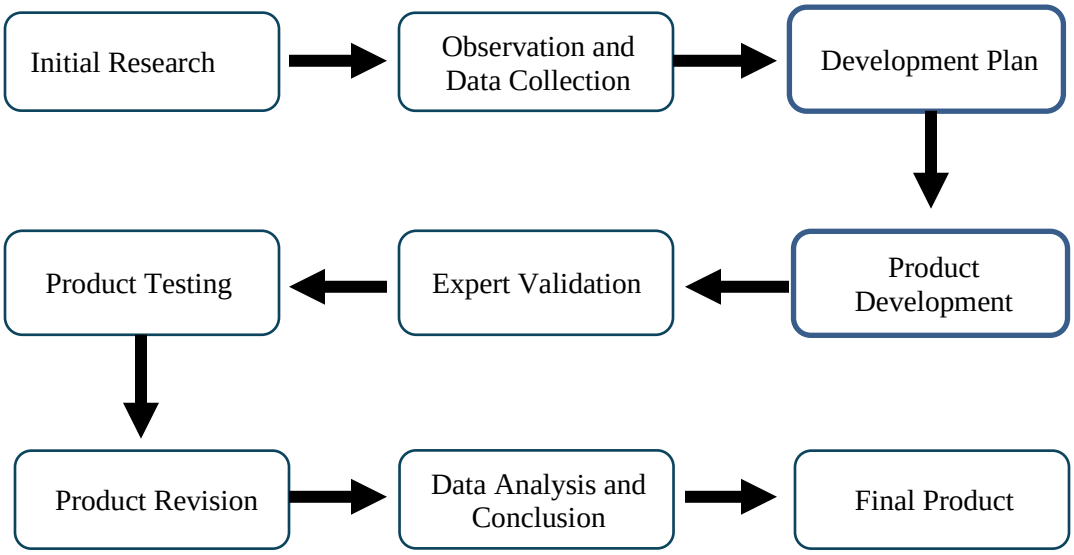


Figure 1. Development Research Stage

The research data were collected using expert validation sheets that assessed: content validity through material expert evaluation, which examined the alignment with Learning Outcomes (LO), material accuracy, and inquiry stimulation; and media expert evaluation, which examined software engineering aspects, visual communication, and overall application functionality. Data analysis employed the Likert scale methodology (Sugiyono, 2017). The feasibility percentages for both material and media expert validations were calculated using the following formula:

$$\text{Feasibility Percentage} = \frac{\text{Number of Obtained Score}}{\text{Total Score Obtained}} \text{ x } 100\%$$

The evaluation results from experts, teachers, and students were interpreted according to the criteria presented in Table 1. The response data from teachers and students regarding the WPPLI were collected using a questionnaire with four response options: Excellent (E), Good (G), Poor (P), and Very Poor (VP), scored as 4, 3, 2, and 1,

respectively. The calculated percentage results from these response questionnaires were subsequently categorized according to Table 2.

Table 1. Values and Interpretations of Feasibility Assessment, by Ernawati & Sukardiyono (2017)

Percentage Value (%)	Interpretation
0-20	Not Feasible / Poor
21-40	Less Feasible / Fair
41-60	Moderately Feasible / Satisfactory
61-80	Feasible / Good
81-100	Highly Feasible / Excellent

Table 2. Categorization of Expert, Teacher, and Student Assessment Results (Sugiyono, 2017)

Assessment Result (%)	Category
76 – 100	Excellent
51 – 75	Good
26 – 50	Poor
0 – 25	Very Poor

RESULTS AND DISCUSSION

The development of information and communication technology has demonstrated significant influence in transforming educational processes (Uno & Ma'ruf, 2016). In the current era of globalization, information and communication technology has become a fundamental requirement in supporting education (Sutopo, 2012). Web-based media has proven to be particularly effective as an educational tool (Shabrina & Diani, 2019). Such media can serve as a viable alternative, as it has been shown to enhance student engagement in science education (Asyhari & Diani, 2017). Web-based science education provides students with constructive and interactive learning experiences, thereby expanding their activity scope and enriching their learning experiences (Alo & Origines, 2021). Based on these considerations, an inquiry-based web learning platform for environmental pollution (WPPLI) was developed. The development research of this inquiry-based environmental pollution web learning platform began with a needs analysis, followed by the WPPLI design phase and feasibility testing through expert validation, teacher Assessment, and student response evaluation.

Analysis

The initial phase of designing the web-based learning product commenced with mapping analysis, needs Assessment, and infrastructure analysis. The mapping analysis phase involved examining research relevant to web-based learning. The literature review revealed several pertinent previous studies, including: "Development of Web-based

Learning to Enhance Students' Scientific Literacy" by Gunawan et al., (2022); "Integrated Web-Based Learning" by Alo & Origines (2021); and "Development of Web-Enhanced Course Physics Learning Media with Guided Inquiry Model" by Shabrina & Diani (2019). The subsequent phase involved needs Assessment, comprising curriculum analysis and student characteristics evaluation. The curricular analysis revealed that SMP Negeri 1 Cibadak implements the Merdeka curriculum. The WPPLI development was aligned with this curriculum, focusing on environmental pollution content.

Regarding student characteristics, the study subjects were seventh-grade students at SMPN 1 Cibadak. Analysis indicated that students aged 12-14 years typically exhibit high levels of curiosity, allowing the WPPLI product to be tailored to their learning characteristics, thereby ensuring achievement alignment with intended learning outcomes. The infrastructure analysis revealed that SMPN 1 Cibadak is equipped with two computer laboratories, each containing 30 PCs and one server, with individual internet connections of 100 Mbps. This infrastructure adequately supports web-based learning implementation, suggesting a high probability of successful learning outcomes. This finding aligns with Darmastuti & Karwanto (2014) assertion that educational program success through learning processes is significantly influenced by various factors, notably the availability of adequate educational infrastructure coupled with optimal utilization and management.

Design

The initial design phase involved determining the learning media specifications, resulting in the development of a web-based learning platform. Subsequently, the web-based learning environment was designed through the creation of a storyboard, which delineated the flow, layout, structure, interface, and input-output mechanisms of the Inquiry-Based Environmental Pollution Web Learning (WPPLI).

Development

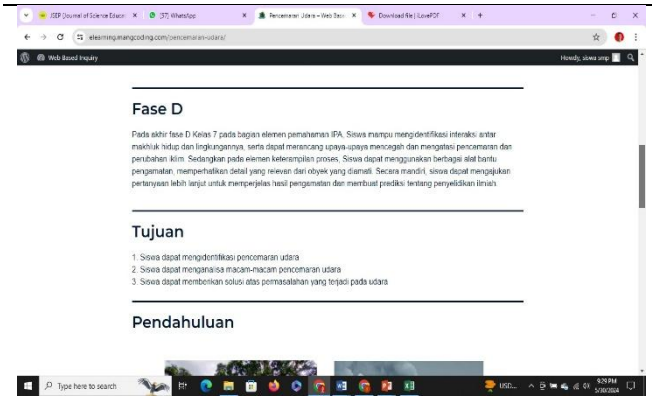
Following successful product development, the next phase involved assessing media feasibility through product validation. This validation process was initiated after the completion of the initial product prototype. The validation was conducted in two distinct categories: content validation and media validation. Prior to product validation, the Assessment instruments were validated by expert faculty members. Validation sheets were distributed to two content experts and two media experts. Subsequently, a limited trial implementation of the WPPLI was conducted with seventh-grade students. The content expert validation Assessment results are presented in Table 3.

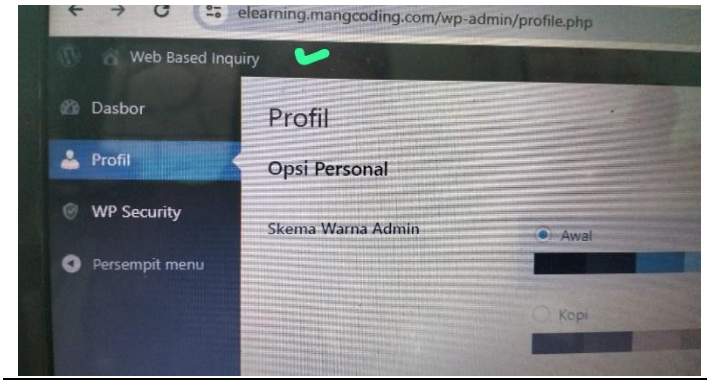
Table 3. Content Expert Assessment Results

Aspect	Expert Assessment (%)
Alignment with Learning Outcomes	95,83
Content Accuracy	97,5
Stimulation of Inquiry	100
Average	**97,77**

The content expert validation Assessment, as shown in Table 3, achieved an average score of 97.77%. According to the Feasibility Assessment Interpretation criteria presented in Table 1, this average score falls within the "Highly Feasible" category. This indicates that WPPLI is highly suitable for use as a learning medium. The expert Assessment results revealed that the lowest score was in the aspect of material alignment with learning outcomes. This aligns with the experts' recommendations as shown in Table 4.

Table 4. Expert-Recommended Modifications to WPPLI Interface

1. WPPLI Interface	**Expert Reccomendation**
	Based on *Merdeka* Curriculum guidelines, Learning Objectives should operationally incorporate three aspects (Competency, Content, and Variation). The Variation aspect was not included and required revision.
2. Web Interface Before Expert Recommendations (Images and photographs were sourced from the internet) 	Use own images, photos, and videos.

Web Interface After Expert Recommendations (Images and photographs were created by the researcher) 	
3. Pre-modification Interface Display: Post-login Profile Redirection 	Expert Observation: The WPPLI dashboard navigation menu lacked sufficient visibility and prominence, resulting in login access difficulties. The recommendation was to implement direct main menu redirection upon login and enhance menu button visibility through increased size.

Media Expert Validation

The media expert validation assessment results are presented in Table 5. Table 5 presents the media expert evaluation results, indicating an average score of 94.02%. According to the Feasibility Assessment Interpretation criteria in Table 1, this average score falls within the "Highly Feasible" category, demonstrating that WPPLI is highly suitable for implementation as a learning medium.

Table 5. Media Expert Assessment Results

Aspect	Assessment (%)
Software Engineering	97,91
Visual Communication	92,5
Overall Application	91,67
Average	**94,02**

The media expert Assessment revealed that the lowest score was in the overall application aspect, specifically in the usage clarity indicator. This aligns with the expert recommendations presented in Table 4. Conversely, the software engineering aspect received the highest evaluation score. This aspect encompasses usability, reliability, and maintainability indicators. The results demonstrate the application system's reliability, ease of application management (maintainability), and user-friendliness (usability). According to Alshehri et al., (2019), these factors are crucial in determining user satisfaction with computer-based instructional materials.

Teacher Response

Following expert validation, the developed website was further evaluated by 10 science teachers. The average teacher response scores for WPPLI across various evaluation aspects are presented in Table 6.

Table 6. Teacher Response Assessment Results

Aspect	Assessment (%)
Content Feasibility	95,00
Linguistic Elements	98,75
Contents	95,83
Media	99,18
Average	**97,19**

The Assessment across all four aspects yielded an average percentage of 97.19%. According to the Assessment Categorization criteria presented in Table 2, this average score places the teachers' evaluation of WPPLI in the "Excellent" category. The content feasibility aspect received the lowest average score among all aspects. This lower score was primarily attributed to the indicator measuring the alignment between the inquiry-based environmental pollution learning web material and the learning outcomes within the content feasibility aspect.

Student Response

Following modifications based on content and media expert recommendations, WPPLI underwent limited trial testing with 32 students to gather student feedback. The average student response assessment of WPPLI, evaluated across learning media, material content, and benefits aspects, is presented in Table 7. The assessment across these three aspects yielded an average percentage of 80.70%. According to the Assessment Categorization criteria presented in Table 2, this average score places the students' evaluation of WPPLI in the "Excellent" category. The material content aspect received the lowest score among all aspects. This lower score was primarily attributed to the indicator measuring the alignment between assessment questions and learning objectives within the material aspect. In this indicator, the evaluation questions integrated into WPPLI were

specifically designed to enhance inquiry skills and sustainability literacy, rather than covering a broader range of assessment objectives.

Table 7. Student Response Assessment Results

Aspect	Students Response (%)
Learning Media	82,03
Content	79,43
Benefits	83,20
Average	**81,55**

CONCLUSION

The objective of this development research is to develop Inquiry-based Environmental Pollution Learning Media (WPPLI). To achieve this goal, the Research and Development (R&D) method is applied with the ADDIE design which consists of five stages, namely analyze, design, development, implementation and evaluation. The developed WPPLI was validated by 2 material experts and 2 media experts with an average of 94.02% and 97.77% with the criteria "Highly Feasible". The results of the response assessment of 10 teachers to WPPLI during the trial use showed a very good category with an average score of 96.83% while the student response to WPPLI showed a "Very Good" category with an average score of 81.55%.

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