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Substitution, Augmentation, Modification and Redefinition (SAMR) Model to Improve Student's Critical Thinking Ability

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Abstract:

The use of technology in learning creates the need for applications and learning media that can improve students' critical thinking skills. The SAMR model (Substitution, Augmentation, Modification, and Redefinition), which offers teaching methods by integrating technology, can affect the learning process by improving students' critical thinking skills. This quantitative study used an experimental approach with a Posttest Only Control Design by dividing the sample into two groups (control and experimental classes) with cluster random sampling technique sampling on 54 students. The results of the post-test cognitive ability of the control class obtained an average value of 16.52, and in the experimental class, 19.63. Furthermore, the results of the post-test effective ability of the control class obtained an average value of 74.76 and in the experimental class of 84.07. This shows differences in students' critical thinking skills between students who use the SAMR model and those who do not use the SAMR model. In the results of the N-Gain analysis that has been carried out on the posttest value of the cognitive ability of the control class and the experimental class, the gain value of 0.33 is included in the medium criteria. While the N-Gain on the posttest value of the cognitive ability of the control class and the experimental class obtained a gain value of 0.19 which is included in the Low criteria. This study proves that the use of the SAMR model influences students' critical thinking skills, and the SAMR model has proven effective in improving students' critical thinking skills.

Keywords: *Critical Thinking Skills, SAMR Model, Technology.*

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Introduction

The ability to think critically is a skill that must be possessed and achieved in the 21st century (Lestari et al., 2020; Wibowo & Munadi, 2020). In the world of education, critical thinking skills are included in the cognitive abilities that are very important for students to have (Wibowo & Munadi, 2020). Critical thinking skills in the 21st century are aimed at achieving Higher Order Thinking Skills (Indriyana & Kuswandono, 2019).Bloom's taxonomy states that the purpose of education includes cognitive aspects, affective aspects, psychomotor aspects (AlMarwani, 2020).

Studies on critical thinking skills have been carried out byWibowo et al. (2018) which measures the level of critical thinking skills of students from 3 Vocational High Schools in Boyolali. This study resulted in the findings that students' abilities in the realm of analyzing, evaluating, and creating were still relatively low. While the research conducted by Wibowo & Munadi (2020) which examines HOTS (Higher Order Thinking Skills) in Vocational High School students referring to Bloom's taxonomy in the form of evaluation, analysis, and creation shows that the HOTS ability of Vocational High School students is still low. This is in line with the study Lestari et al. (2020) regarding the level of critical thinking skills of Vocational High School students, especially the technical skills program which shows that Vocational High School students tend to have low critical thinking skills. The factors that influence the low critical thinking skills of Vocational High School students include the quality of learning and support in learning. Meanwhile, Mahanal et al. (2019) conducted research on the effect of using the RICOSRE learning model (Reading, Identifying

a problem, Constructing the solution, Solving the problem, Reviewing the solution, and Extending the solution) on the critical thinking skills of students with different academic abilities. This study shows that there is a difference between the critical thinking ability of students whose learning is facilitated by RICOSRE and the critical thinking ability of students who take part in ordinary learning is influenced by the interaction between the learning model and students' academic abilities.

Developing students' critical thinking skills is a major goal of education worldwide (Indriyana & Kuswandono, 2019; Larsson, 2017; Song, 2016). Things that can be done to grow and improve students' critical thinking skills are by improving the methods or learning models used in the learning process (Lestari et al., 2020). In addition to more creative learning models or methods, the teaching materials or modules used also have the potential to improve critical thinking skills (Setiarini et al., 2016).

Halpern et al. (2012) in (Mahanal et al., 2019) states that students' critical thinking skills are abilities that need to be considered in learning because critical thinking skills play a major role in students' success in learning. Critical thinking skills can be taught explicitly. Teachers can apply student-centered learning models to help students develop students' critical thinking skills (Mahanal et al., 2019). In recent decades, various models have been developed to integrate technology into teaching and learning processes. The best known are: TIM (Arizona Technology Integration Matrix), ACOT2 (Apple Classrooms of Tomorrow-Today), TPACK (Technological Pedagogical Content Knowledge) and SAMR (Substitution Augmentation Modification Redefinition) (Crompton & Burke, 2020; Retana, 2021).

With the development of technology, the patterns and learning styles of students also change. The use of technology in learning makes the tendency of students to use technology which results in the need for applications and learning media in education to be further developed using this technology (Ismail et al., 2018). This can show that the learning process using technology is currently an interest and an urge in modern times (Izza & Rusydiyah, 2020). Information technology has now been widely used both in schools and universities (Nyayu et al., 2019) such as the integration of the use of computer technology, mobile devices, digital cameras, social media platforms and networks, software applications, the internet, and others. The integration of technology opens the way for students to experience teaching differently and challenges traditional methods in modern teaching and learning processes (Tang et al., 2020). In addition, the integration of technology in education improves the teaching skills of teachers and students' learning abilities. Students and teachers alike are encouraged to integrate new ways to make the learning process more collaborative and progressive (Binangbang, 2020).

The SAMR model offers a method to see how computer technology can affect teaching and learning processes (Izza & Rusydiyah, 2020). The SAMR model as the basis for integrating technology in improving students' critical thinking skills is considered an innovative way of teaching and learning. SAMR is a model in technology integration which consists of four activities, namely: Substitution, Augmentation, Modification and Redefinition (Aprinaldi et al., 2018).The SAMR model offers how technology learning can affect teaching and learning demonstrating the advancement of educational technology as technology develops (Binangbang, 2020).

In the SAMR model there are 4 stages that must be applied, namely: Substitution, Augmentation, Modification and Redefenition. according to Nyayu et al. (2019) explains the stages of the SAMR model including: 1) Substitution, technology is used as a substitute for equipment used without changing its function. For example a computer with word processing software such as Ms. Word functions to replace the writing process that usually uses a pen or paper; 2) Augmentation, technology is used as a substitute for equipment used by adding or improving functions. For example, using the same software using the available functions, such as a function to check spelling, even grammar; 3) Modification, technology makes it possible to change the way things work for the better. For example, by using the same computer, it is possible to connect to the internet. Using Google Docs allows working groups with remote partners to even improve what has been done; 4) Redefinition, at this level, technology allows the creation of ways of working that were never imagined before. For example, using the internet and better software can make the writing process easier by using multimedia applications.

A study on the SAMR model was conducted by Aprinaldi et al. (2018) about the integration of information technology in the vocational education system has an impact on the role of teachers and students which results in that the SAMR learning model is proven to be effectively applied by teachers in integrating information technology in learning that describes the cognitive level, namely Bloom's taxonomy model because both have the same level. In line with the study Nyayu et al. (2019) about the use of the SAMR model as technology integration which shows that the SAMR learning model is effectively applied by teachers in integrating information technology in learning. Meanwhile, Retana (2021) conducted a study on the development of a moderate approach that fills the gap between technology integration and executive education showing that the SAMR and TPACK models have been shown to enable reflection and integration of technology in various fields of education. With this model, the conceptualization of new teaching models in certain disciplines can enable the integration of technology in other academic fields.

The SAMR model helps educators (teachers) in providing an overview of the implementation of learning according to Bloom's taxonomy (Netolicka & Simonova, 2017). This model is a form of technology integration which is one way to turn technology into a mixed learning experience because it has become a necessity for educators who want to engage in student-centered learning in the 21st century (Binangbang, 2020). The SAMR model allows teachers to see how to integrate information technology in the classroom according to a model based on each stage of Substitution, Augmentation, Modification and Redefenition (Aprinaldi et al., 2018).

The impact of the Covid-19 pandemic has caused learning that was originally face-to-face learning to take place online and requires teachers to be able to explain the subject matter clearly as well as students who must be able to capture learning material and think critically about the subject matter received. Vocational High Schools are one of the institutions affected by online learning due to the Covid-19 pandemic, especially in Basic Programming subjects. Basic Programming subject is one of the mandatory lessons because it serves as a basis for understanding for students to understand other subjects, hone critical thinking skills, train logic, creativity and self-development (Mulyono & Agustin, 2020). The lack of students' critical thinking skills is marked by students' understanding of the material that is still lacking when an evaluation is carried out in Basic Programming learning using existing learning media and teaching materials. Efforts that can be made to improve students' critical thinking skills, one of which is by way of teachers providing subject matter with different models, such as using the SAMR model. Therefore, the authors want to know the effect of using the SAMR model on the critical thinking skills of Vocational High School students.

Research Method

This research is a quantitative research using experimental methods with Posttest Only Control Design which is one of the simplest methods but one of the most powerful of all experimental designs (Ary et al., 2010). According to Emmory, experimental research is used to determine what variables and how the relationship between one variable is with another variable (Jaedun, 2011). The experimental method aims to determine the effect of the treatment variable (independent variable) on the impact variable (dependent variable).

This research design uses a quasi-experimental where subjects are not assigned randomly (Ary et al., 2010). This research was conducted by dividing the sample into 2 groups. The first group is the control class which uses the usual learning model during the Covid-19 pandemic and the experimental class uses the SAMR model in the learning process. Both groups will be given a posttest in the form of test questions and questionnaires for later data analysis. This study uses a cluster random sampling technique in which the population used consists of groups not individuals. This technique is used to determine the sample if the object under study has a large data source (Ary et al., 2010). Therefore, researchers must do random on a large enough population so that the selection of the population is based on the group. Cluster random sampling was used on 54 students of class 10 Multimedia, BATIK 2 Vocational High School Surakarta.

Result and Analysis

The data in this study are posttest results in the control class and the experimental class to get differences in students' critical thinking skills in Basic Programming subjects using data types, variables, constants, operators, and expressions. The data of this research has been through normality test, homogeneity test, hypothesis testing and N-Gain analysis using the IBM Statistics 25 application. The results obtained from the two class samples are the posttest score of the essay questions and the posttest score of the questionnaire to determine whether there are differences in students' critical thinking abilities. between the control class using the regular online learning model and the experimental class using the SAMR model.

Furthermore, several statistical tests were carried out, including: normality test to measure whether the data obtained were normally distributed or not, homogeneity test to determine whether the initial state of the sample was homogeneous or not, T test (Independent Samples T Test) to test the hypothesis of this study, and N analysis. -gain to determine the difference between the results of the posttest control class and the experimental class. After testing the hypothesis, then a discussion is carried out with the results of the study as follows:

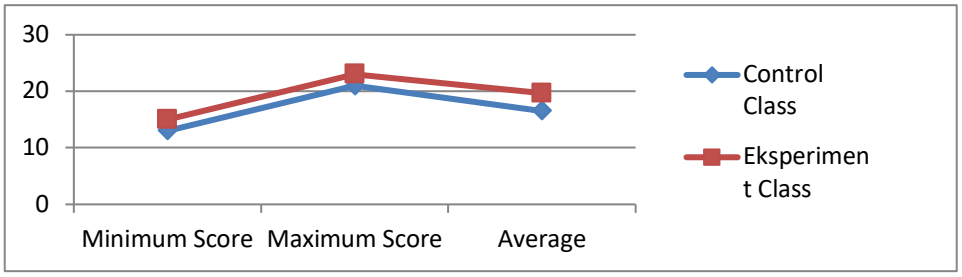
The results of the first hypothesis test can be seen in Table 1.

Table 1. Results of the First Hypothesis Testing Cognitive Ability

Posttest Control Class and Experiment Class	df	Sig.	Significance Level	Information
	52	0.000	-5.039	Ha accepted

The results of the hypothesis test in Table 1 show that Sig. <0.05, which means Ho is rejected and Ha is accepted. The value 0.000 which when this output data was moved from IBM Statistics 25 to Ms. Excel reads 0.00000231 or 2.31019879836863E-06 where this value is so small that the IBM Statistics 25 application reads 0.000. The results of the first hypothesis test show that there are differences in students' critical thinking skills between students who use the SAMR model and students who use the regular online learning model in Basic Programming subjects. Figure 1 shows the comparison of scores between the control class and the experimental class of cognitive abilities.

Figure 1. Comparison of Students' Cognitive Ability Posttest Scores



The results of the second hypothesis test can be seen in Table 2.

Table 2. Affective Ability Hypothesis Test

Posttest Control Class and Experiment Class	df	Sig.	Significance Level	Information
	52	0.003	-3,141	Ha accepted

The results of hypothesis testing in Table 2 show that Sig. <0.05, which means Ho is rejected and Ha is accepted with a Sig value. 0.003. The results of the second hypothesis test indicate that the use of the SAMR model is effective in improving students' critical thinking skills in the Basic Class Programming subject. Figure 2 shows the comparison of scores between the control class and the experimental class of affective abilities.

Figure 2. Comparison of Student Affective Ability Posttest Scores

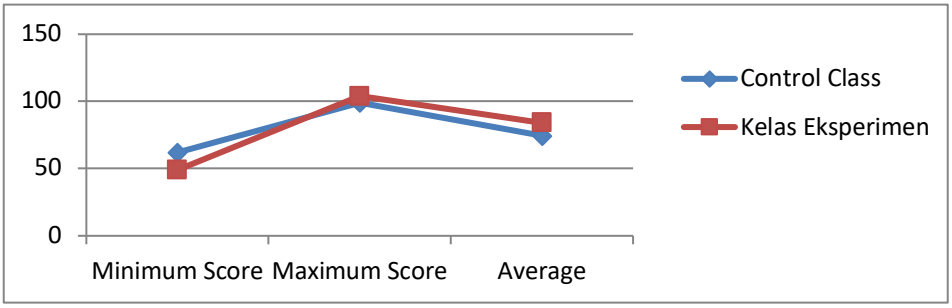


Table 3. Results of Posttest Questions on Students' Critical Thinking Ability

Information	Control Class	Experimen t Class
Number of Respondent	27	27
Average	16.52	19.63
Minimum Value	13	15
Maximum Value	21	23
Total Value	446	530

Based on Table 3, it can be seen that the posttest scores on the description of critical thinking skills of control class students on the use of data types, variables, constants, operators, and expressions have a minimum value of 13, a maximum value of 21 with an average of 16.52. Meanwhile, the posttest score for the experimental class students' cognitive abilities had a minimum score of 15, a maximum score of 23 with an average of 19.63.

Table 4. Results of the Posttest Questionnaire for Students' Critical Thinking Ability

Information	Control Class	Experiment Class
Number of Respondent	27	27
Average	74.46	84.07
Minimum Value	62	49
Maximum Value	99	104
Total Value	1787	2270

Based on Table 4. it can be seen that the posttest score of the critical thinking ability questionnaire for control class students on the use of data types, variables, constants, operators, and expressions has a minimum value of 62, a maximum value of 99 with an average of 74.46. While the posttest value of the experimental class students' cognitive abilities had a minimum score of 49, a maximum value of 104 with an average of 84.07.

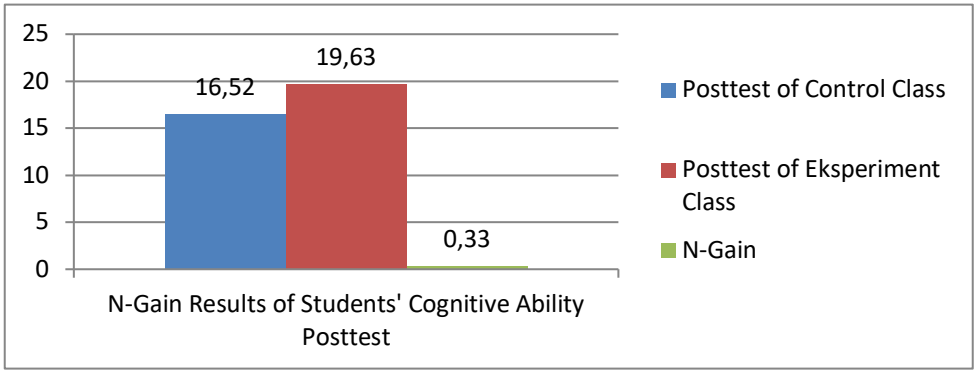
Next, the N-Gain analysis was carried out to determine the effectiveness of using the SAMR model. It can be analyzed by looking at the Gain value where Gain is the term for the difference in the values obtained. This difference in value will prove how effective the use of the SAMR model with ordinary online learning models is for critical thinking skills in Basic Programming subjects. The N-Gain analysis was carried out by calculating the difference between the posttest scores of the experimental class and the control class.

Table 5. Posttest N-Gain Test Questions on Cognitive Ability Description

Posttest Control Class	Posttest Experiment Class	Gain (g)	Criteria
16.52	19.63	0.33	Currently

In Table 5 the N-Gain between the posttest results of the control and experimental classes is 0.33 where the value is included in the moderate criteria with the value between 0.3 <g <0.7.

Figure 3. Posttest N-Gain Diagram of Control Class and Experimental Class Description Questions



In Figure 3, it can be seen that there are differences in the posttest results of the control class and the experimental class on the posttest of description questions or cognitive abilities which indicate that there is an increase in students' critical thinking skills in the experimental class using the SAMR model compared to the control class that does not use the SAMR model.

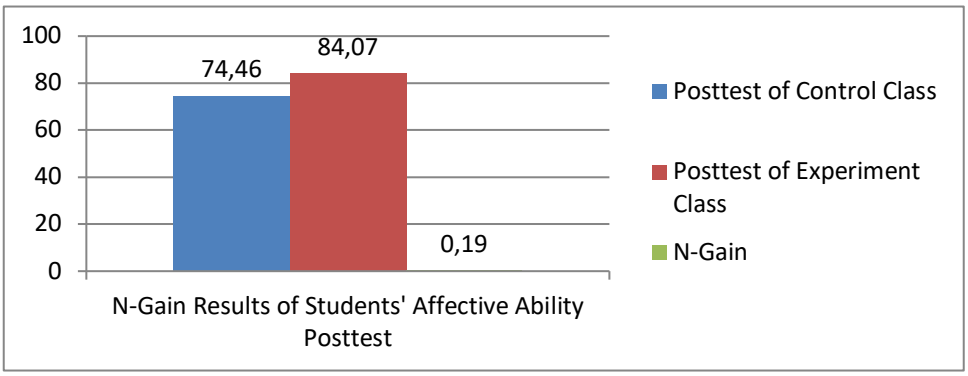
Furthermore, the N-Gain value for the posttest results of the control class and experimental class can be seen in Table 6.

Table 6. N-Gain Test Posttest Affective Ability Questionnaire

Posttest Control Class	Posttest Experiment Class	Gain (g)	Criteria
74.46	84.07	0.19	Low

In Table 6, the N-Gain between the posttest results of the control and experimental classes is 0.19, where this value is included in the low criteria with a g value of <0.3.

Figure 4. N-Gain Diagram of Posttest Values for Control Class and Experiment Class



In Figure 4. it can be seen that there are differences in the results of the posttest control class and the experimental class on the posttest questionnaire or affective ability which shows that there is an increase in students' critical thinking skills in the experimental class that uses the SAMR model compared to the control class that does not use the SAMR model.

After testing the hypothesis, then a discussion is carried out with the results of the study as follows:

There are differences in students' critical thinking skills between students who use the SAMR model and students who use the usual online learning model

The posttest result data was obtained after the students received treatment from the researcher. The treatment in the control class is to carry out regular online learning using the discovery learning model on the material using data types, variables, constants, operators, and expressions and in the learning experiment class with the SAMR model. Learning in the control class takes place by providing material by providing learning modules in WhatsApp groups such as the learning model usually applied by Basic Programming subject teachers, while learning in the experimental class uses Microsoft Teams and Replit (online IDE / Integrated Development Environment) applications. In accordance with the Crompton & Burke, (2020), Nyayu et al. (2019), and Retana (2021) which explains the stages of the SAMR model and technology integration where the learning process using technology is currently an interest and urgency in modern times (Izza & Rusydiyah, 2020). The first stage of SAMR starts from Substitution where modules and videos explain the use of data types, variables, constants, operators, and expressions in the Microsoft Teams class. In the second stage of Augmentation, the learning process takes place by utilizing the online IDE, namely Replit and introductions on how to use Replit to students. The third stage is Modification by maximizing the use of Replit when implementing the use of data types, variables, constants, operators, and expressions in simple programs. Furthermore, at the Redefinition stage, students are given the opportunity to redefine the material taught in the previous stage, which is to explain the structure of the simple program that has been made.

After the treatment was carried out in the control class and the experimental class, students were given essay test questions and questionnaires to determine the extent to which the SAMR model had an effect on students' critical thinking skills in both the control class and the experimental class. The description questions given are 6 questions and the questionnaire questions are 29 statement questions with a rating scale of 1-4 where each student can get a maximum score of 24 and a minimum score of 6 on the description questions, while in the questionnaire the maximum score is 116 and a minimum score of 29. the control class obtained data after the posttest of description questions with an average value of 16.52 while the experimental class obtained an average value of 19.63. While the posttest value of the questionnaire in the control class obtained an average value of 74, 46 and in the experimental class the average value obtained was 84.07. Furthermore, a prerequisite test is carried out, namely the normality test to find out whether the data is normally distributed or not. After the normality test was carried out, the results of the posttest normality test for the description of the control class obtained the value of Sig. of 0.200 and in the experimental class the value of Sig. obtained is 0.073 with the provisions of the value of Sig. > 0.05 then the data is normally distributed. In the results of the posttest normality test of the control class questionnaire, the value of Sig. of 0.193 where Sig. > 0.05 and in the experimental class the value of Sig. The obtained value is 0.111, which means that the data is normally distributed. Then the homogeneity test was conducted to determine whether the sample was taken from a homogeneous population or not. The results of the posttest homogeneity test of the description obtained the value of Sig. of 0.062 while the results of the description test obtained the value of Sig. of 0.225 provided that if the value of Sig. > 0.05 then the data is homogeneous. After going through the prerequisite test, then hypothesis testing was carried out on the posttest results of the description questions in the control and experimental classes, the Sig value was obtained. of 0.00000231. If the value of Sig. <0.05, it indicates that there is a difference in students' critical thinking skills between students who use the SAMR model and students who use ordinary online learning models in Basic Programming subjects where this is

in accordance with research conducted by then tested the hypothesis on the results of the posttest on the description of the control class and the experiment obtained the value of Sig. of 0.00000231. If the value of Sig. <0.05, it indicates that there is a difference in students' critical thinking skills between students who use the SAMR model and students who use ordinary online learning models in Basic Programming subjects where this is in accordance with research conducted by then tested the hypothesis on the results of the posttest on the description of the control class and the experiment obtained the value of Sig. of 0.00000231. If the value of Sig. <0.05, it indicates that there is a difference in students' critical thinking skills between students who use the SAMR model and students who use ordinary online learning models in Basic Programming subjects where this is in accordance with research conducted by Mahanal et al. (2019) which also shows that the learning model used can affect students' critical thinking skills..

The use of the SAMR model is effective in improving students' critical thinking skills

The results of hypothesis testing in Table 2 show that Sig. < 0.05 with a value of Sig. 0.003 which means that the use of the SAMR model is effective in improving students' critical thinking skills in Basic Programming subjects. An N-Gain analysis was conducted to determine the effectiveness of using the SAMR model. It can be analyzed by looking at the Gain value where Gain is the term for the difference in the values obtained. This difference in value will prove how effective the use of the SAMR model with ordinary online learning models is for critical thinking skills in Basic Programming subjects. The N-Gain analysis was carried out by calculating the difference in the posttest value of the description of the experimental class and the control class with a gain value of 0.33 where the value according to Hake (1998) included in the moderate criteria with values between $0.3 < g < 0.7$. In Figure 1 and Figure 2 it can be seen that there are differences in the results of the posttest control class and the experimental class in the posttest on descriptions or cognitive abilities which indicate that there is an increase in students' critical thinking skills in the experimental class using the SAMR model compared to the control class that does not use the SAMR model. This is in line with what was stated by Aprinaldi et al. (2018) about the integration of information technology in learning proved to be effectively applied by teachers in improving students' cognitive abilities.

Next, the N-Gain calculation was carried out for the posttest results of the control class and experimental class with a gain value of 0.19 where this value was included in the low criteria with a g value of <0.3. In Figure 4 it can be seen that there are differences in the posttest results of the questionnaire or affective abilities of the control class and the experimental class which shows that there is an increase in students' critical thinking skills in the experimental class using the SAMR model compared to the control class that does not use the SAMR model where this is in accordance with Lestari et al. (2020) and Setiarini et al., (2016) which suggests that students' critical thinking skills can be improved by improving the methods or learning models used..

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The use of the SAMR model is effective in improving student' critical thingking skills

The results of hypothesis testing in Table 2 show that Sig. < 0.05 with a value of Sig. 0.003 which means that the use of the SAMR model is effective in improving students' critical thinking skills in Basic Programming subjects. An N-Gain analysis was conducted to determine the effectiveness of using the SAMR model. It can be analyzed by looking at the Gain value where Gain is the term for the difference in the values obtained. This difference in value will prove how effective the use of the SAMR model with ordinary online learning models is for critical thinking skills in Basic Programming subjects. The N-Gain analysis was carried out by calculating the difference in the posttest value of the description of the experimental class and the control class with a gain value of 0.33 where the value according to Hake (1998) included in the moderate criteria with values between $0.3 < g < 0.7$. In Figure 1 and Figure 2 it can be seen that there are differences in the results of the posttest control class and the experimental class in the posttest on descriptions or cognitive abilities which indicate that there is an increase in students' critical thinking skills in the experimental class using the SAMR model compared to the control class that does not use the SAMR model. This is in line with what was stated by Aprinaldi et al. (2018) about the integration of information technology in learning proved to be effectively applied by teachers in improving students' cognitive abilities.

Next, the N-Gain calculation was carried out for the posttest results of the control class and experimental class with a gain value of 0.19 where this value was included in the low criteria with a g value of <0.3. In Figure 4 it can be seen that there are differences in the posttest results of the questionnaire or affective abilities of the control class and the experimental class which shows that there is an increase in students' critical thinking skills in the experimental class

using the SAMR model compared to the control class that does not use the SAMR model where this is in accordance with Lestari et al. (2020) and Setiarini et al., (2016) which suggests that students' critical thinking skills can be improved by improving the methods or learning models used.

Conclusion

Based on the results of the posttest on the description or cognitive ability of the control class, the average value was 16.52 and in the experimental class, the score was 19.63. Furthermore, the posttest results of the questionnaire or affective ability of the control class obtained an average value of 74.76 and the experimental class obtained a value of 84.07. This shows that there are differences in students' critical thinking skills between students who use the SAMR model and students who use the regular online learning model. In the results of the N-Gain analysis that has been carried out on the posttest value of the description of the control class and the experimental class, the gain value is 0.33 where the value is included in the Medium criteria. While the N-Gain on the posttest value of the control class questionnaire and the experimental class obtained a gain value of 0, 19 where this value is included in the Low criteria. N-Gain on the Medium and Low criteria shows that the use of the SAMR model is quite effective in improving students' critical thinking skills. Therefore, it can be concluded that the SAMR model has an effect on improving students' critical thinking skills in Basic Programming subjects.

Suggestion

Based on the research results obtained, there are several suggestions including: learning media in the online learning period is something that needs to be considered, especially cellphone memory and internet connections so that learning involving applications and stable internet connections can run well, material stabilization by subject teachers before applying the SAMR model so that the learning process at each stage of the SAMR model is well planned and the material delivered is right on target or in accordance with the application of technology and prepares students for learning before using the SAMR model related to mobile devices and a stable internet considering the involvement of several online applications that students need to access.

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