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ICARE Model (Introduction, Connection, Application, Reflection, Extension) in Physics Learning: Analysis of its Effect on Students' Computational Thinking Skills based on gender

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Abstract

This study aims to determine the effect of the ICARE learning model on students' computational thinking skills, the effect of gender differences on students' computational thinking skills, and the interaction between the ICARE learning model and gender differences in students' computational thinking. The research method used is quasi-experimental. This research was conducted at high school, SMA Muhammadiyah Bandar Lampung. The population in this study is class X MIPA with a sample of X MIPA 1 and X MIPA 3. The sampling technique is cluster random sampling. Hypothesis testing using a two-way ANOVA test with a 2x2 factorial design. The results of this study are: 1) there is an effect of the ICARE learning model on students' computational thinking skills, with a significance level of 0.000 <0.05, 2) there is no effect of gender differences on computational thinking skills, with a significance level of 0.628 > 0.05, and 3) there is no interaction between ICARE learning models and gender differences on computational thinking skills, with a significance of 0.320> 0.05. Problem-solving in physics learning can use computational thinking skills, namely by indicators of decomposition, abstraction, algorithms, and generalization of patterns. So that, computational thinking skills are important in the physics learning process.

Keywords: computational thinking skills, gender, ICARE learning model

INTRODUCTION

Computational thinking skills are essential and must be possessed by individuals in the 21st century (Wing 2006, Grover 2018, Riddell 2018). Computational thinking is included in basic skills that complement writing, reading, and arithmetic (Khine 2018). As stated by Wings, Computational thinking is a basic skill that must be possessed by individuals (Karaahmetoğlu and Korkmaz 2019). Computational thinking can be applied in various sciences, not just in computer science (Ansori 2020), so that it can be used to solve all problems that are not only related to computers (Syarifuddin et al. 2019). This is in line with Kalelioglu's opinion that computational thinking does not only include one type of skill but can include more than one type of skill (Kalelİoğlu, Gülbahar and Kukul 2016). The results of research that has been carried out show that computational thinking can be integrated with all subjects, not only computer science. This can be proven by the results of research in Australia, which shows that the Unified Modeling Language principles in software engineering can be integrated into language learning in elementary school (Zuhair 2021).

Learning and assessment related to 21st-century skills Computational thinking is still very little done (Grover and Pea 2013). However, many countries have incorporated computational thinking into the learning curriculum (Chioccariello et al. 2016), namely the United Kingdom, which has included it in curriculum 21 since 2012 (Kuswanto et al. 2020) and included computational thinking material since 2014 (Syarifuddin et al. 2019). In addition, countries that have integrated computational thinking in educational curricula include Malaysia in 2017 (Ling et al. 2018), the United States in 2016 (Zuhair et al. 2021), Singapore (Hyo-Jeong, Jong and Liu 2020), New Zealand (Collins 2017), Australia (Ling et al. 2018) and countries that entered the European Union in 2016-2017 (Chioccariello et al. 2016). Meanwhile, developed countries in Asia, such as Hong Kong, Japan, China, and Taiwan, integrate computational thinking by incorporating computer programming into the curriculum (Hyo-Jeong, Jong and Liu 2020). This proves that computational thinking is not only developing in one country but has become a new idea for decades in various countries (Grover and Pea 2013)

In Indonesia, there are still very few studies related to computational thinking, so the application of learning in improving computational thinking has not been done much (Ansori 2020). Computational Thinking in Indonesia cannot be separated from ICT subjects or information technology and computers, but these subjects were abolished in implementing the 2013 curriculum (Hidayat, Muladi and Mizar 2016). One of the essential competencies learned in informatics subjects is computational thinking. This is officially contained in the attachment of Permendikbud No 37 (Zuhair 2021). Therefore, students' computational thinking skills in Indonesia need to be improved because they are still at a low level (Sulistiyo and Wijaya 2020). So the government needs to incorporate computational thinking into compulsory subjects (Kuswanto et al. 2020).

Along with technology development, computational thinking is considered a crucial problem-solving ability (Hyo-Jeong, Jong and Liu 2020) (Nazhifah, Pasaribu and Wiyono 2022). Where these abilities must be mastered in the 21st century (Kaniawati and Utari 2015). But on the other hand, educators and students still have minimal knowledge related to computational thinking (Zuhair et al. 2021). In an education system, computational thinking is a basic ability to think for educators and students in solving problems and creating opportunities (Kuswanto et al. 2020). In the 21st century, computational thinking can potentially improve students' problem-solving abilities in learning (Maharani et al. 2020). This is in line with the researchers' findings that computational thinking can improve problem solving skills and reduce individual's higher order thinking skills (Fessakis, Gouli and Mavroudi 2013). Computational thinking can be applied to all subjects (Zhong et al. 2016) and types of reasoning in all fields of knowledge (Isnaini, Budiyanto and Widiastuti 2019). So that it can increase the effectiveness of learning (Elkin, Sullivan and Bers 2014) and students' analytical skills (Atmatzidou and Demetriadis 2016) (Bers and Portsmore 2005).

In a problem-solving process, one factor that plays an important role is gender differences that can affect the results of a learning. Because between men and women there are differences in mindset, learning styles and ways of solving a problem (Hodiyanto 2017). Male students are curious and more interested than female students (Pusfarini 2017). A study shows that men and women have different ways of solving problems. Women are more detailed and orderly in writing solutions, while men can solve problems directly by using examples in the form of pictures. (Avianti and Ratu 2020).

Male and female students' low computational thinking skills is evidenced by the results of a pre-study in one of the primary schools in Lampung. From the results of the pre-research that has been done at SMA Muhammadiyah Bandar Lampung in the form of essay test questions in class X MIPA 1 and X MIPA 3. From the results, the average test score is still very low. This is reinforced by the results of interviews with class X physics teachers that during the learning process, the educators never give questions that emphasize students' computational thinking skills, and the learning model used is less effective. One of the learning models that can be used to improve computational thinking skills is the ICARE learning model. Where the ICARE learning model can be used to improve students' problem solving skills (Yasa, Astawa and Sudiarta 2019) because the model is based on life skills which are also implied in the curriculum (Hadiansah, Safitri and Suhada, 2019). Problem-solving ability is strongly related to computational thinking skills (Selby and Woollard 2014). The ICARE model has stages from implementation to evaluation (Suendarti and Liberna 2018). ICARE's learning model is student center (Mahdian, Almubarak and Hikmah 2019). The ICARE model can provide opportunities for students to apply knowledge from learning (Belen, Sukandi and Dkk 2010). Which consists of 5 elements that become stages in the learning process: Introduction, Connection, application, reflection, and extension (Mahdian, Almubarak and Hikmah 2019). By emphasizing at each stage, it can positively impact students' ability to solve problems (Dwijayani 2018). This is evidenced by one of the results of research conducted by (Yasa, Astawa and Sudiarta 2019) that students' mathematical problem-solving ability is better with the implementation of the ICARE learning model.

Several studies have been conducted to improve computational thinking skills, including the effectiveness of the Inquiry based learning model in improving computational thinking skills (Sulistiyo & Wijaya 2020), application of design based learning to develop computational thinking skills (Saritepeci 2020), through the application of flipped classroom to find out the factors that affect computational thinking (Gong, Yang and Cai 2020) and to develop children's computational thinking skills using project-based programming learning (Nurhopipah, Nugroho and Suhaman 2021).

Research on the application of learning models has been carried out to improve computational thinking skills. However, research using the ICARE learning model has never been carried out, and in previous studies, the improvement in computational thinking was only seen from the effect of the applied learning model, not yet seen from other factors such as in terms of gender differences. Based on this, no research has ever been conducted regarding the effect of the ICARE learning model on students' computational thinking skills in terms of gender. Therefore, the purpose of this study is to determine the effect of the ICARE learning model on students' computational thinking skills in terms of gender.

METHODS

The research method used is quasi-experimental. This research was conducted at SMA Muhammadiyah Bandar Lampung. The population in this study were students of class X MIPA, totaling 129 students. The sampling technique in this study used a cluster random sampling technique, where class X MIPA 1 was the control class (the class that received the conventional model treatment) which consisted of 28 students and X MIPA 3 was the experimental class (the class that received the ICARE learning model treatment)—consisting of 32 students. The research design used is a 2x2 factorial design. The research factorial design can be seen in TABLE 1.

TABLE 1. Factorial Design

Treatment (A)	**Gender (B)**	
	Male (B_1)	**Female (B_2)**
ICARE learning model (A_1)	A_1B_1	A_1B_2
Conventional learning model(A_2)	A_2B_1	A_2B_2

The research procedure to determine students' computational thinking skills can be seen in FIGURE 1. The instruments used in this research are computational thinking skills test instruments and observation sheets on implementing the learning model. Before being given treatment, students are given a pretest, and after being given treatment, at the end of the lesson, they are given a posttest in the form of a computational thinking skills test. The test instrument used has been tested for feasibility through a validity test, reliability test, difficulty level test (DL) and discriminatory power test (DP). TABLE 2 is the result of the instrument's feasibility test.

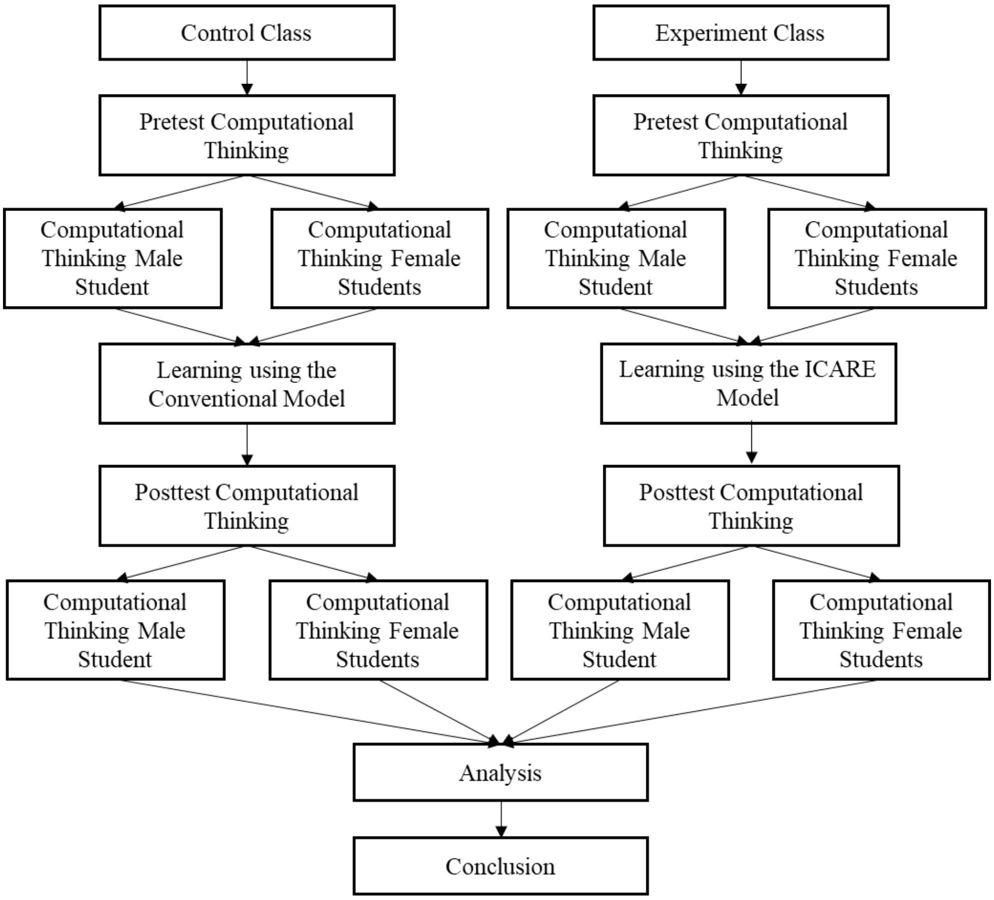

FIGURE 1. Research Flow Chart

TABLE 2. Test Instrument Feasibility Test Results

PRETEST (Work and Energy Materials)					
No	**Sub Material**	**Question indicator**	**Validity**	**DL**	**DP**
1	Work	Students can describe the concepts of work, force, and displacement on an object	Valid	Medium	Good
		Learners can abstract problems from factors that can affect work	Valid	Medium	Good
		Students can analyze the direction of the force by using the steps	Valid	Medium	Enough
		Students can make patterns to determine the effort of an object	Valid	Medium	Enough
2	Energy	Students can conclude the types of energy in a reading	Valid	Medium	Enough
3	Kinetic energy and potential energy	Students can analyze the difference between the concepts of kinetic energy and potential energy	Valid	Medium	Enough
		Students can analyze problems related to the force and effort used to move an object with steps	Valid	Medium	Enough
		Students can make patterns as solutions to problems on the potential energy (gravity and spring) of an object	Valid	Medium	Enough
4	Power	Students can solve problems to determine the amount of power by using steps	Valid	Medium	Enough
5	The law of conservation of mechanical energy	Students can abstract the quantities used to determine the amount of mechanical energy	Valid	Medium	Enough
		Students will be able to describe the law of conservation of mechanical energy	Valid	Medium	Enough
		Students can analyze the steps to determine the law of conservation of mechanical energy	Valid	Medium	Enough

TABLE 3. Test Instrument Feasibility Test Results

POSTTEST (Work and Energy Materials)					
No	**Sub Material**	**Question Indicator**	**Validity**	**DL**	**DP**
1	Work	Students can analyze the direction of the force by using the steps	Valid	Medium	Good
2	Kinetic energy and potential energy	Students can create problem patterns on the relationship between work and potential energy	Valid	Medium	Enough
		Students can solve problems by arranging patterns to determine the magnitude of the velocity on the kinetic energy of an object	Valid	Medium	Good
		Students can analyze problems in determining the potential energy of a spring using the steps	Valid	Medium	Bad
3	Power	Students can analyze the relationship between effort and power	Valid	Medium	Good
		Students can conclude the factors that influence the magnitude of a power	Valid	Medium	Enough
		Students can solve problems to determine the amount of power by using the steps	Valid	Medium	Enough
4	The law of conservation of mechanical energy	Students can abstract the quantities used to determine the amount of mechanical energy	Valid	Medium	Enough
		Students will be able to describe the law of conservation of mechanical energy	Valid	Medium	Good

TABLE 4. Test Instrument Reliability Test Results

Statistics	Information	
	Pretest	***Posttest***
r_{11}	0,62	0,60
Conclusion	High reliability	

Instruments that have been declared valid and meet the criteria according to the feasibility test can be used in research.

Then, after the research data was obtained, it was continued with the analysis prerequisite test, namely normality and homogeneity tests. The normality test determines if the data comes from a normally distributed sample (Syafril 2019). The normality test in this study used the Kolmogorov-Smirnov program on the SPSS 23. The homogeneity test is used to determine whether the sample in the research class has the same or different variance. A homogeneity test was carried out using the SPSS 23 program with a significance level of 5%.

If the analyzed data is typically distributed and homogeneous, it can be done with parametric statistical tests (Sugiyono 2018). Hypothesis testing using a two-way ANOVA test (two-way ANOVA) with a 2x2 factorial design.

RESULTS AND DISCUSSION

The research data shows that the experimental and control classes have the same initial ability. This can be seen in the following figure.

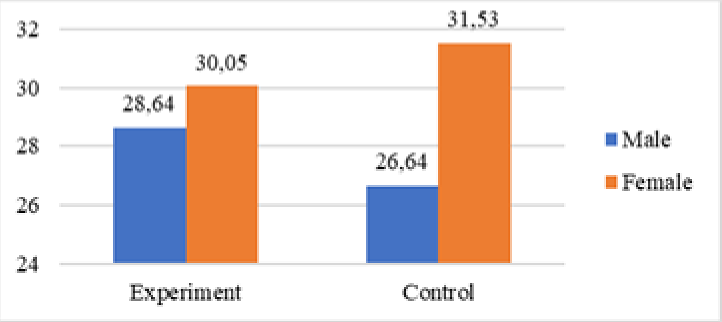

FIGURE 2. Computational Thinking Skills Pretest Results

FIGURE 2 shows the average score on the computational thinking test of male students in the experimental class is higher than in the control class. Meanwhile, the average score of female students in the control class was higher than the experimental class. After receiving treatment with the ICARE and conventional learning models, the teacher gave a posttest with essay questions.

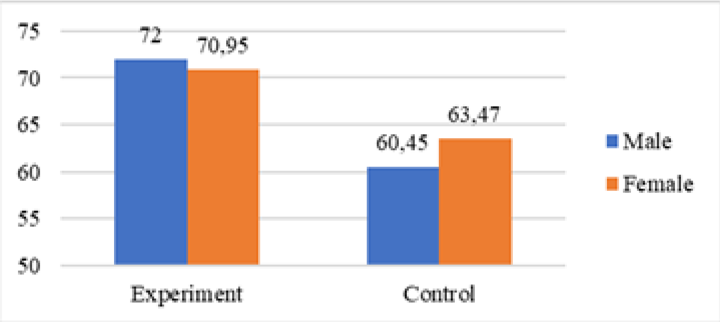

FIGURE 3. Computational Thinking Skills Posttest Results

FIGURE 3 shows the average score of male and female students in the experimental class is higher than the control class. These results show an increase in students' computational thinking skills from the pretest to the posttest. To determine the effect of the ICARE learning model, normality and homogeneity tests were first carried out with a significance level of 5% using the SPSS 23 program. The normality and homogeneity test results are shown in TABLE 5.

TABLE 5. Normality and Homogeneity Test Results

	Normality				**Homogeneity**	
Computational thinking skills	Experiment		Control		Experiment	Control
	Pretest	*Posttest*	*Pretest*	*Posttest*	0.160	
	0.082	0.053	0.108	0.060		
Conclusion	Normal				Homogeneous	

TABLE 5 shows that the pretest and posttest data on computational thinking skills in the experimental class and control class are normally distributed and homogeneous. Testing the data hypothesis using a two-way ANOVA test with a 2x2 factorial design.

TABLE 6. Hypothesis Test Results

No.	**Two Way Anova Hypothesis**	**Significance**	**Test Result**
1.	ICARE models	0.000	H_o rejected
2.	*Gender*	0.628	H_o accepted
3.	ICARE model interactions and gender differences	0.320	H_o accepted

The results of the first hypothesis indicate that there is an effect of the ICARE learning model on computational thinking skills. The results of computational thinking skills per indicator in the experimental class and control class can be seen in the following picture.

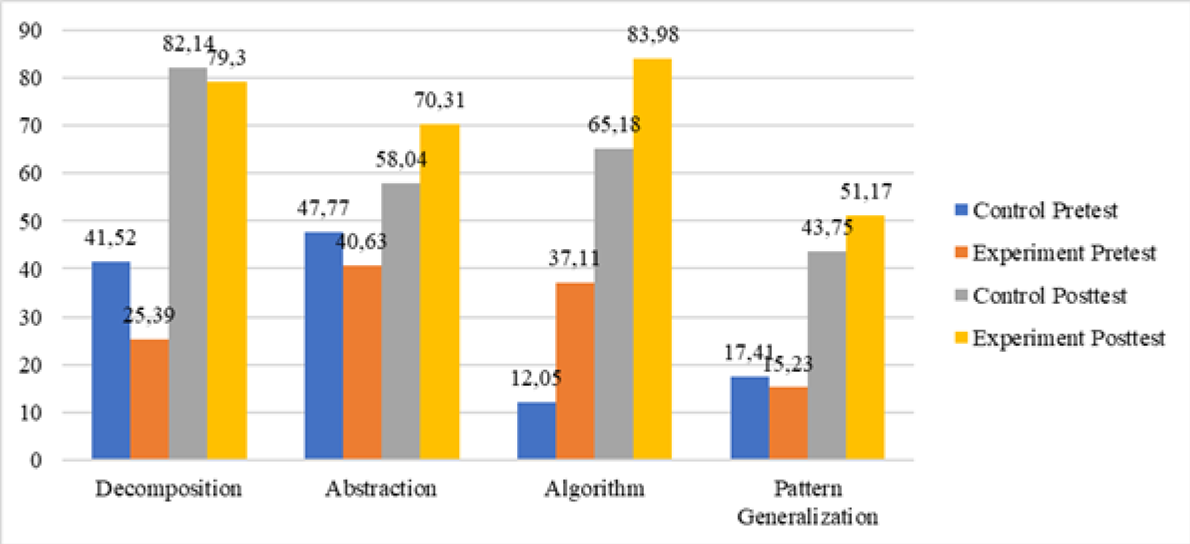

FIGURE 4. Computational Thinking Skills Test Results

FIGURE 4 shows that the results of the pretest in the research class are still at a low level in all computational thinking indicators. And the posttest results showed an increase in all indicators. However, the highest results from both classes were on the decomposition and algorithm indicators, while the still low indicator was the pattern generalization indicator. However, the results of research conducted by Kuswoyo et al. Show that all computational thinking indicators are in the sufficient category. The highest scores are indicators of decomposition, generalization of patterns, and abstraction. At the same time, the lowest value is on the indicator algorithm (Kuswanto et al. 2020).

In the experimental class with the ICARE learning model, there are learner-centered learning steps(Siahaan, Dewi and Suhendi 2020), so that students not only listen and also read but can apply the knowledge gained by discussing to solve problems at the application stage, and at the student extension stage. Given homework to develop computational thinking skills so that students can improve their computational thinking skills. Computational thinking is concerned with problem-solving. This is following research conducted by (Yasa, Astawa and Sudiarta 2019) and (Yumiati and Wahyuningrum 2015) that the ICARE learning model is better at improving problem-solving skills. TABLE 7 describes the process carried out by researchers during learning to improve students' computational thinking skills.

TABLE 7. Storyboard of the Implementation of ICARE's Learning Model

ICARE Learning Model Stages	Activity Description	Indicator Computational Thinking Skills
Introduction	In this stage, the teacher plays an active role. The teacher explains the material and learning objectives (Belen, Sukandi etc. 2010) and provides motivation and apperception so that students are more enthusiastic about the learning that will be carried out (Anugrawati 2016).	
Connection	Students can connect their previous knowledge of students with new knowledge (Dwijayani 2018). Educators only act as facilitators by providing questions that can make students discover new concepts, namely by outlining and abstracting. (Yasa, Astawa and Sudiarta 2019).	Decomposition Abstraction
Application	Students can apply the knowledge gained from the connection stage to solve a problem (Dewi, Ardana and Sariyasa 2019). Problem-solving using systematic and structured steps or algorithms is part of computational thinking skills.(Azmi and Ummah 2021)	Algorithm Pattern generalization
Reflection	In this stage, students can reflect on the material obtained so that students knowledge becomes stronger (Siahaan, Dewi and Suhendi 2020) and can also evaluate errors in problem-solving	Abstraction

ICARE Learning Model Stages	Activity Description	Indicator Computational Thinking Skills
	and draw conclusions from learning outcomes (Azmi and Ummah 2021).	
Extension	Educators give problems outside of class hours as homework (Carni, Maknun and Siahaan 2016) in the form of questions containing computational thinking indicators (Azmi and Ummah 2021).	Decomposition Abstraction Algorithm Pattern generalization

In contrast to the control class, which uses the conventional think pair share model. The researcher gives a problem, then the students solve it by discussing it in pairs, then presenting the results. So the lack of motivation and initial knowledge of students. In the think pair share model, no extension stage can help students develop computational thinking skills outside of class hours.

The results of the second hypothesis show no difference in the computational thinking skills of male and female students. This is because when discussing and exchanging ideas, the group consists of male and female students, so the final results are relatively the same. However, based on existing theory, there are differences between men and women in problem-solving (Davita and Pujiastuti 2020). The results of the average computational thinking skills in FIGURE 3 show no significant difference between male and female students.

The results of the third hypothesis indicate no interaction between the learning model and gender on computational thinking skills. The average value of computational thinking of male and female students is relatively the same. The scores obtained by male and female students are relatively the same. There is no significant difference between the two. So, students can follow the learning well using these two models. This follows research conducted by (Hodiyanto 2016) that there is no interaction between the learning model and gender. However, the discrepancy between the results and the existing hypothesis was caused by several factors, including unfavorable classroom conditions and limited learning time. And also there is no significant difference in the computational thinking skills of male and female students in each of the applied learning models.

There have been many studies on improving computational thinking skills with various learning models and approaches. However, in this study, we examine the effect of the ICARE learning model on students' computational thinking skills in terms of gender. In addition to focusing on the learning model used, it also focuses on the gender differences of students. The study results show that the ICARE learning model can improve students' computational thinking skills.

Research that has been done (Sulistiyo and Wijaya 2020) shows that applying the inquiry-based learning model is effective in improving computational thinking abilities because inquiry-based learning steps support each computational thinking indicator. Meanwhile, in this study, in improving computational thinking by applying the ICARE learning model, the indicators match the stages of the learning model as described in TABLE 7. Thus, this study's results follow the results of previous studies.

In this study, it was shown that there was no effect of gender differences on computational thinking. This means that male and female students have the same computational thinking abilities. This is in line with research (Murtafiah and Amin 2018) which states that there is no effect of gender differences on problem-solving abilities. However, according to (Wahyudi and Astriani 2014) male students use the right brain more in terms of practice, while women use the left brain so that they are smarter in theory. Thus, male and female students have different abilities and learning styles.

Research conducted by (Sagala et al. 2019) and (Hodiyanto 2016) shows that there is no interaction or relationship between the learning model and gender. In this study, the results showed the same; namely, there was no interaction between learning models and gender differences because the value of computational thinking is relatively the same as the implementation of the two learning models.

CONCLUSION

Based on the objectives, findings and discussion, it can be concluded that there is an effect of the ICARE learning model on students' computational thinking skills with a significance level of 0.000 < 0.05. There is no effect of gender differences on computational thinking skills, with a significance level of 0.628 > 0.05 and there is no interaction between ICARE learning models and gender differences on computational thinking skills, with a significance of 0.320> 0.05.

Researchers suggest further research to apply the ICARE learning model by using appropriate and interesting learning media, and to examine computational thinking skills on all indicators, namely decomposition, abstraction, algorithms, pattern generalization and evaluation.

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