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Needs Analysis to Develop Heat ICT Based Teaching Material with ETHNO-PBL to Promote Students' Critical and Creative Thinking Skills

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ABSTRACT

Critical and creative thinking skills are essential 21st-century competencies that students need to master. However, in reality, the mastery of these skills remains relatively low. This low level of skill is caused by the limited availability of teaching materials that are not yet integrated with Information and Communication Technology (ICT), ethnoscience, and the Problem-Based Learning (PBL) model. This study aims to analyze the needs for developing heat ICT-based teaching materials integrated with the ethno-PBL approach. The research method used is descriptive quantitative research. Data were collected through questionnaire instruments filled out by both the researcher and students. The results of the study revealed six key findings from the needs analysis: (1) the context of heat teaching materials scored 53.75; (2) the integration of ethnoscience into teaching materials scored 31.67; (3) the integration of the PBL model into teaching materials scored 48; (4) students' learning interest scored 57; (5) students' learning motivation scored 47; and (6) students' critical and creative thinking skills were still low, with scores of 39 and 36 respectively. The conclusion drawn from the needs analysis is that the development of heat ICT-based teaching materials integrated with the ethno-PBL approach is highly needed by senior high school students to support the enhancement of their critical and creative thinking skills.

Keywords: ICT-based teaching materials, Ethnoscience, Problem Based Learning, Critical Thinking, Creative Thinking.

I. INTRODUCTION

21st-century education has undergone fundamental changes due to rapid technological advancements. These developments have shifted conventional learning methods toward more interactive approaches, enabling broader, more flexible, and open access to learning materials [1]. Such changes demand that the education system no longer focuses solely on knowledge transfer but also emphasizes the development of critical thinking, creativity, communication, and collaboration skills to prepare students for an increasingly dynamic and globalized world [2]. Thus, 21st-century education requires the integration of knowledge mastery, soft skills development, and effective learning strategies to shape adaptive, collaborative, and resilient individuals capable of facing global challenges.

21st-century learning must be able to develop students' abilities. This is a logical extension of the educational paradigm that highlights the importance of mastering critical thinking, creativity, collaboration, and communication skills as essential tools for navigating complex and dynamic global challenges [3]. Furthermore, problem-solving skills play a crucial role in ensuring that students can adapt to rapid technological developments [4]. To optimize these abilities, learning strategies must not only integrate technology effectively but also be oriented toward students' needs, interests, and characteristics through a student-centered approach.

21st-century skills are essential for every individual to master in order to face real-life challenges. These are known as the 4C skills: critical thinking, creativity, collaboration, and communication [5]. These skills significantly impact career advancement and readiness to meet current industrial demands [6]. Moreover, they are key to enabling education graduates to compete in an increasingly digital and AI-influenced job market [7]. Hence, 21st-century skills are vital not only for individual success but also to meet the evolving needs of society.

Critical and creative thinking skills are among the most important abilities that students must acquire. Critical thinking allows students to deeply understand concepts, analyze problems, and apply knowledge in real-life contexts [8]. It is a valuable asset for navigating current and future challenges [9]. On the other hand, creative thinking enables students to generate new ideas, devise innovative solutions, and make improvements across various situations [10]. Therefore, mastering these skills is essential for meaningful learning, problem-solving, and preparing students to thrive in a constantly evolving world.

In addition to developing these essential skills, students must also master fundamental physics concepts as the basis for scientific literacy and problem-solving. One such crucial concept is heat, which plays a central role in physics learning because it is directly related to various everyday phenomena, including cooking, traditional food preservation, metal processing, and energy use in household and industrial settings. Heat is important to master as it can arouse curiosity [11] and help students understand practical applications in technology and science[12]. Understanding this concept requires critical thinking to analyze relationships between temperature, energy, and matter, as well as creative thinking to design experiments and solutions to contextual problems involving heat transfer and changes in states of matter.

Despite their importance, research indicates that high school students particularly in physics still demonstrate low levels of critical and creative thinking. A study by Irwan et.al. (2021) at SMAN 8 Makassar found that students' critical thinking skills were generally in the low category [13]. Similarly, Asniar et al. (2022) at SMAN 11 Makassar reported that many students had low levels of critical thinking [14]. Research by Hasanah et.al (2021) also revealed that students' creative thinking skills were low. This lack of proficiency impacts students' preparedness for 21st-century learning, which demands higher-order thinking, problem-solving, and innovation as core competencies [15]. If left unaddressed, students may struggle to adapt to 21st-century learning environments, hindering the development of essential skills and reducing their chances of future success [16]. Therefore, efforts must be made to minimize these negative effects. The low critical and creative thinking skills make it difficult for students to meaningfully connect the concept of heat to everyday phenomena such as cooking, food preservation, or energy use in technology.

One solution to address the low levels of critical and creative thinking is the development of ICT-based teaching materials. These materials are designed using digital technologies to support student learning. ICT-based learning resources offer interactive, engaging, and easily accessible content, which helps enhance student motivation and understanding [17]. Research by Agusti and Asrizal (2024) also showed that ICT-based instructional materials positively contribute to students' development of critical and creative thinking [18]. Thus, such materials serve not only as content delivery tools but also as effective learning strategies to improve learning quality and address the widespread deficiency in 21st-century skills.

Integrating ethnoscience into ICT-based teaching materials can further support the development of critical and creative thinking skills through contextual approaches grounded in science and local culture. Ethnoscience-enriched materials not only improve the quality of learning but also instill local cultural values in the school environment [19]. This integration makes learning more meaningful and memorable while encouraging students to think actively, critically, creatively, and analytically [20]. Furthermore, combining local traditions with modern science helps students understand the relationship between the two, promoting an innovative and contextual scientific mindset [21]. As such, the integration of ethnoscience in ICT-based materials is an effective strategy for developing 21st-century skills rooted in local wisdom. In the context of heat, for example, integrating ethnoscience can help students explore local cooking techniques or traditional technologies, thereby connecting scientific concepts to familiar cultural practices.

In addition, the integration of the Problem-Based Learning (PBL) model into ICT-based teaching materials further enhances the development of 21st-century skills. PBL supports students' collaboration, communication, problem-solving, and creativity through group work, social interaction, and active exploration of ideas and solutions [22]. This model encourages students to actively seek solutions, engage in discussions, and develop deep conceptual understanding, thus improving critical thinking, teamwork, and communication skills [23]. The implementation of the PBL model in ICT-based teaching materials is a powerful strategy for equipping students with the essential 21st-century skills needed for current educational and real-world challenges.

The initial stage in developing ICT-based teaching materials is conducting a needs analysis. This step is crucial for identifying the needs of students concerning the materials to be developed, ensuring that the final product is relevant and contextually appropriate. By understanding these needs, the development of ICT-based teaching materials integrated with ethnoscience and the Problem Based Learning model (ethno-PBL) can be effectively designed to promote the improvement of critical and creative thinking skills among senior high school students. Therefore, this study aims to explore and analyze these needs as a foundational step in developing effective and contextually relevant teaching materials.

II. METHOD

The method used in this study is quantitative descriptive research. This research describes the obtained data systematically, factually, and accurately without the intention of making generalized conclusions [24]. The purpose of quantitative descriptive research is to provide answers to problems and to obtain broad information about a phenomenon through several stages of the quantitative approach [25]. The numerical data obtained in this study serve as a reference for drawing conclusions related to the observed problems [26].

The needs analysis in this research aims to identify problems in the learning process to provide a strong foundation for developing technology-based teaching materials integrated with the ethno-PBL model. The needs analysis includes: (1) context analysis of heat teaching (2) analysis of ethnoscience integration in teaching materials, (3) analysis of PBL model integration, (4) analysis of students' learning motivation and interest, and (5) analysis of students' critical and creative thinking skills. The needs analysis was conducted at SMA Negeri 1 Banuhampu. There are two research subjects in this analysis: the teaching materials used by physics teachers and 27 grade XI students in Phase F who chose physics as an elective subject. From the teaching materials used by the physics teacher, information was obtained regarding the context of the teaching materials, the integration of ethnoscience, and the integration of the PBL model in the school's learning process. Meanwhile, information about learning motivation and interest, as well as the level of students' critical and creative thinking skills, was gathered from the Phase F students.

The data collection instruments used in this study consisted of observation questionnaires, respondent questionnaires, and student worksheets. The first three types of questionnaires teaching material context, ethnoscience integration, and Problem-Based Learning (PBL) model integration were observation questionnaires completed by the researcher through a review of the physics teaching materials used in the school. The assessment was conducted based on specific indicators to measure the extent to which the teaching materials addressed the relevant aspects. Meanwhile, the student learning motivation and interest questionnaires were filled in directly by students as respondents, in order to obtain affective data reflecting their engagement and interest in learning physics. In addition to the questionnaires, this study also employed worksheets designed to measure students' critical and creative thinking skills, two key competencies for the 21st century. All instruments were systematically designed and tailored to the needs analysis in order to develop teaching materials that are more contextual, interactive, and based on real conditions in the field.

The data analysis technique used in this research is descriptive statistical analysis. Descriptive statistics are used to present the research subject based on the actual data obtained [27]. The results of the needs analysis are presented in the form of graphs and tables to give a more detailed picture of the quantitative data. These data were then interpreted descriptively to obtain scores. The scoring interpretation categories for the needs analysis results are shown in Table 1.

Tabel 1. Category of Value Interpretation

Intervals	Category
81-100	Very High
61-80	High
41-60	Enough
21-40	Low
0-20	Very Low

(Source : Ref [28])

III. RESULTS AND DISCUSSION

Results

The first research finding pertains to the issue of teaching materials used in the school, with a specific focus on heat (calor) materials as one of the key physics topics analyzed. The data for this aspect were gathered through a questionnaire instrument, which was filled out by the researcher based on systematic observations and evaluations of the existing heat teaching materials. This method was chosen to ensure that the data collected represent an objective and accurate reflection of the real conditions regarding the teaching materials in use.

From the contextual analysis of the teaching materials, it was revealed that the materials currently implemented in the schosol fall into enough, achieving an average score of 53,75. This evaluation was based on ideal standards for teaching materials, which encompass eight key aspects. These aspects include: attractive design (AD), clear and understandable language (CL), interactive presentation (IP), accommodation of various learning styles (LS), alignment with student characteristics, content, and instructional objectives (SCO), compatibility with available supporting facilities (SF), continuity of learning between lessons (CL), and support for virtual learning environments (VLE). The detailed results of this contextual analysis of teaching materials are visually presented in Figure 1.

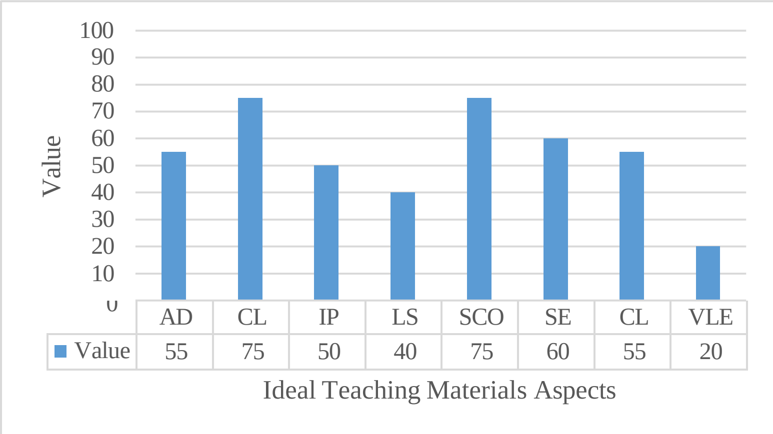

Fig. 1. Results of Context Analysis of Teaching Materials

The data in Figure 1 shows that the teaching materials still have several weaknesses that need to be improved to be more effective. The aspects of attractive appearance and clear discussion or narration each received a score of 55 which is included in the sufficient category and 75 which is included in the good category, but can still be improved. Interactive presentation received a score of 50 which is included in the sufficient category because the questions are still routine and have minimal features such as simulations or QR codes. Learning style received a score of 40 which is the lowest aspect because it does not involve audio, video, or task variations. Suitability with student characteristics and learning objectives received a score of 75 because it is relevant and supports learning outcomes. The supporting facilities aspect received a score of 60 which is still limited in digital interactivity. The Continuous Learning aspect received a score of 55 and is included in the sufficient category. And support for VLE received a score of 20 which is very low because it is not integrated with LMS or online features.

Second research result relates to the integration of ethnoscience in teaching materials. Data were obtained through questionnaires filled out by the researcher based on observations and assessments of the teaching materials in the school. The analysis shows that the integration of ethnoscience in teaching materials is categorized as low with a score of 31.67. The questionnaire analysis consists of three aspects: Science Relevant to Local Culture (SRLC), Science Process Skills Integrated with Local Knowledge (SPSLK), and Scientific Attitude Instilled through Local Wisdom (SAILW). The results of the ethnoscience integration analysis in the teaching materials can be seen in Figure 2.

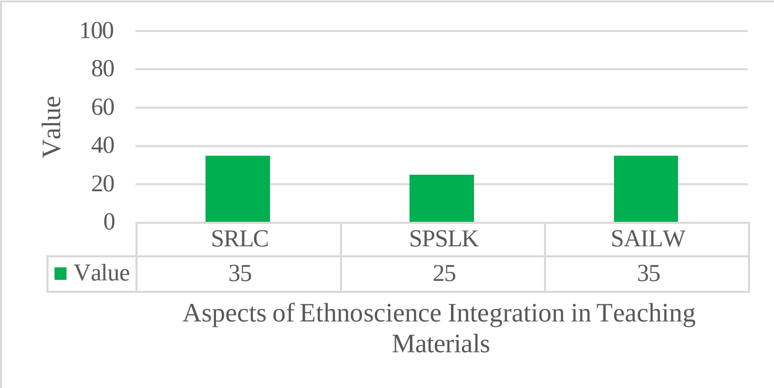

Fig. 2. Results of the Analysis of Ethnoscience Integration in Teaching Materials

Data in Figure 2 show that the teaching materials have not integrated ethnoscience well. The aspect of science concepts relevant to local culture scored 35, categorized as low. Teaching materials do not include explicit examples or scientific explanations related to local traditions. The local cultural context has not been utilized as a bridge to teach abstract concepts. This indicates a disconnect between physics content and students' everyday life in a cultural context. The science process skills integrated with local knowledge aspect scored the lowest, 25, also low. There are no activities involving observation of local cultural practices, experiment design, or tradition-based exploration. Although science exercises exist, they are not embedded in a local context. The scientific attitude instilled through local wisdom scored 35, also low. Values such as precision and curiosity appear but are not linked to local culture. No use of traditions or local values as tools to foster students' scientific attitudes was found. Overall, teaching materials have not yet incorporated ethnoscience elements meaningfully in content or learning activities, so local potential is not utilized to enrich students' science understanding.

The third research result concerns the integration of the Problem Based Learning (PBL) model into the teaching materials. Data were collected through questionnaires completed by the researcher based on observations and assessments of existing teaching materials. The analysis indicates that the level of PBL integration in the teaching materials is classified as moderate, with a score of 48. The questionnaire analysis covered five key aspects: Orientation to the Problem (OP), Organization for Learning (OL), Guidance of Individual or Group Inquiry (GI), Development and Presentation of Work (DP), and Analysis and Evaluation of the Problem-Solving Process (AEP). A detailed overview of the PBL integration results is presented in Figure 3.

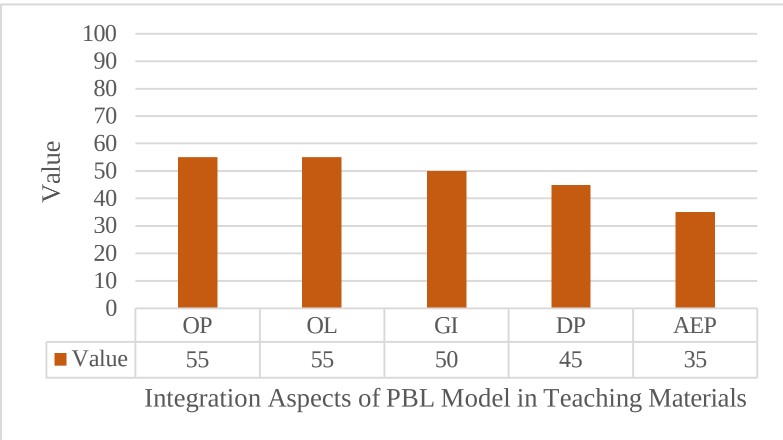

Fig. 3. Results of PBL Model Integration Analysis in Teaching Materials

Data in Figure 3 describe that PBL integration in teaching materials is not yet optimal. The orientation to problem aspect is moderate with a score of 55. Teaching materials have not presented open, challenging, and exploratory problems. Organization for learning also scored 55, moderate. Practical instructions and discussions are provided, but directions for collaboration and problem-solving strategies are not explicit. Guidance of inquiry scored 50, moderate. Experiments are available but limited and do not encourage free exploration. There are no rubrics or encouragement to seek information beyond the materials. Development and presentation of work scored 45, moderate. Experiment reports are present but not aimed at creative products or real solutions. Teaching materials also lack examples of presentation models or encouragement for creative student presentations. The analysis and evaluation of problem-solving scored low with 35. There are no reflection sheets, self-assessment, or guides for evaluating learning processes. Assessment still focuses on results, not strategies or problem-solving processes. Teaching materials used in schools have not integrated PBL optimally.

Fourth research result relates to students' learning interest. Data were obtained by distributing questionnaires to 27 students in Phase F, Grade XI. The analysis shows students' learning interest in physics is moderate with a score of 57. The questionnaire analysis consists of four aspects: Student Attention (SA), Student Interest (SI), Enjoyment (E), and Involvement (I). The results of students' learning interest analysis can be seen in Figure 4.

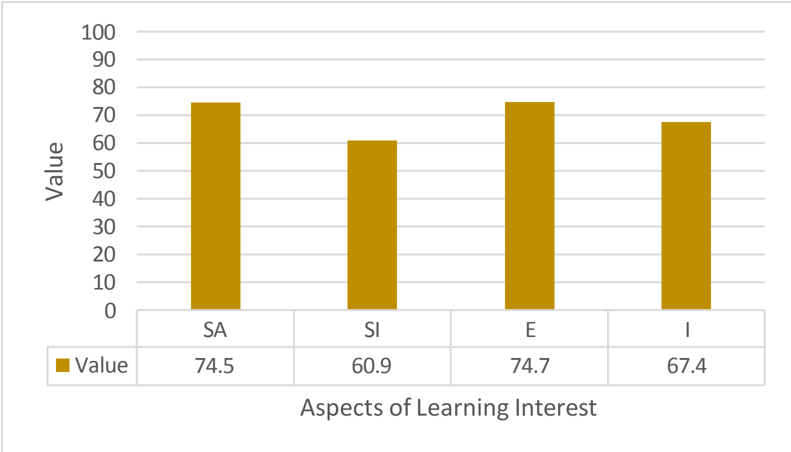

Fig. 4. Results of Analysis of Students' Learning Interests in Physics Learning

Data in Figure 4 show that students have moderate interest in learning, especially physics. The student attention aspect scored 57, categorized moderate, indicating that while students pay attention during lessons, their focus and concentration are not fully optimal. Student interest scored 56, also moderate, suggesting that the material or teaching methods used have not fully attracted students' interest. Enjoyment scored the highest and is categorized as high. This shows that most students feel happy during physics lessons, which can boost positive potential. Involvement scored 56, moderate, reflecting that active participation in discussions and other learning activities is uneven or inconsistent across the class. Despite positive factors such as enjoyment, improvements are needed to better attract attention, increase involvement, and foster student interest. Therefore, more interactive and contextual learning strategies are required to improve overall student interest.

Fifth research result relates to students' learning motivation. Data were obtained by distributing questionnaires to 27 students in Phase F, Grade XI. The analysis shows students' motivation in physics learning is moderate with a score of 47. The questionnaire analysis consists of six aspects: Desire and Will to Succeed (DWS), Drive and Need in Learning (DNL), Hopes and Future Aspirations (HFA), Reward in Learning (RL), Engaging Learning Activities (ELA), and Supportive Learning Environment (SLE). The results of motivation analysis can be seen in Figure 5.

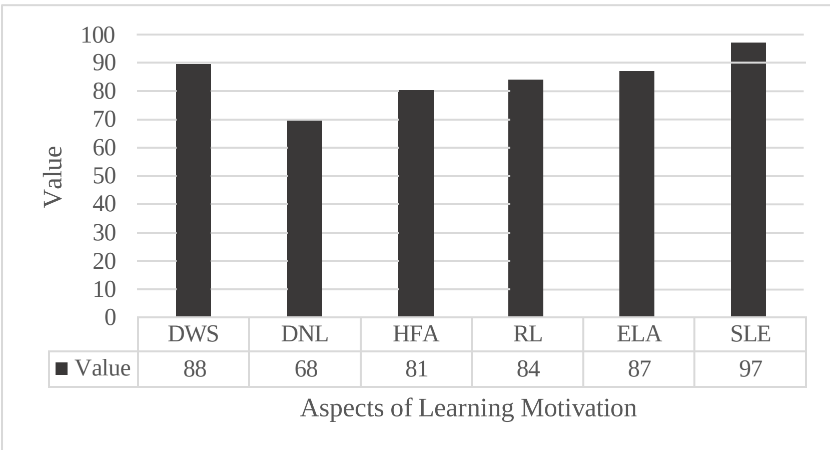

Fig. 5. Results of Student Learning Motivation Analysis

Data in Figure 5 reveal that students have moderate motivation in learning. All motivation aspects fall into the moderate category. Desire and will to succeed scored 49, indicating most students want to succeed in learning, though this is not fully reflected in other motivation aspects. Drive and need in learning scored 46, showing students' internal motivation to meet learning needs is still suboptimal. Hopes and future aspirations scored 47, indicating students have future perspectives but not strong enough to boost higher motivation. Reward in learning scored 47, showing that the reward or recognition system in learning is not effective enough to drive motivation. Engaging learning activities scored 47, indicating activities are not sufficiently attractive to increase motivation. Supportive learning environment scored 47, reflecting the overall learning environment has not fully supported high motivation growth. Therefore, motivation is moderate and needs improvement. Efforts should focus on creating a more supportive environment, designing more engaging learning activities, and strengthening students' hopes and learning goals.

Last research result is about students' critical and creative thinking skills. Data were obtained through worksheets given to 27 students in Phase F, Grade XI. The worksheets consisted of critical thinking skill tasks and creative thinking skill tests. Analysis of the results can be seen in Table 2.

Tabel 2. Results of Analysis of Students' Critical and Creative Thinking Skills

Statistical Parameters	Critical Thinking Skills	Creative Thinking Skills
Number of students	27	27
Mean	39	36
Mode	48	47.5
Median	40	37.5
Minimum	18	12.5
Maximum	62	72.5

Based on data in Table 2, students' thinking skills in physics learning are still low and require serious attention. Students' critical thinking skills have an average score of 39, categorized as low. This indicates most students have difficulties analyzing information, evaluating arguments, and drawing logical conclusions from physics problems. The low ability also reflects limitations in asking deep questions, criticizing existing information, and making decisions based on logical evidence and reasoning. Meanwhile, students' creative thinking skills scored an average of 36, also low. This shows students have not demonstrated optimal ability to generate new ideas, think originally, and develop alternative solutions in physics problem-solving. This may be due to one-way learning, lack of stimulation to encourage idea exploration, or limited opportunities to develop scientific imagination. This condition indicates the importance of developing teaching materials that not only deliver content but also stimulate students' critical and creative thinking skills. Therefore, developing technology-based teaching materials integrated with ethnoscience and the Problem Based Learning (PBL) model is a good strategy to create meaningful, contextual learning that encourages active student engagement. These results provide a strong basis for developing innovative teaching materials to improve the quality of physics education in schools. These results provide a strong basis for the development of innovative, technology-based, and interactive teaching materials that are tailored to students' needs and learning preferences. Such materials are expected not only to enhance students' interest and motivation, but also to improve their engagement, conceptual understanding, and overall learning outcomes, thereby contributing significantly to the quality of physics education in schools.

Discussion

The research findings obtained from the contextual analysis of heat teaching materials and student needs can serve as a foundation for developing ICT-based physics teaching materials integrated with ethno-PBL to promote students' critical and creative thinking skills. The first result concerns the context of the heat teaching materials, where several aspects were found to be insufficient, particularly in terms of interactive presentation, accommodation of learning styles, and support for Virtual Learning Environments (VLE). These deficiencies suggest that the teaching materials in use have not kept pace with technological advancements and pedagogical demands of 21st-century education. This situation raises a critical question about the readiness of current teaching resources to engage digital-native students who require diverse, multimedia-rich, and flexible learning formats. Given these gaps, ICT-based teaching materials are essential because they can provide interactive, engaging, and flexible learning experiences that accommodate various learning styles. ICT-based materials can incorporate features such as videos, audio, simulations, and hyperlinks, making content more dynamic and accessible [29]. Additionally, such materials help address the needs of both visual and auditory learners, enhancing their understanding of physics concepts [30]. Moreover, integration with Learning Management Systems (LMS) can promote a collaborative, adaptive, and student-centered learning environment—something that current materials have yet to fully support [31]. The relatively high interest and motivation shown by students also signal an urgent need for teaching materials that can match their expectations and enhance their learning outcomes.

The research results also show that teachers have not yet used teaching materials integrated with ethnoscience and the Problem-Based Learning (PBL) model. The low score in the ethnoscience aspect and moderate score in the PBL aspect indicate that the existing teaching materials have not successfully connected physics concepts with students' cultural reality and everyday life. Yet, the integration of both is essential to create contextual and meaningful learning, allowing students not only to understand abstract concepts but also to see their relevance in real life. Ethnoscience brings local wisdom as a bridge to scientific understanding, while PBL fosters critical and creative thinking through challenging questions. Teaching materials integrated with ethno-PBL not only increase students' motivation to learn but also develop their creativity and ability to solve real-world problems in a scientific and contextual way [32].

The results of the study indicate that students' interest and motivation in learning physics are still in the sufficient category. Although some students feel happy, their attention, active involvement, and intrinsic motivation have not developed optimally. This gap indicates the need for innovation in the form of interactive, contextual, and interesting ICT-based teaching materials. These teaching materials are able to increase student interest, motivation, and involvement [33]. ICT-based teaching materials make learning more interesting, interactive, and easy to understand, thus encouraging students to be more active, interested, and motivated in participating in physics learning [34].

Furthermore, the analysis of students' critical and creative thinking skills shows that both skills are still at a low level. This means both need to be improved. These skills are crucial in facing challenges in the digital era and globalization. Critical thinking helps students analyze and evaluate information accurately, while creative thinking encourages innovation and the generation of new solutions [35]. Without strengthening these skills, students may struggle to adapt to changing times and be less prepared to face real-world challenges in both the workplace and everyday life. Therefore, it is important for education to intentionally develop higher-order thinking skills through innovative learning approaches and the development of effective teaching materials.

Based on the results of the needs analysis, it was found that the current heat teaching materials are not yet optimal in integrating ICT, ethnoscience, and the Problem-Based Learning (PBL) model, while students' critical and creative thinking skills remain at a low level. This highlights the urgency of developing heat teaching materials that address the demands of 21st-century learning in a more contextual and innovative manner. However, this study has certain limitations, particularly regarding the scope of data collection, which was limited to a single school with a small number of respondents, and the use of descriptive instruments that do not yet provide an in-depth understanding of causal relationships. These limitations should be taken into consideration in the next development phase to ensure that the resulting product is more widely applicable and relevant.

IV. CONCLUSION

Based on the data analysis conducted, six findings emerged from the needs analysis in this study. First, the context of the heat teaching materials was categorized as fair, with a score of 53.75. Second, the integration of ethnoscience into the teaching materials was low, with a score of 31.67. Third, the integration of the PBL model into the teaching materials was considered fair, with a score of 48. Fourth, students' learning interest received a score of 57, which falls into the fair category. Fifth, students' learning motivation was also in the fair category with a score of 47. Sixth, students' critical and creative thinking skills were categorized as low, with critical thinking at 39 and creative thinking at 36. Based on these findings, it can be concluded that the development of heat ICT-based teaching materials integrated with ethno-PBL to promote students' critical and creative thinking skills is highly needed by both teachers and students.

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