

Development of an E-Module on Clean Water for Sanitary Engineering in Building Education

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ABSTRACT	ARTICLE INFO
<p>This project focuses on the development of an e-Module related to Clean Water Material in the Sanitation Engineering Course. This research seeks to deliver engaging, relevant, and efficacious digital learning media to enhance students' understanding and academic achievement on the importance of clean water management. This study utilizes the Research and Development (R&D) methodology based on the 4D development model, which consists of four key phases: Define (identifying user requirements and attributes), Design (creating modules and content), Develop (producing and validating e-Modules), and Dissemination (distribution and execution). The e-Module comprises five principal topics that correspond to curriculum requirements and real-life applications: (1) water sources from the local environment, including rivers, lakes, and wells; (2) potable water sources that adhere to health standards; (3) methods for converting seawater and rainwater into drinkable water; (4) water treatment systems employing slow and rapid sand filtration typically utilized in basic water treatment facilities; and (5) advanced water treatment technologies such as membrane filtration and reverse osmosis. The feasibility test findings indicate that this e-Module obtained excellent evaluations from several stakeholders: material experts scored it at 92.8%, media experts at 92.5%, language experts at 92%, and user responses (students) achieved 95%. A restricted experiment with 20 students demonstrated a notable enhancement in learning outcomes, yielding an n-gain value of 0.70, classified as "high." The data indicates that the e-Module on Clean Water Material is an appropriate and effective learning medium that can enhance the teaching and learning process in the Sanitation Engineering Course.</p>	<p>Article History: Submitted 14 July 2025 First Revised 20 August 2025 Accepted 28 October 2025 Available Online 15 November 2025 Publication Date 15 November 2025</p> <p>Keywords: Clean Water; E-Module; Environment; Sanitation Engineering.</p>

1. INTRODUCTION

The term preference is derived from the English word "preference," which can be defined as the tendency to choose or favor one option over others. Furthermore, preferences are considered as an individual's attitude towards a set of objects that influence a person's behavior in the decision-making process (Aryandhana et al., 2021). Student preferences can be influenced by several factors, including interests, talents, and career aspirations. Understanding student preferences can help in designing effective practical learning programs such as internships.

Vocational High Schools are educational institutions tasked with training human resources and developing individuals with the skills, competencies, and expertise necessary to ensure the success of graduates in their careers (Rojaki et al., 2024). Vocational education has the primary goal of preparing students to master competencies in specific fields through a series of structured learning activities, so they are ready to pursue professional careers in their areas of expertise (Suparyati et al., 2024). After graduation, students are expected to possess sufficient skills and knowledge to enter the workforce, including in the industrial sector or as independent entrepreneurs.

Internship is an activity where students are directly involved in professional work at an institution, company, or organization for a certain period according to the curriculum. Providing recommendations for internship locations is an activity that requires meticulous assessment of prospective internship participants, considering various aspects and using appropriate methods (Melati, 2024). The criteria for internship locations according to the school can encompass various aspects aimed at providing meaningful and relevant internship experiences for students, such as distance and accessibility, company classification, and facilities provided by the company.

The proximity of the internship site to the students' dwellings significantly influences their motivation and performance during the internship (Palkar & Selvi, 2024). Students typically select internship sites that are readily accessible via public or private transportation at a reasonable expense. Students favor internship sites that entail reduced trip durations to mitigate tiredness and optimize their learning opportunities. The swift advancement of technology has profoundly influenced numerous facets of life, particularly in the realm of education. Lubis (2021) asserts that technological improvements transform communication and work methods, while also instigating alterations in the teaching and learning process. Technology has become an essential component of the contemporary education system, necessitating that both educators and learners adeptly engage with and employ diverse technological advancements. Consistent with such perspective, Purba & Saragih (2023) assert that information technology is a crucial instrument for achieving education that is flexible and pertinent to contemporary demands.

One influence is the advent of diverse digital instructional resources that enhance learning efficacy (Latri, 2023). Nevertheless, in actuality, numerous impediments persist in the learning process, especially regarding students' comprehension of the subject. Alditia & Wahyudin (2024) observed that students' inadequate comprehension is frequently attributed to unengaging pedagogical approaches and constraints in instructional resources. Telaumbanua (2022) stated that boring lecture approaches, limited student engagement, and insufficient instructional materials are primary factors contributing to poor learning outcomes. According to Fitri et al. (2023), teaching materials are a systematically arranged collection of information utilizing diverse mediums and sources to facilitate the learning process. Elvareta et al. (2020) assert that effective instructional materials should encompass pertinent information, suitable distribution mediums, and evaluations linked with learning objectives.

One effective form of teaching material is a module. A module is a learning medium that is systematically organized and designed to support the achievement of student competencies (Aransyah et al., 2023). According to Latri (2023), modules not only serve as a means of delivering material but also as self-study guides that help students measure their understanding through exercises and evaluations. With the advancement of technology, printed modules can now be developed into electronic modules (e-Modules). E-Modules are digital learning materials equipped with visual elements such as text, images, animations, and can be presented on online platforms (Putri, R. R. R. R. et al., 2022). Irmawati et al. (2023) emphasize that e-Modules have advantages in efficiency, access flexibility, and interactivity, making them more appealing to students.

The use of e-Modules has been proven to have a positive impact on student independence and learning outcomes. Kiptiyah (2021) states that e-Modules can enhance learning independence because they allow students to study anytime and anywhere. In addition, Kosasih (2021) added that e-Modules are capable of deepening the mastery of the material provided in the lecture process, as well as encouraging critical thinking skills through the provision of contextual content. Research by Naufal Dzakwan et al. (2021) shows that the use of e-Modules in Statistics courses results in higher average scores compared to conventional methods. Similarly, Rahmawati (2023) demonstrated that Project-Based Learning-based e-Modules were able to increase the average score by 29.3%, indicating their effectiveness in enhancing student engagement and academic achievement.

A comparable situation is also present in the Building Engineering Education Study Program at Universitas Negeri Jakarta. Students in this academic program acquire knowledge in educational courses as well as civil engineering materials pertinent to environmental and structural preservation. Sanitary Engineering is a crucial course that encompasses subjects including water resources, potable water distribution, and the control of liquid and solid waste. A requirements study of 47 students in the Building Engineering Education Study Program at Universitas Negeri Jakarta revealed that 97.3% indicated the absence of e-Module-based teaching materials for clean water themes.

As many as 66% of students strongly agreed on the need for e-Module development to enhance their understanding, and 57.4% strongly supported the implementation of this e-Module in the course's learning process. Previous research by Fauziah et al. (2023) has developed e-Modules for several topics in the Environmental Engineering course, such as liquid waste, solid waste management, and environmental health. However, the development has not specifically addressed clean water materials. In fact, mastery of clean water materials is very important in the context of environmental sanitation engineering, especially in relation to the provision of safe and potable clean water. Therefore, this research aims to develop an e-Module on Clean Water Material in the Sanitation Engineering Course, designed according to the curriculum needs and student characteristics. This e-Module is designed in PDF format using Canva and Microsoft Word software, with the presentation of material covering: environmental water sources, drinking water sources that meet health standards, seawater and rainwater treatment, slow and rapid sand filtration, as well as modern water treatment methods such as membranes and reverse osmosis.

It is hoped that the development of this e-Module can become an innovative solution to the challenges of conventional learning, as well as facilitate students in understanding the basic principles of clean water management independently and contextually. With an engaging format, high accessibility, and relevant content, this e-Module is expected to become an effective, efficient alternative learning resource that supports a sustainable technology-based learning process.

2. METHOD

This study employs a Research and Development (R&D) methodology utilizing the 4D development paradigm (Define, Design, Develop, and Disseminate) established by Thiagarajan, Semmel, and Semmel. This paradigm was selected for its appropriateness in creating systematic and valid educational products. The research was carried out under the Building Engineering Education Study Program at Universitas Negeri Jakarta, from April to October 2024. The development object is an e-Module on Clean Water Material, comprising five primary topics: (1) sources of water in the surrounding environment, (2) sources of drinking water, (3) processing of seawater and rainwater, (4) slow and fast sand filtration, and (5) modern water processing. The module was created utilizing Canva and Microsoft Word software, subsequently compiled in PDF format with interactive features, including QR codes connected to supplementary instructional films.

During the Define stage, a needs analysis was performed using a survey of 47 students from the Building Engineering Education Study Program. The survey findings revealed that most students reported the absence of e-Module teaching resources for the Clean Water subject. An examination of the material, student attributes, and selection of learning objectives from the Semester Learning Plan was performed.

The Design stage includes the preparation of the e-Module structure, which consists of three main parts: introduction, content, and conclusion. The introduction includes general information, usage instructions, and a concept map. The content section contains the core material accompanied by comprehension tests, while the conclusion section includes a glossary and references. The material is developed with reference to the course learning outcomes.

During the Develop stage, the e-Module is validated by three specialists: content experts, media experts, and language experts. Each expert assesses the dimensions of content, aesthetics, interaction, and language utilizing a validation tool in the format of a validation sheet. Validation is performed via expert assessment on a Likert scale. A limited study was undertaken with 20 students enrolled in the Sanitation Engineering course to assess the efficacy of the E-Module.

Data acquisition was executed via questionnaires, pre-assessments, and post-assessments. Questionnaires were employed to evaluate students' perceptions of the e-Module. Pre-tests and post-tests were employed to assess the enhancement in students' learning outcomes before to and following the utilization of the e-Module. The test results were evaluated utilizing the n-gain formula to ascertain the degree of learning efficacy. The criteria for interpreting n-gain values refer to Hake (1998), namely: <0.3 (low), $0.3-0.7$ (medium), and >0.7 (high).

The Disseminate phase of this research is confined to a limited experiment. The product has not yet been widely disseminated as it remains in the initial stages of development. However, the results of this research are expected to serve as a foundation for further development to be applied on a large scale within the study programs environment and across other study programs.

3. RESULT AND DISCUSSION

This study employs the Four-D (4D) paradigm for research and development (R&D), comprising four primary stages: define, design, develop, and disseminate. This methodology was selected for its ability to systematically and measurably influence the development of instructional goods. During the define stage, a variety of analyses were performed, including starting analysis, student characteristic analysis, task analysis, and concept analysis, to identify the primary challenges encountered by students in comprehending clean water material in the Sanitation Engineering course. The analysis results reveal that pupils struggle to comprehend normally presented material, compounded by the scarcity of technology-based educational resources. Consequently, the e-Module was selected as a solution due to its appealing design, 24/7 accessibility, and facilitation of more flexible autonomous learning. This e-Module's content centers on clean water and is connected with the course learning outcomes outlined in the Semester Learning Plan.

In the design stage, the e-Module was created using Canva software and packaged in an interactive PDF format that is easily accessible to students. The visuals are made attractive, aiming to increase students' reading interest and facilitate understanding of the presented material (Fauzie, 2024). The structure of the module consists of three main parts, namely: (1) Introduction, which includes the cover, module identification, preface, usage instructions, and table of contents; (2) Content section, which contains concept maps, learning objectives, material descriptions, and comprehension tests; and (3) Closing section, which consists of the bibliography, glossary, and author identification.

One of the advantages of this e-Module is the integration of digital media in the form of external links and QR Codes that direct students to additional learning videos, thereby increasing student engagement and reinforcing understanding through audio-visual media. This innovation is expected to meet students' needs for more interactive and applicable learning media. However, it should be noted that the implementation of this e-Module is still limited to one institution and has not yet included long-term evaluations, such as the effectiveness of knowledge retention or its impact on students' field practice skills.

Upon completion of the e-Module design, the process transitions to the development phase, during which a feasibility assessment is performed on the produced product. Validation is conducted by several specialists, including subject matter experts, media professionals, linguistic experts, and users (students). The experts' evaluation is to confirm that the e-Module adheres to quality criteria for content, aesthetics, and language prior to its implementation in the educational process. **Figure 1** displays the outcomes of the validation procedure, depicting the feasibility level percentage of the e-Module according to each evaluative criterion.

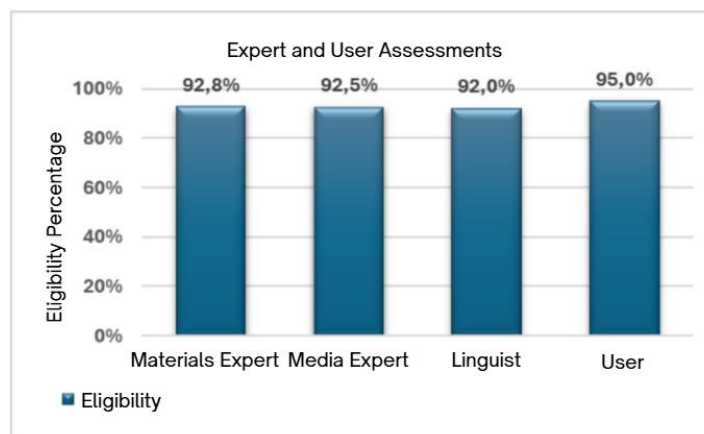


Figure 1. Validity Test Results

In the image, the percentage of expert evaluations is 92.8% for content, 92.5% for media, 92% for language, and 95% for user evaluation, indicating that the e-Module is considered relevant and easy to use by students, in line with the initial development goal of creating interactive and contextual learning media.

Thus, the feasibility assessment of the Sanitation Engineering e-Module indicates that the developed Sanitation Engineering e-Module is suitable for use. Next, a limited trial conducted during the dissemination phase used pre and post-test methods administered to 20 students taking the Sanitation Engineering Course. This assessment began with students completing a pre-test consisting of 20 questions via a Google Form link.

The pre and post-tests aim to evaluate students' understanding of the material before and after studying the designed module. Here are the results of the limited trial on the development of the e-Module for the Sanitation Engineering Course on Clean Water.

Table 1. Limites Trial

	Score		
	Pre-Test Score	Post-Test Score	Percentage Increase (%)
Total Score	840	1650	810
Average	42,00	82,50	40,50

Table 1 indicates a substantial enhancement in scores associated with learning through the Health Engineering e-Module. The mean post-test score of the students rose by 40.5 points relative to the pre-test, and the calculations yielded an n-gain value of 0.70, categorizing it as "High." The utilization of the e-Module significantly enhances students' comprehension of clean water concepts.

The enhancement aligns with the constructivist theory, which posits that learning is more effective when learners engage actively with the information through media that fosters critical and exploratory thinking processes (Hikmawati et al., 2020). In this context, the e-Module enhances the learning experience and promotes autonomous study, as it features appealing visual displays, video links, and QR codes as supplemental resources for comprehension. This aligns with Azizah's (2025) research findings that suitable learning media can improve students' comprehension of the educational content.

The findings align with prior studies by Naufal Dzakwan et al. (2021) and Rahmawati (2023), demonstrating that the implementation of e-Modules not only elevates students' academic performance but also fosters their activity and participation in the learning process. The utilization of digital media, such as e-Modules, is a strategic alternative to address the constraints of traditional teaching approaches.

Thus, based on feasibility tests by experts and limited trial results, it can be concluded that the Clean Water Material e-Module is suitable for use as an effective learning medium in the Sanitation Engineering course. Not only does this e-Module improve students' learning outcomes, but it also encourages positive changes in the way students access, understand, and apply learning materials more flexibly and contextually.

Moreover, the implementation of this e-Module positively enhances students' digital literacy, especially within civil and environmental engineering. The availability of this e-Module offers educational institutions a significant chance to incorporate technology more comprehensively and methodically into the curriculum. Future enhancements to this e-Module could include the integration of an automatic evaluation function utilizing a Learning Management System (LMS) to facilitate quick, real-time assessments. Furthermore, incorporating interactive multimedia elements, such as simulations of the clean water treatment process, can augment students' learning experiences and deepen their comprehension of relevant technical ideas.

4. CONCLUSION

This research effectively created the Clean Water Material E-Module as an educational resource for the Sanitation Engineering Course within the Building Engineering Education Study Program at Universitas Negeri Jakarta, employing the Four-D (4D) development model, which encompasses the phases of Define, Design, Develop, and Disseminate. The validation results indicate that the developed e-Module attained an exceptionally high feasibility rating from experts, with material experts scoring 92.8%, media experts 92.5%, and language experts 92%, all categorized as "Very Feasible," alongside user (student) evaluations averaging 95%. A restricted trial with 20 students revealed a notable enhancement in material comprehension, evidenced by an n-gain value of 0.70, categorizing it as "High." This indicates that the e-Module is both technically and content-wise viable, as well as effective in improving student learning outcomes. This Clean Water Material e-Module serves as an alternative interactive and contextual digital learning medium, with the potential to enhance the quality of the teaching and learning process. It is anticipated to be utilized more extensively and sustainably as a component of educational innovation in environmental sanitation engineering.

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