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Implementation of STEM-Oriented MEA learning model to improve computational thinking skills of learners

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Abstract: Low computational thinking skills cause students to have difficulty solving problems. This study aims to analyze whether there is an increase in students' CT abilities using the STEM-oriented MEA model with conventional learning. The research method is an experiment using an experimental group of 30 students and a control class of 32 students. The research instrument uses questionnaires and rubrics to assess students' CT abilities. The results of the T-test analysis used are Equal variances not assumed, which is 0.000 (Sig. (2-tailed)) > 0.05 means There is an increase in student's CT abilities using the STEM-oriented MEA model with conventional learning, so There is an increase in student's CT abilities using the STEM-oriented MEA model with conventional learning. Thus, there is an increase in the ability of students to think computationally using the STEM-oriented MEA model with conventional learning.

Keywords: Learning; STEM-oriented MEA model; Computational Thinking (CT).

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INTRODUCTION

The current era of the industrial revolution 4.0 continues to develop, especially in the fields of Digital, Biotechnology and Physics (Malik, 2018). This development is supported by advanced technology, especially communication science which gives birth to various innovations continuously (Saputri, Sajidan, Rinanto, Afandi, & Prasetyanti, 2019). Therefore, universities as producers of graduates who will enter the Business World, Industrial World and the World of Work (DUDIKA) must equip these graduates with various skills. One type of skill that students must have in order to compete in these advances is *Computational Thinking* (Hasanah & Haryadi, 2022). *Computational Thinking* is a series of abstract mental activities that include reasoning processes such as abstraction, decomposition, pattern mapping, pattern recognition, algorithmic thinking, automation, modeling, simulation, assessment, testing, and generalization (Ramadhan, Budiyanto, & Yuana, 2023).

Computational Thinking is also a process of solving problems using logic gradually and systematically which is not only important in the process of computer programming, but also needed by students in various fields (Hasanah et al., 2022). Computational thinking can make it easier for students to make decisions and solve a case in learning (Supiarmo & Susanti, 2021). Therefore, in some developed countries have begun to update the educational curriculum in schools to introduce and train computational thinking skills from an early age (Cahdriyana & Richardo, 2020). This is based on the belief that computational thinking is one solution that can stimulate students to think logically, structurally and systematically (Supatmiwati, Suktiningsih, Anggrawan, & Katarina, 2021). But in fact, the learning applied so far actually narrows the space for students to develop *Computational Thinking* skills. *Computational Thinking (CT)* is a problem-solving method designed to be solved and executed by humans, computers or both. The concept of thinking in CT includes problem solving, system design, and understanding human behavior in the basic concepts of computer science (Jamna, Hamid, & Bakar, 2022). CT is not only for computer scientists and engineers, but also for many other professionals. In recent times, there has been an increasing tendency to think of them as basic skills incorporated into primary education.

Through programming languages, students are required to solve problems systematically and structured as computer systems work. However, to be able to learn programming or understand the basics of computer science requires complex thinking skills necessary to apply the rules of logic and solve problems (Supriyadi & Dahlan, 2022). Setiawati & Corebima (2017) suggest that computational thinking is a thinking process that plays a role in formulating problems and their solutions, so that the solutions obtained can be represented. Computational thinking has four operational skills including decomposition, pattern recognition, abstraction and algorithmic thinking. Through these four computational thinking skills, students train students to formulate problems by separating the problem into small parts that are easily resolved (Ansori, 2020). This strategy hones students' thinking skills through simplifying complex problems into several procedures that make it easier for students themselves to understand problems, and train students also to think creatively (Kamil, 2021). Learning carried out in the classroom is still centered on educators, so students still tend to be passive, therefore the need to apply the right learning model to improve students' *Computational Thinking* skills. According to Li (2020), the learning model is a conceptual framework used as a guideline in conducting learning. Furthermore, the concept of the learning model itself is a plan that is used as a guideline in planning classroom learning and tutorial learning (Nieveen, & Folmer, 2013).

Some studies that have been conducted to train analytical skills and Computational Thinking are the use of Block-Based Programming (Fadhillah, Budiyanto, & Hatta, 2023), have integrated the Problem Based Learning (PBL) model with web 2.0 technology using PBL-based interactive media to improve learning outcomes in SMK (Khairudin, Suryani, Widyastuti, & Setiawan, 2018), using WEB for subject assessment LAN network competency standards in SMK (Suryani, Khairudin, Widyastuti, Amelia, & Riska, 2020), using a learning model (Remap-NHT model) (Chen, 2018) and using PQ4R-TPS. While computational thinking skills can be trained using STEM (Science, Technology, Engineering and Math) approaches (Selvaraju, 2020). STEM is a model formed based on a combination of several disciplines, namely Science, Technology, Engineering, and Mathematics (Yang & Baldwin, 2020). Collaboration from these four fields of science can help students think critically and creatively. Learning with the STEM model has been used through a combination of several learning strategies, for example developing a STEM-based digital module

(Suryani, Utami, Khairudin, Ariska, & Rahmadani, 2020). Suryani et al. (2020) introduced STEM Procsi strategies in learning, while the application of STEM models and their effects on learning has been developed including. The application of STEM models carried out in secondary schools can foster student interest in learning (Capraro et al., 2018; Reinking & Martin, 2018; Yildirim, B., & Türk, 2018). In this study will implement the MEA integrated STEM learning model Terminology MEA consists of 3 words element, namely: Means many ways, End end or goal, and Analysis which means analysis or investigate systematically (Sari, Alici, & Sen, 2018). Effectiveness of Learning Methods Means-Ends Analysis (MEA) is a process to solve problems into two or more sub-goals. This model is a development of the problem-solving method, it's just that every problem faced is broken down into simpler sub-sub-problems and then finally reconnected into a main goal. MEA learning syntax is STEM-oriented, finding end-goals, dividing into sub-goals, breaking down in detail into sub-sub goals, actions and reflections (Suryani, 2021).

The type of research used is an experiment by applying the STEM-oriented MEA teaching model. Experimental research methods have clear differences compared to other research methods, namely the control of research variables and the treatment of experimental groups.

METHOD

The research procedure is generally divided into 3 stages, namely:

1) Preparatory Phase

Some of the activities carried out at the preparatory stage are:

a) Determine the location, time and subject of research, in this case the research is carried out in the Informatics and Computer Engineering Education Study Program, Faculty of Teacher Training and Education, Hatta University. The implementation time in the even semester of the 2022-2023 academic year in the Simulation and Modeling course with a total of 32 students.

b) Establish material and prepare learning tools, namely Modules, Learning Media.

c) Dividing the experimental class into 6 groups where the division of groups according to the learning style of students.

d) Prepare research instruments in the form of computational thingking ability test questions.

2) Process Stage

At the process stage the things done are:

a) Carry out learning in experimental classes and control classes. The experimental class uses the STEM-oriented MEA learning model, while the control class is carried out with the discussion method. The learning steps use the STEM-oriented AEC model as Figure 1.

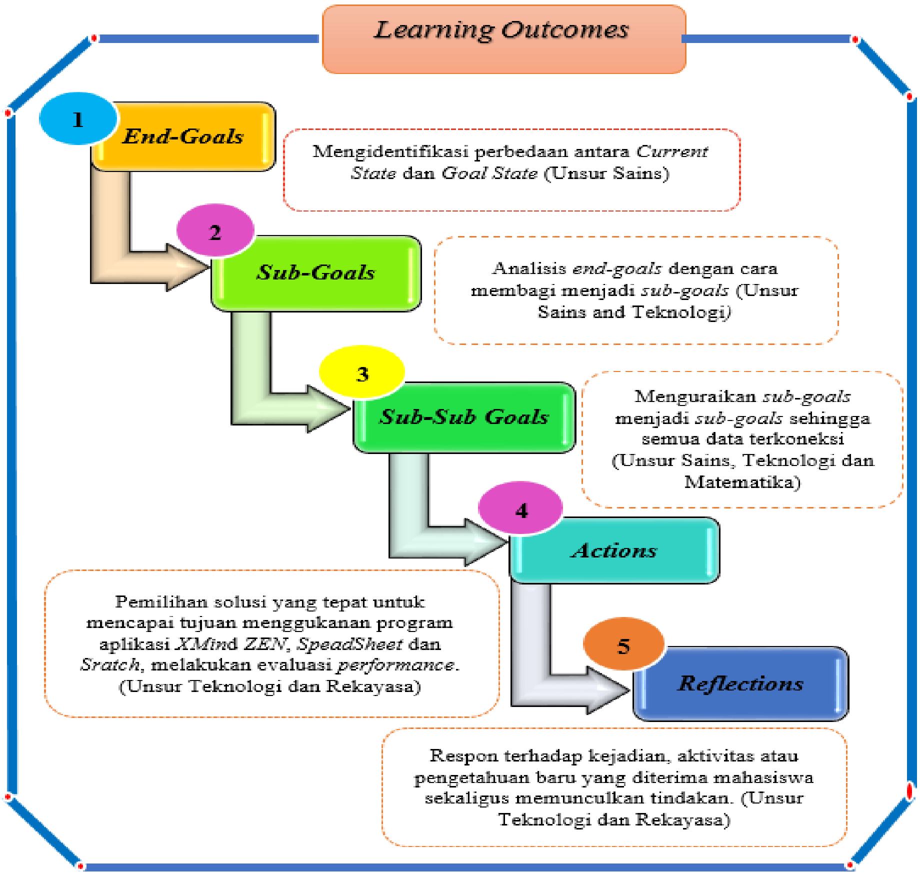

Figure 1. STEM-Oriented MEA Learning Model Steps

Based on Figure 1, the activities that can be carried out by lecturers and students during the learning process are as Table 1.

Table 1. Lecturer and Student Activities in Learning using the STEM-oriented AEC Model

No	Model Syntax	Student Activities during learning	The Role of Lecturers during Learning
1.	*End-Goals*	1. Students open the *Team Viewer* application to join their respective groups then appoint the group leader. 2. Students discuss the final goal of the material that has been delivered by identifying the difference between the *current* statement and the goals to be achieved (*goals state*). 3. Students individually in their respective groups gather relevant sources of information to achieve these goals.	1. The lecturer guides students to sit according to a predetermined group, then joins the *Team viewer* application of each group during lectures in *a sincronous* (virtual face-to-face). 2. The lecturer controls the students who are discussing and directs students to find *the final goals (end-goals*) of learning.
2.	*Sub-Goals*	1. Students continue the discussion to find the difference between the *current* state and *the goals state.* 2. Students divide the *current*	1. Lecturers guide students during discussions to determine the *current* state and *goal state* of the material to achieve *end-goals*.

No	Model Syntax	Student Activities during learning	The Role of Lecturers during Learning
		state into *sub-goals* so that it is easier to achieve the final goal of the course material. 3. Students communicate and collegiate the *subs goals* that have been obtained from each individual in the group.	
3.	*Sub-sub goals*	1. Students independently break back sub goals into *sub-sub goals* so that the final goal of lectures is easier to describe and understand. 2. Students communicate and collaborate with*sub-goals* that have been associated with STEM elements (*Science, Technology, Engeenering, and Math*).	1. Lecturers guide students in determining *Sub-sub* goals of the material that supports the achievement of *end-goals*.
4.	*Actions*	1. The group leader divides the tasks of his group members to create a concept map using the *Xmin ZEN* application, process calculation materials using the *SpreadShe*et application, and create learning animations using the *Sratch application.* 2. Students present the results of the discussion in front of other groups by displaying a concept map that has been made using the *zoom* application	1. The lecturer instructs students to design a concept map using the XMind ZEN application to outline the agreed e nd-goals, sub-goals s and sub-sub goals. Using the *SpreadShe*et application to solve calculation problems, create learning animations using the *Sratch* application, and present the results of discussions by displaying concept maps that have been made using *zoom*
5.	*Reflection*	1. Students listen to the conclusions given by the lecturer and then make additions. 2. Students reveal material that has not been understood during learning. 3. Students listen to the lecturer's explanation about material that has not been understood. 4. Students receive awards from lecturers because their groups have succeeded in giving their best.	1. Lecturers provide feedback on learning that has been carried out by concluding the material that has been delivered with students. 2. The lecturer asks students which part of the material has not been understood. 3. The lecturer repeats the material that the student does not understand. 4. Lecturers give awards to the best group in conveying the results of their discussions.

b) Learning steps implemented with the STEM-oriented AEC model are as shown in Table 2.

Table 2. Learning Steps for Experimental and Control Classes

Experimental Class using MEA Oriented STEM Learning Model	**Control Class Using Discussion Method**
Pre-Learning 1. Lecturers share modules related to modeling and simulation courses related to STEM-oriented MEA learning. 2. Form study groups according to student learning styles	**Introduction** 1. The lecturer gives greetings to open the lesson 2. The lecturer asks the class leader to lead a prayer to open the lesson 3. Lecturers prepare students both physically and follow the learning process well
Introduction 1. The lecturer opens the learning by saying greetings 2. Lecturers check student attendance.	
Core Activities ***End Goals* Phase:** 1. The lecturer asks each group to discuss case studies regarding the queue simulation material provided in order to find the ultimate goal of learning. ***Sub Goals Phase*:** 2. Students continue the discussion to find the difference between the current state and the goals state, then divide the current state into *sub-goals*, making it easier to achieve the final goal of the learning material. ***Sub-sub Goals* Phase:** 3. Lecturers guide students in determining *Sub-sub goals* of the material that supports the achievement of *endgoals*. ***Phase Actions*:** 4. The lecturer instructs students to design a concept map using the XMind Zen application to outline *the agreed endgoals, sub-sub goals*. 5. *SpreadSheet* application to solve calculation problems, create learning animations using the *Scratch* application, and present the results of discussions by displaying concept maps that have been made. ***Phase Reflections*:** 6. Lecturers provide feedback on the learning that has been implemented. 7. Lecturers give awards to the best group in conveying the results of their discussions.	1. The lecturer asks questions about students' understanding of the material to be studied; 2. The lecturer explains the goals and learning outcomes to be achieved by students; 3. Lecturers convey the scope of material to students; 4. Lecturers deliver learning materials with expository methods of questions and answers and class discussions; 5. Lecturers give sample questions and do them classically; 6. Lecturers give practice questions to students and do them individually; 7. The lecturer asks some students to do practice questions in front of the class; 8. Lecturers provide opportunities to ask questions for students who cannot understand learning. 9. The lecturer explains again if there are students who do not understand; 10. Lecturers and students summarize learning; 11. Lecturers give assignments to students to do at home; 12. The lecturer ends the learning by asking students to read the material at the next meeting; 13. 13. The lecturer closes the learning by saying hamdalah;

c) Provide tests of *computational thinking* skills in experimental classes and control classes.

d) Processing and analyzing data from experimental classes and control classes.

e) Draw conclusions from the results obtained in accordance with the technical data analysis used to see students' *computational thinking* skills.

3) Follow-up Stage.

The follow-up stage is the final stage of the research process with activities including:

a) Provide tests of computational thinking skills in experimental classes and control classes in students

b) Processing and analyzing data from experimental classes and control classes.

c) Draw conclusions from the results obtained in accordance with the technical analysis of the data used.

Research Instruments

The instruments used in this study were questionnaires of learners' understanding of the STEM-oriented AEC model used as well as CT ability value measurement rubrics such as Table 3.

Table 3. Indicator of Computational Thinking Ability

Indicators CT	Indicator Description	Question Indicator	Number Question
Decomposition	Deciphering data and problems become simpler so that they are easy to solve.	Presented contextual problems related to modeling and simulation concepts, students can determine the right data to solve the problems of these two themes.	1
Generalization	Identify general patterns of similarities/differences found in a given problem.	From contextual problems related to queuing simulation problems in supermarkets, students are able to identify definitions of simulation concepts and queuing models.	1
Abstraction	Finding objects is important for creating models / representations in solving problems.	Presented with simulation problems and queue modeling, students were able to make a simple model in determining the average waiting time for each customer who came.	2
Thinking Algorithms	Draw up the correct sequence of steps to get a solution to a problem.	Presented a contextual problem that simulates queuing in a supermarket, students are able to determine the arrangement of steps to get a solution to the problem.	3

Data Analysis

The data analysis used was the T test with the help of SPSS

RESULTS AND DISCUSSION

The results of the research on the implementation of the learning model of the STEM-oriented MEA learning model are as follows:

1. Description of Demographic Data data of experimental class students and control classes as Table 4.

Table 4. Student Computational Thinking Value Data Table

Value Letter	Control Class		Experimental Class	
	Number of Students	Percent	Number of Students	Percent
A	4	12,50	8	26,7
A-	2	6,25	16	53,3
B+	3	9,38	4	13,3
B	11	34,38	2	6,7
B-	9	28,13	0	0,0
C+	1	3,13	0	0,0
C	0	0,00	0	0,0
D	2	6,25	0	0,0
E	0	0,00	0	0,0
Total	32		30	

Based on the table 4, it can be seen that there is an increase in students' computational thinking scores as evidenced by the increase in the number of students who obtain A and A- grades. Thus, the STEM-oriented MEA learning model can improve students' computational thinking skills.

2. Data Analysis

Before conducting a hypothesis test data analysis, first go through the following prerequisite tests:

a. Normality Test

Data normality tests were conducted on students' computational thinking scores for experimental and control classes. The number of students converted in the experimental class was 30, and the control class was 32—normality test results such as Table 5.

Table 5. Normality Test Results Experimental Class and Control Class

		Unstandardized Resudial
N		30
Normal Parameters	Means	0E-7
	Std. Deviation	8,6404
Most Extreme Differences	Absolute	,128
	Positive	,128
	Negative	-,128
Kolmogorof-Smirnov Z		,704
Asymp. Sig. (2-tailed)		,705

Based on the results of the normality test (Table 5), a Sig (2-Tailed) value of 0.705>005 is obtained, so it can be concluded that the residual value is normally distributed. Next, a hypothesis test is carried out.

b. Hypotesis Test

Test the hypothesis against the STEM-oriented MEA learning model to improve students' computational thinking skills through T test analysis using the SPSS application. The results of the analysis of the T test are like Table 6.

Table 6. T Test Analysis Results

		Levene's Test for Equality of Variances		t-test for Equality of Means
		F	Sig.	Sig. (2-tailed)
Results	Equal variances assumed	9.979	.002	.000

Table 6 shows that the value of Sig Levene's Test for Equality of Variances 0.002 < 0.05 means that the data is not homogeneous. Therefore, the results of the T-test analysis used are data on the second line (Equal variances not assumed), which is 0.000 (Sig. (2-tailed)) < 0.05, which means reject Ho and accept H1. Thus, there is an increase in the computational thinking ability of students using the STEM-oriented AEC model with conventional learning. A learning model combining four science fields with analysis can hone students' computational thinking skills (Guggemos, 2021).

CONCLUSION

Based on the analysis of the data that has been described, it is concluded that there is an increase in the computational thinking ability of students using the STEM-oriented MEA model with conventional learning. Thus, it is hoped that the STEM-oriented MEA learning model can become an alternative for use in the classroom.

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