
The Influence of Using Module with Computational Thinking Unplugged Approaches and Module with Scientific Approaches Based on Student's Critical Thinking Ability Towards Cognitive Ability the Subject of Temperature and Heat Transfer

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Abstract

The purpose of this research was to determine (1) the difference effect between the use of module with an unplugged computational thinking approach and module with a scientific approach to students' cognitive abilities on the subject of temperature and heat transfer, (2) the differences effect of students' critical thinking abilities in the high and low category on students' cognitive abilities on the subject of temperature and heat transfer, (3) the interaction between the effect of using module with a computational thinking unplugged approach and module with a scientific approach and students' critical thinking skills on students' cognitive abilities on the subject of temperature and heat transfer. This research used a quasi-experimental method with a 2x2 factorial design. The population in this research were all students of the first semester of physics education at Universitas Sebelas Maret. Data collection techniques used are tests and questionnaires. Data were analyzed using a two-way ANOVA with different cell contents. The results of the study show that: (1) there is a difference in the effect between the use of module with a computational thinking unplugged approach and module with a scientific approach to students' cognitive abilities on the subject of temperature and heat transfer (2) there is a difference in the effect of students' critical thinking skills in the high and low categories on students' cognitive abilities on the subject of temperature and heat transfer, and (3) there is no interaction between the effect of using module with a computational approach thinking unplugged and module with a scientific approach and students' critical thinking skills on students' cognitive abilities on the subject of temperature and heat transfer.

Keywords – Computational thinking; Unplugged; Module.



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1. Introduction

Along with the development of the times, digital technology is so influential in people's lives both from the economic, social, and educational. Digital technology cannot be separated from education. The world of education which is responsible for the development of human resources must be able to adapt to the current developments. The 21st century is marked by various challenges and problems faced by humans such as social, economic, and individual problems (Bialik, 2015). Thus, educational institutions must be able to prepare their students with the various competencies needed to meet the competency demands in order to live better in the 21st century (Yasin, 2020: 1). The skills needed to face this era are called 21st century skills or 21st Century Skills (van Laar, 2020). These 21st century skills consist of four skills called the Four Cs, namely Creativity, Critical Thinking, Communication, and Collaboration (Bialik, 2015). The Four Cs are expected to be implemented in school, community, and country to prepare humans for the demands of 21st century.

Over time, computational thinking is added on the four Cs because computational thinking is considered an advanced skill that must be mastered by individuals to solve various problems (Haseski, 2018). Along with the development of digital technology, the relationship between computers and human life is getting closer. Computers have become vital device because they can help and influence a human life. According to (Wing, 2006) computational thinking is a problem-solving approach that uses the basic principles of computer science by reformulating seemingly difficult and complex problems into something that can be solved using the principles of reduction, cultivation, transformation, or simulation. Computational thinking involves solving problems using algorithms, abstractions, and critical thinking skills to solve problems (Yadav, 2017). Based on these definitions, computational thinking includes the ability to solve problems, understand computing, and understand human thought and behavior. This ability will encourage students to think critically in solving problems and understand the use of computers in learning.

Computational thinking can be said as a way of thinking to solve problems. Wing (2006:1) argues that computational thinking is a basic skill for every student that must be mastered by students when learning to read, write, and count. As a problem-solving method, computational thinking refers to aspects of computer science. However, along with the development of the times, the application of computational thinking is not limited to computer science, computational thinking can be applied to all disciplines (Bundy, 2007:1). Computational thinking does have an important role in the development of computer applications, but computational thinking can also be used to support problem-solving in all disciplines including the humanities, mathematics and natural sciences (Voogt, 2015). The importance of computational thinking in human life has encouraged many European countries and the United States to make efforts to include computational thinking in their curricula. United Kingdom implemented computational thinking in the primary and secondary school curriculum through the Computing at School (CAS) program, managed by Barefoot Computing. The main goal of including computational thinking in this curriculum is not to produce novice programmers and computer scientists, but to equip students with various computer science concepts which can be very useful for students in the future to deal with various problems in an interdisciplinary manner. Currently, the United States has also established institutions that focus on promoting the use of computational thinking, such as forming ISTE (International Society for Technology in Education) and CSTA (Computer Science Teacher Association).

There are various forms of computational thinking approaches proposed by researchers. According to Wing (2008) the computational thinking approach consists of solving problems, designing systems, understanding human behavior, automation, and abstraction. Computational thinking can be implemented using decomposition, generalization, algorithmic thinking, evaluation, and abstraction approaches (Israel-Fishelson, 2020). (Angeli, 2016) said that the computational thinking approach includes problem analysis, abstraction, communication, and

collaboration. In addition, (Weintrop, 2016) suggested that a computational thinking approach for math and science classes uses a taxonomy consisting of data practice, modeling and simulation practice, computational problem-solving practice, and systems thinking practice. Of the several forms of this approach, the approach put forward by ISTE and (Weintrop, 2016) has the advantage of being able to explain the application of computational thinking in science learning.

Much research has been done on the impact of applying computational thinking in learning. According to (Voogt, 2015) students who are in schools that apply the computational thinking curriculum know and understand more about the relationships between subjects and life inside and outside the classroom, so that the implementation of learning objectives will be achieved well because students enjoy and enthusiastic in every learning process. Computational thinking is a part of critical thinking that aims to solve problems, make decisions, and interact with the world (Kulles, 2022). Learning physics with computational thinking can improve students' critical thinking skills (Kawuri, 2019). Computational thinking skills are needed to support the application of STEM in the context of problem solving considering that the basis of computational thinking encourages students to think critically (Swaid, 2015). Computational thinking is proven to improve critical thinking skills because computational thinking involves solving problems using algorithms, abstractions, and critical thinking skills to solve problems (Yadav, 2017). (Ennis, 1993) suggests that the aspects of critical thinking skills used in learning activities include: defining and clarifying problems, assessing and processing information as good as solving problems and making conclusions. Of the three aspects of thinking ability, it is clear that filled with computational thinking skills. Thus, the results of this research further strengthen that computational thinking can improve students' critical thinking skills.

Based on the 2013 curriculum or the independent curriculum, physics learning is directed to use a scientific approach. According to (Sufairoh, 2016) learning with a scientific approach is designed in order to make students are

active in constructing concepts through scientific activities such as observing (identifying and finding problems), formulating problems, submitting hypotheses, collecting data with various techniques, analyzing data, drawing conclusions, and communicating the discovered concepts, laws, or principles. (Gracias, 2017) said that the scientific approach is effective in increasing students' critical thinking skills. Module with a scientific approach are effective in improving students' critical thinking skills (Nurhikmayati, 2019). According to (Jatmiko, 2016) learning with a scientific approach is more effective than ordinary learning. Thus, based on the results of this study it can be concluded that learning and module prepared using a scientific approach are proven to be able to improve students' critical thinking skills.

According to (Kawuri, 2019) learning physics which tends to be abstract or less contextual can result in students being less motivated to take part in learning. That's because students think there is no benefit to learning physics that can be used in everyday life. These problems can be used as material for consideration in carrying out learning activities. Teachers can present material based on contextual problems so that students can experience these problems directly based on their experiences in everyday life. Efforts that teachers can take to increase student involvement and make learning material look more contextual are modules. Module are essentially instructional packages that deal with a conceptual unit of subject matter that can provide teachers with opportunities to develop, evaluate, and use various media to optimize instruction for students on exact topics. It also emphasizes students' direct involvement with learning materials. The module will provide students with contextual and meaningful experiences so that their scientific literacy and thinking skills are increase (Mensan, 2020).

Based on the description above, it can be concluded that the use of module with an unplugged computational thinking approach and module with a scientific approach can be used as a solution to improve students' critical thinking skills. However, until now there has been no research between the two module

which one is more effective for improving critical thinking skills. Therefore, this research focuses on three objectives, namely knowing the presence or absence of: (1) the difference in effect between the use of module with a computational thinking unplugged approach and module with a scientific approach to students' cognitive abilities on the subject of temperature and heat, (2) differences in the effect between students' critical thinking skills in high and low categories on students' cognitive abilities on the subject of temperature and heat transfer, (3) the interaction between the effects of using module with an unplugged computational thinking approach and module with a scientific approach and students' critical thinking skills on students' cognitive abilities on the subject of temperature and heat transfer.

2. Method

This research was conducted by an quasi experimental method. This method was chosen because it is in accordance with the research objective, namely to find whether or not there is an effect of treatment on a situation by using statistical data analysis. This study involved an experimental class and a control class with the same initial state which was known based on the pre-test scores. The experimental class was given treatment in the form of using module with an unplugged computational thinking approach and module with a scientific approach while the control class was given treatment in the form of using module with a scientific approach.

The research design used in this study is a 2 x 2 factorial design with this cell frequency is not the same. In simple terms, the research design can be described in table 1.

Table 1. 2 x 2 Factorial Design

Module (A)	Critical Thinking Ability (B)	
	High(B ₁)	Low (B ₂)
With a Computational Thinking Unplugged Approach (A ₁)	A ₁ B ₁	A ₁ B ₂
With a Scientific Approach (A ₂)	A ₁ B ₂	A ₂ B ₂

The population in this study were all students of Physics Education FKIP Sebelas Maret University batch 2021. The research sample consisted of two classes, namely class A as the experimental class with 38 students and class B as the control class with 38 students. Sampling in this study was conducted using cluster random sampling technique. This is in accordance with the statement (Azwar, 2007) which states that sampling by cluster random sampling (cluster random sampling) performs randomization on groups, not on individual subjects.

Statistical tests were conducted to find out whether the two samples to be treated had the same initial conditions, derived from populations that were normally distributed and homogeneous. This statistical test was carried out before the study began. This is done as a condition to prove whether there are differences in the effect of using the module on critical thinking skills only because of differences in treatment, not because of differences in students' initial abilities. The normality test for both samples used the Lilliefors method with a significance level (α) of 5% while the homogeneity test used the Bartlett method with a significance level (α) of 5%. The t-test chosen was the two-tailed t-test with a significance level (α) of 5%.

The data collection technique in this study used a test and questionnaire technique. The test technique was used to determine the students' cognitive abilities and the questionnaire technique was used to determine the students' critical thinking skills. Before the questionnaire was given to students, the validity and reliability were first tested. Test the validity of the questionnaire using Aiken's V content validity coefficient. The reliability test of the questionnaire used the Cronbach's Alpha test. Before the test was given to the students, previously the test questions were tested to determine the discriminatory power of the questions, the level of difficulty of the questions, the effectiveness of the distractors, the validity and reliability of the test. To test the research hypothesis, two-way ANOVA was used. Before the data was tested with two-way ANOVA, the data were first tested for normality and homogeneity. Normality test is used to determine whether the sample comes from a population that is normally distributed or not. Homogeneity test is used to determine whether the variances of a number of populations are the same or not. In this study, the normality and homogeneity test used a significance level (α) of 5%. Hypothesis testing was carried out with Two Way Analysis

of Variance Test (ANOVA) with unequal cell frequencies, this was in accordance with the experimental design used, namely 2x2 factorial (Budiyono, 2004).

Table 2. Summary of Analysis of Variance of Two Paths of Dissimilar Cell Contents

Source Variance	JK	Df	RK	F _{obs}	F _α
A (Module)	JKA	p-1	RKA	F _a	F*
B (critical thinking ability)	JKB	q-1	RKB	F _b	F*
AB (interaction)	JKAB	(p-1)(q-1)	RKAB	F _{ab}	F*
error	JKG	N-pq	RKG	-	-
Total	JKT	N-1	-	-	-

If any hypothesis is rejected, then an ANOVA follow-up test is held with the Scheffe method to determine which independent variable has a better effect on the dependent variable.

3. Result and Discussion

There are two module used in this study, namely module with an unplugged computational thinking approach and module with a scientific approach. Module with a computational thinking unplugged approach use learning activities which include problem formulation, decomposition, pattern recognition, algorithms, simulation, abstraction, and generalization). Module with a scientific approach use activities in the form of: observing (identifying and finding problems), formulating problems, formulating hypotheses, collecting data, analyzing data, drawing conclusions and communicating the concepts or laws.

The results of the students' initial ability normality test showed that the control and experimental classes came from populations that were normally distributed (for the experimental class $L_{\text{observation}} = 0.078$ and for the control class $L_{\text{observation}} = 0.103$ with $L_{\text{table}} = 0.44$). Based on the calculations, it is obtained $\chi^2_{\text{count}} = 0.980 < \chi^2_{\text{table}} = \chi^2_{20.05;1} = 3.841$ so that it can be said that the two samples come from homogeneous populations. The results of the two-tailed t-test calculation show $-t_{\text{table}} < t_{\text{count}} < t_{\text{table}}$, namely $-1.992 < 0.227 < 1.992$. Thus, it

can be concluded that there is no difference in the initial state of the control and experimental classes.

The test results of cognitive instruments which include discriminating power, level of problem difficulty, distractor effectiveness, validity and reliability show that all aspects meet the requirements. For instrument reliability, the reliability coefficient value is 0.90, so it can be concluded that the learning outcome test has high reliability. The results of the calculation of the validity of the critical thinking ability questionnaire show that the value of V is between 0.75-0.86, this shows that the questionnaire instrument is valid. For the calculation of the reliability of the critical thinking ability questionnaire, it was obtained 0.74, this indicates that the questionnaire is in the proper category.

Data on students' critical thinking skills in the experimental class and control class are described below.

Table 3. Data on Critical Thinking Ability of Experiment Class and Control Class Students

Class	total students	Highest Score	Lowest Score	Average
Experiment	38	80,00	40,00	65,37
Control	38	80,00	48,00	61,68

The highest score for the ability to think critically in the two sample classes obtained the same score, namely 80. As for the lowest score, the experimental class was lower than the control class. The average combined critical thinking ability score for the two classes was 63.53. The combined average score is used to categorize the students' critical thinking skills in the high and low groups for both samples. The number of students who have high critical thinking skills in the experimental class is greater than the control. The distribution of the frequency of data on the critical thinking skills of students in the two sample classes is presented below.

Table 4. Categories of Students' Critical Thinking Skills in the Experiment Class and Control Class

Critical Thinking Ability	Class	
	Experiment	Control
High ($X \geq 63,53$)	26	16
Low ($X < 63,53$)	12	22
Total	38 students	38 students

Cognitive ability data obtained from cognitive tests on the subject matter of temperature and heat transfer. Both class samples consisted of 38 students. The lowest score in the experimental class is higher than the control class. This also applies to the lowest value of the two samples. The average scores of cognitive tests in the experimental and control classes were 78.7 and 73.1. The variance obtained by the experimental class is smaller than the control. The experimental class standard deviation is smaller than the control. That is, the range of values for the control class is greater than that of the experimental class.

Table 5. Data Description of Students' Physics Cognitive Ability

Class	total students	Highest Score	Lowest Score	Average	Standard Deviation
Experiment	38	93,3	60,0	78,7	7,8
Control	38	86,7	46,7	73,1	9,1

Prerequisite analysis test was carried out to fulfill the hypothesis requirements by using analysis of variance (ANOVA). Hypothesis prerequisite testing was carried out, namely the normality test and homogeneity test. In the two analysis prerequisite tests, the results of the cognitive physics test on the subject matter of temperature and heat were used. The results of the normality test for the experimental and control classes showed that the observation $<L_{table}$ was $0.128 < 0.144$ for the experimental class and $0.121 < 0.144$ for the control. Thus, it can be concluded that the experimental and control classes, namely the samples come from populations that are normally distributed. The homogeneity test of the experimental class and the control class showed that the cognitive abilities of students in the experimental class and the control class showed that

the value of χ^2_{obs} was 0.87 and χ^2_{table} was 3.841. This shows that the experimental class and control class samples come from a homogeneous population. The research hypothesis was tested using a two-way Analysis of Variance with unequal cell contents. Based on statistical calculations with a significance level (α) of 5%, the results are obtained in the following table.

Table 6. Summary of Two Way Analysis of Variance with Different Cell Contents

Source Variance	JK	Dk	RK	F _{obs}	F _{tabel}
A (Module)	330,1	1	330,1	4,8	3,97
B (Critical Thinking Ability)	351,3	1	351,3	5,2	3,97
AB (interaction)	43,2	1	43,2	0,6	3,97
Error	4925,0	72	68,409	-	-
Total	5649,6	75	-	-	-

Based on the table above, it can be concluded that H_{0A} is rejected, which means that there is a difference in the effect between the use of module with a computational thinking unplugged approach and module with a scientific approach. Based on the table above, it can be concluded that H_{0B} is rejected, which means that there is a difference in the effect of high and low category students' critical thinking skills on students' physics cognitive abilities. Based on the table above, it can be concluded that the H_{AB} is accepted, which means that there is no interaction between the effect of using a module with a computational thinking unplugged approach and a module with a scientific approach and students' critical thinking skills on students' cognitive abilities in physics.

Table 7. Summary of Marginal Average

Module	Critical Thinking Ability		Marginal Average
	High	Low	
Computational Thinking Unplugged Approach	80,51	74,45	78,60
Scientific Approach	74,58	71,67	72,89
Marginal Average	78,25	72,65	

Scheffe test calculation for comparison between line means shows $K = \{F|F > (2 - 1) F_{0.05;1;72}\} = \{F|F > 3.97\}$. The F value obtained is 9.06. Thus, it can be concluded that module with an unplugged computational thinking approach have a better effect on students' cognitive abilities on the subject of temperature and heat transfer. Meanwhile, the scheffe test calculation for the mean comparison test between columns shows that $DK = \{F|F > (2 - 1) F_{0.05;1;72}\} = \{F|F > 3.97\}$. The F value obtained is 8.62. Therefore, it can be concluded that the students' critical thinking skills in the high category have a better influence on students' cognitive abilities on the subject of temperature and heat transfer.

Based on the results in table 7, marginally students who have high critical thinking skills have higher cognitive scores compared to students who have low critical thinking abilities. The general conclusion also applies to students who are taught with unplugged computational thinking module and module with a scientific approach. In the experimental class students who have high critical thinking skills get better cognitive scores than students who have low creativity. For the control class, students who have high critical thinking skills also have better cognitive scores than students who have low critical thinking abilities. When viewed from table 6 which shows there is no interaction between the effect of using module with a computational thinking unplugged approach and module with a scientific approach and students' critical thinking skills on students' Physics cognitive abilities, it shows that learning module and students' critical thinking skills have their own influence on students' physics cognitive abilities.

The results of this study strengthen the previous research. The results of the study which show that module with an unplugged computational thinking approach have a better effect on cognitive abilities than the use of module with a scientific approach further strengthen the opinion of (Kulles, 2022) which states that computational thinking is part of critical thinking in an effort to solve problems. This study also strengthens the results of research by (Kawuri, 2019), (Swaid, 2015), and (Yadav, 2017) which states that students' thinking skills can be

improved by using learning with a computational thinking approach. The results of this study which show that the use of the unplugged computational thinking module has a better effect on critical thinking skills than the use of a module with a scientific approach cannot be a reference to conclude that the unplugged computational thinking module is better than a module with a scientific approach. To prove that the unplugged computational thinking module has a better effect on critical thinking skills than the use of a module with a scientific approach, it is necessary to conduct further research involving more subject matter and more research subjects.

4. Conclusion

Based on the description above, it can be concluded that (1) There is a difference in the effect between the use of a module with a computational thinking unplugged approach and a module with a scientific approach on the cognitive abilities of students on the subject of temperature and heat transfer, (2) there is a difference in the effect between critical thinking skills students in high and low categories on students' cognitive abilities on the subject of temperature and heat transfer, and (3) there is no interaction between the effect of using module with an unplugged computational thinking approach and module with scientific approaches and students' critical thinking skills on students' cognitive abilities on the subject of temperature and heat transfer.

Based on the results obtained, the teacher/lecturer can apply the unplugged computational thinking module in the physics learning process by paying attention to students' critical thinking skills as a supporting factor in achieving high cognitive learning outcomes. The results of this study can be implemented from elementary school to university.

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