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Validation Analysis of Interactive Teaching Materials on Environmental Pollution Integrated with Ethno-Meaningful Learning to Facilitate Students' Knowledge and Creative Thinking Skills

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ABSTRACT

Technological advancements play a vital role in supporting educational processes, particularly in the development of instructional materials. A needs analysis conducted at SMA N 1 Dua Koto revealed that teachers continue to face difficulties in designing technology-based teaching resources. Existing teaching materials have yet to make a significant impact on the improvement of students' knowledge and creative thinking skills. One promising approach to address this issue is the development of interactive teaching materials that integrate ethnoscience and meaningful learning principles. This study aims to evaluate the validity of interactive teaching materials on environmental pollution that are integrated with ethno-meaningful learning. The research employed a Research and Development (R&D) design using the Hannafin and Peck model. The object of the research was the interactive teaching material itself. Data were collected through instruments such as needs analysis questionnaires, validity assessments, and practicality evaluations. The data were analyzed using descriptive statistical methods, particularly Aiken's V formula. The results of the validation process indicated an average Aiken's V score of 0.91 which falls into the "valid" category. These findings suggest that the developed teaching materials are both valid and suitable for implementation in classroom settings, with the potential to significantly enhance students' knowledge and creative thinking skills.

Keywords: Interactive Teaching Materials, Environmental Pollution, Ethnoscience, Meaningful Learning

I. INTRODUCTION

Education is a fundamental human need, serving as a crucial element in preparing human resources for national development. It is expected to produce intelligent individuals capable of contributing to the construction of social systems and global knowledge through institutions managed with competence to ensure quality outcomes. The rapid advancement of technology has significantly influenced the way people perform tasks, interact with others, and manage their daily lives. Entering the 21st century, technological development has permeated various aspects of life, including education. Teachers, educators, and students are now expected to possess the necessary skills to engage effectively in the teaching and learning process [1].

Twenty-first century education demands continuous innovation and the strengthening of human capital to meet global challenges. This transformation highlights the importance of producing high-quality human resources through professionally operated educational institutions. In this context, teachers serve as the main agents of change and are at the forefront of preparing future generations. A 21st-century teacher must not only be proficient in instructional delivery and classroom management, but also be able to foster positive relationships with students and stakeholders, integrate technology to enhance learning, and continuously reflect on and improve their teaching practices. Thus, teachers play a pivotal role in preparing students with the competencies required in the 21st century[2].

Twenty-first century skills refer to a set of essential competencies that individuals must acquire to adapt and thrive amid rapid changes and growing demands of the modern era. These skills are not only necessary for teachers but also for students, who must be equipped with the knowledge and abilities required for effective learning in a 21st-century context. In this era, schools are expected to foster key competencies such as creative thinking, critical thinking, problem-solving, communication, and collaboration—collectively known as the 4Cs. Mastery of the 4Cs (Critical Thinking, Communication, Creative Thinking, and Collaboration) is crucial for 21st-century learners as these skills significantly contribute to their overall academic and personal competence [3].

Creative thinking skills are a key component that must be developed in both teachers and students. For students, creative thinking enables the generation of new ideas or the improvement of existing ones. It also allows them to discover unique learning methods or approaches to idea generation that differ from those of their peers, thereby fostering the development of diverse perspectives [4]. For teachers, this skill facilitates the creation of innovative and engaging teaching methods, inspiring students to think beyond conventional patterns and design creative solutions to existing problems. Therefore, creative thinking is an essential ability for facing future challenges [5].

Rapidly evolving technology is increasingly utilized in the education sector, particularly in the development of teaching materials. Teaching materials make the learning process more enjoyable, efficient, and relevant to real-life contexts. Additionally, the use of teaching materials encourages active involvement from both teachers and students, which enhances the overall effectiveness of learning. The implementation of teaching materials also enables students to acquire various knowledge and skills, while strengthening their self-confidence and capacity for self-actualization [6]. In the learning process, teaching materials play a highly significant and fundamental role, functioning as tools for delivering information, developing skills, and assisting students in achieving pre-established learning objectives.

The needs analysis of Grade X Phase E students at SMA Negeri 1 Dua Koto revealed that physics learning still relies heavily on physical learning resources such as textbooks and student worksheets (LKS), which do not specifically address environmental pollution topics. However, the learning process follows the Merdeka Curriculum CP Phase E according to BSKAP No. 032/H/KR/2024, which encompasses both knowledge and process skills. Observations and questionnaires indicate that the learning tends to be monotonous due to the lack of interactive teaching materials, and teachers face difficulties in creating and mastering software tools (90% and 85%, respectively). Furthermore, the teaching materials have not integrated ethnoscience and meaningful learning approaches adequately, with low integration levels of 87.5% and 90%. These findings highlight the necessity to develop interactive teaching materials integrated with an ethno-meaningful learning approach to support the enhancement of students' knowledge and creative thinking skills.

The use of printed teaching materials has inherent limitations. This medium cannot display moving images necessary to explain psychomotor steps or principles [7]. Several students have assessed that printed books are inadequate for delivering the full scope of learning materials. This aligns with findings from previous research [8] which revealed that textbook content is often too complex for independent comprehension, thus necessitating the selection of appropriate learning media. Therefore, the use of printed teaching materials is considered less effective because they cannot present visual and interactive content, especially for psychomotor learning, and tend to be difficult to understand independently. Hence, there is a need to select more relevant learning media that better support the students' learning process.

The gap between the ideal conditions and the actual situation observed at the school reveals a significant discrepancy, indicating a research problem. The current reality shows that printed teaching materials are still predominantly used because teachers face difficulties in creating technology-based instructional resources. These materials have yet to effectively facilitate students' creative thinking skills or support the enhancement of their knowledge. This situation presents a challenge in improving the quality of learning at the school. One potential solution is to develop interactive teaching materials integrated with ethnoscience and meaningful learning approaches. Teaching materials that leverage technology and local wisdom are expected to make the learning process more meaningful for students [9].

Interactive teaching materials are a type of learning resource that combines various media, such as audio, moving images, text, and graphics, and features interactivity that allows learners to engage directly with the content [10]. The use of multimedia makes learning more effective and captures students' attention when

designed interactively, providing control features that users can operate themselves. This empowers learners to determine and make decisions about the learning flow according to their needs and interests [11]. Interactive teaching materials can increase student engagement in enjoyable and challenging ways, thereby making learning more interesting. Furthermore, these materials support the development of creative thinking skills and provide immediate feedback to correct mistakes and reinforce student understanding. This aligns with the findings of a study [12] on "The Effectiveness of Using Interactive E-Book Teaching Materials in Developing Students' Critical Thinking Skills," which concluded that interactive e-book teaching materials in learning are proven effective in fostering students' critical thinking abilities.

The issues addressed in interactive teaching materials should be relevant and authentic, one approach being the integration of local wisdom or ethnoscience. Ethnoscience is defined as a form of knowledge possessed, developed, and passed down by a particular social group [13]. The application of ethnoscience in learning helps students gain a comprehensive understanding, not only in science but also in environmental and societal dynamics [14]. Through an ethnoscience approach, students find it easier to absorb learning materials as they can observe and directly experience the application of knowledge in real life. This finding aligns with the results of a study [15] on "The Practicality and Effectiveness of Using Physics E-Modules Based on Guided Inquiry Integrated with Ethnoscience to Enhance Students' Critical Thinking." The research concluded that learning processes integrating ethnoscience can motivate students and increase their enthusiasm for learning, due to the relevance of the teaching materials to the students' immediate environment.

Interactive teaching materials integrated with ethnoscience can make learning more meaningful. Meaningful learning is a process that helps students understand concepts by connecting prior knowledge with new information [16]. In this type of learning, students attempt to relate new phenomena to their existing knowledge and link it with the subject matter. This process significantly contributes to their ability to form and develop new concepts. Moreover, enjoyable learning not only provides comprehensive and in-depth information but also enhances students' skills and competencies across various aspects, enabling them to apply the acquired knowledge in their daily activities [17].

Environmental pollution is a relevant and urgent issue in today's society. This topic not only involves scientific concepts but also has a direct impact on the daily lives of communities, especially those with local wisdom. This statement is supported by research [18] which revealed that the Bakung landfill experiences an increase in waste volume of up to 1 ton per day. The rising amount of waste affects the community's environmental conditions, potentially leading to the spread of diseases and a decline in cleanliness. Therefore, the researcher is interested in studying materials related to environmental pollution.

Based on the analysis of the existing problems, the researcher decided to develop interactive teaching materials integrated with ethno-meaningful learning to facilitate students' knowledge and creative thinking skills. The developed materials cover the topic of environmental pollution and are designed interactively to be more engaging and relevant to the students' cultural context. In relation to this, the objective of this study is to evaluate the validity of the interactive teaching materials on environmental pollution integrated with ethno-meaningful learning. Validity assessment is essential to ensure that the teaching materials effectively support meaningful learning and stimulate students' creativity.

II. METHOD

This study uses the research and development method, or R&D (Research and Development). In the book *Research and Development Methods*, Sugiyono explains that this research method is used to develop a specific product as well as to evaluate how effectively the product functions [19]. The object of this research is interactive teaching materials about environmental pollution integrated with ethnoscience and meaningful learning to develop students' creative thinking skills. The trial subjects consisted of three physics lecturers from the FMIPA UNP who served as validators to assess the product's validity, as well as a physics teacher from SMA N 1 Dua Koto who collaborated with students of class X Phase E 7 at SMA N 1 Dua Koto to assess the product's practicality.

In this study, the researcher chose to use the Hannafin & Peck development model. The Hannafin & Peck model is a learning design model aimed at developing learning products, such as educational videos, digital

teaching materials, or modules [20]. The stages in the Hannafin & Peck model include: (1) needs analysis, (2) design, and (3) development and implementation [21].

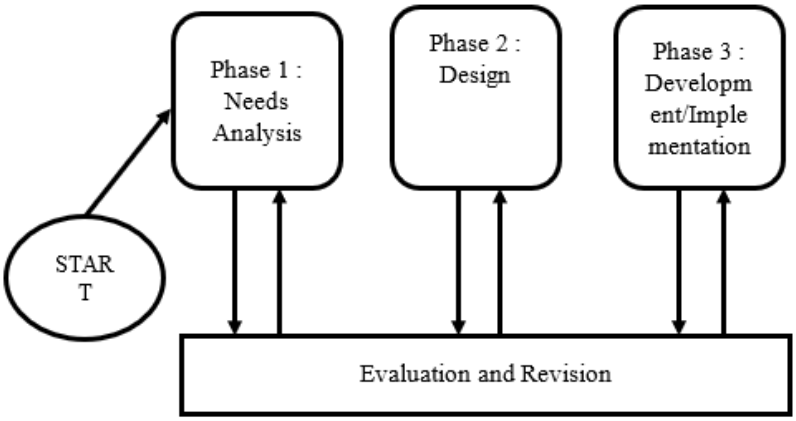

Fig. 1. Hannafin & Peck Development Model

The teaching materials were validated by three experts. If the product is proven valid, the next step is a practicality test. The instruments used were an initial needs analysis questionnaire, a product validity questionnaire, and a product practicality questionnaire. The analysis of the teaching material validation results was obtained through the evaluators' assessments using Aiken's V validity method. Aiken developed the Aiken's V formula to calculate the content validity coefficient, which is based on the ratings from a number (n) of experts regarding the extent to which an item represents the construct being measured. The validity results were calculated using Aiken's (1985) formula as follows:

$$V = \frac{\sum S}{[n(C-1)]} \qquad (1)$$

Keterangan :
$\sum S = R - L_O$
V = Aiken's Index
R = the rating given by each expert
L_O = the lowest possible rating (e.g., 1)
n = the number of experts
C = the number of possible rating categories (e.g., 4)

Criteria Used to Assess the Validity of Interactive Teaching Materials with an Ethnoscience and Meaningful Learning Approach:

Table 1. Criteria for Aiken's V Validity Coefficient

Average Score	Criteria
≥ 0,6	Valid
< 0,6	Not Valid

(Source:Ref[22])

III. RESULTS AND DISCUSSION

Result

Validation of the interactive teaching materials on environmental pollution, which integrate ethno-meaningful learning, was conducted using a validation sheet completed by three validator lecturers. These validators are Physics lecturers from FMIPA UNP who have expertise and experience in their respective fields. The purpose of this validation is to assess the feasibility of the teaching materials and to serve as a reference for revising the prepared materials. The validation instrument covers five assessment aspects, namely: 1) substance feasibility, 2) visual communication feasibility, 3) instructional design feasibility, 4) software utilization feasibility, and 5) feasibility of ethno-meaningful learning integration.

The first component assessed is the feasibility of the content substance (SM). This aspect consists of six indicators: 1) The material in the interactive teaching materials (ITM) on environmental pollution integrated with ethno-meaningful learning is developed in accordance with the Competency Standards (CP) in the curriculum and learning objectives (Relevance), 2) The accuracy of the material content in the ITM on environmental pollution integrated with ethno-meaningful learning aligns with scientific principles (Accuracy), 3) The material in the ITM can broaden knowledge in accordance with scientific developments (Clarity), 4) The ITM on environmental pollution integrated with ethno-meaningful learning is created in accordance with current issues (Up-to-dateness), 5) The questions in the ITM on environmental pollution integrated with ethno-meaningful learning can enhance students' knowledge and creative thinking skills (Guiding Questions), and 6) The language used in the ITM on environmental pollution integrated with ethno-meaningful learning is standard and understandable (Readability). The analysis results of the material content feasibility aspect are presented in Figure 2.

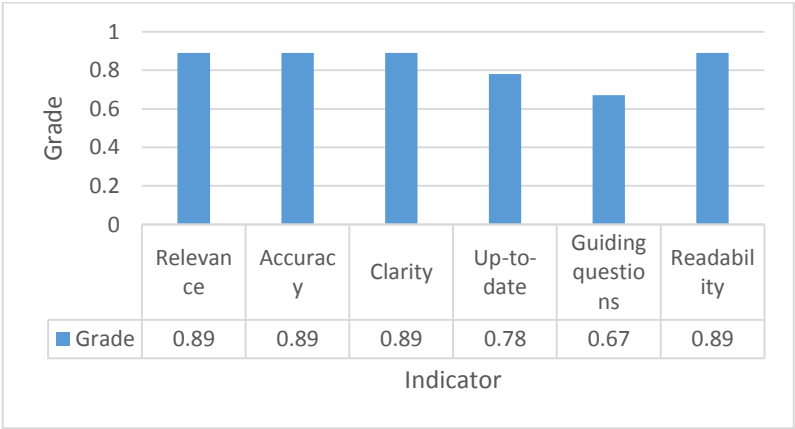

Fig. 2. Validity Results of the Material Content Feasibility Komponen

Based on Figure 2, the interactive teaching materials on environmental pollution received material content scores ranging from 0.56 to 0.89. The assessments given by the validators for each material content aspect fall into the valid category. The indicator for the relevance of the material with the Competency Standards (CP) of the Merdeka Curriculum received a score of 0.89, categorized as valid, meaning the material in the interactive teaching materials is in accordance with the CP in the Merdeka Curriculum. The accuracy indicator scored 0.89, also categorized as valid, indicating that the material content presented in the interactive teaching materials is accurate and does not deviate from established knowledge. The clarity indicator scored 0.89, categorized as valid, meaning the material presented is aligned with the development of scientific knowledge. The up-to-dateness indicator scored 0.78, categorized as valid, meaning the material is relevant and connected to current phenomena that are easily understood by students. The guiding questions indicator in the teaching materials received a score of 0.67, categorized as valid, indicating that the questions in the interactive teaching materials are designed according to indicators of knowledge and students' creative thinking skills. The readability

indicator scored 0.89, categorized as valid, meaning the language used in the interactive teaching materials is standard and easy for students to understand. Overall, the average score of the material content feasibility indicators is 0.83, which falls into the valid category.

The second component is the feasibility of visual communication (KV). This aspect consists of five indicators: 1) The interactive teaching materials (ITM) on environmental pollution integrated with ethno-meaningful learning use basic navigation and hyperlinks that function properly (Navigation), 2) The font appearance in the ITM on environmental pollution integrated with ethno-meaningful learning is readable, proportional, and has a good composition (Typography), 3) The colors used in the ITM on environmental pollution integrated with ethno-meaningful learning are harmonious, well-composed, and visually appealing (Color), 4) The media used in the ITM on environmental pollution integrated with ethno-meaningful learning are appropriate for the learning context (Media), and 5) The layout design of the ITM on environmental pollution integrated with ethno-meaningful learning is proportional and attractive (Layout). The data analysis results for the visual communication feasibility aspect can be seen in Figure 3.

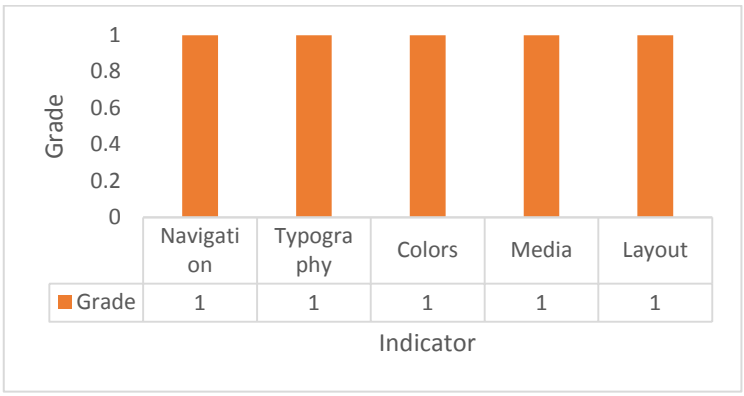

Fig. 3. Validity Results of the Visual Communication Feasibility Component

Based on Figure 3, the scores for each indicator in the visual communication feasibility aspect are all 1. The navigation indicator received a score of 1, categorized as valid, meaning the teaching materials already have good navigation, allowing easy movement from one slide to the next. The typography indicator received a score of 1, categorized as valid, indicating that the teaching materials use appropriate fonts, including proper use of uppercase and lowercase letters. The color indicator scored 1, categorized as valid, meaning the colors used in the teaching materials are harmonious and attractive. The media indicator received a score of 1, categorized as valid, indicating that the media used is appropriate for the learning context and not misleading. The layout indicator scored 1, categorized as valid, meaning the layout of the teaching materials is proportional and not random. Overall, the average score for the indicators in the visual communication feasibility aspect is 1, which falls into the valid category.

The third component assessed is the feasibility of instructional design (DP). This aspect consists of six indicators: 1) The title of the teaching materials corresponds with the content in the interactive teaching materials (ITM) on environmental pollution integrated with ethno-meaningful learning (Title), 2) The ITM on environmental pollution integrated with ethno-meaningful learning aligns with the Competency Standards (CP) of the Merdeka Curriculum (CP), 3) The learning objectives in the ITM on environmental pollution correspond with the CP and clearly state the benefits for students (Learning Objectives), 4) The material in the ITM on environmental pollution integrated with ethno-meaningful learning matches the learning objectives (Material), 5) The questions included in the ITM on environmental pollution integrated with ethno-meaningful learning stimulate students to develop their knowledge (Exercises), and 6) The references used in the ITM on environmental pollution integrated with ethno-meaningful learning are appropriate (References). The analysis results for the instructional design feasibility aspect can be seen in Figure 4.

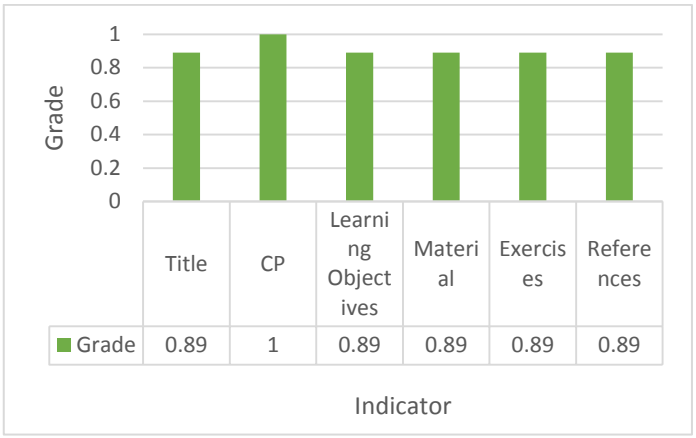

Fig. 4. Validity Results of the Instructional Design Feasibility Component

Referring to Figure 4, the scores for each indicator in the instructional design feasibility aspect range from 0.89 to 1. The title indicator received a score of 0.89, categorized as valid, meaning the material in the teaching materials matches the title. The CP (Competency Standards) indicator received a score of 1, categorized as valid, indicating that the teaching materials use the current applicable CP, namely CP based on BSKAP No. 032/H/KR/2024. The learning objectives indicator scored 0.89, categorized as valid, meaning the objectives in the teaching materials align with and are derived from the CP. The material indicator received a score of 0.89, categorized as valid, meaning the material matches the expected learning objectives. The exercises indicator scored 0.89, categorized as valid, indicating that the exercises are designed to achieve the learning objectives and are consistent with the material. The references indicator scored 0.89, categorized as valid, meaning the teaching materials use appropriate and up-to-date references. The overall average score for the instructional design feasibility aspect is 0.91, which falls into the valid category.

The fourth component is the feasibility of software utilization (PS). This aspect consists of four indicators. These indicators include: 1) The Canva application used to create the interactive teaching materials (ITM) on environmental pollution integrated with ethno-meaningful learning is very good and attractive (Canva), 2) The Heyzine Flipbook application used to create the ITM on environmental pollution integrated with ethno-meaningful learning makes it more engaging and efficient (Heyzine Flipbook), 3) The Google Form and Wordwall applications used for exercises and evaluations make the ITM on environmental pollution integrated with ethno-meaningful learning more interactive and efficient (Assessment Applications), and 4) The images and videos in the ITM on environmental pollution integrated with ethno-meaningful learning are partially self-produced, while the rest are sourced externally (Originality). The analysis results of the software utilization feasibility aspect can be seen in Figure 5.

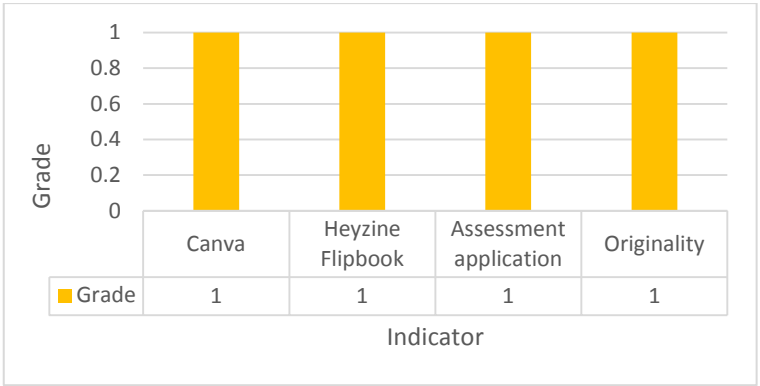

Fig. 5. Validation Results of the Software Utilization Feasibility Component

Based on Figure 5, the scores for each indicator in the software utilization feasibility aspect are all 1. This data shows that the interactive teaching materials on environmental pollution utilize various software

applications during their development and use. The use of the Canva application received a score of 1, categorized as valid, meaning the use of Canva is good and attractive for creating the teaching materials. The use of the Heyzine Flipbook application received a score of 1, categorized as valid, indicating that this application is effective and makes the interactive teaching materials more efficient. The use of Google Form and Wordwall applications received a score of 1, categorized as valid, meaning these applications make the teaching materials more interactive and provide system-generated feedback to users, both through exercises and the learning process. The originality of images and videos in the teaching materials received a score of 1, categorized as valid, indicating that the images and videos created and sourced from elsewhere in the teaching materials are appropriate. Overall, the average score for the software utilization feasibility aspect is 1, which falls into the valid category.

The final component is the feasibility aspect of integrating ethnoscience and meaningful learning (EM). This aspect consists of four indicators: 1) The interactive teaching materials (ITM) on environmental pollution integrated with ethno-meaningful learning present local cultural values relevant to the learning topic (Relevant), 2) The integration of local cultural values in the ITM on environmental pollution integrated with ethno-meaningful learning is delivered proportionally and does not disrupt the learning flow (Proportional), 3) The ITM on environmental pollution integrated with ethno-meaningful learning includes activities or assignments that support students in exploring, discovering, and constructing knowledge and creative thinking skills (Supportive), and 4) The ITM on environmental pollution integrated with ethno-meaningful learning presents questions that connect new concepts with prior knowledge (Displays). The analysis results of the feasibility aspect of ethnoscience and meaningful learning integration can be seen in Figure 6.

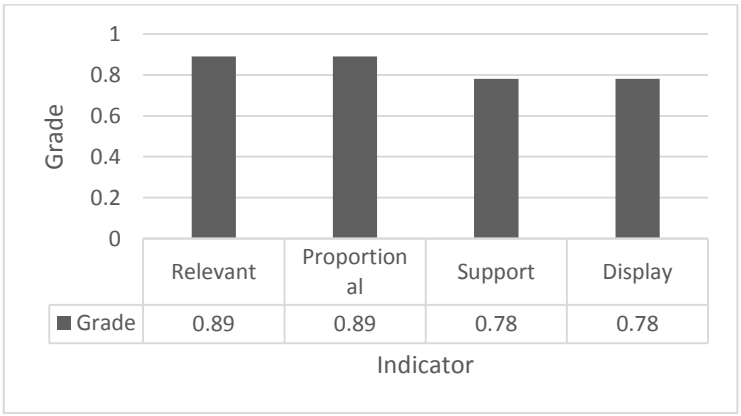

Fig. 6. Validation Results of the Feasibility Component of Ethno-Meaningful Learning Integration

Based on Figure 6, the interactive teaching materials integrated with ethno-meaningful learning show scores ranging from 0.89 to 1. The indicator for the relevance of local cultural values to the learning topic received a score of 0.89, which falls into the valid category. The indicator for the proportional of local culture received a score of 0.89, categorized as valid, meaning the local culture is presented well and does not disrupt the learning flow. The indicator for the provision of activities and assignments received a score of 0.78, which is in the valid category, indicating that the activities and assignments in the teaching materials support exploring, discovering, and constructing knowledge and students' creative thinking skills. The indicator for displaying questions that connect new concepts with prior knowledge received a score of 0.78, categorized as valid, meaning the questions are presented in a way that guides students to relate new concepts to prior knowledge. Overall, the average score for the feasibility aspect of integrating ethno-meaningful learning is 0.83, which falls into the valid category.

Based on the scores of each indicator on the validation sheets, the average value for each assessment aspect can be determined. These aspects include the feasibility of content substance (SM), feasibility of instructional design (DP), feasibility of visual communication (KV), feasibility of software utilization (PS), and feasibility of ethno-meaningful learning integration (EM). The validation scores are plotted on the Y-axis, while each aspect on the assessment items is placed on the X-axis. The validation analysis results can be seen in Figure 7.

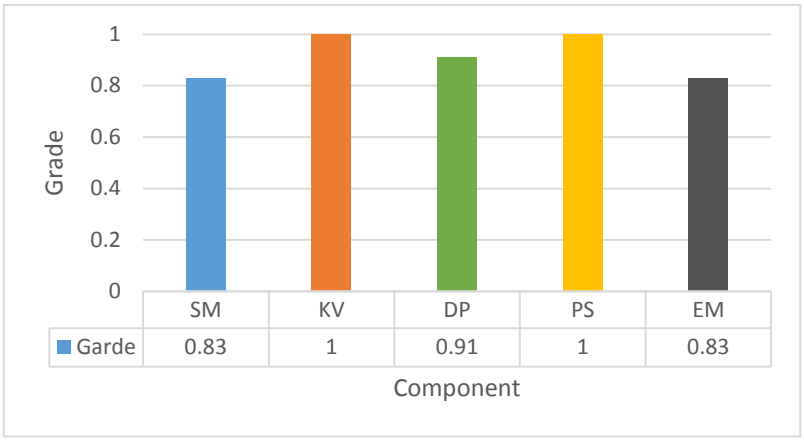

Fig. 7. Validation Results of the Interactive Teaching Materials

Based on the data analysis in Figure 7, it can be seen that the scores for each aspect vary, with the lowest score being 0.83 and the highest score 1. The validity score of the interactive teaching materials on environmental pollution integrated with ethno-meaningful learning, according to expert assessments, was obtained by calculating the average of all assessment aspects. From the analysis results, the average score for the content substance feasibility component is 0.83, which falls into the valid category, meaning the content substance in the interactive teaching materials is suitable for use. The visual communication feasibility component received an average score of 1, categorized as valid, indicating that the visual communication used in the interactive teaching materials is appropriate and feasible. The instructional design feasibility component received an average score of 0.91, categorized as valid, meaning the instructional design used in the teaching materials is appropriate and feasible. The software utilization feasibility component received an average score of 1, categorized as valid, indicating that the applications and software used in the interactive teaching materials are appropriate and support the material presented. The feasibility component for integrating ethno-meaningful learning received an average score of 0.83, categorized as valid, meaning the integration of ethno-meaningful learning in the interactive teaching materials is appropriate and supports the material presented. Overall, the average validity score of the interactive teaching materials on environmental pollution integrated with ethno-meaningful learning is 0.91, which falls into the valid category. This indicates that, overall, the interactive teaching materials on environmental pollution integrated with ethno-meaningful learning have high quality and relevance of content and are suitable for use in supporting the learning process.

Overall, this interactive teaching material uses the ethno-science and meaningful learning approaches. Interactive exercises and assessments are designed using Google Forms and Wordwall with the aim of increasing students' interest in completing the exercises as well as supporting their knowledge and creative thinking skills. The teaching material is designed to be as engaging as possible to facilitate students in learning physics. An illustration of the interactive teaching material's interface can be seen in Figure 8.

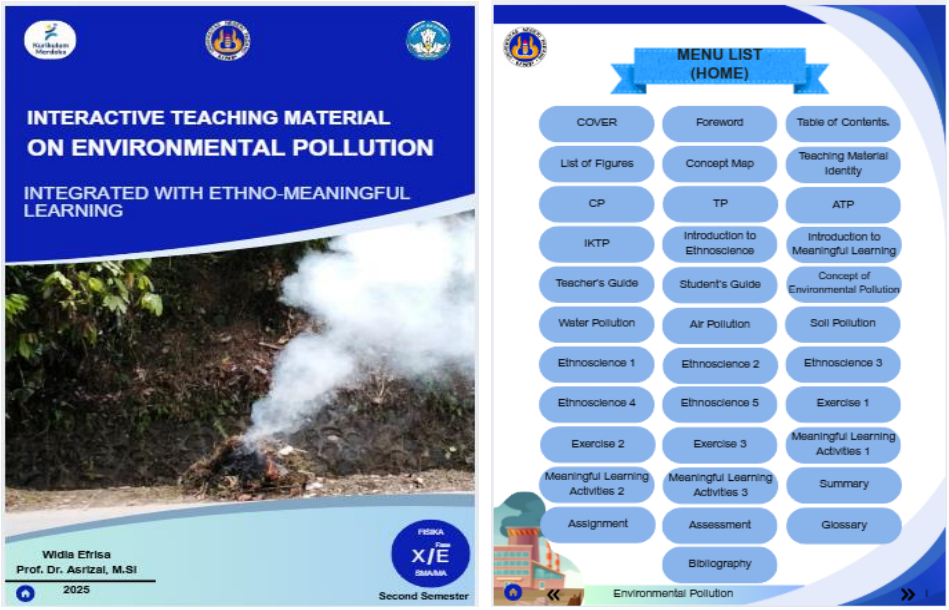

Fig. 8. Cover and Main Menu Display of the Interactive Teaching Material

During the validation process with three validator lecturers, they provided various suggestions aimed at improving the quality of the developed product. These suggestions served as guidelines for revising the interactive teaching materials on environmental pollution integrated with ethno-meaningful learning. The first revision involved the term "evaluation." Before the revision, the interactive teaching materials used the term "evaluation." The validators suggested replacing it with the term "assessment." The second revision concerned the concept map. Before the revision, the concept map in the interactive teaching materials was unclear and blurry. The validators recommended improving the concept map by removing some parts. The third revision was the addition of a home button and tabs. Before revision, each page in the interactive teaching materials on environmental pollution integrated with ethno-meaningful learning did not have a home button or tabs. The validators suggested adding a home button and tabs on every page.

Discussion

The interactive teaching material on environmental pollution integrated with ethno-meaningful learning was developed based on the guidelines from the Ministry of National Education (Kemendiknas, 2010) and is equipped with Learning Outcomes (CP), Learning Objective Pathways (ATP), and content aligned with the Merdeka Curriculum. The material presented is part of Phase E, second semester, covering the topic of Environmental Pollution. In its development, this interactive teaching material includes several essential components, such as identity (title, class, semester, and developer information), CP and ATP, instructional content, practice questions, competency tests, and reference [23]. he material was digitally developed using Canva and Heyzine Flipbook applications.

The validity of the interactive teaching material on environmental pollution integrated with ethno-meaningful learning was assessed by three expert validators. Five aspects were evaluated: content substance feasibility, visual communication feasibility, instructional design feasibility, software utilization feasibility, and the integration of ethno-meaningful learning [23]. An interactive teaching material is considered valid if it meets the standard score for each of these components. According to experts, teaching materials can be deemed feasible if they are rated valid in each component and aligned with the learning indicators [24]. Based on this assessment, it can be concluded that the product has a very high level of validity and is suitable for optimally supporting the learning process.

In the material substance feasibility component, one indicator received a low score, namely the indicator related to the questions in the environmental pollution BAI integrated with ethno-meaningful learning, which aims to enhance students' knowledge and creative thinking skills. This is because the validators were not yet able to confirm that the questions presented would effectively improve students' knowledge and creative

thinking skills. To determine whether these questions can indeed enhance those aspects, an effectiveness test must first be conducted [15]. However, the question indicators in the interactive teaching materials have already incorporated indicators of students' knowledge and creative thinking skills.

The visual communication feasibility component was categorized as valid. This finding suggests that the visual elements of the interactive teaching materials effectively facilitate student engagement and usability. Clear navigation, legible text, supportive media elements, appropriate layout, and balanced color usage all contribute to the instructional quality. Attention to visual design is essential in educational materials to ensure effective information delivery. For instance, the appropriate selection of typography can significantly influence readers' comprehension levels [23]. Furthermore, data from the instructional design feasibility component indicate that the titles within the interactive teaching materials are consistent with the presented content. The digital learning materials are aligned with the intended learning objectives and outcomes as outlined in the *Merdeka Curriculum*. Additionally, the materials integrate both instructional content and evaluation components that enhance the learning process. High-quality instructional materials should be developed with a coherent structure, logical content flow, and systematic presentation, all grounded in established principles of effective learning design [24].

In interactive teaching materials, the utilization of software plays a crucial role as it must be capable of facilitating interaction between the user and the presented content. Therefore, an appropriate application is required to ensure that this interaction occurs optimally [25]. Based on the data obtained, the software utilization feasibility component received a valid rating and is deemed suitable for use. The alignment with the ethnoscience and meaningful learning approaches makes the learning process more contextual and relevant for students. Consequently, students find it easier to understand and relate the material to their daily lives [26]. Overall, the interactive teaching material on environmental pollution integrated with ethno-meaningful learning is considered feasible for use in learning. This aligns with the view of [27] who state that teaching materials can be declared feasible if they receive valid assessments on all their components and are consistent with the learning indicators.

This study has several limitations that need to be addressed with appropriate solutions. The first limitation lies in the interactive teaching material on environmental pollution, which covers only one topic due to time constraints during its development process. Therefore, it is recommended that the teaching material be further developed to encompass the entire physics curriculum, in order to enrich learning resources and enhance students' creative thinking skills. The second limitation is that the research stage only reached the product validity testing phase, also due to limited time. To overcome this, product trials need to be conducted directly with students to obtain more comprehensive information regarding the validity, practicality, and effectiveness of the product.

IV. CONCLUSION

Referring to the research findings and analyses presented, interactive teaching materials on environmental pollution integrated with ethno-meaningful learning were developed to facilitate students' knowledge and creative thinking skills. The assessment of the interactive teaching materials indicated that the material substance feasibility component falls into the valid category. The visual communication feasibility component is also categorized as valid. Similarly, the instructional design feasibility component received a valid rating. The software utilization feasibility component was likewise deemed valid. Additionally, the ethno-meaningful learning integration component was rated as valid. Overall, the validity of the interactive teaching materials on environmental pollution integrated with ethno-meaningful learning obtained an average score of 0.91, which is classified as valid. These results demonstrate that the interactive teaching materials have undergone evaluation by validators and are considered feasible, thus allowing progression to the practicality testing phase with students.

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