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Needs Analysis for The Development of a Digital E-Module Oriented to Scientific Literacy on Heat and Temperature Topic

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ABSTRACT: This research aims to identify the needs for developing a Digital E-Module using the Flipbook platform, integrated with scientific literacy, focusing on the topic of heat and temperature at the junior high school level. The research approach employed is descriptive qualitative and quantitative, with data gathered through interviews at five Muhammadiyah junior high schools in Makassar and relevant literature reviews. Additionally, a needs analysis for the development of digital teaching materials was conducted through a science literacy skill test and student response questionnaires regarding the learning process and use of science teaching materials in class. The study findings indicate that teachers believe using a Digital E-Module can promote a more interactive learning process and deepen students' understanding of heat and temperature concepts. Initial data shows that students' scientific literacy skills are predominantly in the low category. Student responses also revealed that most were not interested in the science learning process led by teachers in class. Moreover, the questionnaire data showed that the science teaching materials used were unengaging and did not sufficiently support students in developing their scientific literacy, with most materials still being manual and not integrated with interactive digital technology. Based on these results, there is a need to develop a Science Literacy-Oriented Digital E-Module that includes experiments, interactive simulations, and tasks designed to foster critical thinking and problem-solving skills aimed at developing students' scientific literacy abilities.

KEYWORDS: Digital E-Modul, Science Literacy, Flipbook Platform, Heat and Temperature Topic, Science Teaching.

I. INTRODUCTION

Scientific literacy represents a fundamental competency essential for students navigating the complexities and demands of contemporary society, particularly in the face of rapid technological advancements and global challenges. According to the Organisation for Economic Co-operation and Development (OECD, 2019), scientific literacy encompasses an individual's ability to engage with science-related issues critically and reflectively, making informed decisions about various scientific phenomena encountered in daily life. It involves not merely accumulating scientific knowledge but effectively applying it to interpret, evaluate, and make informed decisions about real-world problems. This comprehensive view aligns with the objectives outlined by the Programme for International Student Assessment (PISA), which consistently highlights scientific literacy as central to educational frameworks globally (OECD, 2019).

Numerous international assessments reveal significant disparities in scientific literacy achievement among students worldwide, with developing countries typically trailing behind their counterparts in more developed regions. The results of PISA assessments consistently demonstrate gaps in students' capacity to engage with scientific concepts critically and contextually (OECD, 2019; Schleicher, 2024). These findings underscore the urgency for educational systems globally, particularly in developing countries, to adopt more effective teaching methodologies and resources capable of bridging these competency gaps (Hwang et al., 2020; Gokmenoglu & Clark, 2021).

A pivotal area within science education that frequently proves challenging for students is the subject matter of heat and temperature. This topic requires learners to grasp complex concepts such as heat transfer mechanisms, thermodynamic processes, and the critical distinction between heat and temperature. Studies indicate that misconceptions in this area remain widespread and persistently problematic, significantly hindering the achievement of adequate scientific literacy levels (Yeo & Zadnik, 2018; Alwan, 2020). Research by Pathare and Pradhan (2019) reveals prevalent misconceptions among students, notably confusion over fundamental concepts such as thermal equilibrium and energy transfer processes. Chu et al. (2021) also document that students often

erroneously equate heat with temperature, reflecting fundamental misunderstandings that obstruct further learning and comprehension of related scientific phenomena.

The persistence of such misconceptions underscores the critical role instructional materials play in shaping students' scientific understanding. Recent educational theories and empirical studies emphasize the necessity for resources that actively engage learners and facilitate deep conceptual understanding, moving beyond mere rote learning (Mayer, 2021; Falloon, 2019). Digital learning resources, notably digital e-modules, have been identified as effective tools to enhance students' understanding and retention of complex scientific concepts. The interactivity, flexibility, and personalized learning capabilities inherent in digital e-modules make them particularly suitable for addressing challenging topics like heat and temperature, where traditional teaching methods may fall short (Chen & Tsai, 2020; Lim et al., 2021).

Digital e-modules offer significant advantages over traditional instructional methods by allowing students to engage with content interactively and adaptively. Research by Mayer (2021) identifies that multimedia learning, a key component of digital e-modules, significantly improves students' cognitive processes by integrating visual, auditory, and interactive elements into learning activities. Similarly, Falloon (2019) highlights the efficacy of digital resources in fostering student-centered learning, encouraging active participation, and promoting critical thinking and problem-solving skills essential for scientific literacy.

However, despite these documented benefits, the implementation of digital e-modules in educational contexts frequently lacks adequate integration of scientific literacy frameworks. Studies conducted by Chen and Tsai (2020) and Lim et al. (2021) reveal that many digital educational resources currently available fail to adequately incorporate essential elements of scientific literacy, such as critical thinking, problem-solving, and real-world applicability. This limitation significantly constrains their potential impact, reducing the effectiveness of these resources in genuinely enhancing students' scientific literacy competencies.

Preliminary studies examining educational practices reveal a concerning disconnect between existing digital instructional resources and the scientific literacy competencies emphasized by international frameworks such as PISA. Ismail et al. (2022) and Rahmawati and Agustina (2021) highlight critical gaps in current educational approaches, underscoring a mismatch between available digital learning materials and the specific literacy skills students require to succeed in a scientifically complex world. These studies call attention to the critical need for comprehensive needs analyses that can precisely identify educational gaps, conceptual misunderstandings, and essential features required for instructional resources aimed at enhancing scientific literacy.

In response to these identified gaps, the present study focuses explicitly on conducting a systematic needs analysis to inform the development of a digital e-module oriented towards scientific literacy specifically tailored for the topic of heat and temperature. The central objective is to comprehensively identify critical educational needs, prevalent conceptual misunderstandings among learners, and optimal instructional strategies perceived as effective by educators and students alike. This approach ensures that subsequent educational interventions are data-driven and strategically designed to maximize their impact on scientific literacy.

A thorough needs analysis is indispensable because it provides foundational data and clear guidelines for designing effective digital e-modules. According to Morrison et al. (2019), needs analysis in educational research is critical as it illuminates learners' current competencies and gaps, guiding the targeted development of instructional materials. Likewise, Brown and Green (2020) argue that identifying learner characteristics and instructional needs significantly enhances the effectiveness and efficiency of educational interventions.

Furthermore, recent empirical studies underline the effectiveness of needs analyses in educational technology integration. Research by Mulyani and Simatupang (2021) and Arifin and Rusli (2022) confirms that rigorous needs assessments substantially contribute to the success of digital learning resource implementations, particularly in complex subject areas such as science. These assessments provide valuable insights into learner preferences, technological competencies, and instructional challenges, thus enabling the development of highly tailored and effective digital educational tools.

By explicitly addressing these critical aspects, this research aims to bridge existing gaps in the literature and contribute significantly to advancing scientific literacy education. The outcomes of this needs analysis will form the basis for subsequent phases in the development of a targeted, scientifically robust digital e-module that effectively integrates critical literacy components, ultimately enhancing student comprehension and application of heat and temperature concepts in real-life contexts.

Overall, this introduction outlines the rationale, significance, and methodological approach to a detailed needs analysis for the development of a scientifically literate-oriented digital e-module on heat and temperature topic, emphasizing the necessity of tailored educational tools for enhanced scientific understanding and literacy.

II. METHOD

This study was conducted using a qualitative descriptive approach aimed at exploring the needs for developing a Science Literacy-Oriented Digital E-Module using the Flipbook platform on the topic of heat and temperature at the junior high school level. The data collection methods employed included in-depth interviews, systematically designed to obtain direct information from teachers and students as the primary actors in the learning process. In addition, a test assessing students' initial scientific literacy profile was

administered. To reinforce the needs analysis, a questionnaire was used to gather student responses about the science learning process and the quality of teaching materials used by teachers in the classroom.

The data analysis model used followed the Miles and Huberman approach, which consists of four stages: data collection, data reduction, data display, and conclusion drawing or verification (Sugiyono, 2016). This approach was chosen for its ability to capture the complexity of qualitative data through an analytical and flexible structure.

Interviews, tests, and questionnaires were conducted at five Muhammadiyah junior high schools in the city of Makassar, South Sulawesi: SMP Unismuh Makassar, SMP Muhammadiyah 1 Makassar, SMP Muhammadiyah 10 Makassar, SMP Muhammadiyah 11 Tello Baru Makassar, and SMP Muhammadiyah 14 Makassar. In the interview activities, six teachers and six students were selected as research subjects. The selection was done purposively, taking into account the diversity of backgrounds and levels of understanding related to science learning oriented toward scientific literacy. For the tests and student response questionnaires, one class was selected from each of the schools studied.

The instruments used in this study included a scientific literacy ability test, a student response questionnaire related to the science learning process and teaching materials, and interview guides designed for both teachers and students. Teacher interviews focused on their knowledge and experience in implementing science literacy-oriented teaching, the challenges faced, strategies used, students' science literacy capabilities, use of learning modules, and teachers' responses to developing an E-Module. The teachers interviewed represented various characteristics: two teachers experienced in literacy-oriented science learning, two novice teachers, and two senior teachers with extensive teaching experience. This composition aimed to provide a comprehensive picture of the understanding, challenges, and real needs in the field regarding science education with a literacy focus.

Student interviews explored several aspects, including: interest in science subjects; level of understanding of the material and learning challenges encountered; participation in practicum or project activities and their impact on learning motivation; the use of learning media perceived as most effective and enjoyable; and the availability of supporting facilities such as lab equipment and digital devices.

Students interviewed included two with low cognitive abilities, two with moderate abilities, and two with high abilities. This variation was important to capture the differences in perception and needs that may arise based on their cognitive levels.
Data from the interviews, tests, and student response questionnaires served as the primary foundation in compiling a comprehensive needs analysis. Through direct dialogue with teachers and students, the researchers were able to identify gaps between the ideal and actual learning conditions, including aspects related to scientific literacy understanding, technological readiness, and facility limitations. This information formed the basis for formulating the direction for developing a Digital E-Module that is not only content-innovative but also contextual and applicable to the real conditions of junior high schools in Indonesia in general, and Muhammadiyah schools in particular.

III. RESULT AND DISCUSSION

A. Needs Analysis Based on Students' Initial Science Literacy Profile Test

The initial study results mapping students' science literacy abilities using a PISA-based science literacy test instrument showed that 56% of students were in the low category, 20% in the medium category, and 24% in the high category. These findings indicate the urgent need for educators and education stakeholders in Indonesia to make a concerted effort to improve junior high school students' science literacy skills.

B. Needs Analysis Based on Student Response Questionnaire

Initial findings from student response questionnaires regarding the science teaching materials used by teachers indicated that teachers primarily relied on printed textbooks commonly found in schools as the sole teaching resource. A major shortcoming of these textbooks is their lack of contextual material that fosters the development of students' scientific literacy. Additionally, the textbooks do not provide opportunities for students to build their science literacy skills. Furthermore, the questionnaire analysis revealed that: 60% of students had difficulty connecting science concepts, 53% struggled to understand the material, 87% were not interested in the textbook presentation, 97% wanted materials that were integrated with videos and accessible anytime, anywhere.

In terms of digital technology proficiency, about 90% of students from Muhammadiyah junior high schools in Makassar are already skilled in using Android smartphones. This indicates that students are well-prepared for the development of digital-based e-modules to be used in the learning process.

The questionnaire analysis further revealed that students considered the topic of Heat and Temperature in grade 8th science to be among the most difficult to understand. They noted that many concepts in this topic are abstract, closely related to daily life, and challenging to grasp. Due to these challenges, there is a need for teaching materials—such as instructional modules—that can support the development of students' problem-solving skills through the use of enjoyable and engaging digital technology in science learning.

C. Needs Analysis Based on Teacher Interviews

Interviews conducted at five Muhammadiyah junior high schools (SMP Unismuh Makassar, SMP Muhammadiyah 1 Makassar, SMP Muhammadiyah 10 Makassar, SMP Muhammadiyah 11 Tello Baru Makassar, and SMP Muhammadiyah 14 Makassar) revealed various conditions reflecting the real needs for developing a Science Literacy-Oriented Digital E-Module on the topic of heat and temperature. Each school presented different challenges and opportunities depending on the teachers' preparedness, the implemented curriculum, and the availability of supporting facilities.

SMP Unismuh Makassar. Although teachers had a good understanding of science literacy-oriented learning, implementation was limited by difficulties aligning teaching modules with curriculum changes, especially during the transition from the 2013 Curriculum to the Merdeka Curriculum. Teachers also faced issues accessing relevant digital learning resources. Therefore, a systematically designed Digital E-Module is seen as helpful for lesson planning and execution. Students' science literacy levels varied depending on their access to learning facilities at home. Teachers recommended the use of visual media and active communication with parents as improvement strategies.

SMP Muhammadiyah 1 Makassar. Science literacy-oriented teaching had not been explicitly implemented, especially as the Merdeka Curriculum tends to separate subjects. However, during the 2013 Curriculum period, the school had used literacy-oriented learning media such as wind-powered vehicles. Teachers found such media effective when they understood the tools' functions and principles. Student literacy was still low—many could read but not comprehend content, emphasizing the need for interactive visual media in the Digital E-Module to enhance conceptual understanding.

SMP Muhammadiyah 10 Makassar. Teachers had unknowingly applied science literacy principles through projects such as assembling electric circuits. This shows the need for more structured training and conceptual understanding to guide instructional practices. The school faced difficulty aligning learning materials with students' abilities and had limited access to digital devices, making it essential to develop E-Modules suitable for available technologies.

SMP Muhammadiyah 11 Tello Baru Makassar. The school had no experience in implementing science literacy-oriented teaching, with teachers still using conventional methods. Student literacy levels were notably low—many struggled even with basic reading. The school addressed this by offering remedial classes. Here, a Digital E-Module could provide appealing visual media and support more interactive learning.

SMP Muhammadiyah 14 Makassar: Although the school had begun implementing science literacy-oriented teaching, it faced challenges with student discipline and limited experimental tools and materials. Despite these challenges, the school was relatively open to technology. Electronic modules had been introduced using devices like projectors. However, students' readiness to independently use technology at home remained a concern. Therefore, the development of adaptive Digital E-Modules supported by teacher training is a crucial need.

D. Needs Analysis Based on Student Interviews

Interviews with students from various schools revealed that the majority showed strong interest in science, especially when involved in practical or project-based activities. This enthusiasm positively influenced their motivation to learn. However, their understanding of the material varied, particularly when it involved scientific terminology or required visualizing abstract concepts such as heat and temperature.

Students reported that activities like making piggy banks, assembling traffic light circuits, or conducting electricity experiments helped them grasp concepts more concretely. Teachers also played a vital role in boosting motivation, especially when they incorporated digital learning media such as Let's Read, educational TikTok videos, or YouTube content. Nevertheless, challenges in terms of facilities still existed. In many cases, students had to bring their own tools or materials from home because the schools lacked consistent resources. This highlights the importance of careful planning in developing Digital E-Modules to ensure all students have equal learning experiences, regardless of their family's economic background.

E. Needs Analysis Based on Literature Review

The literature reviewed in this study underscores a significant gap between the conventional learning approach still dominant in junior high schools and the need for more contextual, integrated learning innovations. The literature analyzed came from previous studies focused on the development of teaching modules and science literacy-oriented E-Modules, particularly at the junior high level.

The main findings from Wulandari & Ramadhani (2020) and Supriadi & Rahmawati (2021) indicated that learning processes in junior high schools generally still rely on lecture-based methods and homework assignments as primary strategies. The use of teaching modules tends to be sporadic and not integrated holistically into the learning process. Often, teaching modules are used merely as assessment tools after the material has been delivered, rather than as resources for active and ongoing knowledge construction.

Many teachers also still depend on government-provided thematic books and online sources that are not pedagogically curated. In some cases, students are not allowed to take their books home due to limited copies, which restricts their ability to explore materials independently outside school hours (Diliberti et.al., 2020; Pondiscio, 2019; Wright, 2021). The development of Science Literacy-Oriented Modules is still very limited, and teaching modules often simply replicate or adapt questions from the internet (A'yuni, 2020; Mahmud, et.al., 2023).

Some researchers emphasize that students are beginning to lose interest in science learning due to monotonous and uninspiring approaches. They highlight the need for teaching materials that not only meet curriculum goals but also spark motivation and active engagement through attractive and literacy-rich module design (Suryanto, 2023; Wested, 2022; Adesoji & Idowu, 2024; Pradana & Fitriyani, 2023). Others point out that many teachers misunderstand the function of teaching modules, often seeing them as mere tools for testing competencies rather than as guides to support students through an exploratory and problem-solving learning process (Bayih et.al., 2023).

In essence, science literacy-oriented learning places students at the center of the educational experience, actively engaging them in inquiry, investigation, and solving real-world problems. Therefore, this literature collectively underscores the urgent need to redesign science teaching modules into Digital E-Modules oriented to scientific literacy. These materials should ideally be packaged in digital formats featuring introductory videos to stimulate learning, core content, demonstrations of relevant experiments, systematic practicum steps, and learning activities that encourage scientific reasoning and reflection. With this approach, students are expected to make connections between observed phenomena in daily life and the scientific principles they learn. Activities within the E-Module are designed to stimulate higher-order thinking skills and foster continuous development of science literacy.

Overall, the literature review supports field findings that structured, interactive, and digitally integrated Science Literacy-Oriented Digital E-Modules are an urgent need in junior high science education. Without transforming teaching materials and enhancing teacher capabilities, achieving 21st-century learning standards at the secondary level will remain a significant challenge.

IV. CONCLUSIONS

Based on the in-depth analysis conducted through tests, questionnaires, and interviews with teachers and students, as well as the review of relevant literature, this study identifies a pressing need for the development of a Science Literacy-Oriented Digital E-Module in science education, specifically on the topic of Heat and Temperature in junior high schools. This conclusion emerges from several key findings that highlight a gap between the ideal learning conditions and the actual practices observed in the field—from the perspectives of teachers, students, and the education system as a whole.

From the teachers' standpoint, several challenges are evident, including limited understanding and application of science literacy-oriented learning, lack of training in developing digital teaching media, and difficulty in integrating fragmented curricula. Teachers also struggle to align instructional materials with students' diverse learning abilities and to provide resources that foster active student engagement. Therefore, the development of a Science Literacy-Oriented Digital E-Module is not only needed as a learning aid but also as a strategic tool to enhance the overall quality of teaching and learning planning and implementation.

From the students' perspective, despite their high interest in science—especially when engaged in hands-on activities or projects—their ability to comprehend scientific concepts is still heavily influenced by the learning approach used. Students show enthusiasm for experiential and exploratory learning, but this is often not optimally facilitated due to limited facilities and the lack of media or instructional materials that bridge conceptual understanding with real-world practice. Hence, the presence of a Digital E-Module that is interactive, visually engaging, and contextually relevant is essential to foster scientific understanding and strengthen science literacy from an early stage.

In addition, the analyzed literature emphasizes the need for a paradigm shift in instructional material development. The literature consistently indicates that traditional, teacher-centered approaches are no longer adequate to meet the challenges of 21st-century education. Therefore, the development of a Science Literacy-Oriented Digital E-Module must aim to create learning experiences that are collaborative, exploratory, and geared toward solving real-world problems.

Overall, the development of a Science Literacy-Oriented Digital E-Module is viewed as a strategic solution to meet the demands of more meaningful, relevant, and technologically adaptive science education. Such an E-Module must be designed with consideration for school infrastructure availability, teacher readiness, and student characteristics. More than just digital instructional content, the Digital E-Module must serve as a bridge between theory and practice, curriculum and classroom reality.

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