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# The Aspects Of Critical Thinking Toward Students' Psychomotor Skill In Learning Of Microprocessor And Microcontroller Programming Techniques

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**ABSTRACT**
This study aims to determine the effect of critical thinking aspects on students' psychomotor skills. Aspects of critical thinking include interpreting, planning, predicting, analyzing, evaluating, and decision-making. This research was applied to a microprocessor and microcontroller programming technique subject at a vocational higher school in Surabaya-Indonesia. The multiple linear regression method was chosen to analyze the effect of simultaneous and partial aspects of critical thinking on students' psychomotor skills. The results showed that there was a significant influence between aspects of critical thinking simultaneously on students' psychomotor skills. While partially, only the predicting aspect has a significant influence on students' psychomotor skills. For other aspects, there is no significant effect on students' psychomotor skills.

## 1. INTRODUCTION

The ability to think critically and psychomotor skills are the skills needed in the 21st-century skills. The ability to think critically is one of the basic needs (Dwyer et al., 2014) and becomes a projection of needs in the education component (ŽivkoviĿ, 2016). Critical thinking is an urgent need in dealing with the dynamics of life during information flow (Franco et al., 2018). Critical thinking includes thinking and using logical reasons, including skills to compare, classify, sequence, connect cause and effect, describe patterns, make analogies, arrange circuits, give reasons deductively and inductively, forecast, plan, and formulate hypotheses (Browne & Keeley, 2015). According to (Benítez, 2013) critical thinking is the ability that students have to examine, relate, and evaluate an event based on previously obtained data. Further, according to (Hanna, 2013) critical thinking such as an intellectually disciplined process in which a person actively and skillfully interprets, plans, predicts, analyzes, evaluates, making decisions on various information that collects or is taken from experiences, observations, reflections made, reasoning or communication made. On-the-job activities, critical thinking is an aspect that must be considered. Employers value critical thinking skills highly as they are necessary for success in the job (Sola et al., 2017). Therefore, the learning process requires critical thinking skills to be trained and taught to students in educational

institutions. The beneficial critical thinking to be taught to the students is that the students can estimate, interpret, predict, and analyze the causes and effects of a problem taught in an educational institution source.

Psychomotor skills are skills needed to be able to compete in the current competency era. Psychomotor skills are methods of learning that involve athletic, manual, and other physical skills that include abilities ranging from simple mechanical activities to activities that involve coordination and neuromuscular strategies (Ivey & Parrish, n.d.). Psychomotor skills are abilities that students achieve in the learning process by applying knowledge to perform performance tasks or work procedures motorically, such as using tools and making products or projects (N. Huang et al., 2020). Psychomotor skills can be taught and trained in educational institutions to provide skills for students ready to work (Harimurti et al., 2018). Implementation of psychomotor skills in learning simple plane materials that have set the target of completeness can be achieved by students effectively (Azhar, 2022).

The urgency of this research is how to teach students with skills such as critical thinking and psychomotor in vocational high school. SMK KAL-1 Surabaya-Indonesia as a vocational high school needs critical thinking skills to find solutions to problems encountered in the learning process of Microprocessor and Microcontroller Programming Techniques. There is a problem in which some students are not capable of using aspects of critical thinking such as estimating, interpreting, predicting, and analyzing a problem in learning Microprocessor and Microcontroller Programming Techniques. The research problems are: 1) How does the influence aspects of critical thinking on students' psychomotor skills in learning microprocessor and microcontroller programming techniques simultaneously? 2) How do the influence aspects of critical thinking on students' psychomotor skills in learning microprocessor and microcontroller programming techniques partially?

### 1.1. Aspects of Critical Thinking

According to (Dwyer et al., 2017) critical thinkers have several characteristics which include: (1) posing important questions and formulating them carefully; (2) being able to come up with new ideas, and being able to modify them; (3) able to evaluate information and abstract ideas; (4) able to conclude with strong evidence; (5) able to think openly, and look for relationships between assumptions; (6) able to distinguish between facts, theories, opinions, and beliefs; (7) able to communicate ideas from complex problems; and (8) honest with oneself, neutral, rejecting manipulation. Critical thinking skills require continuous practice and habituation. Because not everyone can do well without practicing.

According to (Duron et al., 2006) aspects of critical thinking include: asking vital questions and problems, formulating them, gathering and assessing relevant information, using abstract ideas, being open-minded, and communicating effectively with others. Author (Judge et al., 2009) argue that aspects of critical thinking are: (1) not having antipathy towards the ideas and views of others; (2) able to make positive and negative judgments/considerations; (3)

being flexible in considering various alternatives and problem solutions; (4) being honest in conveying arguments from a personal point of view; and (5) being aware of the strengths and weaknesses of the personal arguments presented. Sharpening the ability to think critically is obtained through continuous and continuous practice through experiences from oneself and others.

### 1.2. Psychomotor Skills

The authors (Ali Begam et al., 2018) (Zanal et al., 2023) view the elements of psychomotor learning outcomes as including (1) skill in using tools; (2) the ability to plan, implement, and analyze until the work is completed; (3) the ability to read technical drawings and symbols; (4) the ability to make decisions using the theory obtained; (5) the time required to complete the work; and (6) the quality of the tasks completed. The authors (Mayuze et al., 2023) (Salim et al., 2012) (Seth et al., 2016) argue that the assessment of psychomotor skills can be carried out based on the following (1) planning the steps of the work process in sequence; (2) able to choose the appropriate materials; (3) determine the amount of material needed; (4) able to choose the appropriate tools; (5) following the correct procedures for each implementation; (6) able to make decisions using the necessary theory; (7) able to analyze work with the correct procedures.

### 1.3. Training Kit of Microprocessor and Microcontroller

The author (Jambari et al., 2018) argues that media trainers are made to overcome the limitations of objects and situations so that the learning process continues. Modeling an object or prop that allows it to be made at a low cost can be identified as the process of forming the media of a system. Training kit to support the student learning process in applying concepts to real objects, so that the trainer concept can generally be used in learning and the use of mock- ups, working models, and print media can train students to achieve learning goals (Rusimamto et al., 2021). Author (Somantri, 2016) states believes that the microcontroller training kit is a microcontroller training tool that is integrated between hardware and software to help make application programs for keypads, push buttons, LEDs, seven segments, LCD displays, relays, motors, and sensor applications.

In this study implementing IoT (Internet of Things) as a medium for learning microcontroller training kits in the subject of Microprocessor and Microcontroller Programming Techniques at SMK KAL-1 Surabaya based on the SMK curriculum structure to support basic competencies (KD) of class XI students which include: (1) planning a simple application program with a microcontroller, and (2) planning a simple microcontroller control system application. The Arduino Uno microcontroller training kit is used during learning. Learning activities or practices given to students with the Arduino Uno microcontroller media trainer are controlling input and output ports to control LEDs, 16x2 LCD displays, DC Motors, Buzzers, and Sensors. The learning media for the Arduino Uno microcontroller trainer is shown in Figure 1. The hypothesis of this study such as:

a. There is a significant effect of aspects of critical thinking on students' psychomotor skills in learning microprocessor and microcontroller programming techniques simultaneously.
b. There is a significant effect of aspects Interpretation (CT1) of critical thinking on students' psychomotor skills in learning microprocessor and microcontroller programming techniques partially.
c. There is a significant effect of aspects Planning (CT2) of critical thinking on students' psychomotor skills in learning microprocessor and microcontroller programming techniques partially.
d. There is a significant effect of aspects Predicting (CT3) of critical thinking on students' psychomotor skills in learning microprocessor and microcontroller programming techniques partially.
e. There is a significant effect of aspects Analyzing (CT4) of critical thinking on students' psychomotor skills in learning microprocessor and microcontroller programming techniques partially.
f. There is a significant effect of aspects Evaluating (CT5) of critical thinking on students' psychomotor skills in learning microprocessor and microcontroller programming techniques partially.
g. There is a significant effect of aspects Decision-Making (CT6) of critical thinking on students' psychomotor skills in learning microprocessor and microcontroller programming techniques partially.


**Figure 1.** Training Kit Mikrokontroler Arduino Uno

## 2. METHODS

### 2.1. Sample

The sample of this study used 31 students of class XI of the Electronics Engineering Expertise Program SMK KAL-1 Surabaya for the 2022–2023 school year.

### 2.2. Instrument

The aspects of the critical thinking instrument used are shown in Table 1. The critical thinking instrument consists of 6 aspects such as interpreting, planning, predicting, analyzing, evaluating, and decision-making [6]. Each of these aspects is developed into several indicator questions. The aspect of interpreting was developed into three questions, the aspect of planning into three questions, the aspect of predicting into two questions, the aspect of analyzing into four questions, the aspect of evaluating into two questions, and the aspect of decision making one question. The total number of question items is 15 questions. The rating scale used is a scale from 1-5.

**Table 1.** The aspects of critical thinking instrument

| The Aspects of Critical Thinking | the Aspects of Critical Thinking |
|---|---|
| Interpretation (CT1) | The ability to interpret and evaluate the amount of voltage and program commands on the input and output ports of the microcontroller. |
| Planning (CT2) | The ability to compile flowcharts and simple application programs for control systems with microcontrollers |
| Predicting (CT3) | The ability to predict the causes of errors in simple microcontroller programming commands |
| Analyzing (CT4) | The ability to analyze the function or implementation of program language commands on hardware work processes and analyze input and output port wiring diagrams based on program instructions. |
| Evaluating (CT5) | The ability to express ideas related to combining input application programs with output application programs on the microcontroller |
| Decision -Making (CT6) | The ability of decision-making after the identification of input and output devices or components on the microcontroller system |

Table 2 shows the psychomotor instruments and the question indicators. Questions were made one item each for each indicator so a total of 20 questions were made. The rating scale used is a scale from 1-5

**Table 2.** The psychomotor instrument

| No | The psychomotor indicator |
|---|---|
| 1 | Wearing complete, neat practice clothes, and paying attention to K3 equipment during the temperature monitoring application programming practicum using a temperature sensor (DS 18B20). |
| 2 | Preparing tools and practicum materials for application programming for temperature monitoring microcontroller programs using temperature sensors (DS 18B20). |
| 3 | Determining the amount of materials and equipment needed for practicum activities according to the practicum module. |
| 4 | Selecting and checking the appropriate materials/equipment for practicum purposes. |
| 5 | Making flowcharts for temperature monitoring application programs using temperature sensors (DS 18B20). |
| 6 | Planning the steps for the work process for making a temperature monitoring application program using a temperature sensor (DS 18B20) in sequence according to the work steps in the practicum module. |
| 7 | Following the correct procedures for each implementation. |
| 8 | Reading the wiring diagrams and technical symbols. |
| 9 | installing components according to wiring diagrams or temperature monitoring |

| No | The psychomotor indicator |
|---|---|
| | application circuit schemes using temperature sensors (DS 18B20) neatly and correctly. |
| 10 | Using the tools properly and skillfully according to Procedures Operating Standard |
| 11 | Working by following work procedures according to Procedures Operating Standard |
| 12 | Creating programs and transferring program commands to a minimum system trainer based on IoT microcontrollers |
| 13 | Making decisions using the necessary theory. |
| 14 | Analyzing the working principle of a series of temperature monitoring applications using a temperature sensor (DS 18B20) correctly. |
| 15 | Completing all work steps and practicum assignments within the time provided. |
| 16 | Conducting trials of a series of temperature monitoring application programs using a temperature sensor (DS 18B20) according to the procedure. |
| 17 | Cleaning the workplace, tools, and lab materials after use. |
| 18 | Demonstrating the work of a temperature monitoring application program using a temperature sensor (DS 18B20) systematically. |
| 19 | Programming a temperature monitoring application using a temperature sensor (DS 18B20) functions properly. |
| 20 | The results of analysis and practicum reporting are carried out correctly. |

## 3. RESULTS

The results of calculating the validity of the critical thinking instrument using SPSS found that Cronbach's Alpha value was 0.897 for 15 questions. The Cronbach's Alpha value is greater than 0.6 so the critical thinking instrument is valid. Table 3 shows the validation of the critical thinking instrument.

**Table 3.** The critical Thinking instrument validation results

| Cronbach's Alpha | N of Items |
|---|---|
| 0.897 | 15 |

The results of calculating the validity of the psychomotor instruments instrument using SPSS found that Cronbach's Alpha value was 0.746 for 20 questions. The Cronbach's Alpha value is greater than 0.6 so the psychomotor instruments are valid. Table 4 shows the validation of psychomotor instrument.

**Table 4.** The psychomotor instrumen validation results

| Cronbach's Alpha | N of Items |
|---|---|
| 0.746 | 20 |

Table 5 shows the ANOVA calculation to determine the effect of the independent variable or the aspects of critical thinking (CT) simultaneously on the dependent variable or psychomotor skill (Y). SPSS running results show that the significance value (Sig.) is 0.49. Because Sig. 0.49 < 0.05, the decision is that the null hypothesis is rejected and H1 is accepted, so that there is a significant effect of the independent variables CT1, CT2, CT3, CT4, CT5, and CT6 simultaneously on the psychomotor skill of students (Y).

**Table 5.** The Anova calculations

| ANOVA[a] | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| 1 | Regression | 116.782 | 6 | 19.464 | 2.517 | 0.049[b] |
| | Residual | 185.605 | 24 | 7.734 | | |
| | Total | 302.387 | 30 | | | |

a. Dependent Variable: Y
b. Predictors: (Constant), CT6, CT1, CT5, CT2, CT3, CT4

Table 6 shows the regression equation formed between aspects of critical thinking and psychomotor skills such as: Y = 86.022 +0.085*CT1 + 0.101*CT2 - 0.149*CT3 - 0.164*CT4+0.123*CT5-.006*CT6. Furthermore, Table 6 also shows the calculation of the t-test for partial calculations between the aspects of critical thinking (CT) and the psychomotor skills variable the dependent variable (Y). The calculation results show that the significance value of the independent variable is smaller than the alpha value (0.05) only for the aspect of CT3 (predicting) which is equal to 0.025 while the others are larger. Therefore the hypothesis decision is as follows: The second hypothesis is that there is no significant effect between CT1 (interpreting) and Y, the hypothesis third is that there is no significant effect between CT2 (planning) and Y, the fourth hypothesis is that there is a significant effect between CT3 (predicting) and Y, the fifth hypothesis is that there is no significant effect between CT4 (analyzing) and Y, the sixth hypothesis is that there is no significant effect between CT5 (evaluating) and Y, the seventh hypothesis is that there is no significant effect between CT6 (decision-making) and Y. That there is a significant effect for the aspects predicting of critical thinking (CT3) on psychomotor skill (Y) partially while for the aspects of interpreting (CT1), planning (CT2), analyzing (CT4), evaluating (CT5), and decision-making (CT6), they do not have a significant effect on psychomotor skill (Y) partially. However, this research is still in line with research (McBride et al., 1990) that students who are taught repeatedly will improve their cognitive abilities if they are trained to use critical thinking skills. By increasing critical thinking skills, students' psychomotor skills also increase.

**Table 6.** The equation coefficient and the t-test result

| Coefficients[a] | | | | | | |
|---|---|---|---|---|---|---|
| | | Unstandardized Coefficients | | Standardized Coefficients | | |
| Model | | B | Std. Error | Beta | t | Sig. |
| 1 | (Constant) | 86.022 | 3.735 | | 23.034 | 0.000 |
| | CT1 | 0.085 | 0.056 | 0.347 | 1.526 | 0.140 |
| | CT2 | 0.101 | 0.114 | 0.344 | 0.883 | 0.386 |
| | CT3 | -0.149 | 0.063 | -0.639 | -2.386 | 0.025 |
| | CT4 | -0.164 | 0.145 | -0.604 | -1.136 | 0.267 |
| | CT5 | 0.123 | 0.082 | 0.452 | 1.512 | 0.144 |
| | CT6 | -0.006 | 0.053 | -0.033 | -0.117 | 0.908 |

a. Dependent Variable: Y

Next is the calculation of R Square to find out how much the independent variable simultaneously influences the dependent variable. Table 7 shows that the R square is 0.386. This shows that the variables CT1, CT2, CT3, CT4, CT5, and CT6 simultaneously influence on the psychomotor skills variable (Y) of 0.386 or 38.6%. This shows that the critical thinking aspect as a whole can influence psychomotor skills. Therefore, there is a significant effect for the aspects of critical thinking (CT) on psychomotor skill (Y) simultaneously. This finding is in line with research (M.-Y. Huang et al., 2017) which states that pupils' critical thinking abilities had improved along with their basketball skills.

**Table 7.** The Calculation of R square

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|---|---|---|---|---|
| 1 | 0.621[a] | 0.386 | 0.233 | 2.7809 |

a. Predictors: (Constant), CT6, CT1, CT5, CT2, CT3, CT4

b. Dependent Variable: Y

Critical thinking aspects of students' psychomotor skills in learning microprocessor and microcontroller programming show that teaching computational thinking can help students develop the critical and analytical thinking skills needed in microprocessor and microcontroller programming.

Several studies show that project-based teaching and problem-based teaching can help students develop their critical and analytical thinking skills in the context of microprocessor and microcontroller programming.

In addition, the use of learning models that focus on problem-solving processes and the use of software and applications designed to develop computational thinking abilities can also help students develop their critical and analytical thinking abilities in the context of microprocessor and microcontroller programming.

## 4. CONCLUSION

The conclusion of this research is as follows:

The results of this study only answer one hypothesis the aspects of critical thinking from the 6 hypotheses in total. This aspect is the CT3 aspect, namely the student's predictive ability regarding psychomotor skills. The other aspects of CT on the subject of Microprocessor and Microcontroller Programming Techniques, do not show any significance on students' psychomotor skills. The aspects of critical thinking only have one significant effect on psychomotor skill (Y) partially but there is a significant effect for the aspects of critical thinking (CT) on psychomotor skill (Y) simultaneously.

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