

**ICT THEMATIC SCIENCE TEACHING MATERIAL  
WITH 5E LEARNING CYCLE MODEL TO DEVELOP  
STUDENTS' 21ST-CENTURY SKILLS****Asrizal\*<sup>1</sup>, Yurnetti<sup>2</sup>, E. A. Usman<sup>3</sup>**<sup>1</sup>Physics Department, Faculty of Mathematics and Science, Universitas Negeri Padang, Indonesia<sup>2</sup>Science Education Department, Faculty of Mathematics and Science, Universitas Negeri Padang, Indonesia<sup>3</sup>Master of Physics Education Study Program, Postgraduate, Universitas Negeri Padang, Indonesia**DOI: 10.15294/jpii.v11i1.33764**Accepted: December 9<sup>th</sup> 2021. Approved: March 30<sup>th</sup> 2022. Published: March 31<sup>st</sup> 2022**ABSTRACT**

Twenty-first-century learning should develop students' 21st-century skills, including aspects of knowledge, attitudes, character, and 4C skills. These students' skills need to be widely developed in science learning to handle the challenges of this century. The preliminary study results indicate that integrating learning materials in science learning and students' 4C skills were low. Thematic science teaching materials integrated the 5E learning cycle model can solve the problem. The study aims to investigate the effect of thematic science teaching material integrated with the 5E on various aspects of students' 21st-century skills, including knowledge, attitudes, and 4C skills. The research method is quasi-experimental, and the design is a randomized control group posttest-only, which is suitable for determining the effect of a treatment on a dependent variable. The knowledge aspect is measured using a written test sheet in multiple-choice, the attitude aspect using an observation sheet, and the 4C skills aspect using a performance assessment sheet. Data were analyzed using a comparison test for the two sample groups and the Mann-Whitney U test. The data analysis state that the application of thematic science learning material integrated with the 5E has a positive effect on students' 21st-century skills, including aspects of knowledge, attitudes, and 4C skills: critical thinking skills, creative thinking skills, and communication skills. The study concludes that applying thematic science learning material integrated with the 5E learning cycle model effectively develops the three aspects of students' 21st-century skills.

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Keywords: 4C skills; 21st-century skills; learning cycle model; thematic

**INTRODUCTION**

The 21st-century requires every human being to have comprehensive abilities. They must use a balanced ability between knowledge, skills, attitudes, and values in their lives (Chalkiadaki, 2018; Schleicher, 2018; Wang et al., 2018). They must utilize and handle rapidly evolving information, computing, automation, and communications in everyday life. Human resources need to be well prepared to exist and compete globally. Science education is needed to prepare superior

human resources in the mastery of science, engineering, and technology.

The challenges of the 21st-century can be answered by education. 21st-century education needs to integrate knowledge, attitudes, skills, and mastery of information technology (Aabla, 2017; Malik, 2018; Afandi et al., 2019). The implementation of education must facilitate students to enter the era of globalization, anticipate the fast advancement of science and technology, and utilize information technology in various activities. For this reason, 21st-century education should produce human resources with comprehensive abilities to face various challenges and opportunities in this 21st-century.

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The implementation of learning in the 21st-century must comprehensively integrate various students' abilities. Students need comprehensive knowledge, skills, and attitudes to think and act reasonably in their lives (Ang, 2018; Malik, 2018; Abaniel, 2021). Learning should facilitate students to use of information technology in constructing their abilities. In addition, learning should develop students' 21st-century skills. The 21st-century skills are a broad set of a person's abilities, including knowledge, skills, work habits, attitudes, characters to achieve success in study, everyday life, and the world of work (Tindowen et al., 2017; Hadinugrahaningsih et al., 2017; Luka & Seniut, 2019; Proud & Potter, 2020; Semilarski et al., 2021; Ahmed & Taha, 2021). A person needs these skills to solve problems, collaborate and communicate with others, acquire new information and skills, and adapt to rapidly changing conditions.

The basic principles of 21st-century learning emphasize activity and real-world context. On the principle of 21st-century learning, learning should be student-centered, carried out collaboratively, connected to real-world contexts, and integrated with people's lives (Wulandari et al., 2016; Asrizal et al., 2019; Supriyono & Prabowo, 2019). Learning should be student-centered. In learning, they are actively involved in constructing knowledge by identifying phenomena, solving problems, reading, finding information, investigating, and applying knowledge. Learning should be done collaboratively. Students are trained to cooperate in conducting investigations, solving problems, and doing assignments. Learning should have a real-world context. Teachers motivate students to apply everything they have learned in the classroom to real-world situations they encounter in their daily lives. Learning materials should be related to people's lives. The reason is that science learning materials are widely found and applied in people's lives. Therefore, students need to be trained to relate and apply science learning materials to people's lives to solve problems, increase added value, and provide reinforcement.

Integrated science learning is relevant to 21st-century learning. Science events found in real life are generally in an integrated form. For example, water, air, humans, and other living things can be viewed from various science sub-disciplines, including biology, physics, chemistry, and technology. With this basis, science learning starts from the real-world context. Students are trained in learning to connect science learning materials with real-world contexts. In science learning, students are actively involved in iden-

tifying the context of science in everyday life, formulating problems, formulating hypotheses, conducting investigations, applying knowledge, and transferring it to other fields of science. Thus, the application of integrated science learning is active, authentic, holistic, and meaningful (Rahmania et al., 2017; Asrizal et al., 2018).

The factual field circumstances continue to deviate from the ideal. Evidence of this gap was obtained from the initial studies. Activities in the initial study include analysis of basic competence in science subjects, integration of learning materials in integrated science books, and 21st-century skills of students. From the analysis of the basic competencies of science subjects, it can be stated that the integration of the sub-disciplines of science is still low, with an average value of 58.33. The preliminary studies by other researchers state that science learning in schools was still carried out separately (Ardianto & Rubini, 2016; Wiyanto et al., 2017). The results of the analysis of the integration of learning materials in integrated science books can be grouped into the low category with an average value of 50.21. This analysis indicates that the integration of science learning materials is still low even though the title is already an integrated science book. The results of this analysis are relevant to the results of initial studies from other researchers (Rahmania et al., 2017; Sukariasih, 2017). On the other hand, from the analysis of student performance assessment, it can be stated that the 21st-century skills of students are still in the low category with an average score of 49.61. The research results strengthened the result of this analysis by Alfitriyani et al. (2021), which states that students' critical thinking and creative thinking skills are still in the low category.

Thematic science teaching materials can solve of this problem. Several researchers have researched thematic teaching materials combined with learning models, learning media, or local wisdom in schools. Thematic teaching materials using problem-based learning were carried out by Yuliana et al. (2018) and Syofyan et al. (2019), thematic teaching materials with a scientific approach by Sirait et al. (2019), thematic teaching materials based on interactive multimedia by Nuraripin and Jaja (2021), and thematic teaching materials based on wisdom local by Shofa et al. (2021). Several other researchers also conducted research using thematic models, such as Chumdari et al. (2018), Aisyah et al. (2019), and Hasi-buan et al. (2021). These studies still use thematic science teaching materials in printed form, apply them to elementary school students, measure student learning outcomes, and only improve critical thinking skills or creative thinking.

There are at least three differences between this study and other studies. These differences become the specification of science teaching materials applied to junior high school students. The specifications of thematic science teaching materials include using ICT in thematic science materials, integrating the 5E learning cycle model, and the main target for developing students' 21st-century skills. This research solution is important to provide alternative science learning during the COVID-19 pandemic, support 21st-century learning, and help implement integrated learning based on real-world contexts by applying ICT relevant to the industrial revolution 4.0.

Thematic science teaching materials are developed using a webbed or thematic model. A theme is identified and used in the webbed model to integrate content from sub-disciplines (Carroll & McCulloch, 2018). The webbed model is a pattern of integration using a theme to integrate and connect several interrelated sub-disciplines (Sukariasih, 2017; Mulyani et al., 2020). Thematic learning can be considered efficient because students are actively involved in learning in a coherent and holistic context, linking the concepts they learn to their environment and real-life examples (Twining et al., 2019). Learning in the thematic model is formed through a theme, and a theme is integrated into several sub-disciplines of science to strengthen students' knowledge and skills and create meaningful learning (Mukniah, 2020; Widiyana et al., 2020).

The importance of ICT in science learning to 21st-century education is unmeasurable. In science learning, it is used to handle data, communicate data, collect data, simulate experiments, and present information (Maharaj-Sharma & Sharma, 2017). Various application software is used in science learning, such as word processing, presentations and publications, databases, multimedia, web browsers, e-mail, and others (Salihi, 2015). The use of ICT in learning can create student-centered learning, encourage interaction between learning components, facilitate the acquisition of basic skills, arouse curiosity and enthusiasm for learning, change the learning environment, reach learning materials widely and efficiently (Saxena, 2017; Saravankumar, 2018; Das, 2019; Zafar, 2019). Therefore, ICT needs to be used in science learning to create active, interactive, and meaningful learning.

ICT to develop science teaching materials is well-known during the industrial revolution 4.0 and pandemic. ICT-based teaching materials are teaching materials that are compiled and designed using ICT tools to achieve student com-

petence (Arimbawa, 2013; Ugwu & Nnaekwe 2019; Usman & Asrizal, 2021). The advantages of ICT-based teaching materials: providing convenience in the learning process, encouraging activeness and interest in discussing learning materials, making it easier to assess learning progress, providing convenience in communicating using internet services, without regard for location or time, and making it easier to discuss and interact by using internet facilities.

The relevant 5E model integrates ICT-based thematic science teaching materials. The reason is that this learning model is a simple structured inquiry learning model and is based on a constructivist approach (Amwe, 2018). Another reason is that this learning model can encourage interactive learning and active student participation (Nurdini et al., 2021). The learning model consists of 5 phases: engage, explore, explain, elaborate, and evaluate. Each phase has a specific function and helps students formulate and understand scientific knowledge, attitudes, and skills (Lin et al., 2014; Ong et al., 2020; Grau et al., 2021). This learning model can facilitate students to understand scientific problems and phenomena, develop critical skills and scientific attitudes, improve learning achievement, provide opportunities for students to be directly involved in conducting scientific investigations (Qarareh, 2012; Faizin et al., 2018).

The 21st-century skills of students must be developed through thematic science teaching materials. These skills are needed by students in the face of rapid changes in this world. They must apply these skills to compete in this destructive era. The 21st-century skills are needed to deal with these changes and challenges. The Partnership for 21st-Century Skills (P21) identifies four learning skills in the 21st-century: critical thinking, creative thinking, collaboration, and communication (Rochmawati et al., 2020; Triana et al., 2020; Supena et al., 2021; Novitra et al., 2021). These four learning and innovation skills in the 21st-century are also known as 4C skills (Khan et al., 2019; Stehle & Burton, 2019; Selman & Jaedun, 2020; Suryandari et al., 2021; Indrawati, 2021; Purwasih et al., 2021; Songkram et al., 2021). Critical thinking skills are skills to think deeply from different perspectives to find valuable solutions. Creative skills help generate new ideas and new ways of doing things. Communication skills help communicate with others both orally and in writing. On the other hand, collaboration skills help participate in an activity together.

ICT-based thematic science teaching materials with the theme of motion by integrating the 5E model is the right solution to the problems encountered. Several advantages of the chosen solution support this. The first advantage is that ICT-based science teaching materials integrate the 5E model used during the current COVID-19 pandemic and support learning in the 4.0 revolution era.

The second advantage is that ICT-based science thematic teaching materials integrate the 5E model accessible on various smart devices anywhere and anytime. The third advantage is that ICT-based science teaching materials integrate the 5E model, which is more interesting because it contains images, videos, and animations. These thematic science teaching materials provide opportunities to develop students' various abilities.

Using ICT-based thematic science teaching materials integrated with the 5E model will improve students' 21st-century attitudes, knowledge, and skills. For this reason, it is necessary to research ICT-based thematic science teaching materials integrated with the 5E model. The study aims to investigate using ICT-based thematic science teaching materials to integrate the 5E learning cycle model on students' 21st-century skills, including knowledge, attitudes, and 4C skills. Investigating 4C skills includes critical thinking, creative thinking, and communication skills. The effect of the teaching materials in question is to positively influence the 21st-century skills of the target students of this study.

## METHODS

The research method is quasi-experimental research. Only a randomized posttest may be used to include this research design into the control group design. The design consisted of experimental and control groups (Johnson & Christensen, 2019). The experimental group used ICT-based science teaching materials to integrate the 5E learning cycle model, while the control group did not use it. At the end of the activity, both groups were given a posttest to determine the effect of using ICT-based science teaching materials integrated with the 5E model.

The quasi-experimental research stages carried out were the same as the experimental research stages by not controlling all variables tightly. The first stage is conducting a literature survey related to the problem: science teaching materials, ICT use, cycle learning model, and

21st-century skills. The stage was followed by identifying and analyzing problems in science learning by conducting a preliminary study. The third stage is formulating the research hypotheses to estimate the effect of integrated thematic science teaching materials on the cycle learning model on students' abilities. The next stage is constructing a research plan with the experimental group design and the control group, posttest only. The last stage is, experimenting by providing integrated thematic science teaching materials with cycle learning models in the experimental group, while the control group did not. Sixth, processing raw data from instruments into data in the form of values. Seventh, applying statistical tests according to the characteristics of the students' 21st-century knowledge, attitudes, and 4C skills.

The research population is the students of SMPN 8 Padang. The sample was determined using random cluster sampling from two classes with the same ability. This research was conducted on the experimental group and the control group. There were 29 students in experimental group, and 28 in control group. The comparison test was carried out in both groups before providing thematic learning material. This test aims to determine the initial ability of the two groups. The mean value of the experimental group was 60.69, while the control group was 61.07. The data on learning outcomes from sample groups has a normal distribution and the same variance. From the mean comparison test for the independent sample group, the value of  $t = 0.07$  was obtained. This test indicates that the initial abilities of both sample groups are the same.

The instrument for collecting data consists of three parts: a written test, an observation sheet, and a performance assessment sheet. The students' knowledge is measured using a written test that relates to the concept of work, simple machines, and their application in daily life and the work of human skeletal muscles. The written test used 25 objective questions as a posttest in the two sample groups. The type of question is multiple-choice with five options. The questions on the test have been tested to determine the questions that meet the criteria. The reliability and correlation coefficients of the posttest questions are 0.92 and 0.85, respectively. Questions are done online using Google Form. Observation sheets measure the aspect of students' attitudes that are used online. The indicators of students' attitudes observed in science learning include living up to religious teachings, discipline, responsibility, and self-confidence.

On the other hand, the performance assessment sheet is the instrument for measuring 4C skills. The data from the written test is already in the form of a value scale. On the other hand, the data from the attitude observation sheet and the performance assessment sheet with a Likert scale were converted into a value scale to analyze this data using statistics.

Three aspects of students' 4C skills are measured: critical thinking skills, creative thinking skills, and communication skills. Meanwhile, collaboration skills cannot be measured due to the COVID-19 condition. The indicators for assessing critical thinking skills consist of asking questions, looking for ways, answering questions, and looking for reasons. The indicators for assessing creative thinking skills include asking many questions, thinking in various ways, giving many answers, and giving various reasons. On the other hand, the indicators for assessing communication skills include vocabulary, voice intonation, facial expressions, and message delivery.

Research data from aspects of knowledge, attitudes, and skills were analyzed by either the comparison test of the mean of two independent sample groups or the Mann-Whitney U test. Before statistical tests, normality and homogeneity tests were conducted. For parametric statistics, the comparison test of the mean of two sample groups is employed for data with normal distribution and the same variance. Meanwhile, if the study has data without normal distribution or the same variance, the Mann-Whitney U test for non-parametric statistics is utilized.

## RESULTS AND DISCUSSION

The research results were obtained based on the research objectives. This study has three results: the effect of ICT-based thematic science teaching materials integrated with the 5E learning cycle model on aspects of knowledge, attitudes, and skills. The aspects of skills investigated in the research are the 4C learning skills, including critical thinking skills, creative thinking skills, and communication skills.

The first results of the study relate to aspects of students' attitudes. Using attitude observation sheets, data on students' attitudes were collected during the learning process. The following are attitude indicators: respecting and living up to religious teachings, discipline, responsibility, courtesy, and self-confidence. The average value for attitude indicators is in Figure 1.

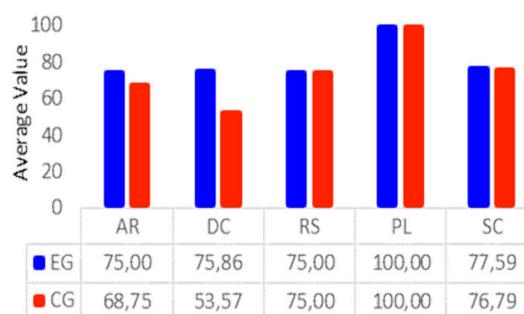


Figure 1. The Value of Students' Attitudes Indicators

According to Figure 1, the experimental group's average value of all indicators is greater than the control group's. It indicates that ICT-based science teaching materials integrated with the 5E model can influence students' attitudes. The parametric statistics value of attitude competence is in Table 1.

Table 1. The Parametric Statistics Value of Attitude

Parameter	Experiment Group	Control Group
Mean (average)	80.69	74.82
Median	80.00	70.00
Mode	80.00	70.00
Minimum	75.00	65.00
Maximum	90.00	90.00
Range	15.00	25.00
Variance (S <sup>2</sup> )	24.51	62.00
Standard deviation (S)	4.95	7.87
Normality test	0.21	0.27
Homogeneity test	2.53	
Mann-Whitney U Test	-2.90	

Based on Table 1, the experimental group's ability score in attitude is greater than the control group's. The experimental and control groups' average values were 80.69 and 74.82, respectively. Several other descriptive statistical parameter values are presented in Table 1. Descriptive statistics of student attitude data in the group using ICT-based thematic science teaching materials integrated with the 5E model are higher than the control group score.

Attitude data of experimental and control group students were tested for normality and homogeneity tests. Using a significant level of 0.05, the normality test value in sample groups was greater than the reference value. This shows that the data obtained from the experimental and control groups' observation sheets are not normally distributed. The F test was used to determine homogeneity. The F test resulted in a greater value than the reference value, indicating that the experimental and control groups' data on attitude competence are neither homogenous nor have the same variance.

Mann-Whitney U test was conducted to determine the effect of ICT-based thematic science teaching materials integrated with the 5E model on attitude competence. The Mann-Whitney U test was performed because the data were not normally distributed. With a significance level of 0.05, the Mann-Whitney U test analysis of sample groups obtained  $Z_C = -2.90$  and  $Z_T = -1.96$ .  $Z_C$  value is not in the range of acceptability of the null hypothesis, accepting the working hypothesis. So, it is possible to conclude that there is a considerable difference in attitude competence between

the group that used ICT-based thematic science teaching materials integrated with the 5E model and the group that did not use it. From these results, it can be said that the use of ICT-based science teaching materials integrated with the 5E model significantly affects students' attitudes at SMPN 8 Padang. Thus, using ICT-based science teaching materials integrated with the 5E model has a significant effect on the attitude aspect at the 5% significance level.

The second results of the study relate to aspects of students' knowledge. The experimental group used ICT-based thematic science teaching materials integrated with the 5E model as learning support material in the learning process, while the control group used teaching materials commonly used in schools. After using ICT-based thematic science teaching materials integrated with the 5E model, the same posttest was administered to both the experimental and control groups. The posttest results from both groups were examined using the relevant statistics. The parametric statistics value of the two sample groups is in Table 2.

**Table 2.** The Parametric Statistics Value of Knowledge

Parameter	Experiment Group	Control Group
Mean (average)	80.14	77.00
Median	80.00	76.00
Mode	84.00	72.00
Minimum	64.00	60.00
Maximum	96.00	96.00
Range	32.00	36.00
Variance ( $S^2$ )	79.41	108.59
Standard Deviation (S)	8.91	10.42
Normality test	0.09	0.15
Homogeneity test		1.37
t- test		3.30

According to Figure 2, the experimental group's knowledge competence value is greater than the control group's. The scores for each group were 80.14 and 77.00. Several other descriptive statistical parameter values are in Table 2. Descriptive statistics of student knowledge data in the group using ICT-based thematic science teaching materials integrated with the 5E model are higher than the control group score.

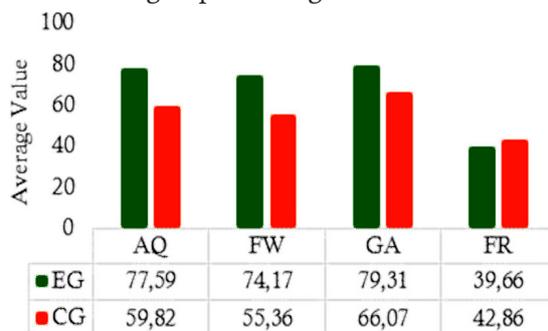
Knowledge data of experimental and control groups were tested for normality and homogeneity. Using a significant level of 0.05, the nor-

mality test value in both groups was lower than the reference value. This shows that the data obtained from the experimental and control groups' observation sheets are normally distributed. The F test was used to determine homogeneity. The F test resulted in a lower value than the reference value, indicating that the experimental and control groups' data on knowledge competence are homogenous and have the same variance.

A t-test was conducted because the data in the experimental and control groups were normally distributed. With a significance level of

0.05, the results of the t-test analysis showed the value of  $t_c = 3.30$  and  $t_t = 1.96$ . The t value is not in the range of acceptability of the null hypothesis, accepting the working hypothesis. So, it is possible to conclude that there is a considerable difference in knowledge competence between the group that used ICT-based thematic science teaching materials integrated with the 5E model and the group that did not use it. From these results, using ICT-based science teaching materials integrated with the 5E model has a 5% significant effect on students' knowledge.

The critical thinking component has four assessment indicators. The indicators of this assessment are asking questions (AQ), looking for ways (FW), giving answers to questions (GA), and looking for reasons (FR). The analysis of critical thinking components for the experimental and control groups is in Figure 2.



**Figure 2.** The Value of Students' Critical Thinking Indicators

Figure 2 presents the value of the four critical thinking indicators for the experimental and control groups. The analysis results show that the experimental group's values are greater. However, there is still one indicator with a low value from the control group, which is the indicator of looking for reasons. Overall, the average values of the four critical thinking indicators for the experimental and control groups are 67.67 and 56.03. This indicates a difference in the values obtained after students use ICT-based science thematic teaching materials integrated with the 5E model. This can happen because of the integrated ICT-based thematic science teaching materials, and the 5E model trains students to solve problems in the real world. Students' critical thinking can emerge and be honed when faced with a problem.

The third result of the study relates to students' 4C skills. It was assessed using a performance assessment sheet on students' assignments related to 4C skills indicators: critical thinking, creative thinking, and communication skills. The creative thinking component has four assessment indicators. The assessment indicators are asking a lot of questions (ALQ), thinking in various ways

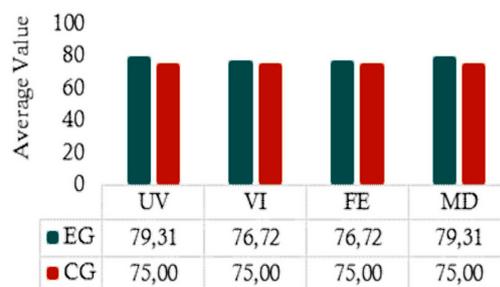
(PVW), giving a lot of answers (GLA), and giving a lot of reasons (GLR). The creativity component analysis results for two sample groups are in Figure 3.



**Figure 3.** The Value of Students' Creative Thinking Indicators

Figure 3 presents the values of the four indicators of creative thinking skills for the experimental group and control group. The analysis results show that experimental group's values are greater. However, the value of each indicator is still low. Three indicators still have low values: asking many questions, giving various ways, and giving many reasons. Students are still limited to giving only one question, method, and reason. It is expected that students can provide more than one question, method, and reason. This is what makes the three assessment indicators have low values. Nevertheless, the average values of the four indicators of creative thinking skills for the experimental and control groups are 40.52 and 35.94. This indicates a significant difference in the values obtained after using ICT-based thematic science teaching materials integrated with the 5E model. A person is creative if he can formulate new and unique ways and reasons.

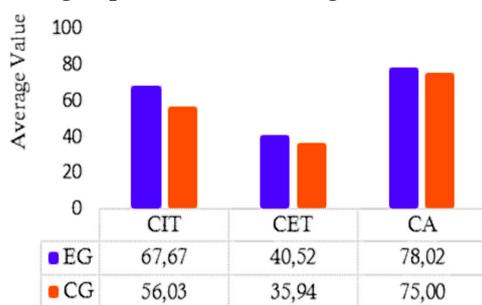
The communication skill component has four assessment indicators. The indicators of this assessment are the use of vocabulary (UV), voice intonation (VI), facial expressions (FE), and message delivery (MD). The results of the component analysis of communication skills for the experimental and control group is in Figure 4.



**Figure 4.** The Value of Students' Communication Skills Indicators

Figure 4 shows the values of the four indicators of communication skills for the experimental group and control group. The analysis results show that the experimental group's values of the four indicators are higher. Overall, the average values of the four indicators of communication skills for the experimental group and the control group are 78.02 and 75.00. This indicates a significant difference in the values obtained after students use ICT-based thematic science teaching materials integrated with the 5E model.

The 4C skills assessed are the three components used in the research: critical thinking, creative thinking, and communication skills. For a comparison of the three components based on the average value obtained from the experimental group and the control group, it can be seen in Figure 5.



**Figure 5.** The Average Value of the 4C Skills Component

Based on Figure 5, the 4C skills of students in the experimental and control groups are different. The results obtained of each component show that the values of the experimental group are higher than the value of the control group. The results of the 4C skills analysis of the control and experimental groups are in Table 3.

**Table 3.** The Parametric Statistics Value of the 4C Skills

Parameter	Experiment Group	Control Group
Mean (average)	62.07	55.65
Median	60.42	55.21
Mode	60.42	50.00
Minimum	47.92	45.83
Maximum	72.92	70.83
Range	25.00	25.00
Variance (S <sup>2</sup> )	33.29	32.42
Standard deviation (S)	5.77	5.69
Normality test	1.94	0.13
Homogeneity test	1.03	
Mann-Whitney U Test	-3.82	

Based on Table 3, the experimental group's 4C skills value is greater than the control group's. The values obtained for each group are 62.07 and 55.65. Several other descriptive statistical parameter values are in Table 3. Descriptive statistics of the 4C skills data of students in the group using ICT-based science teaching materials integrated with the 5E model is higher than the value in the control group.

Data on the 4C skills of experimental and control group students were tested for normality and homogeneity tests. Using a significant level of 0.05, the normality test results in the experimental group are greater, while it is lower than reference value in the control group. The control group's data is normally distributed, while the experimental group's data is not. F test was used to test homogeneity. The result of the F test is less than the value of the reference value. The data on students' skill values in the experimental and control groups are homogenous or have the same variance.

To determine the effect of ICT-based science teaching materials integrated with the 5E model on aspects of 21st-century skills, the Mann-Whitney U test was conducted. It was performed because the data were not normally distributed. With a significance level of 0.05, the test analysis got the value of  $Z_c = -3.82$  while  $Z_t = -1.96$ .  $Z_c$  value is not in the range of acceptability of the null hypothesis, accepting the working hypothesis. So, it is possible to conclude a considerable difference in the 4C skills between the group that used ICT-based science teaching materials integrated with the 5E model and the group that did not use it. Using ICT-based science teaching materials integrated with the 5E model significantly affects the students' 4C skills. Thus, the use of ICT-based thematic science teaching materials integrated with the 5E model significantly affects students' 4C skills at the 5% significance level.

The study results reveal that thematic science teaching materials could improve students' abilities in the aspect of knowledge. Increased knowledge can occur because students are actively involved in connecting learning materials with real-world contexts. In learning, students are actively involved in formulating problems, formulating hypotheses, conducting investigations, communicating the results of investigations, and applying knowledge. The thematic model provides opportunities for students to improve their mastery holistically and learn meaningfully (Pursitasari et al., 2020). Learning with the theme provides a meaningful experience and completes students' mastery of concepts (Amini et al., 2019). Using ICT and the learning cycle model in thematic science teaching materials encourages students' motivation and involvement in constructing knowledge to create meaningful

learning. Students' motivation and involvement in learning will affect students knowledge. Applying the 5E model strengthens learning outcomes in the aspect of students' knowledge (Rahmawati et al., 2021). The results are pertinent to research that states that thematic science teaching materials and thematic science modules significantly influence students' learning outcomes in the knowledge aspect (Handayani, 2018; Wardani et al., 2020; Pursitasari et al., 2020).

Using ICT-based thematic science teaching materials integrated with the 5E model can also develop students' 21st-century skills in critical thinking, creative thinking, and communication. This can happen because students are motivated to work on assignments in teaching materials based on real-world contexts and scientific processes that require students to think critically and creatively. Assignments in the form of discourse and scientific processes are well reported so that they can improve students' communication skills. Thematic science teaching materials can improve students' critical thinking and character (Pursitasari et al., 2015; Perwitasari & Djukri, 2018; Twiningsih et al., 2019). Using science teaching materials based on ICT in online science learning can encourage students to think critically, think creatively, and communicate actively. These results are relevant to the result of research by Indrawati (2021), which states that online learning has a positive effect on students' learning and innovation skills. This means that online learning positively affects students' critical thinking, creative thinking, collaborating, and communicating skills.

The results achieved show that using ICT-based thematic science teaching materials integrated with the 5E model effectively improves students' 21st-century skills, including aspects of students' knowledge, attitudes, and 4C skills. Science teachers, as an implication of the results, can apply ICT-based thematic science teaching materials integrated with the 5E model as an alternative learning resource in science learning in schools. Students can also apply the same material as a learning resource to help them build knowledge, attitudes, and 4C skills in science. Therefore, ICT-based thematic science teaching materials integrated with the 5E model are an alternate option in incorporating integrated science learning and developing of students' skills in the 21st-century.

Integrating science and the 5E model into teaching materials-based ICT has improved students' 21st-century skills. Students' skills can be improved in knowledge, attitudes, and 4C skills. The integration between the sub-disciplines of science and the 5E cycle learning model to deve-

lop students' 21st-century skills is the main characteristic of this science teaching material as a differentiator from other studies and as a finding of this study. Integration of the learning material in science can create active, authentic, and meaningful learning. This happens when science learning is based on real-world contexts in students' lives. This is reinforced by integrating the 5E learning cycle model, so that science teaching materials encourage students to construct their 21st-century skills through science learning. Thematic science teaching materials encourage students to explore, explain, and extend science learning materials to develop their 21st-century skills.

## CONCLUSION

From the data analysis and research results, conclusions can be drawn from this study. The research concludes that using ICT-based thematic science teaching materials integrated with the 5E learning cycle model significantly affects three aspects of students' 21st-century skills: knowledge, attitudes, and 4C skills. The influence of these science teaching materials on 4C skills includes critical thinking, creative thinking, and communication skills. This significant influence shows that ICT-based thematic science teaching integrated with the 5E model effectively develops 21st-century skills of junior high school students. The development of 21st-century skills can occur because, in this thematic science teaching material, students are motivated and actively involved in relating science learning materials to real-world contexts based on a theme, conducting a scientific investigation, writing investigative reports, and solving contextual problems to practice critical thinking creative thinking skills. As an implication of the results of this study, science teachers must motivate, direct, and guide students to construct their 21st-century skills through ICT-based thematic science teaching material by integrating the 5E learning cycle model.

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