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The influence of a STEM-based digital classroom learning model and high-order thinking skills on the 21st-century skills of elementary school students in Indonesia

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Abstract

The aim of the current research is to develop a STEM-based digital classroom learning model based on the 21st-century skills and characteristics of elementary school students. To enable the dissemination of this learning model, further research is needed to determine the effect of the STEM-based digital classroom learning model on the 21st century skills of elementary school students. The lack of 21st-century skills among elementary school students and the necessity for a study of the influence of higher-order thinking skills as one of the capabilities that primary school students must develop are contributing factors to this research. This advancement would lead to an understanding of how STEM and HOTS affect student's skills. This was experimental research with 100 fourth-grade students. The data analysis methods employed by SPSS included two-way ANOVA tests, homogeneity tests, normality tests and descriptive tests. The study's findings revealed that: (1) students who are taught with STEM-based digital and conventional learning models have different 21st-century skills, (2) students with high and low higher- order thinking skills have different 21st-century skills, and (3) students with high and low higher- order thinking skills who are taught with STEM-based digital and conventional learning models have a connection to 21st-century skills. Education professionals can use the implications of this research as a guide to develop 21st-century skills for elementary school students.

Keywords: 21st-century skills, Digital classroom, Learning model, STEM, HOTS.

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Contents

Contribution of this paper to the literature
This research is different from the others because the STEM-based digital class is a digital class that researchers have developed before and has never been developed by other researchers. In addition, this STEM-based digital class was developed to improve the 21st century skills of elementary school students. In addition, it is necessary to study the HOTS of elementary school students on 21st century abilities that have never been studied before.

1. Introduction

There are several terms used to describe the twenty-first century. The 21st-century is also known as "the era of knowledge, the knowledge-based economy, globalization, the industrial revolution and other similar terms. The 21st-century is marked by several abrupt developments that affect many different areas, including technology, communication, information and so forth (Horoshko, Horoshko, Bilyuga, & Horoshko, 2021). The changes take place quickly. This sudden change can be used as an opportunity, if handled properly but if not, it can also be dangerous and even disastrous. For instance, one aspect of 21st-century development is in technology. Today's technological advancement cannot be stopped (Helsa & Kenedi, 2019). Technology use has the potential to be the community's primary tool for carrying out life processes but it also has the potential to be a disaster. In order to prepare for disasters that may occur in 21st century and to make the century a chance for community self-development, it is vital to get the community ready to learn 21st-century skills.

The term "21st-century skills" refers to abilities that society as a whole must possess (Silber-Varod, Eshet-Alkalai, & Geri, 2019). Critical thinking, collaboration, creative thinking, character education, citizenship and communication are among the 21st-century skills (Anugerahwati, 2019). The ability to grasp 21st-century abilities is crucial (Satori, Komariah, & Suryana, 2019). This is because the changes that take place now and in the future will result in a variety of complex issues that call for a variety of abilities to solve. Problems must be resolved by a process of critical and creative thought. Collaboration will also speed up the process of solving these issues. In addition, future success will depend on not only cognitive abilities but also on other abilities connected to affective and psychomotor growth. Therefore, affective and psychomotor skills like citizenship, character, and communication are also essential in the twenty-first century.
Everyone has to learn these 21st-century skills including elementary school students (Kenedi, Ahmad, Sofiyan, & Helsa, 2019). Elementary schools are the first formal institutions concerned with developing basic concepts and skills (Hamimah, Zuryanty, Kenedi, & Nelliarti, 2019). Teaching 21st-century skills to elementary school students is considered important because these fundamental concepts and skills are meant to support students' growth in secondary education. Furthermore, for primary school students to achieve the defined learning objectives more easily, they must develop 21st-century skills.

However, the initial ability test that the researchers conducted in five elementary schools revealed that the 21st century skills of elementary schools students were still lacking. The student's average score was 56.78 which place their level of proficiency in 21st-century skills in the low range. (Abualrob, 2019; Asrizal, Yurnetti, & Usman, 2022; Jannah, Prasojo, & Jerusalem, 2020; Perdana, Apriani, Richardo, Rochaendi, & Kusuma, 2021; Putra, Wiyanto, & Linuwih, 2020; Rochmawati, Wiyanto, & Ridlo, 2019). In order to enhance the 21st century skills of those students, this problems need to be handled as the primary school children have a significant role in future.

According to the researcher's analysis of the current issues and concluded that the reason for elementary school student's inadequate levels of 21st century skills is teachers' lack of precise use of the learning model. The advancement of technology is a characteristic of the twenty-first century. Students are impacted by this technology's development as well. Students in elementary schools are capable of using technology like computers, laptops and smartphones. This demonstrates how attitudes and behaviors around technology are changing in elementary schools right now. This is the solution to the issue. By connecting and improving technology-based learning processes, teachers must be able to adapt the educational process to the mindset and behavior of elementary school students. To provide elementary school students with the skills they need for the 21st century, teachers must create technology-based learning.

According to the researcher's research, one of the appropriate learning models for 21st-century learning is digital classroom learning (Hover & Wise, 2022; Kong et al., 2014; Phoon, Idris, & Nugrahani, 2021). Digital classroom is applied during 4.0 era (Ariani, Helsa, & Kenedi, 2020). Online learning takes place in a digital classroom. Virtual learning is provided by digital classroom learning. Students can access online education at any time and from any location. In this study, a digital classroom with a STEM (science, technology, engineering and mathematics) focus was created. Science, technology, engineering and mathematics are collectively referred to as "STEM". STEM was selected because it is a subject that is appropriate for 21st-century study (Hendri, Handika, Kenedi, & Ramadhani, 2021). Experts have approved the use of the digital classroom learning model based on STEM. The STEM-based digital classroom learning approach was created by taking into account both the characteristics of 21st-century learning and those of elementary school students. Therefore, the researchers state that the STEM-based digital classroom learning approach can help elementary school students develop their 21st-century skills.

In addition to the use of learning models, the ability of students to think critically has an impact on 21st-century skills. Higher-order thinking skills (HOTS) are one of the cognitive abilities connected to 21st-century skills (Fakhomah & Utami, 2019). One of the abilities that elementary school students need to master is HOTS (Rahayu, Ladamay, Wiyono, Susanti, & Purwito, 2021; Rintayati, Lukitasari, & Syawaludin, 2021; Vidergor, 2018). A higher-order thinking skill is called HOTS (Ahmad et al., 2017; Liu, Ma, Sun, Zhu, & Xu, 2021). It requires special cognitive processes to have this skill. The process of analyzing, assessing and creating is a component of the cognitive ability known as HOTS (Lu, Pang, & Shadiev, 2021; Lu., Yang, Shi, & Wang, 2021). Students must be able to analyze a problem to demonstrate their HOTS skills. The ability to comprehend the issue as a whole is necessary for this analysis process. Students must be able to identify several sorts of problem solutions after the analysis and determine which solution is the best that can be achieved. The best solution to the problem must then

be developed by the students. Higher-order thinking skills are used during the processes of analyzing, assessing and creating. Therefore, researchers focused that HOTS affect elementary school students' 21st-century skills.

Researchers seek how STEM-based digital classroom models and higher-order thinking skills affect primary school students' 21st-century skills in the light of these issues. Earlier studies on the impact of online learning on elementary school students' learning and middle school students learning were done by Yuelin, Yujie, and Xiaohui (2021). According to the study's findings, online education can raise the standard of learning. This study is distinct from the research that will be conducted to determine how the HOTS and STEM-based digital classroom model that has been designed have affected elementary school students' acquisition of 21st-century abilities. The following questions will be addressed in this study:

1. Do students using STEM-based digital classroom learning models and those who use traditional learning models differ in terms of their 21st-century skills?
2. Do students with high and low HOTS differ in terms of 21st-century skills?
3. Do students with high and low HOTS abilities that are taught using STEM-based digital classroom learning models and conventional learning models connect in terms of 21st-century skills?

These questions will be answered by this study.

2. Research Methodology

This study uses a 2x2 experimental design. The treatment of the learning model (A) is the first factor while HOTS (B) is the second.

Table 1. Experimental design for 21st-century skills.

Treatment variable / Attribute variables		Learning model (A)	
		STEM-based digital Classroom model (A1)	Conventional learning model (A2)
Learning motivation (B)	High (B1)	A1B1	A2B1
	Low (B2)	A1B2	A2B2

Annotation:
A1 = students who are taught with a STEM-based digital classroom learning model.
A2 = Students who are taught with conventional learning models.
B1 = Students who have high HOTS.
B2 =Students who have low HOTS.

From Table 1, it can be seen that the treatment by level 2 x 2 table consists of two main factors, namely the treatment of the learning model (A) and HOTS (B). These two factors were developed into derivative factors, namely students who use STEM-based digital classroom models with high learning motivation (A1B1), students who use STEM-based digital classroom models with low learning motivation (A1B2), students who use conventional learning models with high learning motivation (A2B1) and students who use conventional learning models with low learning motivation (A2B2).

The study's sample consists of 100 fourth grade elementary school students. The experimental class and the control class both had 50 students. The learning model and HOTS are the two independent factors in this study while 21st century skills are the dependent variable. A questionnaire is used to collect information on 21st century skills. There are 30 questions in the questionnaire. The outcomes of the tests are used to determine the HOTS category. Validity and variability were assessed for questionnaires and HOTS questions. The measurement findings demonstrate the validity and high dependability of each question. SPSS 26 (Statistical Package for the Social Sciences) assisted in the data analysis process. SPSS is a statistical data processing software or used for interactive or batch statistical analysis. Descriptive analysis, prerequisite test analysis (normality test and homogeneity test) and inferential analysis using two-way analysis of variance were all performed on the data analysis.

3. Results and Discussion

Data was gathered after treatment for both the control class and the experimental class. The measurements are then tabulated against the data. The following table displays the data tabulation results:

Table 2. Descriptive results of statistical data.

Descriptive statistics					
Class	**N**	**Minimum**	**Maximum**	**Mean**	**Std. deviation**
STEM-based digital classroom, high HOTS	25	90	97	93.72	2.777
STEM-based digital classroom, low HOTS	25	83	90	86.84	2.035
Conventional classroom, high HOTS	25	60	77	70.08	5.082
Conventional classroom, low HOTS	25	57	60	58.92	1.470
Valid N (listwise)	25				

Table 2 shows that the STEM-based digital classroom group with high HOTS has an average value of 93.72. The group of STEM-based digital classrooms with low HOTS has an average value of 86.84. The conventional classroom group with high HOTS has an average value of 70.08 while the conventional classroom group with low HOTS has an average value of 58.92.

The normality test was then conducted. The purpose of the normality test is to determine whether or not the four variables are regularly distributed. The sig value was greater than 0.05 following the Shapiro-Wilk and Kolmogorov-Smirnov tests. We can infer a normal distribution for the research data. The research data are normally distributed, allowing for the implementation of parametric statistical tests. The homogeneity test comes next. Based on the results of the SPSS test, it can be concluded that the variance is the same or homogeneous because the significance value (sig) based on the mean is 0.650 > 0.05.

The next stage is to do a two-way ANOVA analysis when the data have been declared normal and homogeneous. The following table displays the computation results:

Table 3. Results of two-way ANOVA test.

Tests of between-subjects effects					
Dependent variable: Twenty_first_century skills					
Source	**Type III sum of squares**	**df**	**Mean square**	**F**	**Sig.**
Corrected model	18763.710[a]	3	6254.570	628.021	0.000
Intercept	598921.210	1	598921.210	60137.683	0.000
Learning_model	16615.210	1	16615.210	1668.333	0.000
HOTS	2034.010	1	2034.010	204.235	0.000
Learning_model* HOTS	114.490	1	114.490	11.496	0.001
Error	956.080	96	9.959		
Total	618641.000	100			
Corrected total	19719.790	99			
a. R squared = 0.952 (Adjusted R squared = 0.950)					

Note: * is interaction between learning model and HOTS.
To respond to the formulated hypotheses, Table 3 is employed as the basis.

3.1. Measurement Results of Hypothesis 1

The next test is to determine whether students who are taught using conventional learning models versus those who use STEM-based digital classroom learning models differ in terms of their 21st-century skills. This is the research hypothesis:

Ho $_{(A)}$: Students who are taught using STEM-based digital classroom learning models and those who use conventional learning models have the same 21st-century skills.

H1 $_{(A)}$: Students who are taught using STEM-based digital classroom learning models and those who use conventional learning models have different 21st-century skills.

Table 3 shows that the learning model's significance of the P test results is equal to 0.00. Table 3 shows that H0 is rejected and H1 is accepted since the significance of the test results (Sig) is lower than the significance level ($0.00 < 0.05$). Meaning those children who are taught using STEM-based digital classroom learning models and those who use conventional learning models have different 21st-century skills.
The data can be viewed in the following table to support it.

Table 4. The average value of the two learning model classes.

Descriptive statistics					
Class	**N**	**Minimum**	**Maximum**	**Mean**	**Std. deviation**
STEM-based digital classroom	50	83	97	90.28	4.228
Conventional class	50	57	77	64.50	6.744
Valid N (listwise)	50				

Table 4 shows that the STEM-based digital classroom learning model class has a higher average value than the conventional class. This demonstrates that the STEM-based digital classroom learning model is successful in enhancing elementary school students' 21st-century skills.

3.2. Measurement Results of Hypothesis 2

The next measurement is to determine whether students with high and low HOTS differ in terms of 21st-century skills. The research hypothesis is Ho (a) and H1 (a). Table 3 shows that the significance of the P HOTS test results is equal to 0.00. H0 is rejected and H1 is accepted if the significance of the test results (Sig) is lower than the significance level ($0.00 < 0.05$), indicating that students with high and low HOTS have different 21st-century skills.

The data can be viewed in the following table to support it.

Table 5. The average value of the two HOTS classes.

Descriptive statistics					
Class	**N**	**Minimum**	**Maximum**	**Mean**	**Std. deviation**
High HOTS	50	60	97	81.90	12.609
Low HOTS	50	57	90	72.88	14.211
Valid N (listwise)	50				

Table 5 shows that students with high HOTS have a higher-class average value than students with low HOTS. This demonstrates that students with high HOTS are successful at enhancing elementary school children' 21st-century skills.

3.3. Measurement Results of Hypothesis 3

The next measurement will determine whether students with high and low HOTS abilities who are being taught using STEM-based digital classrooms and conventional learning models are connected in terms of 21st-century skills. Following is the research hypothesis:

H0 $_{(AB)}$: Students with high and low HOTS abilities who are taught using STEM-based digital classrooms and conventional learning models do not connect in terms of 21st-century skills.

H1 $_{(AB)}$: Students with high and low HOTS abilities who are taught using STEM-based digital classrooms and conventional learning models are connected in terms of 21st-century skills.

Table 3 shows that the significance of the interaction P test results equals 0.001. H0 is rejected and H1 is accepted, if the significance of the test results (Sig) is less than the significance level ($0.00 < 0.05$). In other words,

students with high and low HOTS abilities who are taught using STEM-based digital classrooms and conventional learning models are connected in terms of 21st-century skills. These results demonstrate that the learning model and students' HOTS have an influence on elementary school student's 21st-century skills.

4. Discussions

Students in elementary school have a significant role in the advancement of society. Elementary schools must be able to help students develop their fundamental knowledge and abilities so that they may use them in real-world situations and proceed to higher levels (Kenedi., Helsa, Ariani, Zainil, & Hendri, 2019). Today's elementary school students must acquire skills appropriate for the twenty-first century. This is because future elementary school students will encounter more difficult issues (Helsa, Kenedi, & Ariani, 2020). Solving this problem calls for the application of several different skills. They are referred to as 21st-century skills.

Critical thinking, collaboration, creative thinking, character education, citizenship, and communication are among the 21st-century skills (Afandi, Sajidan, Akhyar, & Suryani, 2019). Elementary school students need to be proficient in these six skills. The learning process can help one develop 21st-century skills. This suggests that teachers must be able to create a learning process that can help primary school students develop their 21st-century skills. As a result, a learning model has been created in earlier studies that are in line with the characteristics of elementary school students as well as the characteristics of 21st-century development. The learning model is a STEM-based. The digital classroom learning model is a STEM based that has been approved for use in developing 21st- century skills.

According to the study's findings, students who were educated using STEM-based digital classroom learning models and those who used more conventional learning models had different 21st-century skills. This demonstrates how the STEM-based digital classroom learning model is successful in enhancing elementary school students' 21st-century skills. Other studies support the findings of this one. Wei and Chou (2020) research indicates that the quality of learning is impacted by online learning. According to the study's findings, online learners' demonstrated greater learning performance and satisfaction compared to traditional learners. According to Dumford and Miller (2018) research findings, online learning can enhance student learning outcomes. According to the current study's findings, students who studied online achieved higher learning outcomes than those who took regular classes. According to research by Martin and Bolliger (2018), students' perspectives are impacted by online learning. According to Nambiar (2020), online learning influences learning satisfaction. The findings showed that online learning is appreciated by both teachers and students. Online learning has an impact on student learning satisfaction and learning results (Baber 2020). According to the findings, online learners have higher levels of learning achievement than traditional learners. It is clear from the findings of earlier studies that the quality of learning is impacted by the online learning process. Those studies focus on online courses only. However, this study provides different techniques for digital classes. The STEM method is the best strategy and aligns with 21st-century skills. Therefore, the findings of this study differ from others.

The STEM-based digital classroom learning model offers real-world STEM challenges. The purpose of presenting these issues is to help children in primary school. To solve these challenges, elementary school students must be able to think critically and creatively. This requires them to consider all possible solutions before selecting one. Elementary school students must be able to cooperate and respect one another to solve these difficulties. After working together to solve an issue, students must be able to effectively convey the solution. The development of primary school students' 21st-century skills is the result of this process.

The ability of HOTS is to incorporate cognitive processes in the analysis, assessment and creative processes. HOTS are special way of thinking. For a comprehensive understanding of the information, advanced thought processes are required. The findings of this study demonstrate that children with high and low HOTS have different levels of 21st-century skills. There are several studies that confirm these HOTS findings. According to Jensen, McDaniel, Woodard, and Kummer (2014) research, students' conceptual understanding is impacted by their HOTS abilities. . According to the study's findings, children with high HOTS comprehend new information more quickly. According to Nourdad, Masoudi, and Rahimali (2018), HOTS has an impact on students' reading skills. According to the current study's findings, students with high HOTS showed strong reading abilities. According to research by Putranta, Setiyatna, Choiriyah, and Dwandaru (2021), the HOTS capacity affects students' learning results. Children that possess the HOTS ability will experience successful learning outcomes. According to research by Alrawili, Osman, and Almuntasheri (2020), incorporating students' HOTS into the classroom process can enhance learning quality. According to the results, student engagement in HOTS learning process has increased. It is clear from the results that HOTS has an impact on student engagement, learning outcomes and critical and creative thinking skills. This study's findings show that students' HOTS have an impact on their 21st-century skills which is new.

According to research by Mulyanto, Gunarhadi, and Indriayu (2018), problem-based learning models and students' critical thinking abilities have an impact on learning outcomes. The problem-based learning model and critical thinking abilities both have an impact on the learning outcomes of students which leads to this connection. According to research by Priawasana, Degeng, Utaya, and Kuswandi (2020), there is a connection between students' development of critical thinking skills and the elaboration learning process. According to the results, interactions that come from mutual influences have an impact on both student accomplishment in critical thinking abilities and the elaboration learning model.

This relationship exists because both research-based learning and creative thinking abilities have an impact on learning outcomes. However, there are different findings in this study. In this study, it was found that there was a relationship between the learning model and students' HOTS in the 21st-century skills of elementary school students.

There is a connection made as a result of elements of the STEM-based digital classroom learning model that demand analytical, evaluative and practical skills from students. Students are assigned problems to solve in the digital classroom learning model. These issues call for both ordinary thinking and higher-order thinking. Additionally, in the STEM-based digital classroom model, students are challenged with identifying a range of

potential answers to issues and determining which ones may be improved upon to create new potential solutions. In the end, students must decide on and create a novel, creative solution to the problem. In order to facilitate communication and have an impact on 21st century skills in elementary school, STEM-based digital classroom models and HOTS are employed in this exploration process.

5. Conclusion

The study's findings showed that students who learn in a STEM-based digital classroom have different 21st century skills than those who learn in conventional learning models. The analyzed results show that the STEM-based digital classroom learning model class has a greater average value than the conventional class. This demonstrates how the STEM-based digital classroom learning model is effective in enhancing elementary school students' 21st-century skills. The results also demonstrate that students with high and low HOTS have different levels of 21st-century skills. The result shows that students with high HOTS have a higher-class average value than students with low HOTS. This demonstrates how effectively students with high HOTS levels may help children in elementary school develop their 21st-century skills. The results highlighted that students with high and low HOTS abilities who are taught using STEM-based digital classroom learning models and conventional learning models are connected in terms of 21st-century skills.

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