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Development of STEM-Integrated Static Fluid E-Modules to Improve Students' Creative Thinking and Science Process Skills

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ABSTRACT

The 21st century learning should apply the skills of grade 21 students which include the 4C skills, namely creative thinking, critical thinking, communication, and collaboration. This skill is needed in solving a problem. The learning outcomes show the low ability of students to think creatively and scientifically. The STEM integrated e-module is the solution to this problem. The purpose of this study was to determine the initial studies, the validity and practicality of using STEM integrated e-modules. This research method uses research and development research using the Hannafin and Peck development model. Research instruments include needs analysis instruments, validation questionnaires and practicality. The data analysis technique used is descriptive statistics. Based on the data that has been analyzed there are three research results. First, the results of the needs analysis obtained an average value of 69.4 in the good category. Second, product validation results obtained an average value of 84.1 with a very good category. Third, the product practicality results obtained an average value of 93 in the very good category. The implication of the results of this study is that teachers must construct students' skills through e-modules. The meaning of the results of this study is that the STEM integrated e-module is valid and practical for use in learning.

Keywords: E-module, Static fluid, STEM, Creative thinking, Science process

INTRODUCTION

The implementation of learning in the 21st century should encourage students' 21st century skills. 21st century skills are a set of abilities that include knowledge, skills, work habits, attitudes, character for the achievement of learning success (Hoir et al., 2019; Tindowen et al., 2017; Proud & Potter, 2020). The skills demanded in the 21st century today are 4C skills including creative thinking, critical thinking, communication and collaboration skills (Zubaidah, 2016; Trilling & Fadel, 2012; Salleh & Puteh, 2017; Chalkiadaki, 2018). Jobs related to complex problem solving require critical thinking skills, creativity supported by collaboration skills, and increasingly higher digital literacy abilities (Mutohhari et al., 2021; Rizaldi et al., 2020; Semilarski et al., 2021; Wang et al., 2018). 21st century skills are needed for students to solve problems, communicate, collaborate with others in obtaining new information and adapt quickly in new environments (Ahmed & Taha, 2021). The 21st century skills are important to provide to students in learning and should be included in the curriculum (Sibille et al, 2010; Greenstein, 2012; Griffin, 2017).

The 21st century learning centers on life in the real world of students. The principle

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applied in 21st century learning is student-centered learning or learning that requires students to be active collaboratively and connected to real-world contexts that are integrated with community life (Wulandari et al., 2016; Asrizal et al., 2018; Supriyono & Prabowo, 2019). 21st century learning requires students to have skills in solving a problem, including creative thinking skills and science process skills. Creative thinking skills really need to be improved so that students can provide several ideas in solving a problem (Armandita et al, 2017). Creative thinking skills are needed nowadays because creativity can allow someone to create new ideas that have never been put forward by others. Then the important science process skills are developed so that students are able to observe, formulate problems, provide hypotheses, conduct experiments and conclude a problem from various natural phenomena that occur (Nugraha, 2005). The 21st century learning provides opportunities for students to develop their skills in mastering technology and information. Thus, students can develop their knowledge and skills through the application of technology and information into learning.

ICT is important to be applied in learning in order to form a learning process that makes students more active by encouraging interaction between learning components so that students are more eager to learn (Saxena, 2017; Das, 2019; Zafar, 2019). ICT-based teaching materials are teaching materials that are designed and compiled using ICT devices to make it easier for students to learn. ICT-based teaching materials have advantages, namely: providing convenience in learning, encouraging interest and activeness in the process of discussing learning material, making it easier to assess learning progress, and making it easier to discuss and interact using internet facilities (Ugwu & Nnaekwe 2019; Usman & Asrizal, 2020). ICT teaching materials need to be utilized in physics learning to create active, interactive, and meaningful learning. Therefore, the use of ICT in learning can make it easier for students to develop their thinking skills (Asrizal et al., 2022).

The problems that occur in the field show that students' creative thinking skills and science process skills are still not in accordance with the expected conditions. Based on the results of the initial study conducted at SMAN 6 Padang using the instrument of giving test questions on creative thinking skills and performance assessment worksheets on students' science process skills. The results of creative thinking skills are still low with an average score of 43. These results are supported by the research of Alfitriyani et al. (2021), Yustina et al (2021) and Ernawati et al. (2019) which states that skills that require students to think creatively are still low. Low creative thinking skills are due to a lack of student ability to generate ideas. The results of students' science process skills are still low with an average score of 54. These results are reinforced by the research of Ayuningtyas et al. (2015), and Darmaji et al. (2019) which states that students' science process skills are still relatively low. Problems related to low science process skills and students' creative thinking need a solution.

The use of E-modules can overcome these problems. Some researchers have examined e-modules that are integrated with learning models. E-modules based on project-based learning integrated with STEM by Cahyani et al. (2020) and E-modules integrated with problem-based learning by Rizaldi et al. (2022). Several other researchers also examined using the STEM learning approach, such as Mahjatia et al. (2020), and Cahyani et al. (2020). The research used student worksheets and electronic modules in learning, applying them to high school students, measuring creative thinking skills and science process skills. This previous research is a fundamental source in determining the differences in the research to be studied.

This research has three differences with previous research. The first difference is that the teaching materials used are ICT-based. The second difference is that the teaching materials integrate STEM learning based on real-world problems. The third difference is that the four studies are aimed at grade XI students at SMAN 6 Padang. This research has novelty from previous research. The first novelty lies in the teaching materials developed in the form of electronic modules that can be used on smartphones through internet access. The second novelty, the e-module is made interactive with the addition of videos, images, google forms and phet simulation that can generate student interest in learning.

E-modules are important because they can be interactive which can motivate students to learn, train independence, provide feedback and measure learning achievement. E-Modules are packaged in electronic form which makes it easy for students to be able to access learning quickly through software without having to spend money to get it (Kosasih, 2021). E-modules consist of various series of learning activities in achieving a learning objective. E-Modules must be arranged systematically, which means that the module has conformity with predetermined learning objectives, needs and characteristics so that it can train students' independence (Asrizal et al., 2013; Festiyed et al., 2020). The developed e-module integrates STEM into learning. The e-module contains static fluid material in it. Static fluid can be defined as fluid whose flow is still (Kertiasa, 2017).

The STEM learning approach uses a science, technology, engineering and mathematics learning approach which is commonly referred to as a disciplinary approach to learning (Cheng, et al., 2020). In this STEM approach, the concept of material is adjusted first before being taught and then associated with life in the real world. Research results according to Shernoff et al. (2017) that STEM can reduce the burden on students in recognizing problems in the real world and then solving problems through the application of concepts that link various sciences. Another opinion according to Sulaeman et al. (2020) the STEM learning approach can trigger the formation of students' interest in learning and perceptions of STEM-related professions. The STEM approach is very important in training students to be able to integrate every aspect of STEM at once. The learning process involved in the STEM approach involves four aspects that can shape student knowledge optimally. STEN learning applied to physics learning can help students in making a technology through an experimental process in an effort to prove a concept, principle and law of science based on mathematically managed data (Permanasari, 2016).

The use of STEM-integrated e-modules will improve students' creativity and science process because it implements real-world problems into students' lives. In addition, this STEM-integrated e-module will improve students' knowledge, attitudes and skills because it is in accordance with 21st century learning. This research is needed to develop teaching materials that are interesting and interactive in the learning process. The interactive process is needed because it can clarify a material taught through an interesting video display. The purpose of this research is to determine the results of the initial study research, determine the results of the validity test, and determine the results of the practicality test of using STEM integrated e-modules.

METHODS

The research conducted by researchers is development research (Research and Development). Development research is a type of research used in making a product and then testing the validity and practicality of the product that has been developed. The purpose of R&D efforts in education is not just testing a theory but so that the products developed become more effective for students to use in schools so as to increase student knowledge (Sugiyono, 2010). The research conducted used the Hannafin & Pack design model in making the product. Hannafin & Pack development research has the aim of making a product that helps the problem-solving process (Wahidah et al., 2021). The Hannafin and Peck model is a model in designing a product by taking simpler steps so that it does not take a long time. The Hannafin & Pack design model has three main steps starting from needs analysis, design or design and development and implementation (Hershey, 2019).

The first phase of the research was needs and context analysis. Activities that have been carried out in this phase include: analyzing learning problems, analysis of students' creative thinking skills and science process skills, analysis of student characteristics, analysis of learning objectives and analysis of learning settings. Analysis of learning problems related to the analysis of ICT teaching material problems. Analysis of student characteristics regarding learning interests, learning attitudes, learning motivation and student learning styles. Analysis of learning objectives related to the difference between ideal learning objectives and learning objectives used by teachers based on the operational verbs used. Analysis of learning settings related to opening, content and closing activities.

The second phase of the research is the design of STEM-integrated fluid e-modules. Activities that have been carried out include designing e-modules. The e-module uses the Canva application in its creation. The material chosen in this e-module is KD 3.3, namely the application of the laws underlying static fluid material and its application in everyday life. The e-module designed includes a learning approach in it, namely the STEM learning approach. This stage also designed the instruments needed to produce prototypes. The structure of the e-module is cover, preface, table of contents, introduction, core part and cover. In this e-module design, it will be made interactive such as providing videos, gogle form links and phet simulation links to carry out the practicum process.

The third phase of the research is development and implementation. This activity is carried out after the e-module has been designed. At the development and implementation stage, validity and practicality tests were carried out to perfect the e-module. The product validation test aims to find out that the product developed has been declared valid by experts so that it is suitable for use by students in learning. The next step is testing the practicality value of the product. The product practicality test aims to find out that the product is practical to use in learning.

This research uses instruments in collecting data in the form of validation questionnaire sheets and practicality questionnaire sheets. Data analysis techniques in this study used descriptive statistics in analyzing validity and practicality. Statistical analysis is displayed in graphical form. The validation questionnaire validated by validators as many as 3 experts who are lecturers at FMIPA UNP consisting of material substance components, learning design validation, visual communication display validation, software utilization validation and STEM integration validation. According to Riduwan, (2019) validation and practicality analysis can be obtained by dividing the score obtained by the maximum score and then multiplying by one hundred percent. In addition, the validity and practicality value categories ranging from 0 to 20 are categorized as not good, 21 to 40 are categorized as less good, 41 to 60 are categorized as quite good, 61 to 80 are categorized as good, 80 to 100 are categorized as very good.

RESULTS AND DISCUSSION

Results

Hasil Analisis Kebutuhan dan Konteks

Based on the data that has been analyzed, there are three research results in accordance with the stages of the Hannafin & Pack design model, namely the results of needs analysis, validity, and practicality. The first needs analysis is the analysis of learning problems at SMAN 6 Padang. The instrument used is a questionnaire of learning problems obtained from 2 teachers of SMAN 6 Padang. Some learning problems obtained from the teacher's questionnaire as in Table 1.

Table 1. Results of Problem Analysis Learning

Identification of Physics Learning Problems	Value
Constraints in designing e-modules	63
Obstacles in making e-modules	75
Obstacles in mastering software	70
Obstacles in making e-modules with softwere	75
Obstacles in using e-modules in learning	63

Based on Table 1, it is found that the physics learning problems are in the range of scores 63 to 75. The score range of 63 to 75 is included in the high enough category which shows that physics learning still experiences various obstacles. First, obstacles in designing e-modules are still quite high such as difficulties in designing covers, designing concept maps, designing material content and designing evaluation questions. Second, the obstacles in making e-modules are still quite high such as difficulties in making learning objectives, making learning indicators, linking material with real-world contexts. Third, obstacles in mastering software are still quite high such as difficulties in utilizing google form, phet simulation and word software in learning. Fourth, obstacles in making e-modules with software such as difficulties in inserting certain software into learning. Fifth, obstacles in using e-modules in learning such as difficulties faced when teaching using e-modules.

The second needs analysis is the analysis of student characteristics at SMAN 6 Padang. The instrument used was a questionnaire of student characteristics. The analysis of student characteristics has 4 components, namely: learning interest (LI), learning motivation (LM), learning attitude (LA), and student learning style (LS). The analysis of student characteristics can be seen as Figure 1.

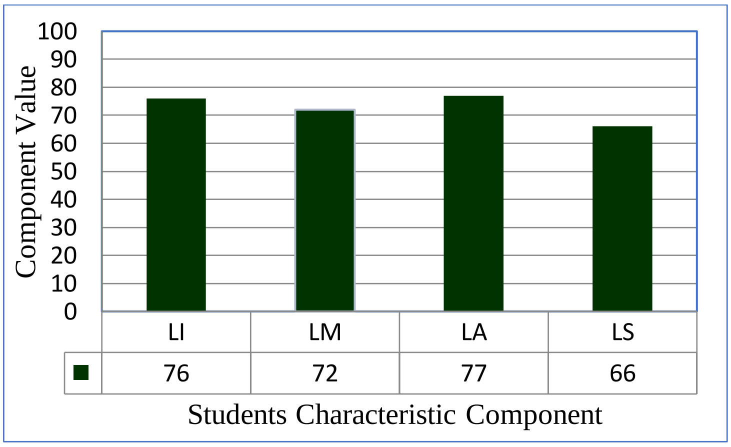


Figure 1. Analysis of Student Characteristics

Based on observations of 33 students, the results of student interest in learning were obtained with a score of 76; student learning motivation 72; student learning attitudes 77 and student learning styles 66. Overall, student characteristics with an average score of 72.5 are in the good category. Student learning motivation greatly affects student interest in learning. The higher the learning motivation, the higher the student interest in learning. Learning motivation can be increased through implementing students' real-world problems into learning. Student learning styles are related to how students understand learning while learning attitudes are related to student behavior during the learning process. Overall, student characteristics can affect students' thinking skills.

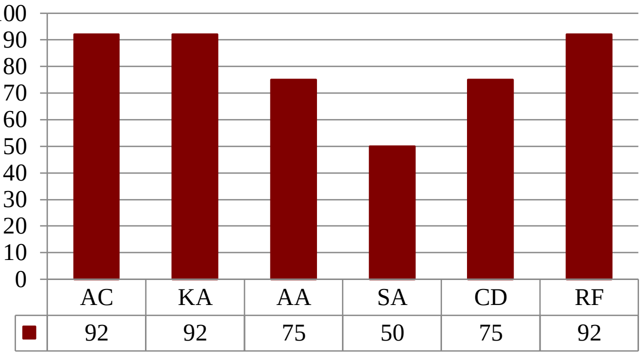
The second group of student characteristics analysis is related to creative thinking skills, student science process skills and student knowledge. The instrument used is an observation instrument for students' creative thinking skills and science process skills, while the value of student knowledge comes from student learning outcomes in the form of mid-term test scores. This analysis aims to determine the value of creative thinking skills, science process skills and student knowledge. Analysis of creative thinking skills (CTS) and science process skills (SPS) and student knowledge can be seen in Table 2.

Table 2. Satistical Parameter Values of Students's CTS, SPS and Knowledge

Parameter Statistic	CTS	SPS	Knowledge
Average	43	54	41
Mode	41	50	40
Median	41	50	40
Lowest score	31	40	20
Highest score	63	75	83
Reach	32	35	63

Based on Table 2, it can be explained that the lowest scores of the assessment of skills, creative thinking, science process and student knowledge are 31, 40, and 20, respectively, while the highest scores are 63, 75 and 83, respectively. The average of students' creative thinking skills is 43, students' science process skills is 54, and students' knowledge is 41. This shows that the average value of students' creative thinking skills, science process, and knowledge is in the low category. The range of values from the assessment results of students' creative thinking skills, science process, and knowledge are 32, 35, and 63, respectively. The values that often appear in the assessment of students' creative thinking skills, science process, and knowledge are 41, 50, and 40, respectively. These three values are in the low category. The middle scores of the research of students' creative thinking skills, science process, and knowledge are 41, 50, and 40. These three are also at low scores. Based on these three assessments, it can be seen that the science process skills of creative thinking skills, and student knowledge have not achieved the expected results so that this requires a renewal in learning so as to get more optimal results and in accordance with expectations.

The third needs analysis is the analysis of learning objectives on 3 physics materials through the physics teacher's learning implementation plan. The observation instrument used is guided by the suitability of using the ABCD structure in the learning objectives made by the teacher. The components in the preparation of teaching materials use the audience component (AC), knowledge ability (KA), attitude ability (AA), skill ability (SA), Condition (CD) and degree (RF). The audience component is a component of a learning objective aimed at students. The behavior component is a component that emphasizes something that must be possessed by students such as knowledge, attitudes, and skills. The condition component is something that is used as a reference for the achievement of learning objectives such as the application of a learning model to the learning objectives. The degree component is something that is emphasized in the success of learning objectives. Analysis of the completeness of learning objectives based on lesson plans can be seen in Figure 2 below.

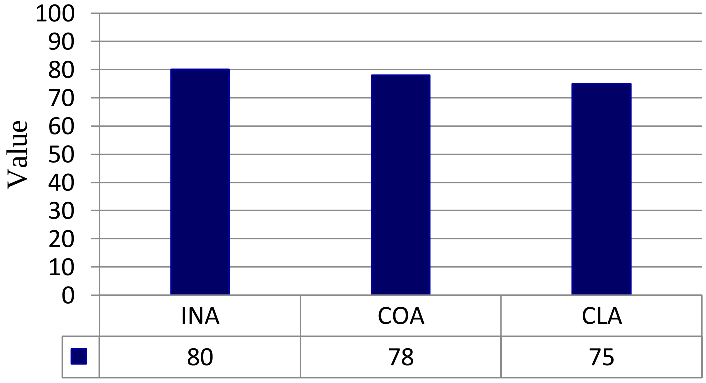


	AC	KA	AA	SA	CD	RF
■	92	92	75	50	75	92

Figure 2. Analysis of Learning Objectives

Based on the observation sheet of learning objectives analysis for three basic competencies (BC), the results are in the range of 50 to 92. The results for the audience component of 92 are categorized as good, this is because the learning objectives are aimed mostly at students. The result for knowledge ability of 92 is categorized as very good, this is because the learning objectives focus on students' knowledge with appropriate operational verbs. The result for attitude ability is 75, this is because some learning objectives do not include the attitudes that learners must have. The result for skill ability of 50 is categorized as quite good, this is because the learning objectives have not used C6 operational verbs to conduct experiments. The results for conditiom and degree are categorized as good because the learning objectives use a learning model and also affirm the learning success criteria.

The fourth needs analysis is the analysis of learning settings. The observation instrument used is guided by Permendikbud 2016 Number 22 regarding the process of learning activities that take place in the classroom. The learning activity process is carried out by implementing the lesson plans that have been made by the teacher. The learning activities carried out include introductory activities (INA), core activities (COA) and closing activities (CLA). Analysis of learning problems can be seen as Figure 3 below.



	INA	COA	CLA
■	80	78	75

Figure 3. Learning Setting Analysis Results

Based on the observation results in the learning setting analysis table related to the analysis of activities during the learning process, namely opening activities, content activities and lesson closing activities. Activities to open learning with a value of 80 which is categorized as good, but there are shortcomings in this activity, namely the lack of providing learning motivation to students and the lack of explanation of the learning objectives to be achieved in detail. Core learning activities with a score of 78 which is categorized as good, but here there are shortcomings, namely not causing active participation of students in learning. Closing activities with a score of 75 in this activity there are deficiencies such as not using words that encourage students who are already active in learning. Overall the average score obtained is 77.6 learning activities at SMAN 6 Padang are in accordance with the implementation of ideal learning. The implementation of learning has not used the STEM approach to learning.

Description of STEM Integrated Static Fluid E-Module

The next research result is product description. The product developed is a STEM-integrated static fluid e-module in improving students' science process skills and creative thinking skills. The e-module is designed based on the e-module writing structure. The following is the result of the e-module cover which can be seen in Figure 4.

(a) (b)

Figure 4. (a) E-Module Cover Display, (b) E-Module Main Menu Display

At the beginning of this e-module there is a cover and main menu. On the e-module cover display which contains the title, author, semester and class. The title section explains the material to be studied, namely static fluid material. This teaching material is provided for high school students in grade XI in semester 1. This cover view of the sentence is written in English and made as interesting as possible by balancing the colors. On the cover of the e-module there is a submarine that represents the static fluid material that will be studied. In the e-module main menu display section which contains the table of contents in the e-module. In learning activities there are learning objectives, material descriptions that contain material with a STEM approach, conclusions, exercises and evaluations. In the learning evaluation, objective test questions related to STEM are given and packaged in google form. In the evaluation questions, the answer key is given at the end of this e-module as a form of feedback to students.

The resulting integrated static fluid e-module is of high quality, so the validators provide various suggestions for improving the e-module. Suggestions given by several validators in the form of input given by the validator on the quality of the product developed. As for some of the main suggestions from the validators. First, the cover display on the e-module adjusts to the material being taught. Second, the learning objectives should be adjusted to the cognitive level. Third, the STEM approach is still not visible in the e-module. Fourth, the images contained in the e-module include references. Suggestions given by validators are used as the first step to improve the e-module.

Improvements to the e-module were made in accordance with the validator's suggestions. Repairing the e-module cover by adding a picture of a submarine in it to match the static fluid material. Improvement of learning objectives by adjusting the operational verbs used. Improving the STEM approach in the e-module by adding aspects of science, technology, engineering and mathematics related to students' real life. Adding references at the bottom of the e-module image. This e-module improvement aims to make the e-module valid in its use.

Validity Test Results of STEM Integrated Static Fluid E-Module

The next result is the result of product validation. The e-module that has been developed is then validated by experts to determine the validity of the e-module. The validation instrument used has assessment components which include material substance (MS), visual communication display (VC), learning design (LD), software utilization (SU) and STEM assessment (SA). The results of product validation can be seen in Figure 5.

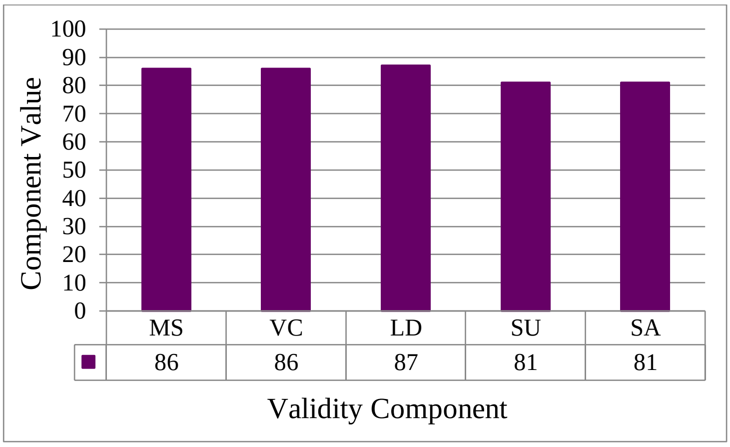


Figure 5. Validator Component Validation Results

Based on the data analysis in the figure, it can be explained that the value of each component varies with the lowest value of 81 and the highest value of 87. The value of the validation test results according to experts on static fluid e-modules can be determined by finding the average value of all assessment components. The average value of the STEM-integrated static fluid e-module validation results according to experts is 84.1 which is in the very good category. The material substance component (SM) consists of four indicators, namely: 1) truth, 2) material coverage, 3) current, 4) readability. The validation results for the substance of the material varied between 81 to 90. The value given by the validator for each component of the substance of the material can be categorized as very good. The learning design component (DP) consists of 6 indicators, namely 1) title, 2) CC and BC, 3) material, 5) practice questions, 6) references. The validation results for learning design varied between 79 to 92. Thus, the overall appearance of the e-module design is in the excellent category. The third component is the visual communication display which is related to the appearance of the e-module. The results of the validation of the visual communication display (VC) varied between 79 to 92. Thus, the visual communication display on the static fluid e-module can make it easy for students to run the e-module with a clear navigation display, legible font display, media that helps learning and proportional color combinations and there is already a media such as videos and images that can motivate student learning.

The software utilization component (PS) consists of 4 indicators, namely 1) interactivity, 2) canva, 3) phet simulation, 4) Gogle form. The results of the validation of software utilization were assessed to vary between 75 to 92. The validity results of the 4 indicators show that indicators with very good categories are at a value of 92 while indicators with good categories in the range of 75 to 79. Overall, the utilization of software in e-modules is in the good category. Thus the utilization of software in e-modules can facilitate users in using static fluid e-modules. The STEM Assessment Component (PT) consists of science, technology, engineering and mathematics. The results of the STEM assessment vary from 79 to 88. Science, engineering and mathematics indicators obtained a score of 79 including in the good category while the technology indicator is valued above 88, so it can be said to be in the very good category. Overall, the static fluid e-module already contains STEM indicators well.

Practicality Test Results of Using STEM-Integrated Static Fluid E-Modules

The results of the research after the product have been validated, then the student practicality test is carried out to determine the practicality of the product that has been developed. The practicality instrument used has assessment components which include benefits (BF), ease of use (EU), attractiveness of presentation (AP) and clarity (CL). The analysis of each component of practicality can be seen in Figure 6.

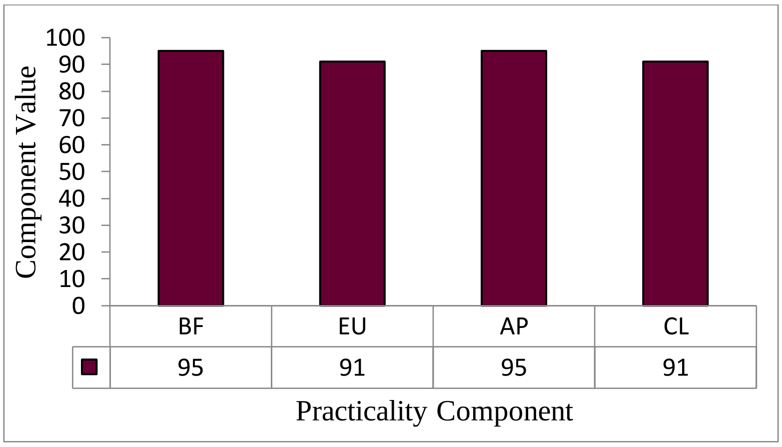


Figure 6. Practicality Component Results

Based on the data analysis of the practicality component, the value is obtained in the range of 91 to 95. The average value of the practicality component is 93 in the good category. The value given by students on the instrument of the practicality test sheet states that the STEM-integrated static fluid e-module is practically used in physics learning. The benefit component indicators consist of 1) can be used as a reference, 2) can help understand learning, 3) can be used to increase independence, 4) can improve science process skills, 5) can improve creative thinking skills. The average value of the benefit component indicator is 94.6 in the excellent category. The easy-to-use component has 5 indicators. The easy-to-use component indicators consist of 1) making it easy to understand learning, 2) making it easy to do experiments, 3) using e-modules repeatedly, 4) using e-modules anywhere, 5) using e-modules anytime. The results of the analysis of the easy-to-use component indicators are in the range of 83 to 97. The average value on the easy-to-use component indicator is 91, which is in the very good category.

The presentation attractiveness component has 5 indicators. The indicators of the presentation attractiveness component consist of 1) the cover looks interesting, 2) the pictures on the e-module are interesting, 3) the context of the e-module is interesting, 4) the template is interesting, 5) the colors on the e-module are interesting. The results of the analysis of the presentation attractiveness component are in the range of 91 to 98. The average value of the presentation attractiveness indicator is 95.2 in the very good category. The clarity component has 5 indicators. The indicators of the clarity component consist of 1) the picture looks clear, 2) the objectives and indicators are clear, 3) the instructions on the e-module are clear, 4) the font on the e-module is clear, 5) the activities and instructions on the e-module are clear and understandable. The results of the data analysis of the e-module clarity component are in the value range from 83 to 97. The average value of the clarity component indicator is 91, which is in the very good category.

Discussion

Based on the results of the needs analysis research, the learning process carried out by teachers did not follow the demands of the 2013 curriculum, the results obtained corresponded with previous research showing that the results of observations of students' creative thinking skills carried out at SMAN 6 Padang were still in the low category. This result is in accordance with previous research which shows that students' ability to think creatively in physics learning in high school is still in the low category which can be seen through giving creative thinking ability test questions and the results obtained are still many students who do not produce answers with many ideas or ideas (Armandita et al, 2017; Alfitriyani et al., 2021). (2021). The results of students' science process skills during the practicum are still in the low category. These results are in accordance with previous research that students' science process skills are still low because learning does not carry out practicum in the classroom so that it does not train students' abilities in problem solving (Suwasono, 2011; Ayuningtyas et al. 2015).

The results showed that STEM-integrated electronic teaching materials were declared valid and practical in improving students' skills. These results are in accordance with research conducted by Mahjatia et al. (2020), Amrul et al. (2019) and Cahyani et al. (2020) that electronic teaching materials can improve students' creative thinking skills and science process skills. The STEM learning approach helps students in making a technology through an experimental process that can prove the laws or concepts of science based on mathematically managed data (Permanasari, 2016; Sulaeman et al., 2020). The application of the STEM approach in learning can also improve student learning outcomes. This result is in accordance with previous research that the stem approach affects student learning outcomes (Maharani et al., 2022).

This research focused on developing an electronic module. The electronic module integrates the STEM learning approach in improving students' creative thinking skills and science process skills as the findings of this research. Teaching materials in the form of electronic modules provide encouragement to students in exploring, expanding and explaining learning materials to develop their creative thinking skills and science process skills. The implication of the results of this study is that teachers should provide learning motivation, guide, and direct students in constructing or building students' skills through ICT-based electronic modules by integrating the STEM learning approach. The development of electronic modules is limited by the electronic modules developed using ICT in learning, the research is only limited to class XI at SMAN 6 Padang, and this research uses canva software in designing e-modules.

CONCLUSION

Based on the objectives and results of the study, three conclusions can be drawn. First, the results of the needs analysis with an average of 69.4 are in the good enough category. This shows that students' creative thinking skills and science process skills are still low. Second, the validity of static fluid electronic teaching materials integrated with the STEM approach with an average value of 84.1 is in the very good category. The excellent validity of the e-module can be interpreted that the e-module developed has been tested by experts and can proceed to the practicality test stage for students. Third, the practicality value of using static fluid electronic teaching materials integrated with the STEM approach with an average value of 93 is in the very good category. The excellent practicality of e-modules means that e-modules provide benefits and convenience for students in learning. The implication of the results of this study is that teachers must provide learning motivation, guide, and direct students in constructing or building student skills through ICT-based electronic modules by integrating the STEM learning approach.

REFERENCES

Ahmed, S. D., & Taha, F. K. A. (2021). Analysis of the Chemistry Book for the Third Grade Medium on the Skills of the 21st Century. *Turkish Journal of Computer and Mathematics Education*, 12(6), 1237-1246.

Alfitriyani, N., Purwitasari, I. D., & Kurniasih, S. (2020). Profile of Students' Critical and Creative Thinking Skills. *Proceedings of the 5th Asian Education Symposium*, 566(3), 120-128.

Amrul, F., Mayasari, T., & Kurniadi, E. (2019). Development of STEM Physics Module Integrated with Local Wisdom "Beduk" to Improve Creative Thinking Ability of Junior High School Students. *Journal of Physics Education Scientific Periodical*, 7(1), 1-10,

Armandita, P., Wijayanto, E., Rofiatus, L., & Susanti, A. (2017). Analysis of Creative Thinking Ability in Physics Learning in Class XI MIPA 3 SMANegeri 11 Jambi City. *Journal of Education Science Research*, 10(2).

Asrizal, Yunerti, E. A., Usman, A. (2022). ICT Thematic Science Teaching Material With 5E Learning Cycle Model to Develop Students' 21ST-Country Skills. *Indonesian Journal of Science Education*, 11(1), 61-72.

Asrizal, Amran, A., Ananda, A., Festiyed, F., & Sumarmin, R. (2018). Development of Integrated Science Instructional Materials to Improve Students' Digital Age Literacy in Scientific Approach. *Indonesian Journal of Science Education*, 7(4), 442-450.

Ayuningtyas, P., Soegimin, W. W., & Supardi, I. Development of Learning Tools to Train Students' Science Process Skills on Static Fluid Material. *Surabaya State University Postgraduate Science Education Journal*. 4(2),

Cahyani, A. E. M., Mayasari, T., & Sasano, M. (2020). Effectiveness of STEM-Integrated Project-Based Learning E-Modules on Creativity of SMK Students. *Scientific Journal of Physics Education*, 4(3), 15-22.

Chalkiadaki, A. (2018). A systematic Literature Review of 21st Century Skills and Competencies in Primary Education. *International Journal of Instruction,* 11(3), 1-16.

Cheng, L., Antonenko, P., Dawsom, K., Miller, D. (2020). Exploring the Influence of Teachers Beliefs and 3D Printing Integrated STEM Instruction on Students STEM Motivation. *Elsevier*, 3(1), 7.

Das, K. (2019). The Role and Impact of ICT In Improving the Quality of Education: An Overview. *International Journal of Innovative Studies in Sociology and Humanities*, 4(6), 97-103.

Festiyed, Desnita, Afradisca, E, Sari, L. P. (2020). Availability of Learning Resources for Enrichment Learning at Senior High School in West Sumatra. *Journal of Physics: Conference Series*, 1481, 2.

Greenstein, L. (2012). *Assessing 21st Century Skills. A Guide to Evaluating Mastery and*

Authentic Learning. California: SAGE Company

Hershey. (2019). *Multicultural Instructional Design: Concepts, Methodologies, Tools, and Aplications*. United State of America: IGI Global.

Hoir, S., Subandowo, M., & Wiyarno, Y. (2019). Improve Your English Through The 21st Century Skills. *Journal of Educational Technology Studies*, 4(1), 38-48.

Kertiasa, N. (1997). *Physics 1*, Jakarta: Balai Pustaka.

Kosasih. (2021). *Teaching Material Development*, Jakarta: Bumi Aksara.

Maharani, A., Asrizal, Festiyed, & Afrizon, R. (2022). Validity of STEM Integrated Static Fluid Improve Students' Learning Outcomes. *Journal of Pillar of Physics Education*, 15(1), 74-83.

Mahjatia, N., Susilowati, E., & Miriam, S. (2020). Development of STEM-Based LKPD to Train Students' Science Process Skills through Guided Inquiry. *Scientific Journal of Physics Education*, 4(3), 139-150.

Mufit, F., Hidayati, H., & Afrizon, R. (2021). 'Design and Validity of Cognitive Conflict-Based Interactive Multimedia on Vector Materials for Class X SMA/MA. *Journal of Physics Learning Research*, 12(2), 182-195.

Mutohhari, F., Sutiman, S., Nurtanto, M. (2021). Difficulties in Implementing 21st Century Skills Competence in Vocational Education Learning. *International Journal of Evaluation and Research in Education*, 10(4), 1229-1236.

Nugraha, A. (2005). *Science Learning Development in Early Childhood*. Jakarta: Department of National Education.

Permanasari, Anna. (2016). STEM Education: Innovation in Science Learning. *Proceedings of the National Seminar on Science Education*, 2(2).

Proud, K., & Potter, L. (2020). Integrating 21st Century Skills in a CTE Setting. *International Journal of Education and Social Science*, 7(1), 42-57.

Riduwan. (2019). *Learning Easy Research for Teachers-Workers and Research Beginners*. Bandung: Alfabeta.

Rizaldi, D. R., Nurhayati, E., & Fatimah, Z. (2020). The Correlation of Digital Literation and STEM Integration to Improve Indonesian Students' Skills in 21st Century. *International Journal of Asian Education*, 1(2), 73-80.

Rizaldi, R., Syahwin., & Ramadani. (2022). Effectiveness of E-Modules of Physics Practicum Based on Problem Based Learning Model Using Smart Apps Creator on Science Process Skills of SMA/MA Students. *Journal of Mathematics and Natural Sciences Education*, 12(3)

Saleh, N., & Puteh, S., (2017). A Review of the 21st Century Skills in Technical Vocational Education and Training (TVET). *Advanced Science Letters*, 23, 2, 1225-1228.

Saxena, N. (2017). The Role and Impact of ICT in Improving the Quality of Education: An Overview. *International Journal of Engineering Sciences & Research Technology*, 6(3), 501-503.

Semilarski, H., Soobard, R., & Rannikmäe, M. (2021). Promoting Students' Perceived Self-Efficacy Towards 21st Century Skills Through Everyday Life-Related Scenarios. *Education Sciences*, 11(10), 1-18.

Shernoff, D. J., Sinha, S., Bressler, D. M., & Ginsburg, L. (2017). Assessing Teacher Education and Professional Development Needs for the Implementation of Integrated Approaches to STEM Education. *International Journal of STEM Education*, 4(1), 1-16.

Sibille, K., Greene, A., & Bush, J.P. (2010). Preparing Physicians for the 21st Century: Targeting Communication Skills and the Promotion of Health Behavior Change. *Annals of Behavioral Science and Medical Education*, 16(1), 7-13.

Sugiyono. (2012). *Quantitative, Qualitative and R&D Research Methods*, Bandung: Alfabeta.

Sulaeman, N. F., Putra, P. D., Mineta, I., Hakamada, H., Takahashi, M., Ide, Y., & Kumano, Y. (2020). Engaging STEM Education for High School Students in Japan: Exploration of Perception to Engineer Profession. *Journal of Science Research and Learning*, 6(2), 189-205.

Supriyono, S., & Prabowo, J. (2021, April). The Transformation of 21st Century Learning Assessment in Courses of Curriculum 2013. *English Language and Literature International Conference (ELLiC) Proceedings*, 3(5), 215-222.

Suwasono, P. (2011). Efforts to Improve the Science Process Skills of Physics Students Class Of 2010/2011 Offering M Class G Through the Application of Physics Learning Guided Inquiry Model. *Journal of Physics and Its Learning*, 15(1).

Tindowen, D. J. C., Bassig, J. M., & Cagurangan, J. A. (2017). Twenty-First-Century skills of alternative learning system learners. *Sage Open*, 7(3).

Trianto. (2012). *Designing Progressive Innovative Learning Models*. Jakarta: Kencana Prenada Media Group.

Trilling, B., & Fadel, C. (2012). *21st Century Skills: Learning for Life in Our Times*. San Francisco: Calif.

Ugwu, N. P., & Nnaekwe, K. (2019). The Concept and Application of ICT to Teaching Process. *International Research Journal of Mathematics, Engineering and IT*, 6(2), 10-22.

Usman, E. A., & Asrizal, A. (2020). Results of Validity and Practicality Test of ICT-Science Learning Material with Learning Cycle Model for Improving Digital Literacy of Students. *International Journal of Progressive Sciences and Technologies*, 23(2), 580-588.

Wahidah, N. I., Sakung, N. T., Festiana, I., Rikarda, W. A., & Kamarudin, A. (2021). Analysis of Needs in the Development of Website-Based E-Modules for Self-Study. *International Journal of Education, Information Technology and Others*, 4(4).

Wang, Y., Lavonen, J., & Tirri, K. (2018). Aims for Learning 21st Century Competencies in National Primary Science Curricula in China and Finland. *EURASIA Journal of Mathematics, Science and Technology Education*, 14(6), 2081-2095.

Wulandari, S. P., Budiyono, B., & Slamet, I. (2016). The Development of Learning Module with Discovery Learning Approach in Material of Limit Algebra Functions. *Proceeding of ICMSE*, 3(1), 165-166.

Yustina, Mahadi, I., & Ariska, D. (2021). The Effect of E-Learning Based on the Problem-Based Learning Model on Students' Creative Thinking Skills During the Covid-19 Pandemic. *International Journal of Instruction*, 15(2), 329-348.

Zafar, S. M. T. (2019). Role of Information Communication Technology (ICT) in Education and Its Relative Impact. *International Journal of Engineering Research & Technology (IJERT)*, 7(04), 1-10.

Zubaidah, S. (2016). 21st Century Skills: Skills that are Taught Through Learning. *National Seminar on Education*, 2, 1-17.