The Development of Module Based on Microcontroller in Improving Student Computational Thinking Skills

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ABSTRACT

Computational thinking is a method for solving problems using algorithms similar to techniques used in software programming. The purpose of this research is to examine the validity, practicality and effectiveness of microcontroller-assisted modules. The type and design of the research includes the type of research (research and development) R & D that has been developed using Plomp's research design through the following steps, namely preliminary research, prototyping phase, and assessment phase. Data collection uses several techniques, namely interviews, questionnaires, computational thinking tests. The instruments used are validation sheets, student anget sheets, and observation sheets. The feasibility of the module is measured using a validation sheet and to measure student interest in the product that has been developed using a student response questionnaire sheet. The results of the validity analysis of 89% were declared very valid obtained from the three validators, 92% practicality was declared very practical with practicality indicators in the form of student fluency in using the module, and effectiveness of 0.78 obtained from n-gain analysis which means quite effective and the results of the student response questionnaire sheet in the good category of 72%. The results of the analysis obtained show that the use of microcontroller-assisted modules that are valid, practical, and effective in earth science courses can improve student computational thinking.

Keywords: module, microcontroller, computational thinking

INTRODUCTION

The industrial revolution 4.0 in the 21st century is known for the rapid development of technology and information and has an impact on various lives such as education. According to Anggraeni et al (2023), the rapid development of technology in education provides space for the world of education to continue to adapt to technological developments in order to improve the quality of education. In facing the era of the Industrial Revolution 4.0 and creating a generation that can survive and compete, several preparatory steps need to be taken, including the development of an innovative learning system, adaptive policy adjustments, and the preparation of responsive, adaptive, and competent human resources in the face of changes that occur in the industrial revolution (Mustofa et al, 2023).

One important ability that supports the rapid development of information technology is computational thinking (Barr, Harrison, & Conery, 2012). Computational thinking is a method for solving problems using algorithms similar to techniques used in software programming (Sa'adah et al., 2023). Computational thinking is not only an investment for computer science but can be applied in various disciplines as a step in solving high-level thinking problems including humanities, mathematics and natural sciences (Yasin, 2020). This is supported by the opinion of Ridlo et al. (2022) computational thinking can train students to analyze, identify and have a solution to a problem.

Since 2014, the British government has introduced Computational Thinking Skills to students in several educational units so that these students can make decisions and also solve existing problems (Malik, 2019). However, in Indonesia, the introduction of Computational Thinking Skills is still low. Kemendikbudristek has conducted an internal study that there are limitations in the implementation of computational thinking skill learning in Indonesia (Ridlo et al, 2020). The implementation of learning computational thinking skills in

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Indonesia is still limited to primary and secondary schools (Ismarmiaty et al., 2020). Based on the results of a survey conducted in the research of Muhammad. (2023), conventional teaching models are still often used, resulting in students feeling bored and sleepy during the teaching and learning process.

An alternative way to overcome the low computational thinking of students in earth science is by presenting teaching materials in the form of microcontroller-assisted modules. The use of microcontroller learning media has been tested by Manalu (in Husain's thesis, 2019) which shows the results of microcontroller learning media design can adjust the needs that can help students in mastering the material effectively. The same thing was also conveyed by Morton (in Husain's thesis, 2019) in Husain's thesis (2019) in his research entitled "A Student Constructed Microprocessor Development Board For Teaching Microcontrollers" which shows that students feel happier in assembling and are more interested because they feel they "own" the circuit that has been built. This is applied in this study, which is a microcontroller trainer in the form of a separate module, where students must assemble themselves and program themselves so that the circuit can function according to the results of their respective work.

The results of observations in the field show that the low level of computational thinking is caused by lecturers still using makeshift references without making their own teaching materials to support learning activities, and the lack of learning media such as modules that are interesting to improve students' computational thinking. Therefore, it is important to develop teaching materials as an effort to improve students' computational thinking. The development of teaching materials aims to be able to meet the needs of students in the face of the 21st century and improve the quality of learning at the university level after the development of increasingly sophisticated educational technology.

METHOD

The type of research is included in R & D (Research and Development) research. The research refers to the Plomp Model development research procedure with three steps, namely the preliminary assessment, the prototyping phase, and the phase of assessing students' abilities Plomp (2010). The research was located in the Bachelor of Science Education study program, Faculty of Teacher Training and Education, University of Jember with the research time during the odd semester of the 2024/2025 academic year. Research participants were 3rd semester students of the Bachelor of Science Education study program. There are three data collection techniques, the first technique uses a questionnaire in which there is a validation sheet to measure the feasibility of the microcontroller-assisted module that has been developed to suit the needs and objectives of the study. Three validators conducted validation using a validation sheet.

The implementation sheet filled by three observers aims to find out how the implementation of learning when using a microcontroller-assisted module. The second technique is using a computational thinking test with several indicators, namely abtraction, decomposition, generalization, algortms, debugging. The test is implemented in the form of a pretest before students use the product and a posttest is given after students use the product. The test serves to determine the extent to which the microcontroller-assisted module can improve student computational thinking, later the value of the science literacy test results of this ability is useful as data to determine the effectiveness of the module product itself. The third technique uses interviews conducted in the early stages of research, namely preliminary research aimed at lecturers who teach earth science courses. The goal is to find out the problems and needs in learning that have been implemented so far. This module development research design uses Plomp's research design. The following are the modified steps of the development model according to Plomp (Figure 1).

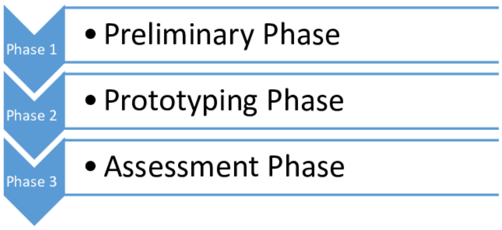

Fig 1. Model of Developmental Research

The Plopmp development model requires product validation in the form of content validity and construct validity before being used by students. The value of the validator obtained from the validation sheet will be analyzed with calculations from relevant theories. The calculation formula to analyze validity is as follows:

$$Va = \frac{T_{SE}}{T_{SM}} \text{ x } 100\ \% \qquad (1)$$

Description:

Va = Expert validation

TSE = Total empiric score

TSM = Total maximum score

The practicality of the module was carried out by observing the implementation of learning by three observers through the implementation sheet. The practicality indicator used is when using a microcontroller-assisted module. The results obtained will be analyzed using the formula:

$$KP= \frac{Total\ score\ obtained}{Total\ maximum\ score} \text{ x } 100\ \% \qquad (2)$$

Descrpition:

Kp = practicality score from the observation of implementation by the observer

The effectiveness of the microcontroller-assisted module to improve students' computer thinking skills is measured through tests and student response questionnaires. The test scores will then be analyzed using the n-gain test so that it can be seen how much improvement. The n-gain value can be determined using the following calculation formula according to Hake (1998):

$$<g> = \frac{(S\ post-test)-(S\ pre-test)}{S\ max-(S\ pre-test)} \qquad (3)$$

Description:

<g> = average of n-gain score

Furthermore, the student response questionnaire, after using the microcontroller-assisted module with assessment indicators in the form of interest, motivation, response, satisfaction, and interest. The student response questionnaire will be analyzed using a Likert scale with a choice of 4 scales using. the calculation formula for the percentage of student responses, namely as follows:

$$P = \ = \frac{Item\ score\ obtained}{Maximum\ score} \text{ x } 100\ \% \qquad (4)$$

Description:

P = max score

RESULT AND DISCUSSION

The results of the research will be used to create printed and online educational products that will improve students' computational thinking. This will be done through the preparation of materials and practice questions that are aligned with indicators of computational thinking.

Preliminary Research

Analysis of problems and needs experienced in learning in earth science courses as an initial description related to the research to be carried out through literature studies from previous research. The acquisition of the analysis

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of problems and needs is that the learning carried out often uses power point. on the other hand, students' computational thinking skills are still low and have never used microcontroller-based modules in earth science courses. In addition, through interviews with lecturers in the earth science course held on Tuesday, September 24, 2024. Interviews are conducted to find out how the learning process includes media and teaching and learning applications, student abilities and so on. The results obtained were that the learning carried out only used power points made by students and presented in front of the class, causing students to lack understanding of the subject matter directly related to the surrounding environment. The subject matter given to the students is the evidence of the Earth's past, the process of determining the age of structural rocks and the constituents of the atmosphere and microclimate parameters shown in Figure 2 below.

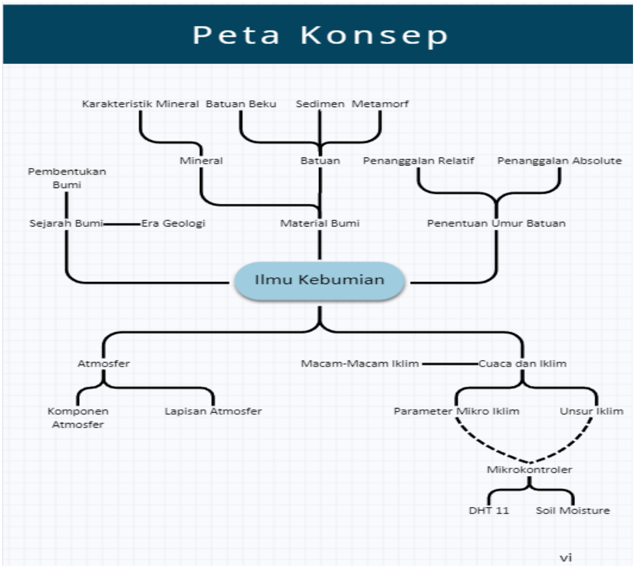

Fig 2. Earth Science Concept Map

Prototyping stage

At this stage, the design of product development, learning devices and instruments is carried out. The features of the microcontroller-based module are made based on the problems found in the preliminary stage, these features include an attractive appearance, the design of a microcontroller that will be used by students to solve problems based on computational thinking indicators. In the design of supporting devices, researchers compiled learning devices in the form of semester learning plans and syllabi, which previously had to be validated by validators, while for the design of instruments, researchers compiled instruments in the form of validation sheets, implementation sheets and test questions. The design of this product development researcher designs modules on an editing website, namely canva.com. on the website, the researcher designs the appearance and compiles the module content. One of the microcontroller-based module contents is shown in Figure 3 below.

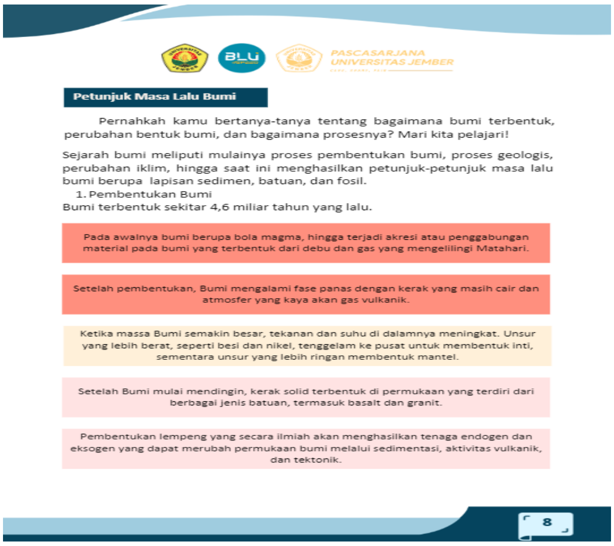

Fig 3. Theoretical Framework

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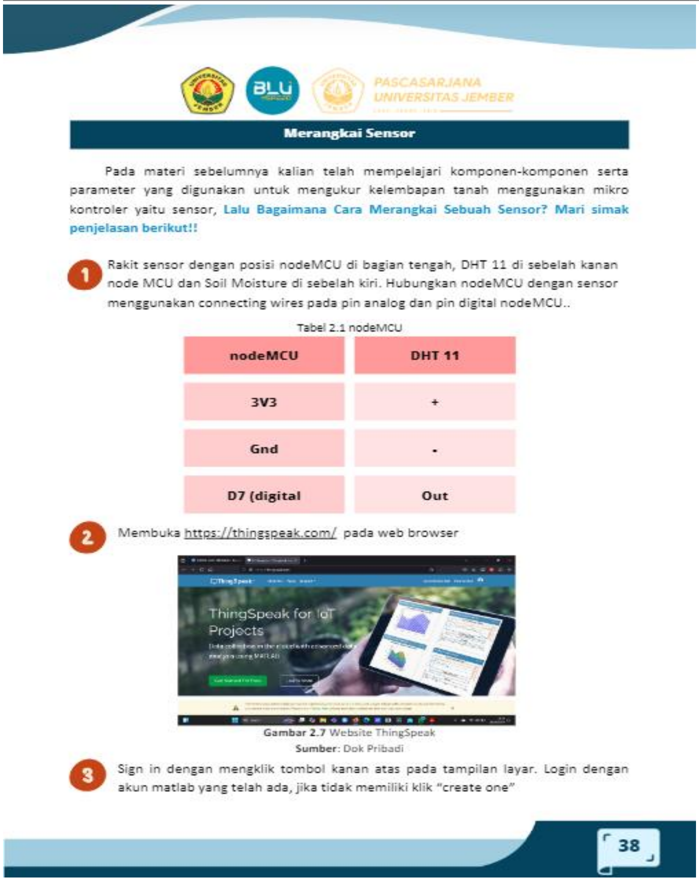


PASCASARJANA UNIVERSITAS JEMBER

Merangkai Sensor

Pada materi sebelumnya kalian telah mempelajari komponen-komponen serta parameter yang digunakan untuk mengukur kelembapan tanah menggunakan mikro kontroler yaitu sensor, **Lalu Bagaimana Cara Merangkai Sebuah Sensor? Mari simak penjelasan berikut!!**

1 Rakit sensor dengan posisi nodeMCU di bagian tengah, DHT 11 di sebelah kanan node MCU dan Soil Moisture di sebelah kiri. Hubungkan nodeMCU dengan sensor menggunakan connecting wires pada pin analog dan pin digital nodeMCU..

Tabel 2.1 nodeMCU

nodeMCU	DHT 11
3V3	+
Gnd	-
D7 (digital	Out

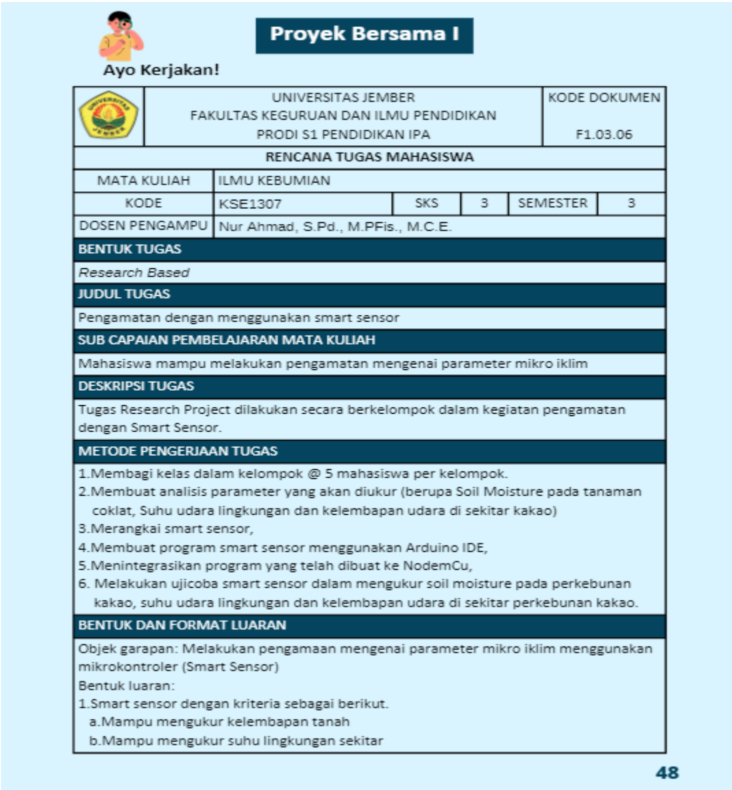
2 Membuka https://thingspeak.com/ pada web browser

Gambar 2.7 Website ThingSpeak
Sumber: Dok Pribadi

3 Sign in dengan mengklik tombol kanan atas pada tampilan layar. Login dengan akun matlab yang telah ada, jika tidak memiliki klik "create one"

38

Fig 4. Good Practice



Proyek Bersama I

Ayo Kerjakan!

UNIVERSITAS JEMBER FAKULTAS KEGURUAN DAN ILMU PENDIDIKAN PRODI S1 PENDIDIKAN IPA				KODE DOKUMEN F1.03.06	
RENCANA TUGAS MAHASISWA					
MATA KULIAH	ILMU KEBUMIAN				
KODE	KSE1307	SKS	3	SEMESTER	3
DOSEN PENGAMPU	Nur Ahmad, S.Pd., M.PFis., M.C.E.				
BENTUK TUGAS					
Research Based					
JUDUL TUGAS					
Pengamatan dengan menggunakan smart sensor					
SUB CAPAIAN PEMBELAJARAN MATA KULIAH					
Mahasiswa mampu melakukan pengamatan mengenai parameter mikro iklim					
DESKRIPSI TUGAS					
Tugas Research Project dilakukan secara berkelompok dalam kegiatan pengamatan dengan Smart Sensor.					
METODE PENGERJAAN TUGAS					
1.Membagi kelas dalam kelompok @ 5 mahasiswa per kelompok. 2.Membuat analisis parameter yang akan diukur (berupa Soil Moisture pada tanaman coklat, Suhu udara lingkungan dan kelembapan udara di sekitar kakao) 3.Merangkai smart sensor, 4.Membuat program smart sensor menggunakan Arduino IDE, 5.Menintegrasikan program yang telah dibuat ke NodemCu, 6. Melakukan ujicoba smart sensor dalam mengukur soil moisture pada perkebunan kakao, suhu udara lingkungan dan kelembapan udara di sekitar perkebunan kakao.					
BENTUK DAN FORMAT LUARAN					
Objek garapan: Melakukan pengamaan mengenai parameter mikro iklim menggunakan mikrokontroler (Smart Sensor) Bentuk luaran: 1.Smart sensor dengan kriteria sebagai berikut. a.Mampu mengukur kelembapan tanah b.Mampu mengukur suhu lingkungan sekitar					

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Fig 5. New Activities

In addition, the microcontroller-based module was implemented or tested by students to determine the level of practicality of the product. However, before the product is tested, it must first be validated to see the feasibility of the product that has been made. The design of support devices for the application of microcontroller-based modules in learning in the form of Semester Learning Plan, which will later become a reference for researchers

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in the learning process in the classroom. The Semester Learning Plan focuses on the implementation of learning in Earth Science courses by using teaching materials in the form of microcontroller-assisted modules to train students' computational thinking. This is followed by the design of instruments, namely expert validation sheets for development products, syllabus and semester learning plan. The second instrument is the learning implementation observation sheet to measure the practicality of using the development product. The third instrument is a test question used to measure the effective use of the product. The test questions were prepared based on the indicators of computational thinking, each test had 10 items of computational thinking questions.

Each course learning sub-achievement has computational thinking indicators facilitated by microcontrollers in the module so that it helps to improve students' computational thinking. The prepared module is then validated by experts, namely three lecturers consisting of two lecturers of earth science courses and one expert lecturer in the field of microcontroller. The validation of the module result in the following table is a bellow:

Table I Microcontroller-Assisted Module Validation Result

No	Assessment aspect	Interval Score			%	Category
1.	Content and material aspects	0,83	0,93	0,98	91%	Very Valid
2.	Presentation aspect	0,70	1,00	0,95	88%	Very Valid
3.	Graphical Aspectf	0,71	1,00	0,96	89%	Very Valid
Average Scoreqqqqq		0,75	0,98	0,96	89%	Very Valid

At the validation stage there was input from the three validators about the design, layout and writing model. Evaluation is carried out in the form of suggestions from validators on the products developed to function as a reference for product improvement so that when applied it can be a product that is suitable for use and makes students more eager to learn. According to Husada et al (2020) the purpose of product development is not only to produce a feasible and valid product, but also to find and correct product deficiencies and weaknesses through suggestions and criticisms from validators.

Assesment stage

After the completion of the development product, supporting devices and instruments have been validated and declared valid, the next step is the evaluation stage. in the evaluation stage, field trials of development products, namely module flipbooks, are conducted to measure the effectiveness and practicality in learning. The development product was tested in learning for five sessions. The trial was carried out only once, because through the trial, the researcher had obtained the results or an overview of the students' shortcomings. The results of the product practicality analysis are measured through assessment activities carried out during learning, such as the usefulness of the implementation of activities in the module and the readability of the module, which when described in student activities are in the following table:

Table II Module Practicality Test Results

Aspects Observed						Average	Category
	1	2	3	4	5		
Indoduction	100	85	89	96	96	93%	Very Practical
Core	93	98	91	89	100	94%	Very Practical
Closing	96	89	85	85	85	88%	Very Practical
Average Presentation						92%	
Score Criteria						Very Practical	

The practicality of the microcontroller-assisted module is shown by the implementation of the learning process using the microcontroller-assisted module which will be measured based on the learning implementation sheet by three observers. When viewed based on table 2, the implementation of learning in five meetings obtained an average percentage value of 92%. Based on this percentage value, it can be interpreted that learning by applying microcontroller-assisted modules is included in the practical category when implemented. In accordance with the criteria for the level of practicality of learning implementation stated by Nesri and Kristanto (2020) that microcontroller-assisted modules can be said to be very practical if they obtain a percentage of learning implementation in the range of 80%-100%. This statement is also reinforced by the research of Masruroh et al., (2022) that the average percentage of implementation using the module is very practical to use with a score of 87%. The implementation of learning using the developed microcontroller-assisted module teaching materials, students are quite enthusiastic and play an active role when learning takes place. Students are not considered to have difficulties in using microcontroller-assisted modules. However, there are some obstacles in the implementation of learning using the module, namely there are some students who are a little unclear about the questions given in some of the activities in the module because each question is inserted with computational thinking indicators, besides that there are some students who are a little difficult in assembling the sensors they will use to complete the project together because they did not enter the previous meeting.

Table III Module Effectiveness Test Results

Component	Class B		N-gain	Category
	Pretest	Postest		
Total Students	33		0,78	High
Lowest Score	12	72		
Highest Score	50	94		

Based on Table 3, it can be seen that the students' n-gain value is 0.78, which is in the high category. These results indicate an increase in students' computational thinking skills after using a microcontroller-based module on the topic of Earth's Past Directions, determining the age of rocks, atmosphere, and microclimate parameters. The test consisted of ten items, with each item consisting of five computational thinking indicators (abstraction, generalization, decomposition, algorithm, and debugging). In addition, validity data were also analyzed based on each indicator.

Table IV Results of N-gain Analysis of Computational Thinking Indicators

Indicator Computational Thinking	Average Pre-test	Average Pos-test	N-gain	Category
Abstraction	3,97	8,70	0,78	High
Generalitation	4,85	9,18	0,84	High
Decomposition	3,73	7,85	0,66	Medium
Algortms	0,48	8,97	0,89	High
Debugging	0,79	8,28	0,81	High

Table 4 shows the results of the analysis of each indicator of students' computational thinking, students' ability to recognize patterns to formulate problems (decomposition) is still relatively low because students still have difficulty in gathering information and connecting the problems given. This is in line with the results of research by Litia et al. (2023) the generalization indicator (pattern recognition) obtained the lowest average percentage compared to other computational thinking indicators, namely 74%. Meanwhile, what has a very significant increase is the algorithm indicator because students can design problem steps after fully going directly to the field to see the surrounding conditions and learn in advance about programming that is organized and logical to solve the problems given. In line with Cahdriyana and Rino's statement (2020) Logical thinking is closely related to problem solving. Therefore, computational thinking, whose thinking comes from computer science, is an essential skill for solving problems that are urgently needed by learners in the era of the industrial revolution 4.0.

However, it is not uncommon for some students to still be confused about how to do the pre- and post-test computational thinking questions. This happens because students have never been presented with questions that include indicators of computational thinking skills. The result of the n-gain analysis is 0.78, where according to

Hake (1998), the n-gain is said to be high if it exceeds 0.70, which means that the students' computational thinking skills have increased. According to Mustofa et al (2023), the use of modules in learning helps students to better understand the material independently and the effectiveness of the teaching and learning process can be known through test results that meet the learning objectives.

Table V Student Response Questionnaire Analysis Results

No	Assessment indicators	Presentase (%)	Category
1	Attraction	85	Very Good
2	Material	71	Good
3	Language	60	Good
Average Score		72	Good

Effectiveness is also seen from the students' responses to the development of microcontroller-based modules. In Table 5, the results of the analysis of the student response questionnaire include 3 indicators consisting of 5 items of interest indicators, 3 items of material indicators, and 3 items of language indicators. The analysis of students' responses is useful for measuring students' comments after using a microcontroller-based module. The results of the questionnaire analysis of students' answers after using the microcontroller-based module from 33 students obtained an average percentage of 72% with good criteria. According to Murniati et al. (2023), the acquisition of high scores in the student response questionnaire is an indicator that the teaching materials used have a high appeal to students. This is also supported by the research of Tukan et al. (2020), which suggests that the results of student response questionnaires in the excellent category show that the module is classified as an effective teaching material in attracting students' interest in learning. The effectiveness of the product is described based on the improvement of students' computational thinking as measured by computational thinking tests in the form of tests.

Based on the results of the research and the presentation of the data that has been described, the development of a microcontroller based module using the Plomp (2010) development model on the topic of the Earth's past clues, determining the age of rocks, atmosphere and microclimate parameters in the Earth Science course in the odd semester of the academic year 2024/2025 with valid, practical and effective criteria.

CONCLUSIONS

The validity of the module has been declared valid where the module is equipped with microcontroller preparation along with the coding used to solve problems in the environment in accordance with the learning outcomes of the Earth Science course with a validity score of 89% which is included in the very valid category. The data analysis of the practicality obtained an average of 92%, which means very practical. Effectiveness with an n-gain of 0.78 means high. The students' response to the microcontroller-based module is quite good because it has a percentage of 72% of the overall average indicator. Thus, it can be concluded that the microcontroller-based product can be implemented in the learning process as an effort to improve students' computational thinking skills.

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