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Development of Ethno-STEM Integrated Digital Teaching Material of Heat Concept to Promote Students' Learning and Innovation Skills

Hafiz Almahfuz Agusti[1], Asrizal[1*], Rose Amnah[2], Hidayati[1], Helma[3]

[1] Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang, Padang, Indonesia.
[2] Department of Mathematics and Science Education, Faculty of Education, University Malaya, Malaysia, Malaysia.
[3] Department of Mathematics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang, Padang, Indonesia.

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Corresponding Author:
Asrizal
asrizal@fmipa.unp.ac.id

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Abstract: Twenty-first century learning requires students to have student' learning and innovation skills. However, in fact, students' learning and innovation skills are still low. The solution to this problem is the development of ethno-STEM integrated digital teaching material of heat concept to promote students' learning and innovation skills. The aims of this study were to determine the needs analysis, validity, and practicality of the use of ethno-STEM integrated digital teaching materials. The type of research is research and development (R&D) using the Hannafin and Peck model. The research instruments used include needs analysis, validity, and practicality instruments. Data analysis techniques using descriptive statistical analysis. Based on the data analysis, there were three research results. First, the needs analysis showed that students' critical and creative thinking skills were categorized as less with values of 54.36 and 52.92, respectively. Second, the product validity test obtained a value of 91.44 in the excellent category. Third, the product practicality test obtained a value of 82.29 in the excellent category. These results indicate that students' learning and innovation skills can be improved through digital teaching materials. Therefore, the ethno-STEM integrated digital teaching materials are valid and practical for use in learning.

Keywords: Digital teaching materials; Ethno-STEM; Heat concept; Learning and innovation skills

Introduction

The 21st century skills are key to preparing for increasingly complex global challenges. In the ever-evolving digital era, various skills such as critical thinking skills, creative thinking skills, and adaptability are very important (Lavi et al., 2021; Susetyarini et al., 2022). Students must be trained to deal with rapid and diverse technological changes. Students are also required to be able to communicate effectively through various digital platforms. In addition, collaboration, problem-solving, and information management skills are also very much needed in preparing for future careers (Alismail & McGuire, 2015; Asrizal et al., 2022). Thus, the 21st century skills can help individuals become more competitive and ready to face various challenges in a dynamic and changing future.

Learning and innovation skills are skills needed in the 21st century education. Learning and innovation skills are valuable abilities that are useful in various aspects of life. Students who have learning and innovation skills can adapt to various dynamic learning situations (Stehle & Peters-burton, 2019). Students who have these skills will be able to face challenges

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effectively, increase their knowledge, and develop critical thinking skills (Fuad et al., 2017; Liesa-Orús et al., 2020). These skills also enable students to think creatively, find alternative solutions, and develop new ideas (Kwangmuang et al., 2021). The existence of learning and innovation skills can encourage students to be more independent in exploring information. Students will also be better prepared to face challenges in the future. Learning in schools must provide freedom in exploring problems and prioritize the development of learning skills to ensure that students develop optimally (Hanif et al., 2019). Thus, students can not only understand basic concepts but can also apply them in real contexts and contribute to the progress of society. Learning that trains learning and innovation skills is very important to form a generation that is intelligent, adaptive and ready to face the challenges of the world in the 21st century.

The 21st century learning is an educational paradigm that focuses on developing students' learning skills and innovation. Students' learning and innovation skills in the 21st century learning include critical thinking skills and creative thinking skills (Agaoglu & Demir, 2020; Sumarni & Kadarwati, 2020). In the 21st century learning, students are not only seen as recipients of information. However, students are also seen as active learners who use technology to access global learning resources, interact with the international community, and develop relevant digital skills. The 21st century learning also emphasizes the importance of critical thinking, creative thinking, problem solving, and adaptation to socio-technological changes. The demands of the 21st century learning are very important so that they can produce students who are ready to face future challenges (Ahonen & Kinnunen, 2015; Laar et al., 2017). Thus, the 21st century learning aims to produce a generation that is critical, creative, and competitive in an increasingly complex digital era.

Information and Communication Technology (ICT) has become an important component in the 21st century learning. With ICT, students can access information widely and deepen their knowledge through various online sources (Asrizal et al., 2022; Zokirovna, 2020). In addition, ICT allows students to interact with teachers and friends in real-time and facilitates a more interactive and dynamic learning process. The use of ICT in learning such as in digital teaching materials allows students to learn anytime and anywhere (Du et al., 2019). Learning that utilizes ICT can also increase flexibility and efficiency in the learning process. Thus, ICT not only enriches the academic learning experience but also helps students become more adaptive and ready to face global challenges.

The 21st century learning has various demands to create ideal learning. However, findings of conditions in the field do not match the conditions expected in the 21st century learning. Based on the initial study conducted, it was obtained that students' critical and creative thinking skills were categorized as less. The average critical and creative thinking skills of students were 54.36 and 52.92 respectively. The same problem was also expressed by other researchers. The findings of other researchers revealed that students' critical and creative thinking skills were still relatively low (Fatmawati et al., 2019; Purwati & Alberida, 2022; Sukarmin & Sani, 2023; Yanti et al., 2023). Students with low critical and creative thinking skills will have difficulty dealing with problems in the 21st century learning (Ahmed & Ibrahim, 2023; Kardoyo et al., 2020). If this problem is not resolved immediately, students will have difficulty adapting to the 21st century learning. The difficulties experienced by students will hinder students from achieving success in the future (Tiong & Bakar, 2022). To overcome this problem, an effort is needed so that the negative impacts caused can be minimized.

Digital teaching materials are one solution to improve students' critical and creative thinking skills. The existence of digital teaching materials can encourage students' interest in the learning materials being studied (Hendri et al., 2021; Hidayati et al., 2023). This will encourage students who are usually passive to become active in learning (Yulando et al., 2019). This change is in line with the 21st century learning so that students can have the skills required in the 21st century. Digital teaching materials can also be designed according to students' needs and characteristics. The results of research conducted by Seruni et al. (2020) and Yerimadesi et al. (2022) also show that the use of digital teaching materials in learning has a positive influence on students' critical and creative thinking skills.

The research conducted has differences with existing research. The differences in this study are a novelty in the research. There are several novelties in this study. First, the digital teaching materials developed are integrated with ethno-STEM aspects. These digital teaching materials are integrated with cultural and STEM aspects simultaneously. The cultural aspects studied come from Minangkabau culture which is close to students' daily lives. Second, the ethno-STEM integrated digital teaching materials developed aim to improve students' critical and creative thinking skills. These digital teaching materials are not only expected to encourage critical thinking skills or creative thinking skills. However, this teaching material was developed to encourage the improvement of students' critical and creative thinking skills simultaneously. Third, the material in the ethno-STEM integrated digital teaching

materials is heat material which is one of the materials in physics learning. So far, the study that has been carried out, no ethno-STEM integrated digital teaching materials have been found to improve critical and creative thinking skills in depth, especially in heat material.

Digital teaching materials play an important role in the learning process. Digital teaching materials are essentially a collection of materials that are arranged sequentially and systematically and developed using technological aids so that they can produce quality information (Asrizal & Utami, 2021). Digital teaching materials are delivered through technology-based media such as computers, tablets, or mobile devices. Digital teaching materials are also seen as one of the learning resources used in learning and utilizing technological advances to facilitate the learning process (Hasanah et al., 2022). In digital teaching materials, the aspects contained therein are displayed using technology. The use of technology in digital teaching materials provides flexibility for students to learn anytime and anywhere.

The use of digital teaching materials can be supported by the integration of ethnoscience in teaching materials. Ethnoscience is a learning approach that connects community knowledge with scientific knowledge (Ardianti & Raida, 2022; Sari et al., 2023). The integration of ethnoscience allows students to recognize their respective regional cultures and helps develop learning that is relevant to life. In addition, the application of ethnoscience also has a positive impact on learning. The integration of local culture and scientific concepts makes it easier for students to connect more with learning materials contextually and can help students improve their understanding (Ardianti & Raida, 2022; Kamila et al., 2024). The positive impact of ethnoscience integration in learning will support students in facing the 21st century learning.

Digital teaching materials can also be supported by STEM integration. The integration of STEM in the world of education is an innovation in the 21st century learning The purpose of STEM integration in learning is so that students have the skills needed in the the 21st century, such as critical thinking skills and creative thinking skills (Asrizal et al., 2023; Sumarni & Kadarwati, 2020; Zakiyah & Sudarmin, 2022). The integration of STEM is also expected to produce students who have a good understanding of physics, are skilled in innovation, and are competitive in facing the development of the times. Thus, STEM integration can produce students who are able to adapt to the 21st century learning.

The development of ethno-STEM integrated digital teaching materials is a solution to overcome problems that occur in learning. Ethno-STEM integrated digital teaching materials aim to improve critical and creative thinking skills possessed by students. Based on the background of the problems that have been described, the researcher is interested in conducting a study entitled Development of Ethno-STEM Integrated Digital Teaching Material of Heat Concept to Promote Students' Learning and Innovation Skills. The aim of this research is to determine the results of the needs analysis, validity, and practicality of ethno-STEM integrated digital teaching materials.

Method

The type of research used is Research and Development (R&D). R&D research is the process of developing a new product or improving an existing product. The goal is to create or develop a product that can be in the form of new products, methods, techniques, and so on (Sugiyono, 2022). The development model used in this study is the Hannafin and Peck model.

There are 3 phases in the Hannafin and Peck development model. The three phases are Need Assess, Design, and Develop/Implement. Need assess is the phase of analyzing needs and conducting literature reviews. Design is a phase in designing a solution to solve a problem. The last phase of develop/implement is the phase where the product is developed and implemented in a certain scope. The phases of the Hannafin and Peck's development model can be seen in Figure 1.

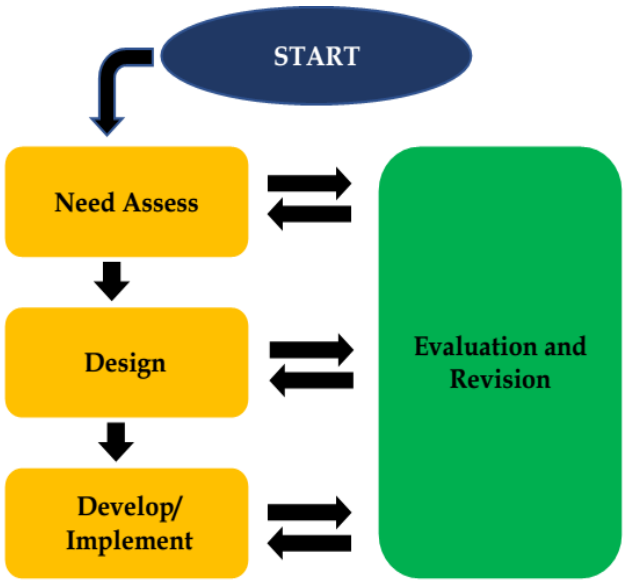

Figure 1. Hannafin and Peck's development model

There are three stages in the Hannafin and Peck development model. The first stage is the needs analysis stage. At this stage, analysis from various aspects of

physics learning is carried out. The goal is to obtain a strong foundation in developing products in the form of ethno-STEM integrated digital teaching materials. The analysis carried out was student knowledge analysis, critical thinking skills analysis, and student creative skills analysis. Knowledge analysis is seen from the scores obtained by students during school exams. Analysis of critical and creative thinking skills was obtained by testing test instruments to phase F students of grade XI of high school.

The second stage in Hannafin and Peck's development model is the design stage. At this stage, the development of digital teaching materials is focused on creating storyboards for teaching materials. Storyboards serve as a frame of reference in the creation of digital teaching materials. Storyboard creation refers to the analysis of the need for digital teaching materials in physics learning that has been obtained in the previous stage. The result of this stage is in the form of a storyboard describing the design of ethno-STEM integrated digital teaching materials.

The final stage of Hannafin and Peck's development model is the development and implementation stage. Storyboards that have been created in the previous phase have been developed into digital teaching materials that suit the needs of phase F students of grade XI of high school. The digital teaching materials that have been developed are then validated by 3 experts who are Lecturers at the Department of Physics, Faculty of Mathematics and Natural Sciences, Universitas Negeri Padang. Furthermore, improvements are made to digital teaching materials if there are weaknesses and shortcomings in accordance with input and suggestions from validators. The purpose of this improvement is to produce better and more perfect digital teaching materials so that they can be implemented in school learning.

The implementation at this stage is carried out by piloting revised digital teaching materials in the learning process. The trial of digital teaching materials was carried out on a limited basis for phase F students of grade XI of high school. The purpose of this trial is to find out the ease of use of the product in the learning process. From the data obtained, it will be known the level of practicality of using digital teaching materials in the learning process.

The instruments used to collect data in this study consist of three instruments. The three instruments are the needs analysis instrument, the validity instrument, and the practicality instrument. The needs analysis instrument is in the form of essay test questions designed according to aspects of critical and creative thinking skills. The aspects of critical thinking skills consist of interpretation, analysis, inference, evaluation, explanation, self-regulation (Facione, 2020). The aspects of creative thinking skills consist of fluency, flexibility, originality, and elaboration (Harisuddin, 2019). The validity instrument is in the form of a validity test questionnaire. The validity test questionnaire is compiled based on the components contained in the Digital Teaching Materials Development Guide (Kemdiknas, 2010). The components on the validity test questionnaire are the substance of the material, visual communication display, learning design, software utilization, and ethno-STEM integration. The practicality instrument is in the form of a practicality test questionnaire according to students. The practicality test questionnaire consists of five components. The five components are usable, easy to use, appealing, clarity, and cost effective (Virijai & Asrizal, 2023).

The results of the study were analyzed using descriptive statistical analysis. In this analysis, a discussion was carried out about the data on the results of the validity test and the results of the practicality test. The research data is presented in the form of graphs. The results of validity and practicality in this study are obtained through equations (1).

$$Value = \frac{Score}{Maximum\ Score} \times 100 \quad (1)$$

The categories of interpretation of the validity test results and the practicality test results of ethno-STEM integrated digital materials can be seen in Table 1.

Table 1. The Categories of Value Interpretation (Arikunto, 2018)

Interval	Category
30-39	Fail
40-55	Less
56-65	Enough
66-79	Good
80-100	Excellent

Result and Discussion

Result

There are three results obtained in this study. The three results of the research are the results of the needs analysis, the results of the validity test, and the results of the practicality test. The results of the needs analysis are a strong foundation in product development in the form of ethno-STEM integrated digital teaching materials. In the needs analysis stage, learning outcomes (LO), critical thinking skills (CT), and creative thinking skills (CV) of students were obtained. The analysis of the three data can be seen in Table 2.

Table 2. Statistical Parameters of Learning Outcomes, Critical Thinking Skills, and Creative Thinking Skills

Statistical Parameters	LO	CT	CV
Average	73.08	54.36	52.92
Median	78.00	55.00	53.13
Mode	80.00	55.00	46.88
Minimum	35.00	35.00	37.50
Maximum	96.00	75.00	65.63
Range	61.00	40.00	28.13

Based on Table 2, it can be seen that the lowest scores for students' learning outcomes, critical thinking skills, and creative thinking skills are 35.00, 35.00, and 37.50, respectively. The highest scores were 96.00, 75.00, and 65.63, respectively. The average of the learning outcomes was classified as good with a score of 73.08. This shows that students' abilities are good in terms of knowledge. Critical thinking skills obtained an average of 54.36 with the category of less. This number shows that students have not been able to manage deep thinking well. The creative thinking skills of students obtained an average of 52.92 in the category of less. The numbers obtained show that students are not used to finding new ideas in solving a problem in learning. From this assessment, it can be seen that students' critical and creative thinking skills still have not achieved the expected results. An innovation in learning is needed so that students' thinking skills are more optimal and in accordance with the expected results.

The results of the validity test of ethno-STEM integrated digital teaching materials were obtained from the results of the assessment of 3 experts. The assessment was carried out on 5 components on the validity questionnaire. These components are the substance of the material (SM), visual communication display (VS), learning design (LD), software utilization (SU), and ethno-STEM integration (IE). The results of the validity test of ethno-STEM integrated digital teaching materials on each component can be seen in Figure 2.

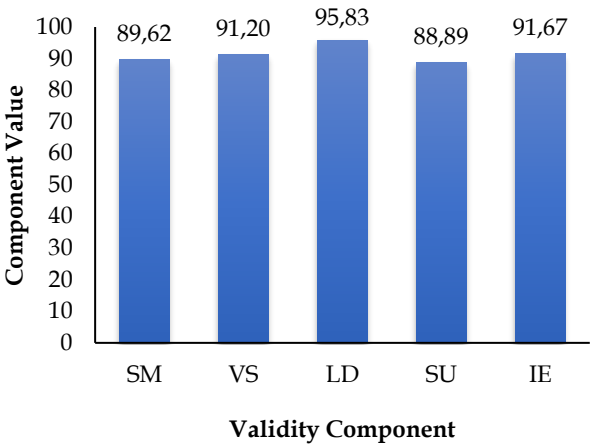

Figure 2. Product validity test results

Based on Figure 2, it can be revealed that the average validity test results of each component of the assessment of ethno-STEM integrated digital teaching materials have a variation in values between 88.89 to 95.83. The component of the validity of ethno-STEM integrated digital teaching materials that received the highest score was the learning design component with a score of 95.83. The validity component that obtained the lowest score was the use of software with a value of 88.89. Even though it obtained the lowest score, the software utilization component is still classified as excellent. Other validity components such as the substance of the material, visual communication display, and ethno-STEM integration each obtained scores of 89.62, 91.20, and 91.67. Overall, the average result of the validity test of all components was 91.44. Based on the average score obtained, the results of the validity test of ethno-STEM integrated digital teaching materials are classified as excellent. This shows that the ethno-STEM integrated digital teaching materials developed have been tested for feasibility. Based on data analysis, overall ethno-STEM integrated digital teaching materials are valid and can be used to optimize the learning process in schools.

The results of this study produced a product in the form of ethno-STEM integrated digital teaching material of heat concept to promote students' critical and creative thinking skills. The development of ethno-STEM integrated digital teaching materials refers to the guidelines for the development of ICT-based teaching materials (Kemdiknas, 2010). Ethno-STEM integrated digital teaching material are adjusted to the applicable independent curriculum, one of which is the use of learning outcomes. The material presented in ethno-STEM integrated digital teaching material is heat concept material intended for high school students in phase F class XI in semester 2.

The developed digital teaching materials were designed using Microsoft Word and Canva software. The use of these two software in the design process makes the developed digital teaching materials interesting and in accordance with student characteristics. The design of the developed digital teaching materials was displayed with the help of Heyzine software. The appearance of the Heyzine software makes digital teaching materials more interactive. This is because Heyzine software can display images, videos, and audio in teaching materials so that they can support learning materials. In addition, the attractive and modern appearance of Heyzine can increase students' attraction to learning materials. The display of ethno-STEM integrated digital teaching material of heat concept to promote students' critical and creative thinking skills can be seen in Figure 3.

Ethno-STEM integrated digital teaching materials have an introduction section. This section consists of a preface, table of contents, table list, picture list, video list, instructions for use, learning instructions, and ethno-STEM explanations. The preface contains an introduction to the preparation of ethno-STEM integrated digital teaching materials. Table of contents, table lists, picture lists, and video lists are lists of information to make it easier to find content in digital teaching materials. Instructions for use and learning instructions contain how to use the application as well as instructions for teachers and students in using digital teaching materials. The ethno-STEM explanation contains information about the two integrations of digital teaching materials so that users have an overview of ethno-STEM.

Figure 3. The display of ethno-STEM integrated digital teaching materials

Ethno-STEM integrated digital teaching materials contain learning materials specifically in physics learning. The learning material in this teaching material is heat material. The heat learning material in ethno-STEM integrated digital teaching materials is divided into 3 sub-materials, namely the concept of heat, expansion of substances, and heat transfer. Each sub-material consists of a learning description and a summary of the learning. The learning description explains the entirety of each sub-material in the digital teaching material. The learning summary is a summary of the learning material so that it can make it easier for students to understand the learning material.

Ethno-STEM integrated digital teaching materials are also equipped with practice questions and competency tests. Practice questions in this teaching material are made to improve students' critical and creative thinking skills. The competency test as a student assessment is linked to a Google Form, the purpose of which is to find out the level of student understanding of the material studied. In addition, the use of Google Form aims to enable students to get feedback in the form of scores obtained and information on correct/false questions from what students have done. The ethno-STEM integrated digital teaching materials that have been developed are presented as attractive as possible so that they can make it easier and motivate students to learn physics anywhere and anytime.

The results of the research after the product is validated are the results of the practicality test. Ethno-STEM integrated digital teaching materials were tested for practicality by 35 students of Class XI F-1 SMA Negeri 3 Payakumbuh. The results of this practicality test were obtained from the practicality questionnaire sheet. The practicality questionnaire distributed consists of 5 components. These components are useful (US), easy to use (EU), appealing (AP), clarity (CL), and cost-effective (CE). The results of the test of the practicality of ethno-STEM integrated digital teaching materials on each component can be seen in Figure 4.

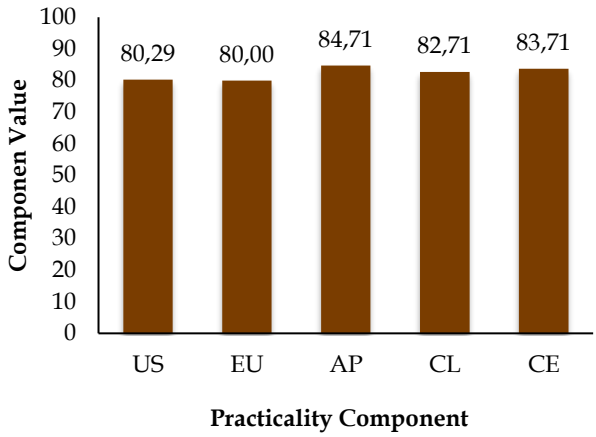

Figure 4. Product practicality test results

Based on Figure 4, it can be stated that the average results of the practicality test of each component of the assessment of ethno-STEM integrated digital teaching materials have a variation in values between 80.00 to 86.71. The value obtained from each component of practicality is classified as excellent. The component of the practicality of ethno-STEM integrated digital teaching materials that received the highest score was the interesting component with a score of 84.71. The practicality component that received the lowest score was the easy-to-use component with a value of 80.00. Despite obtaining the lowest score, the level of practicality of this component is still in the excellent category. Other practicality components such as useful, clarity, and cost-effective each obtained scores of 80.29, 82.71, and 83.71. Overall, the average results of the practicality test of all components were 82.29. Based on the average obtained, the results of the test on the

practicality of ethno-STEM integrated digital teaching materials are classified as excellent. This means that ethno-STEM integrated digital teaching materials are useful, easy to use, have attractiveness and clarity, and are cost-effective to use. Therefore, overall, ethno-STEM integrated digital teaching materials are very practical to use in physics learning.

Discussion

The results achieved in this study are three according to the research objectives. The three results are the results of an analysis of the needs, validity, and practicality of ethno-STEM integrated digital teaching materials. The first result achieved in the study was an analysis of the need for the development of ethno-STEM integrated digital teaching of heat concept material to promote students' learning and innovation skills. Based on data analysis, it was obtained that the results of students' critical and creative thinking skills were still relatively low. In fact, these two skills are among the basic skills that students need to have in facing the 21st century learning (Agaoglu & Demir, 2020). One of the causes of the low level of students' critical and creative thinking skills is the lack of teaching materials that can facilitate students to improve their critical and creative thinking skills (Mutohhari et al., 2021).

The second result achieved in this study is the validity of ethno-STEM integrated digital teaching of heat concept material to promote students' learning and innovation skills. The validity of the developed product is tested by experts in order to obtain a level of product validity. There are four components that are validated by experts, namely the substance of the material, the display of visual communication, the design of learning, and the use of software (Kemdiknas, 2010). Another component added to assess the validity of the developed product is the Ethno-STEM integration component. Ethno-STEM integrated digital teaching materials can be said to be valid if they have reached the standards of the assessment component and meet certain criteria. Based on the analysis of data from the assessment provided by experts, it was obtained that the ethno-STEM integrated digital teaching materials are valid. This is in line with the results of the study Zakiyah et al. (2022) related to the development of ethnoscience-integrated STEM teaching materials that produce valid teaching materials. Valid ethno-STEM integrated digital teaching materials can be used so that they can optimize the physics learning process.

The third result of the research is the practicality of development of ethno-STEM integrated digital teaching of heat concept material to promote students' learning and innovation skills. The practicality test aims to find out the extent of the practicality of the product being developed. The practicality of ethno-STEM integrated digital teaching materials is obtained by piloting products in the field and asking students to assess their practicality. There are five components that students assess, namely useful, easy to use, appealing, clarity, and cost-effective (Virijai & Asrizal, 2023). Based on the results of data analysis from the questionnaire filled out by students, it was obtained that the value of each component was in the excellent category. This shows that students feel the ease of using digital teaching materials in the learning process. This means that ethno-STEM integrated digital teaching materials are practical. The results of this study are in accordance with the results of the research Putra et al. (2023) related to the development of ethno-STEM teaching materials in the making of Jambi Batik that produces practical and easy-to-use teaching materials.

Based on the three results obtained from the research, namely the analysis of the needs, validity, and practicality of ethno-STEM integrated digital teaching materials, the products developed can be used in physics learning. Ethno-STEM integrated digital teaching materials can be one of the learning resources used by teachers and students, especially in heat materials. This is in accordance with the results of the study which shows that ethno-STEM integrated digital teaching materials have been tested for validity and practicality so that they can be used in physics learning.

Conclusion

Based on the objectives and results of the study, three conclusions can be obtained. First, the results of the needs analysis show that students' critical and creative thinking skills are still classified as less. The average scores of students' critical and creative thinking skills were 54.36 and 52.92, respectively. This shows that students' learning and innovation abilities, including critical and creative thinking, are still low. Second, the validity value of the ethno-STEM integrated digital teaching material of heat concept to promote students' learning and innovation skills is 91.44 which is in the excellent category. Digital teaching materials with a high level of validity show that the teaching materials have been tested for feasibility and validity. Third, the practicality value of the use of ethno-STEM integrated digital teaching material of heat concept to promote students' learning and innovation skills is 82.29 with the excellent category. This shows that digital teaching materials are easy and practical to use in the learning process. Therefore, the ethno-STEM integrated digital teaching materials are valid and practical for use in learning.

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Author Contributions
All authors in this article have their own important roles so that this research can be carried out well. H.A.A, contributed to data collection, data processing, analysis, and preparation of draft papers. A., contributes as a supervisor for the implementation of research and review of paper. R.A, H., and H., contributed to concept design, suggestions, and input to the development of ethno-STEM digital teaching material in implementation of research. All authors have read and approved the published version of the manuscript.

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Conflicts of Interest
There is no conflict of interest in this research article.

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