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Development of Integrated Science E-Learning Materials Integrated with Ethno-PjBL to Encourage Students' 21st Century Skills

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Abstract: In the 21st century, students are required to master the 4C skills, including critical thinking, creativity, communication, and collaboration. These four skills are essential so that students are ready to face various complex challenges in the future. To achieve this goal, success is needed in the learning process, including in integrated science learning. One concrete effort to support the success of integrated science learning is through the development of effective teaching materials, especially electronic teaching materials that can be used independently by students. In the context of this study, the product developed is an integrated science e-teaching material integrated with the Project-based Learning (PjBL) model and the ethnoscience context. This e-teaching material is specifically designed to encourage mastery of 21st century skills in grade VIII junior high school students. The e-teaching material was developed using Flip PDF Professional software. The development model used in this study is the ADDIE model (Analysis, Design, Development, Implementation, Evaluation). These stages include needs analysis, product design, teaching material development, implementation, and evaluation to ensure product quality. The results of the study indicate that the development of integrated science e-teaching materials that integrate the PjBL and ethnoscience models is proven to be valid and practical for use in learning. The implication of this study is the availability of innovative teaching materials that have great potential to improve students' 21st century skills, in line with the demands of contemporary education. The existence of these e-teaching materials is expected to be a solution in overcoming the 4C skills gap that is still found in students, as well as encouraging a more effective and relevant integrated science learning process.

Keywords: Ethnoscience; E-teaching materials; Integrated science; PjBL model

Introduction

The 21st century is characterized by rapid technological development. Technological development has been rapid in the last decade. The rapid development of technology at this time makes it easy for us to access various information without space and time limits, of course this has a positive impact in all aspects including in the development of the world of education. Education should apply technology in classroom learning. Learning must change and be able to keep up with the times. An educator must understand digital mastery in the field of education, teachers must be able to use technology in learning at school.

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Education in the current era is commonly referred to as 21st century learning. 21st century learning applies learning and innovation skills, information skills, and media and technology skills (digital literacy). 21st century learning demands four competencies, namely creativity and innovation, critical thinking to solve problems, communication and collaboration. That 21st century learning has competencies including: creativity and innovation, critical thinking in solving problems, communication and collaboration. Similarly, Jannah et al. (2022) argue that 21st century skills include critical thinking skills, creative thinking skills, communicative, and collaborative. These four skills must be possessed by learners to face the world in the 21st century.

The first 21st century skill is critical thinking skills. Critical thinking skills are aspects where students can practice to find the truth of any information they get. This skill is needed to overcome the negative impact of unlimited access to information in the era of the industrial revolution 4.0. Critical thinking skills are the basis that must be mastered, especially in facing the era of the industrial revolution 4.0. Critical thinking skills are skills to train reflective and productive thinking that involves evaluating evidence. Critical thinking skills consist of several indicators. The critical thinking indicators considered in this study are understanding the problem, planning or modeling the solution, implementing the model or planning the solution and calculation, and drawing conclusions (Facione, 2014).

Meanwhile, creative thinking skills are the skills of learners to generate new ideas in solving a problem. This is in line with the opinion of Yunita et al. (2021) which states that creative thinking skills are the skills of students to see problems from various sides or perspectives, with the result that students will be more open in solving problems. Creative thinking skills are the skills to build ideas or solutions to solve problems and create things that are not expected. Creative thinking has 4 indicators, namely fluent thinking, flexible thinking, original thinking, and elaboration. Fluent thinking is the ability to generate many ideas, flexible thinking is the ability to generate varied ideas, original thinking is the ability to generate new ideas or ideas that did not exist before, and elaboration thinking is the ability to develop or add ideas so that detailed ideas are produced.

Communication skills are the ability of students to convey their ideas and thoughts quickly, clearly and effectively (Oktasari et al., 2019). Communicative skills are the ability of students to convey ideas, during the implementation of discussions. Communicative skills consist of four assessment indicators. The four indicators of communicative skills are expressing information and ideas to individuals or groups, paying attention when others speak, responding, and asking questions (Qomariyah & Subekti, 2021).

Collaboration skills are one of the skills developed in 21st century skills. Collaboration skills are skills in building cooperation or collaboration with others to achieve goals set together. This skill aims to prepare students to be able to work together in future life (Sari & Atmojo, 2021). Collaboration skills have five indicators that reflect the ability of a collaboration skill. Indicators that reflect collaboration skills are actively contributing to the group, working productively, showing flexibility and strong compromise in the group, responsibility and respect for other group members.

The government has made various efforts in the field of education to encourage students' 21st century skills. One of the efforts made is in terms of curriculum changes and improvements. The current curriculum in Indonesia is an independent curriculum that supports the realization of 21st century skills. The implementation of an independent curriculum is appointed to answer the challenges of the times on education, namely to produce graduates who are critical, creative, communicative and collaborative. The development of an independent curriculum is one of the relevant approaches in improving 21st century skills in education. The independent curriculum is able to answer social challenges in improving 21st century skills. According to him, the independent curriculum offers an inclusive and flexible approach, which allows learners to develop skills according to their interests, talents and needs. Independent curriculum, learners are given the freedom to choose the learning path that suits them best, so that they can reach their potential more optimally.

The independent curriculum supports 21st century skills. This is in line with Fahlevi (2022) which states that the independent curriculum is able to emphasize critical thinking skills. In addition, this curriculum also encourages the development of students' creativity by providing space to imagine, create, and innovate in the learning process. In addition to critical and creative thinking skills, the independent curriculum also gives great attention to communication and collaboration skills. To produce graduates who have these 21st century skills requires success in the learning process. Success in the integrated science learning process is highly dependent on the use of selected teaching resources and materials.

However, the reality on the ground is not as expected. This is reflected in the preliminary analysis conducted. Preliminary analysis is carried out to find out the initial information of the research. The preliminary analysis was conducted as a guideline in determining the next steps in the research. This analysis stage is carried out to identify the urgency of developing integrated science teaching materials integrated with the Project Based Learning (PjBL) model and ethnoscience. The preliminary analysis conducted in this study focused on three aspects: the characteristics of students, the condition of existing teaching materials, and the level of 21st century skills. The revealed that the initial research obtained the value of the problem of using teaching materials, analyzing the characteristics of students and analyzing learning objectives. In addition, preliminary analysis is carried out to analyze learning problems and analyze the characteristics of students.

The analysis consists of three aspects, namely analyzing the characteristics of students, analyzing teaching materials, and analyzing the 21st century skills of students. Based on the results of the analysis of the characteristics of students, it is known that only 52.68% of students are interested in science subjects. This means that students' interest in learning science subjects is low. The motivation of students to learn science subjects is also low with a percentage of 53.65%. This indicates a gap between expectations and reality in the field. This condition is in line with the views of Djamarah (2012); Syah (2017), who emphasize that interest and motivation are crucial factors in the success of the learning process. When students' interest and motivation are low, they tend to be less actively involved in learning (Uno, 2008) and learning outcomes can be affected.

On the other hand, in terms of learning styles, it is known that 62.15 students like kinesthetic learning styles, one of which is in the form of practical activities. This is an opportunity, considering that practical methods can increase students' interest and understanding of science concepts (Johnson, 2002). For the attitude aspect, it is known that 63.50 learners can cooperate in the assigned group. This shows that although there is potential, collaboration skills still need to be improved. This figure, although higher than some other aspects, still indicates that most learners have not fully mastered collaboration skills, an essential 21st century competency (Wagner, 2010). Group collaboration is essential for effective learning, especially in science subjects that often involve practical activities and joint problem solving (Johnson & Johnson, 1987; Slavin, 1995). If collaboration skills are not optimally honed, this can hinder the achievement of learning objectives that involve social interaction and teamwork.

The second analysis is the analysis of teaching materials. Based on the results of the analysis, it is known that the science teaching materials used are not electronic or not technology-based, still in the form of printed teaching materials. The second indicator in the analysis of teaching materials is the effectiveness of teaching materials. The effectiveness of the teaching materials analyzed was only in the less category, namely 53.13. This means that teaching materials at school have not created an effective learning process. In this digital era, technology-based teaching materials have great potential to increase learner engagement and understanding through interactive and multimedia features (Means et al., 2013; Prensky, 2012). Reliance on printed teaching materials alone can limit the exploration of complex scientific concepts, under-accommodate learners' diverse learning styles, and ultimately, hinder the achievement of optimal learning objectives (Clark & Mayer, 2023; Mayer, 2014).

In addition to the effectiveness of teaching materials, it is also necessary to analyze whether the teaching materials used have been associated with the culture around where students live. Based on the results of the analysis obtained only 58.33 with the category less. This means that the teaching materials used have not been integrated with ethnoscience. Integrating cultural elements in science learning can help students understand abstract concepts better through contexts that are familiar to them (Aikenhead & Ogawa, 2007; Jannah et al., 2022). When teaching materials are not relevant to learners' daily lives and experiences, they tend to struggle to make connections between new and existing knowledge, reducing motivation and deep understanding of the material (Gay, 2018; Sleeter, 2011).

In addition, science teaching materials should be presented in the form of integrated teaching materials. This integrated science teaching material is intended so that students are trained to be able to find their own various concepts that are learned as a whole (holistic), meaningful, authentic and active. However, based on the results of the analysis, it is known that the integration of teaching materials is only 50.00 with a category of less. Integrated teaching materials are very important to train students to find concepts holistically, meaningfully, authentically, and actively. Integrated learning helps learners see connections between concepts and disciplines, which is essential for deep understanding and the development of critical thinking.

In addition to the integration of a teaching material, it is also expected that the learning model is integrated. One of the learning models that supports 21st century skills is the PjBL model. Based on the results of the analysis, it is known that 41.67 teaching materials are integrated learning models. This means that many teaching materials have not integrated learning models. PjBL is known to be effective in increasing learner engagement, facilitating active learning, and developing 21st century skills such as problem solving, collaboration, and critical thinking through real projects.

The third analysis is the analysis of learners' 21st century skills. The analyzed 21st century skills of learners include critical thinking, creative, communicative and collaborative skills. This is in accordance with the opinion expressed by Morocco et al. (2010), which states that in the 21st century there must be at least four skills, namely critical thinking skills, creative thinking skills, the ability to communicate as well as collaborate.

The analysis of critical and creative thinking skills was carried out through a test sheet in the form of 4 essay questions, while the analysis of communicative and collaborative skills was carried out through a performance assessment sheet. Based on the results of the analysis, it was found that the average value of critical thinking skills on the interpretation indicator was 54.82. In the analysis indicator, the average value is 54.82. While the evaluation indicator obtained an average value of 28.64 and for the inference indicator obtained an average value of 43.75. When viewed as a whole, the average value of critical thinking skills is 45.51. This figure is far below the level expected in the 21st century (Wagner, 2010). This finding indicates that learners have difficulty in assessing information and drawing logical conclusions, even though this ability is fundamental for problem solving and decision making in various contexts . Low critical thinking skills can negatively impact learners' ability to understand subject matter in depth, complete complex tasks, and adapt to real-world challenges. Therefore, effective interventions are needed to improve learners' critical thinking skills.

In creative thinking skills, there are four indicators analyzed. The four indicators are fluency, flexibility, originality, and elaboration. The results of the analysis of students' creative thinking skills on fluent indicators are 20.05 with the category less. In the flexible indicator, the average obtained is 35.29. Meanwhile, for the original indicator, the average skill value is 19.92 with a very poor category. For the indicator of detailing skills, the average is 18.23 with a very poor category. Overall the average value for students' creative thinking skills is 26.99 with a category of less. This condition is very worrying, considering that creativity is one of the essential skills of the 21st century that is crucial for innovation and complex problem solving (Plucker et al., 2004). This low level of creativity indicates that the current learning process is not optimal in encouraging learners to explore ideas, think out of the box, or communicate their ideas in innovative ways.

In fact, various recent studies emphasize the importance of learning environments that support exploration, experimentation and tolerance of error to foster creativity. This gap indicates the need for significant changes in the design of learning and teaching materials to actively develop learners' creative potential, especially in science subjects that actually have a lot of room for exploration and innovation. Analysis of learners' communicative skills shows that their abilities are still low and uneven in four main indicators, namely expressing information and ideas (56.70%), paying attention when others speak (53.30%), responding (45.56%), and asking questions (45.30%). This reflects a significant gap in students' communication competence, which is crucial to master in the 21st century era (Partnership for 21st Century Skills.

Effective communication skills, including active listening and asking questions, are essential foundations for deep understanding, shared problem solving and discussion-based learning (Johnson & Johnson, 1987). When learners are reluctant to ask questions or lack responsiveness, this can hinder the knowledge construction process and limit opportunities to clarify doubts or explore new ideas. Therefore, learning strategies that focus more on developing communicative skills holistically, encouraging learners to more actively interact and participate in class discussions are needed.

In collaborative skills, there are five indicators analyzed. The five indicators are actively participating, working productively, taking responsibility, flexibility and compromise, and mutual respect. The results of the analysis of students' collaborative skills showed that only 57.29% of students actively participated in learning activities. As for working productively, the percentage is only 48.96% of learners. In learning activities, students who are responsible for their duties are 59.38% and only 57.30% of students are able to be flexible and compromise. On the other hand, for collaborative skills on the indicator of mutual respect is only achieved by 59.38% of learners. These figures indicate that learners have not fully mastered the ability to work together effectively, which is one of the four 4C skills that are crucial in the 21st century (Wagner, 2010). Lack of active participation and productivity in groups can hinder the process of shared knowledge construction and effective problem solving (D. W. Johnson & Johnson, 1987). In addition, low levels of individual responsibility, flexibility, compromise and mutual respect represent challenges to healthy and productive group dynamics (Muammar, 2024; Syarif et al., 2024). The ineffective collaborative learning can result in suboptimal understanding of the material and low soft skills needed in the world of work. Therefore, systematic learning interventions are needed to develop these collaboration skills, such as the implementation of learning models that encourage interaction, shared responsibility, and constructive conflict resolution.

Based on the facts described, it is necessary to find solutions to overcome these problems. One solution that can be done is to develop integrated science teaching materials integrated with PjBL and ethnoscience models to improve the 21st century skills of grade VIII junior high school students. This is supported by several advantages of the proposed solution. Integrated science e-teaching materials integrated with PjBL and ethnoscience models can improve students' 21st century skills. Electronic teaching materials are teaching materials that can improve student learning outcomes. Meanwhile, the use of electronic teaching materials is very effective for increasing student learning motivation, besides that it is also effective for improving student learning outcomes, as well as critical thinking skills. Based on the learning outcomes test (simulation test) the practicum stated that PjBL-based e-teaching materials had a positive effect in improving 21st century learning. Integrated integrated science electronic teaching materials integrated PjBL and ethnoscience models have several advantages. First, teachers and students have attractive electronic teaching materials. Second, this teaching material can optimize implementation in the learning process because it is not limited by time and place. Third, it helps more directed learning. Fourth, students can build critical, creative, and collaborative thinking skills in accordance with the demands of the 21st century.

Integrated science teaching materials integrated with technology are one of the important learning resources to support the learning process. Teaching materials are all forms of material used to assist teachers in carrying out teaching and learning activities (Asrizal et al., 2018). Examples of integrated science teaching materials integrated with technology are electronic teaching materials. Integrated science electronic teaching materials are an important component to support the achievement of optimal learning. This is supported by Aisyah et al. (2020) who revealed that teaching materials are an important source of material for teachers in carrying out the learning process.

Teaching materials have many roles in learning. Teaching materials can make it easier for educators in the learning process to explain abstract things, changing the role of students from being passive to active and having an interest in the material being discussed, students can learn or study teaching materials at any time because teaching materials can be stored on a computer, educators and students can use teaching materials or learning instructions that are structured and scheduled through an intranet or internet network, so that both can assess each other to what extent the teaching materials have been studied, the availability of e-moderating facilities where educators and students can communicate easily through internet facilities regularly or whenever communication activities are carried out without being limited by distance, place and time, both educators and students can discuss and interact through internet facilities that can be done in groups. Electronic teaching materials also support open learning and can be owned by students because they are easy to share, for example through social media such as Facebook, WhatsApp, Telegram and the like. So that students really know what basic competencies they must master in each learning implementation. This is in accordance with 21st century learning skills.

Science learning has several characteristics. One of the characteristics of science learning is that learning is carried out in an integrated manner. Integrated learning has a positive impact on children to obtain completeness and completeness of knowledge and completeness of views about life, the real world and natural phenomena. Integrated science teaching in the current curriculum is very different from the previous curriculum. In the current curriculum, integrated science teaching has a combination or combination of science subjects, while in the previous curriculum they were separated. For example, the subject of physics is separated from the subject of biology. The integrated learning, several concepts that are relevant to be used as themes do not need to be discussed repeatedly in different fields of study, so that the use of time for discussion is more efficient and the achievement of learning objectives is also expected to be more effective.

In 21st century integrated science learning, a learning model is needed that is integrated into electronic teaching materials. Integrated science electronic teaching materials that are integrated with learning models are expected to help students think critically, creatively, collaborate and work together. Integrated science learning can be done by applying various learning models. The PjBL model can influence learning motivation, creativity, critical thinking skills, and cognitive abilities of students (Insyasiska et al., 2017). The project-based learning model or Project Based Learning (PjBL) is one of the learning models recommended in the independent curriculum to be implemented in the learning process. The PjBL model emphasizes learning through integrated projects or assignments (Natty et al., 2019). According to Noviati (2021) PjBL is a learning model that makes students actively involved and think critically through a project. The PjBL learning model is an innovative learning model that is centered on students and places teachers as motivators and facilitators, where in this case students are given the opportunity to work autonomously to construct their learning.

Ethnoscience needs to be integrated into integrated science electronic teaching materials. Science concepts in integrated science electronic teaching materials begin with natural and cultural phenomena that exist around students (Kantina et al., 2022). Integrated science electronic teaching materials are contextual in nature, which is intended so that the study of the material is adapted to the learning environment and is easy for students to understand. . Ethnoscience can also be said to be an understanding to identify the knowledge system of society related to conditions in the surrounding environment. Humans, the environment, and culture are three parts that are interrelated internally. Ethnoscience is important to integrate into learning. Ethnoscience is a strategy to create a learning environment by collaborating culture into part of the science learning method that can be beneficial for students' lives. Ethnoscience can also be explained as a component of community or ethnic knowledge obtained through procedures with procedures that are part of community customs so that their knowledge can be proven valid.

To support the success of improving students' 21st century skills, effective teaching materials are needed. Teaching materials are all forms of materials used to assist teachers in carrying out teaching and learning activities (Asrizal et al., 2023). Teaching materials that can support students in independent learning are modules (Depdiknas, 2010). In e-teaching materials, there is control over learning outcomes through the use of competency standards that must be achieved by students. This means that students become more responsible for all their actions. Therefore, integrated science e-teaching materials integrated with the PjBL and ethnoscience models are very much needed in the learning process to see success in improving students' 21st century skills.

Based on research the e-teaching materials can improve students' critical thinking skills. The use of e-teaching materials can meet the demands of 21st century learning. Meanwhile, electronic-based teaching materials need to be developed and used to empower students' 21st century skills in science learning. Based on previous research, it was concluded that the use of integrated science e-teaching materials integrated with the PjBL and ethnoscience models can improve students' 21st century skills.

The purpose of this study is to describe the results of the development stages of integrated science e-teaching materials integrated with the PjBL and ethnoscience models to improve students' 21st century skills in valid and practical criteria. Good results can provide a wealth of more innovative and creative learning resources. It is hoped that the products developed will be useful for further learning and research. Furthermore, this study is expected to be an input for further research.

Method

This research is included in research and development or R&D. The development model used in this research is the ADDIE development model. At the analysis stage, the main activity is to analyze the need for the development of integrated science e-teaching materials integrated with the PjBL model and to analyze the feasibility and requirements for the development of integrated science e-teaching materials integrated with the PjBL model.

At this stage, an analysis of student characteristics, an analysis of integrated science e-teaching materials, and an analysis of 21st century skills were carried out. Analysis of student characteristics needs to be carried out for the development of integrated science e-teaching materials integrated with the PjBL model. Analysis of student characteristics is intended to determine the needs of students and their initial provisions. Analysis of student characteristics consists of four indicators, namely: learning interest, learning motivation, learning style and student attitudes towards integrated science learning. Analysis of student characteristics was carried out at SMPN 3 Danau Kembar class VIII with 25 students. Analysis of e-teaching materials in this study used sheets in the form of questionnaires. The questionnaire sheets were distributed to science teachers from three schools, namely SMPN 3 Danau Kembar, SMPN 1 Danau Kembar, and SMPN 7 Lembah Gumanti. The purpose of this analysis is to determine whether the teaching materials used in schools are electronic, effective, integrated, and integrated with learning models and ethnoscience. The third analysis is the analysis of students' 21st century skills. The 21st century skills of students analyzed include critical, creative, communicative and collaborative thinking skills. Analysis of critical and creative thinking skills is carried out through a test sheet in the form of 4 essay questions, while the analysis of communicative and collaborative skills is carried out through a performance assessment sheet.

The design stage aims to provide a clear picture of the product design that is made. The product produced in this study is an integrated science e-teaching material integrated with the PjBL and ethnoscience models to improve students' 21st century skills. The PjBL model integrated into the e-teaching material is seen in the student worksheet. In addition, the worksheet also contains components of critical, creative, and collaborative thinking for students. The product design that will be made in this study consists of title, instructions for Use, Competencies to be achieved and materials, Supporting information, Worksheet, Results Assessment and evaluation.

The development stage is a continuation of the design stage. At this stage, the design of integrated science e-teaching materials integrated with the PjBL and ethnoscience models that has been prepared at the design stage will be developed into a complete product. At this stage, a validity test needs to be carried out on the developed product. The validity test of integrated science e-teaching materials integrated with the PjBL and ethnoscience models is carried out by experts or practitioners who act as validators. The validity test uses a validity sheet consisting of several assessment indicators that refer to the Ministry of National Education (2010) regarding the development of teaching materials. The assessment indicators are the substance of the material, learning design, appearance or visual communication used in the integrated science teaching materials integrated with the PjBL model. The processing of validity values using the Aiken's V Formula 1.

$$V = \frac{\sum s}{[n(c-1)]} \quad (1)$$

Validation is said to be complete if the validator states that the integrated science e-teaching material integrated with the PjBL model is valid so that it is ready to be tested. The validity category can be seen in Table 1.

Table 1. Validity Categories (Azwar, 2019)

Values	Criteria
≥ 0.6	Valid
< 0.6	Invalid

The implementation stage is a real step to implement integrated science e-teaching materials integrated with the PjBL and ethnoscience models that have been created. At the implementation stage, the teaching materials that have been prepared will be run to see the practicality of the teaching materials in learning. This implementation stage is tested in a school. The trial is carried out if the product that has been developed has been declared valid. The purpose of conducting a product trial is to determine the practicality of using the product. The processing of practicality values uses the Formula 2.

$$P = \frac{f}{n} x\ 100 \quad (2)$$

Table 2. Interpretation of Practical Data on Teaching Materials

Values (%)	Criteria
81 – 100	Very Practical
61 – 80	Practical
41 – 60	Quite Practical
21 – 40	Less practical
0 – 20	Not Practical

(Source: Riduwan, 2012

Result and Discussion

Results of Student Characteristics Analysis

A preliminary analysis of 25 eighth grade students at SMPN 3 Danau Kembar provides an initial picture of their characteristics. The aspects analyzed include learning interest (LI), learning motivation (LM), learning style (LS), and student attitudes (LA). The results of this analysis, summarized in Figure 1, are an important basis for understanding the initial conditions of students.

From Figure 1. it can be explained that there are four indicators of student characteristic analysis. Some indicators of learning interest are: feelings of pleasure, interest, acceptance, and student involvement. The average learning interest (LI) of students is 52.68%. Although students show sufficient interest and attention (around 55%), the level of enjoyment of science (51.19%) and, most crucially, active involvement in learning (48.81%) are still low. This indicates a passive tendency that needs to be overcome. To arouse students' interest, teachers can link the lessons that will be taught by the teacher with the needs in the students' daily lives, so that students feel that the lesson needs to be learned for their lives (Harianja & Sapri, 2022). Interest has a significant influence on the process and achievement of student learning outcomes, because when interest does not match the lesson, students will never learn well. Furthermore, the lack of active involvement of students in science learning can be a major obstacle in the development of conceptual understanding and critical thinking skills. Ari et al. (2014) emphasized that student-centered learning, by encouraging active participation through discussions, experiments, or projects, will increase interest and learning outcomes. Therefore, more interactive and participatory teaching strategies need to be implemented to shift the paradigm of passive learning to active learning.

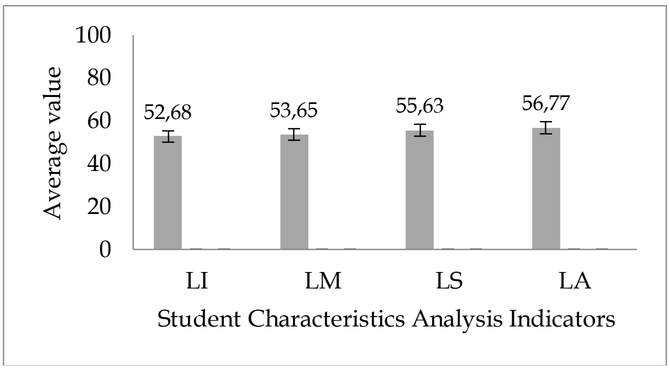

Figure 1. Results of Student Characteristics Analysis

Second, science learning motivation (LM). The average learning motivation is 53.65%. Students are quite proactive in creating a learning environment (57.14%) and interesting activities (55.95%), but the ability to find independent solutions when facing difficulties (48.81%) is still weak. This finding indicates a gap between proactive initiatives in creating a conducive learning environment and independence in overcoming difficulties. Intrinsic motivation, one of which is reflected in proactive ability, is very important in forming the will to learn. However, this motivation needs to be supported by independent problem-solving skills. Low levels of this ability can hinder students when faced with complex challenges. Students with high motivation but lacking in problem-solving skills will tend to rely on external assistance, which has an impact on their independent learning process. The ability to find independent solutions is at the core of 21st-century skills, especially problem-solving and critical thinking. The mastery of 21st century skills is highly dependent on an individual's ability to learn independently and find solutions to the problems they face.

Third, science learning styles (LS). The average learning style is 55.63%, the highest among all categories. Students learn most effectively through a combination of practicum (59.52%), visual observation (58.33%), listening, and verbal interaction (55.95%). This shows the dominance of the kinesthetic-visual-auditory learning style. This finding is in line with many studies showing that students often do not rely on just one learning style, but rather combine several styles. Students have a mixed learning style preference, with a combination of visual, auditory, and kinesthetic being the most common in science learning. This shows that diverse teaching methods are very important to meet students' learning needs. The dominance of the kinesthetic-visual-auditory learning style is also emphasized that science learning that involves direct activities (kinesthetic), use of visual media (visual), and discussion and explanation (auditory) will be more effective in improving students' understanding and learning outcomes. Therefore, teachers need to design learning experiences that accommodate these three modalities in a balanced way, for example through direct experiments, use of diagrams and videos, and interactive discussion sessions.

Fourth, attitude towards science (LA). The average attitude was 56.77%, indicating a positive attitude with high integrity (60.71%), discipline (59.52%), and self-confidence (58.33%). However, the ability to work together in groups (53.57%) still needs to be improved. Overall, the characteristics of students indicate the need for a more active, independent, and collaborative learning approach, as well as utilizing the kinesthetic-visual-auditory learning style preferences. A positive attitude towards a subject, such as science, is very important because it can affect student motivation and engagement. Integrity, discipline, and self-confidence are strong basic capital for learning. As expressed by Dwiyanti et al. (2023), a positive attitude towards science is significantly correlated with increased interest and motivation to learn. They also emphasized that high self-confidence can encourage students to dare to try and face challenges in learning. However, the low ability to work together in groups indicates a gap in students' social and collaboration skills. In fact, collaboration is a crucial 21st century skill. Verster (2024) stated that effective science learning often involves group work and discussion to solve complex problems. They added that the ability to collaborate not only improves conceptual understanding but also fosters essential communication and interpersonal skills.

Results of Analysis of Integrated Science Teaching Materials

The analysis conducted through teacher questionnaires in three junior high schools has revealed several significant weaknesses in the science teaching materials currently used. These findings provide a clear picture of the aspects that need improvement. There are four indicators analyzed, namely the effectiveness of teaching materials (ETM), ethnoscience integrated teaching materials (EITM), integrated teaching materials (ITM) and teaching materials integrated with learning models (LMITM). The detailed results of the teaching material analysis can be seen in Figure 2.

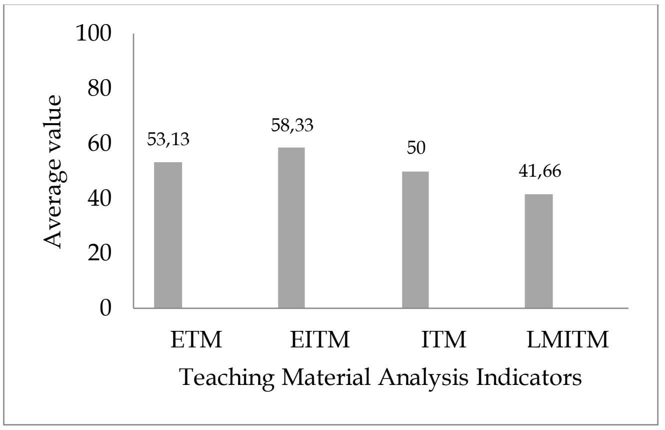

Figure 2. Results of Analysis of Integrated Science E-Learning Materials

From Figure 2. it can be explained first, namely the effectiveness of teaching materials (ETM). The average effectiveness is only 53.13% (category less). Teaching materials are considered less systematic (25.00%) and have not been able to produce effective learning (50.00%). Second, ethnoscience integrated teaching materials (EITM). The average ethnoscience integration is only 58.33% (category less), with a low sub-indicator of closeness to the environment (50.00%). This indicates a lack of contextualization of the material. Third, the integration of teaching materials (ITM). The teaching materials that are less systematic and irrelevant to the local context often fail to facilitate effective learning. They emphasize the importance of well-structured teaching materials and utilize local wisdom (ethnoscience) to improve students' understanding and interest. The contextualization of materials, especially through ethnoscience, can bridge the gap between abstract scientific concepts and the reality of students' lives, so that learning becomes more meaningful and easier to understand. The average integration is only 50.00% (less category), indicating that science learning is still taught separately.

Fourth, integration of learning models (LMITM). The average integration of learning models is very low, only 41.66% (less category). In particular, the integration of the PjBL model is only 25.00%, indicating that teachers rarely apply this innovative model. This finding is consistent with the views who criticized the fragmentation of material in science teaching materials, which can prevent students from seeing connections between concepts. They argue that integrated teaching materials will encourage holistic understanding and interdisciplinary thinking skills. In addition, the low integration of innovative learning models such as PjBL is a serious problem. The implementation of innovative learning models, such as PjBL, is very important for developing 21st century skills such as problem solving and collaboration. If teaching materials do not support the application of these models, the potential for transformative learning will be hampered. The conclusion from the analysis of teaching materials is the need to develop more effective electronic teaching materials, integrated with ethnoscience, presented in an integrated manner, and support the application of innovative learning models such as PjBL.

Results of Analysis of Students' 21st Century Skills

Analysis of students' 21st century skills shows that the four main skills are still at a low or lacking level: First, critical thinking skills. The results of the analysis of students' critical thinking skills can be seen in Figure 3.

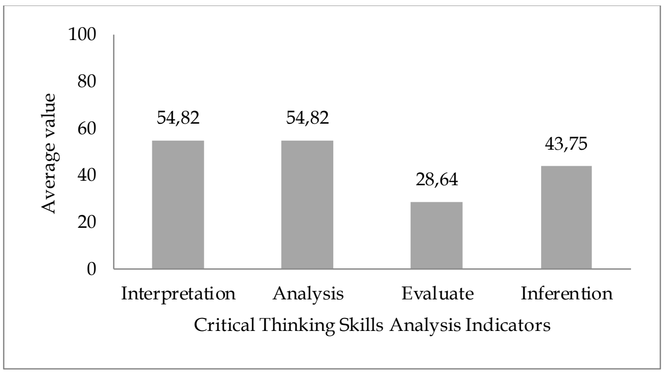

Figure 3. Results of Critical Thinking Skills Analysis

From Figure 3. it can be explained that the overall average of critical thinking skills is 45.51% (sufficient category). The evaluation indicators (28.64%) and inference (43.75%) are the lowest, indicating difficulties in assessing information and drawing logical conclusions. Evaluation skills are the ability to assess the credibility, relevance, and accuracy of information or arguments. When students have difficulty in this aspect, they tend to accept information as it is without going through an adequate filtering process. Weaknesses in evaluating information can make students susceptible to misconceptions and difficulty in distinguishing facts from opinions, especially in the context of science material that requires scientific reasoning. Meanwhile, inference is the process of drawing conclusions based on available evidence or reasons. Low inference skills indicate that students may have difficulty connecting various pieces of information to achieve a deeper understanding or formulate hypotheses. The inference skills are an important foundation in solving scientific problems and developing logical arguments. If students are unable to draw proper inferences, they will have difficulty analyzing experimental results, understanding the implications of a phenomenon, or predicting outcomes based on existing data. Second, creative thinking. The results of the creative thinking analysis can be seen in Figure 4.

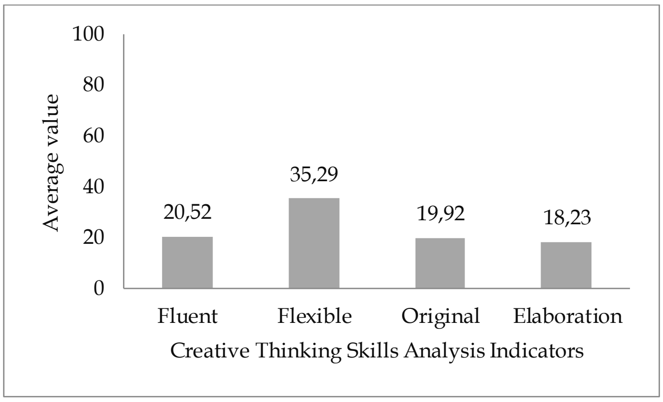

Figure 4. Results of Creative Thinking Skills Analysis

From Figure 4. it can be explained that the average overall creative thinking skills are 26.99% (less category). All indicators are very low, especially originality (19.92%) and elaboration (18.23%), indicating that students have difficulty generating unique ideas and developing them. Originality refers to the ability to generate ideas that are new, unusual, or different from existing ones. The low percentage of originality indicates that students tend to be fixated on conventional ways of thinking. The learning system that emphasizes memorization too much and provides little space for exploring new ideas can hinder the development of originality in students. Meanwhile, elaboration is the ability to enrich or develop an idea in detail and comprehensively. The low elaboration indicator indicates that although students may have an initial idea, they have difficulty developing it into something more detailed, practical, or complete. Elaboration skills are very important in innovation, because even brilliant ideas require thorough development in order to be implemented or have a real impact. Without elaboration, creative ideas often stop at the initial concept stage.

The third is communicative skills. Communicative skills consist of four indicators. The first indicator is expressing information and ideas (SI), the second is giving attention (GA), the third is giving a response (GR) and the fourth is asking questions (GQ). The results of communicative skills can be seen in Figure 5.

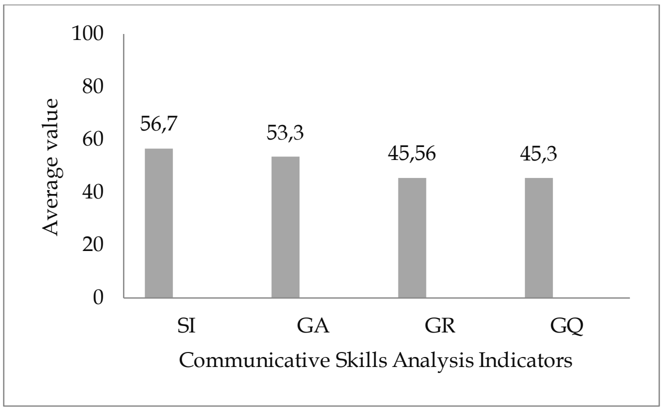

Figure 5. Results of Communicative Skills Analysis

From Figure 5. it can be explained that this skill shows weakness in giving responses (GR) with an average of 45.56% and asking questions (GQ) with an average of 45.30%, indicating passive verbal interaction. The low ability of students to respond effectively indicates their lack of active participation in class discussions or interactive activities. This can be caused by several factors, such as lack of self-confidence, fear of making mistakes, or lack of sufficient stimulation from the learning environment. The lack of opportunities for students to practice speaking and responding in a safe atmosphere can hinder the development of their verbal communication skills. Furthermore, the ability to ask questions is an important indicator of understanding and intellectual curiosity. A low average on this indicator reflects that students may have difficulty identifying areas of their misunderstanding or formulating relevant questions to deepen their understanding. The students who actively ask questions tend to have a better understanding of concepts and show higher involvement in learning. They also argue that a classroom environment that does not support freedom to ask questions can kill students' natural curiosity.

Fourth is collaborative skills. There are five indicators of collaborative skills, namely working productively (WP), actively participating (AP), responsibility (RP), flexible and compromising (FC), and mutual respect (MR). The results of the collaborative analysis can be seen in Figure 6.

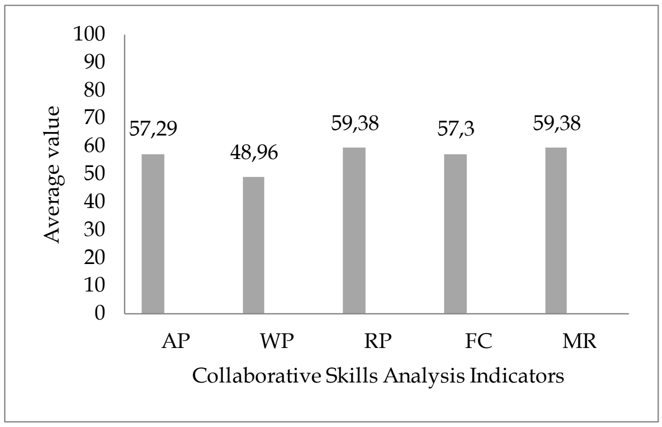

Figure 6. Results of Collaborative Skills Analysis

From Figure 6. it can be explained that the indicators of working productively (WP) with an average of 48.96% and active participation (AP) with an average of 57.29% in groups are still lacking, although the aspects of responsibility (RP), flexibility and compromise (FC) and mutual respect (MR) are quite good. The low ability to work productively in groups indicates that although students may be willing to work together, they are not yet effective in achieving common goals. This could mean a lack of clear division of tasks, poor time management, or a lack of initiative to contribute substantially. As expressed by Susanti et al. (2023), productivity in group work is not only about completing tasks, but also about the efficiency and quality of each member's contribution. If group members are not productive, the final results of the collaboration can be hampered. Meanwhile, low active participation indicates that some students may tend to be passive or reluctant to contribute their ideas and thoughts in group dynamics. This could be due to a lack of self-confidence, fear of being judged, or the dominance of other group members. Datubaringan et al. (2025) emphasized that active participation is the key to successful collaboration, because each member has a unique perspective that can enrich the results. They also emphasized that a supportive and inclusive environment is needed to encourage all members to participate equally.

Based on the three aspects of the analysis, it can be concluded that there is a very urgent need to develop integrated science e-teaching materials integrated with the PjBL and ethnoscience models. These teaching materials are expected to be a solution to increase interest, motivation, and especially 21st century skills (critical, creative, communicative, and collaborative thinking) of students, considering the current condition of teaching materials and challenges in student characteristics.

The current condition of teaching materials which are considered ineffective, not integrated, minimal ethnoscience integration, and rarely support innovative learning models are the main obstacles. On the other hand, the characteristics of students show interests and motivations that still need to be improved, as well as significant weaknesses in critical thinking skills (especially evaluation and inference), creativity (originality and elaboration), communication (giving responses and asking questions), and collaboration (productivity and active participation). The integration of PjBL in e-teaching materials will facilitate active and student-centered learning, where they are directly involved in solving real-world problems. This is in line with the views of Nurdin et al. (2023) who stated that the PjBL model is effective in developing critical and creative thinking skills because it requires students to analyze, synthesize, and create solutions. The PjBL inherently encourages collaboration and communication skills because students work in teams to achieve project goals.

Furthermore, the integration of ethnoscience will make science materials more relevant and meaningful for students. Ethnoscience allows the contextualization of scientific concepts with local wisdom and culture, thereby increasing interest and motivation to learn. Ethnoscience-based teaching materials not only improve conceptual understanding, but also foster a sense of pride in local culture and enrich students' perspectives on science. The combination of PjBL and ethnoscience in the format of e-teaching materials can create a dynamic, interactive, and relevant learning experience, which will ultimately be key to developing 21st century skills that are much needed by students.

After completing the analysis stage that identified various needs and gaps in science learning, the design stage of integrated science electronic teaching materials integrated with the PjBL and ethnoscience models was carried out. The main objective of this stage is to produce a draft of specific electronic teaching materials, meet the established criteria, and address the problems found in the analysis stage. As explained by Luo (2024) in the ADDIE instructional design model, the design stage involves setting learning objectives, selecting instructional strategies, and developing material prototypes. This ensures that the teaching materials to be developed are systematically designed to achieve the desired goals. The context of developing innovative teaching materials, the design stage must explicitly integrate key elements such as PjBL and ethnoscience from the start. The integration of PjBL will ensure that teaching materials support project activities that encourage 21st century skills, while the integration of ethnoscience will ensure the contextual relevance of the material. Thus, the draft teaching materials produced at this stage are expected to be a solid prototype, ready to be evaluated and further developed..

The design of this electronic teaching material follows the seven-component structure referring namely: title, learning instructions, competencies to be achieved and materials, supporting information, exercises, worksheets, and evaluations. This teaching material will be presented in a professional flip PDF format for easy access and interactivity. Based on the results of the needs analysis, the electronic science teaching material is designed in an integrated manner with a shared type, which means that the material on sound waves and the human hearing system will be presented simultaneously to show the relationship between concepts. This kind of integrated approach, especially the shared type, is very important to help students see the relationship between various science concepts, so that they do not learn them in a fragmented manner (Indrawati et al., 2024). The integration of the PjBL and ethnoscience models is at the heart of this design. The PjBL model will be implemented specifically in the worksheet section, which will contain a series of experiments and structured steps to guide students in their projects. The implementation of PjBL in this worksheet is expected to encourage critical and creative thinking skills as well as student collaboration, because they will be directly involved in problem solving and finding solutions, as emphasized by Slamet and Rahayu (2024). Meanwhile, ethnoscience will be displayed throughout the teaching materials, especially in the material and worksheet sections, to connect science concepts with phenomena and local wisdom in the environment around students. This integration of ethnoscience is crucial to make science learning more contextual, relevant, and meaningful, so that it can increase students' interest and motivation to learn.

Specifically, each component of the teaching material is designed as follows: first, the title. The front page will contain the title of the e-teaching material which includes the material on sound and light waves, the name of the compiler, class, educational institution, logo, and relevant supporting images. An attractive visual design in this title is important to attract the initial interest of students and provide a clear identity to the teaching material (Mayasari et al., 2021).

Second, learning instructions. This page provides clear guidance or instructions so that students can use the teaching material independently and in a structured manner. Explicit instructions are essential to facilitate independent learning, which is one aspect of independence that needs to be improved in students (Alperi, 2019).

Third, the competencies to be achieved and the material. This section contains Learning Outcomes (CP) and Learning Objectives (TP) which are expected to improve students' 21st century skills and present facts, concepts, principles, and procedures for sound and light waves systematically so that they are easy to understand. The presentation of facts, concepts, principles, and procedures for sound and light waves will be carried out systematically so that they are easy to understand. Systematic and clearly structured material is essential to minimize misconceptions and build strong conceptual understanding (Indrawati et al., 2024).

Fourth, supporting information. Contains additional data or information to enrich students' understanding of the material. Fifth, exercises. Contains questions to hone students' 21st century skills. These questions not only test conceptual understanding but also encourage application, analysis, and synthesis, thereby honing critical and creative thinking skills.

Sixth, worksheets. This is a crucial part that integrates the PjBL and ethnoscience models through a series of experiments and projects. This worksheet is designed with systematic steps to guide students to work in a focused and orderly manner. The implementation of PjBL through worksheets strategically addresses the low level of active involvement and independence of students, because they are encouraged to collaborate and find solutions independently.

The seventh structure is evaluation. Contains multiple-choice questions designed to test students' mastery of 21st-century material and skills at the end of each chapter. This design strategically addresses the low level of active involvement and independence of students by including PjBL. In addition, the integration of ethnoscience aims to address the lack of contextualization of materials and increase the relevance of learning. The electronic format also supports students' kinesthetic-visual-auditory learning style preferences, making it a concrete step in responding to the 21st-century learning needs identified in the analysis stage.

After completing the design stage, the process of developing integrated science electronic teaching materials integrated with the PjBL and ethnoscience models is continued with the development stage, which focuses on product validity testing. This validity test aims to ensure the truth and validity of the teaching materials developed, by referring to the guidelines for developing ICT-based teaching materials from the Ministry of National Education (2010). Validation is carried out by experts in four main aspects: material substance, visual communication display, learning design, and software use. Validation of the material substance aims to ensure the scientific accuracy, completeness, and suitability of the material with the curriculum and the integrated ethnoscience concepts. The visual communication display aspect is assessed to ensure that the teaching materials are easy to read, aesthetically appealing, and support interactivity through electronic formats (eg, flip PDF professional). Good visual design greatly influences students' motivation and ease of learning (Mayasari et al., 2021). Meanwhile, validation of the learning design is carried out to ensure that the integration of the PjBL and ethnoscience models is truly effective in facilitating learning objectives, including the development of 21st century skills. This includes an evaluation of the sustainability of the project steps on the worksheet and how ethnoscience is presented contextually (Utami & Suryani, 2024). Finally, validation of software usage focuses on the functionality, ease of navigation, and technical stability of electronic teaching materials, ensuring that students can access and use them without technical barriers. This development stage is very important to produce high-quality products before being tested on real users. The results of the validation assessment can be seen in Table 1.

Table 3. Results of Validation of E-Learning Materials

Validation Components	The Experts	
	Aiken's Values	Criteria
Substance of Material	0.88	Valid
Visual Communication Display	0.91	Valid
Learning Design	0.82	Valid
Software Usage	0.78	Valid
Average	0.85	Valid

From Table 3. it can be explained that this e-teaching material has met the overall valid criteria, with an average Aiken's V value of 0.85. Specifically: Material Substance: 0.88 (Valid) Visual Communication Display: 0.91 (Valid) Learning Design: 0.82 (Valid) Software Use: 0.78 (Valid). All components received values above the minimum limit of 0.6, confirming that this electronic teaching material is valid and feasible from an expert perspective. The high Aiken's V value for all components confirms that the integrated science electronic teaching material integrated with the PjBL and ethnoscience models has strong validity. Although declared valid, the validator also provided several constructive suggestions for revision. These suggestions focus on improving the integration of ethnoscience and PjBL in teaching materials, such as: Ensuring that ethnoscience and materials are truly integrated (previously not). Strong integration between ethnoscience and scientific materials is essential to make learning more relevant and meaningful for students, bridging local knowledge with global scientific concepts.

Replacing the Doppler effect video example from an ambulance siren to traditional music "pupuik batang padi" which is relevant to West Sumatran ethnoscience. Adding references to medicinal plants and ethnoscience phenomena to the worksheet before students ask questions. Including an explanation of how "pupuik batang padi" produces sound after the project is completed. Ensuring that the ethnoscience story is related to the material on light waves (previously wrongly related to temperature and heat). The accuracy and relevance of the integration of ethnoscience with the material is key so as not to cause misconceptions and instead strengthen the understanding of scientific concepts. All of these revision suggestions have been followed up on, ensuring that the resulting e-learning materials are not only substantively and technically valid, but also more contextually integrated with ethnoscience and the PjBL model.

The practicality test of integrated science electronic teaching materials using the PjBL and ethnoscience models was conducted to assess the ease of use, attractiveness, and efficiency based on teacher and student responses. This practicality stage is very important because teaching materials that have been validated by experts are not necessarily practical and effective for use in everyday learning contexts. Learning products, no matter how small their validation, must be assessed in terms of practicality in the field so that they can be truly implemented. The practicality test provides direct feedback from end users regarding aspects such as navigation of teaching materials, clarity of PjBL instructions, ease of accessing ethnoscience content, and the extent to which the electronic format (professional flip PDF) supports their learning experience. The attractiveness of teaching materials is a key factor influencing student motivation and interest. If teaching materials feel boring or difficult to use, even if the material is accurate, the impact on learning will be minimal. Therefore, collecting data on the appeal and efficiency of teachers and learners ensures that the developed teaching materials are not only theoretically valid, but also relevant and motivating for their target audience.

Table 4. The Importance of E-Learning by Teachers

Statement	Value	Category
Easy to use	81.25	Very Practical
Interesting	87.50	Very Practical
Efficient	80.00	Practical
Average	82.92	Very Practical

From Table 4. it can be explained that the teacher's response to electronic teaching materials shows a very practical level overall, with an average value of 82.92. The teaching materials are considered easy to use (81.25%) and very interesting (87.50%). The efficient aspect is also in the practical category with a value of 80.00%. This shows that teachers feel that these teaching materials are functional and effective in supporting the learning process. The high value in the ease of use aspect is very important. Easy-to-use teaching materials will reduce the cognitive burden on teachers and allow them to focus on facilitating learning, not on technical difficulties. The user-friendliness is a crucial factor in the adoption of educational technology by teachers. The very high appeal (87.50%) shows that these e-teaching materials are able to attract the attention and maintain the interest of teachers, which in turn can increase their motivation in implementing these teaching materials in the classroom. Visually and content-attractive teaching materials, especially with the integration of ethnoscience and PjBL, tend to be preferred by teachers and students. The efficiency aspect, which is also included in the practical category (80.00%) indicates that the use of this e-teaching material does not take much time or additional resources for teachers, so it can be smoothly integrated into teaching routines. Overall, the positive response from this teacher confirms that the e-teaching material developed is not only valid in substance and design, but also practical and ready for use in the field.

From Table 5. it can be explained that students' responses to electronic teaching materials are also in the very practical category, with an average value of 82.03%. Students consider this teaching material very easy to use (83.62%) and very interesting (82.11%). Similar to the teacher's response, the efficient aspect is in the practical category with a value of 80.35%. This indicates that students feel comfortable and helped by using this electronic teaching material.

Table 5. Results of Practicality of E-Learning Materials by Students

Statement	Values	Category
Easy to use	83.62	Very Practical
Interesting	82.11	Very Practical
Efficient	80.35	Practical
Average	82.03	Very Practical

The high value of ease of use from the perspective of students is a key indicator of the success of digital teaching materials. Intuitive and easily accessible teaching materials will minimize frustration and allow students to focus on the learning content. The user-friendly user interface on electronic teaching materials significantly improves students' learning experience.

The high attractiveness aspect is also very important, considering the low interest and motivation of students in learning science that was previously identified. Visually and content-attractive teaching materials, especially with the integration of relevant ethnoscience and interactive PjBL activities, can trigger active student involvement. The attractiveness of teaching materials is a determining factor in arousing interest and maintaining student attention throughout the learning process. The efficiency aspect which is considered practical shows that this teaching material does not burden students with unnecessary complexity, so that they can learn effectively without obstacles. Overall, the results of the consistent practicality test from both parties, namely teachers and students, confirm that the integrated science e-teaching materials integrated with the PjBL and ethnoscience models developed are very practical and ready to be used in the learning process. Overall, the results of the practicality test from both parties (teachers and students) confirm that the integrated science electronic teaching materials integrated with the PjBL and ethnoscience models developed are very practical and ready to be used in the learning process.

Conclusion

Based on the stages and results of the research that have been presented, it can be concluded that the integrated science e-teaching materials integrated with the PjBL and ethnoscience models that have been developed have met the valid criteria. The results of the expert validation test show that this e-teaching material has a high level of validity (overall Aiken's V value of 0.85) in terms of material substance, visual communication display, learning design, and software use. This indicates that the content, presentation, learning design, and technology used in this teaching material have been assessed as appropriate and in accordance with standards by experts. In addition, e-teaching materials have proven to be practical for use in the learning process. Based on the responses of teachers and students in the field, this electronic teaching material is considered very practical with an average value of 82.92 for teacher responses and 82.03 for student responses, indicating that the electronic teaching material is easy to use, interesting, and efficient.

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Author Contributions

Author contributions include Asrizal: focus on methodology, and review of the paper; I. H and A: data collection, data analysis, writing the original draft.

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Conflicts of Interest

The authors declare no conflict of interest not only in conducting the research but also in scientific publication. This statement ensures the objectivity and integrity of the data and findings presented.

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