DOI: https://doi.org/10.33487/edumaspul.v9i2

EDUMASPUL
JURNAL PENDIDIKAN

Vol 09 No. 02 (2025) page 305-310

p-ISSN 2548-8201 | e-ISSN 2580-0469
https://ummaspul.e-journal.id/maspuljr/

Validation of Educational Robotic-Based Vector Learning Module Using a Structured Inquiry Model to Improve Students' Computational Thinking Skills

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Receive: 11/05/2025	*Accepted: 12/06/2025*	*Published: 01/10/2025*

Abstrak

Permasalahan yang terjadi disekolah penelitian yakni siswa mengalami kesulitan dalam memvisualisasikan materi vektor dengan konteks yang nyata. Setelah melakukan analisis maka solusi yang diberikan pada permasalahan diatas yakni berupa media educational robotic. Penggunaan educational robotic ini diharapkan dapat membantu siswa memahami materi vektor yang dihasilkan dari visualisasi pergerakan robot. Pengembangan ini bertujuan untuk menghasilkan sebuah produk berupa modul pembelajaran berbasis educational robotic menggunakan model inkuiri terstruktur untuk meningkatkan kemampuan computational thinking siswa. Produk yang telah dihasilkan akan diuji validitas oleh ahli materi dan ahli media. Model pengembangan yang digunakan pada penelitian ini yakni model ADDIE yang hanya mencapai tahap pengembangan. Subjek penelitian yakni guru mata pelajaran fisika, ahli materi, dan ahli media. Teknik analisis data yang digunakan saat wawancara yakni spiral. Sedangkan data ahli materi dan ahli media menggunakan analisis deskriptif kuantitatif. Berdasarkan data hasil validasi yang telah didapatkan dari ahli materi pertama sebesar 78,27% dengan kriteria cukup valid. Ahli materi kedua memberikan nilai sebesar 96,53 dengan kriteria sangat valid dan ahli media mendapatkan nilai validasi sebesar 92,83% dengan kriteria sangat valid. Berdasarkan hasil validasi diatas maka modul pembelajaran vektor berbasis educational robotik menggunakan model inkuiri terstruktur untuk meningkatkan kemampuan computational thinking layak digunakan.

Kata Kunci: Model ADDIE; *Educational Robotic*; Modul Pembelajaran Vektor; Inkuiri Terstruktur; Berpikir Komputasi

Abstract

The problem that occurs in research schools is that students have difficulty in visualizing vector material with real context. After conducting the analysis, the solution provided to the above problem is in the form of robotic educational media. The use of educational robotics is expected to help students understand the vector material produced from the visualization of robot movements. This development aims to produce a product in the form of an educational robotic-based learning module using a structured inquiry model to improve students' computational thinking skills. The products that have been produced will be tested for validity by material experts and media experts. The development model used in this study is the ADDIE model which has only reached the development stage. The subjects of the study are physics teachers, material experts, and media experts. The data analysis technique used during the interview is spiral. Meanwhile, data from material experts and media experts used quantitative descriptive analysis. Based on the data of the validation results that have been obtained from the first subject matter expert is 78.27% with fairly valid criteria. The second material expert gave a score of 96.53 with very valid criteria and media experts got a validation score of 92.83% with very valid criteria. Based on the results of the validation above, the educational robotics-based vector learning module uses a structured inquiry model to improve computational thinking skills that are suitable for use.

***Keywords**: ADDIE Model; Educational Robotic; Vector Learning Modules; Structured Inquiry; Computational Thinking*

Introduction

Physics learning in vector materials has abstract characteristics. A vector is an object that has a length that describes the vector quantity and the direction of the arrow indicates the direction of the vector. Vectors are usually visualized in the form of straight lines that have an arrow-like base and end (Bollen et al., 2017). Vector notation is usually written or expressed with a letter accompanied by an arrow above the letter. To understand vector learning, students must have a strong understanding of mathematics and visualization skills to present vectors in either two- or three-dimensional spaces.

Based on the results of interviews conducted by researchers with physics teachers at Xaverius 1 Jambi High School, it was found that students had difficulties in visualizing vector concepts. Vectors that have abstract properties make it difficult for students to relate theories to real contexts, which can reduce students' understanding of vector material. This is in line with the opinion expressed by (Wutchana et al., 2015) that the concept of vector cannot be fully understood or understood by students. This is due to the abstract nature of vectors so that it requires strong visualization to understand it (Budiarti, 2019). This shows that visualization skills are very important for every student to have in presenting vectors. Several media have been used by teachers to assist students in visualizing vector material. However, it is considered not enough to overcome these problems. Based on the above problems, it is very important to find solutions in solving these problems.

Based on previous studies on innovative media used in visualizing vectors, there are macromedia flash-based animations that are considered to improve students' visualization skills (Sani et al., 2018). In addition, previous researchers have also provided solutions by using media line followers and soccer robots in order to increase students' interest in learning in participating in learning activities in the classroom (Setia Asih et al., 2019).

Previous researchers (Hastuti et al., 2017) also offered a solution with a problem-based learning model which was stated as one of the models that requires student involvement during the learning process. Where in the problem-solving process, students are required to be able to visualize physics problems into representations that can be solved (Fitriyani et al., 2019).

Although several approaches have been carried out as a solution to the above problems, there are still shortcomings that have been found. The shortcoming is that the problem-based learning model has a disadvantage in the lack of guidance from the gruu so that it affects the effectiveness of learning. The use of macromedia flash media is indeed stated to help visualization, but not all physics concepts can be visualized. In the research on the use of soccer robots, it only focused on its manufacture and it was not explained how it affected the use of physics learning.

In response to these problems, the researcher provided a solution, namely developing a vector learning module based on eduactional robotics. The update of the module used, which is based on educational robotics, provides an opportunity for students to explore vector concepts by visualizing vector material in real life. Teaching using visual media can provide concrete understanding to students (Ramadani et al., 2022).

Visualizing material using robotic media requires computational thinking skills. Computational thinking skills are the ability to solve problems systematically and logically. According to (Maulidiyah & Anistyasari, 2020) states that robot media used in solving problems and finding solutions can improve computational thinking skills through visualized programming. The programming used is mBlock where mBlock is a block-based visual programming that is very easy for students to use as beginners.

The structured inquiry learning model is a learning model chosen by the researcher used in the learning module. This structured inquiry learning module is considered to be able to invite students to be active in the learning process (Damhuri et al., 2020). The inquiry learning model has been proven to be effective in increasing understanding of (Damhuri et al., 2020). The inquiry learning model has been proven to be effective in increasing understanding of concepts so that students can easily delve into the material. Responding to the challenges that are being faced by students, the educational robotic-based vector learning module can help students visualize the material through the use of robots that have been integrated into the module with learning steps according to the structured inquiry syntax so that it can improve students' computational thinking skills.

Problem Formulation

Based on the above background, the formulation of the problem in this study is as follows:

1. What is the process of developing educational robotics-based vector learning modules with a structured inquiry learning model to improve computational thinking skills?
2. What are the results of the validation of material experts and media experts on the

educational robotic-based vector learning module with a structured inquiry learning model to improve computational thinking skills?

Research Objectives

Based on the formulation of the problem above, the following are the objectives of the research, which are as follows:

1. Explain the stages and processes of developing vector learning modules based on educational robotics with a structured inquiry learning model to improve computational thinking skills.
2. Analyze the validation of material and media experts regarding the development of educational robotics-based vector learning modules with a structured inquiry learning model to improve computational thinking skills.

Research Benefits

This research is expected to provide theoretical and practical benefits, namely the following:

Theoretical Benefits

This research is expected to be one of the sources or references for scientific studies in the field of development of robotic-based educational learning modules.

Practical Benefits

For teachers: The result of this research is an educational robotic-based vector learning module which is expected to be one of the alternative learning media for vector materials.

For schools: The result of this research is an educational robotic-based vector learning module which is expected to be one of the learning innovations that supports the school's vision to develop technology-based learning.

For researchers: The result of this study is that the educational robotic-based vector learning module is a valuable experience for researchers. So that in the future researchers are more motivated to explore this.

Method

The development model used, namely the ADDIE model, consists of the stages of analysis, design, development, implementation, and evaluation. In this study, the ADDIE stage was used only until the development stage. The following is a picture of the stages of ADDIE according to (Branch, 2009), namely:

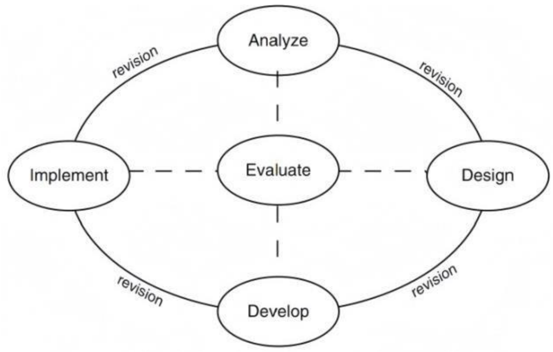

Figure 1. ADDIE Stage

The research was conducted at SMA Xaverius 1 Jambi. The first stage of this study is the analysis stage. The analysis stage consists of several analyses, first needs analysis by conducting interviews with teachers and analysis of needs and characteristics of students. The goal is to find out the extent to which this module can be a solution to teachers' problems and meet the learning needs of students in the classroom. Second, curriculum analysis aims to gain an understanding of the learning outcomes that students must achieve in vector materials. Third, content analysis is carried out to provide an overview of the depth and breadth of the material that will be presented in the module. Finally, a literature analysis that aims to summarize research relevant to the topic raised by the researcher.

The second stage is the design stage which consists of several steps. The first step is to design the design, structure and content of the module which produces a storyboard in the form of an initial design of the module product. The second step is to design a structured inquiry-based learning strategy and adjust it to computational thinking skills consisting of experiment objectives, materials, and problem images that will be presented in the module.

The third stage is the development stage which consists of the content development stage, prototyping of vector learning modules, and finally module validation by material experts and media experts.

The research subjects at the analysis stage were two physics teachers involved in the interview. At the design stage, the research subject is the development team. At the development stage, the research subjects are a development team, two material experts, and media experts. Data collection techniques at the analysis stage are through unstructured interviews or free interviews with two physics teachers, identification of discourse needs to achieve learning outcomes, and literature studies. At the design stage, data collection techniques are in the form of discussions that focus on the development team, and finally at the developer stage by conducting validity tests by material experts and media experts.

The data collection instrument at the analysis stage was using an interview sheet. At the stage of developing the instruments used, namely the validation questionnaire sheet of material experts and media experts. The subject matter expert validation questionnaire consists of twenty-one questions with three aspects. The feasibility aspect of the content consists of indicators of the suitability of the material with the learning objectives, the accuracy of the material, and the support of the learning material. The feasibility aspect of the presentation consists of presentation techniques, presentation support, learning presentation, and completeness of presentation. Language assessment aspects consist of straightforward, communicative, interactive dialogue, suitability with the level of development of students, collapse and integration of thought patterns, and the use of terms along with symbols or icons (Arigiyati et al., 2018). The media expert validation questionnaire consists of 13 assessment items from 5 aspects consisting of aspects of presentation design, ease of use, ease of access, repeat use, and meeting standards (Hamidah et al., 2022).

The data analysis technique used in the analysis stage is using a spiral model consisting of data collection, data management, reading and recording, illustrating, classifying and interpreting, presentation and visualization. In the development stage, the data analysis technique used is quantitative descriptive analysis. Each aspect is scored using a likert scale and then calculated and then analyzed using descriptive analysis to find out whether the module is worth using or needs further improvement. This analysis applies to the validation of material experts and the media.

Result and Discussion

Stages of Analysis

The first step in the analysis stage is a needs analysis consisting of interviews and characteristics along with the needs of 21st century students. The results of interviews that have been conducted with physics teachers have found that many students have difficulty visualizing vector materials in context. The results of the analysis of 21st century students are characterized by digital literacy, creativity and innovation, critical thinking skills, collaboration skills, and information literacy. To meet these characteristics, it requires digital-based learning media that is presented in the form of real context so that it can solve these problems in the team.

The results of the curriculum analysis are that the schools used by the researcher have used an independent curriculum, where the skills of 21st century students are needed, one of which is computational thinking skills and each learning must achieve the predetermined learning outcomes. The results of the material analysis that have been carried out have been found that the depth of the material consists of vector concepts and vector operations. Vector operations consist of addition and subtraction of vectors by graphical methods, addition and subtraction of vectors by analytical methods, and multiplication. Meanwhile, the breadth of the material is presented from definition to presentation.

Based on the results of the analysis above, the educational robotic-based vector learning module is expected to be a solution from the results of the interview analysis, characteristics and needs of students. Where this module has been adjusted to the achievements of the independent curriculum and the module structure has been adjusted to structured inquiry.

Design Stage

The initial step of the design stage is to design the design, structure and content of the module. The following is a table of design design, structure and module contents:

Table 1. Module Structure and Content Design

Module Structure and Content	
Module identity	
Foreword	
Table of contents, figures, and tables	
Instructions for educators	• Introduction • Introduction of mBot robots • Introduction to mBlock programming • Programming algorithms • Example questions • Learning outcomes • Additional information
Vector concept	Activity1
Vector operation • Vector addition and subtraction by graphical method • Vector addition and subtraction by analytical method	• Activity 2 • Activity 3 • Activity 4 • Activity 5

Module Structure and Content	
• Determination of resultant and resultant direction with sine and cosine formulas	
Vector multiplication	
• Point multiplication • Cross-multiplication	• Activity 6 • Activity 7
Bibliography	

The next step is to design a structured inquiry-based learning strategy and adjust it to computational thinking skills. At this stage, the researcher makes a problem formulation that has been adjusted to the vector sub-sub-material. Where this problem will be solved using structured inquiry syntax steps that are integrated with computational thinking indicators and incorporated into one activity. The following is a table of the results of this step:

Table 2. Learning Activity Flow

Learning Activity Flow
• Students can understand the formulation of the problem. • Students can solve problems into pieces that can be solved • Students can simplify problems so that they are easy to solve. • Students can propose hypotheses from the formulation of the problem. • Students carry out data collection by compiling completion steps along with programming algorithms. • Students can recognize the patterns formed whether they are in accordance with the programming and can measure the results of the robot's movements. • Students can test hypotheses and evaluate whether the robot's movements and the data obtained are correct. • Students formulate conclusions to answer the formulation of the problem.

Development Stage

In the development stage, the researcher creates a module from the initial designs that have been made. Create designs, create module structures, create materials, create activities, and make evaluations. The resulting module consists of two modules, namely the student module and the teacher module. The difference between these two modules is that the teacher module contains structures and activities that contain answers. Meanwhile, students have no answers. The following is a cover of the student and teacher modules produced:

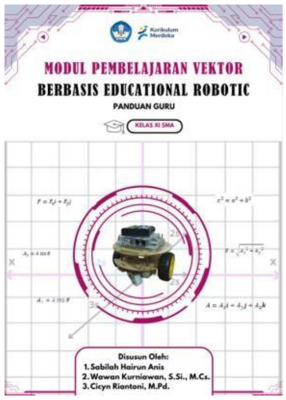

Figure 2. Teacher Module Cover

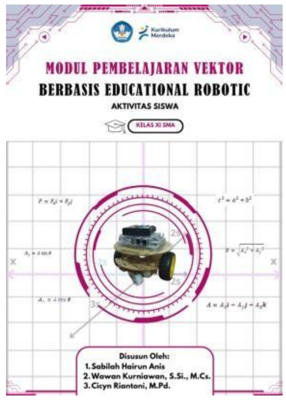

Figure 3. Student Module Cover

The image above is a module cover that has been produced and validated after going through several revisions from both material experts and media experts. After making the cover of the next module, the module contains an introduction, table of contents, list of pictures, list of tables, instructions for educators. Enter the material and activities consisting of vector concepts, vector operations, and vector multiplication, finally the bibliography. The creation of activities has been adjusted to the learning objectives to be achieved. The following is an overview of the 1 vector activity contained in the module:

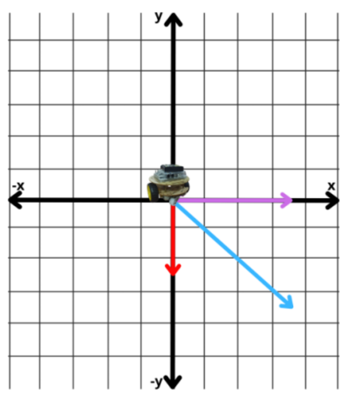

Figure 4. Activity Problem 1

In activity one, students were given problems related to how to program the robot to move south for 1s, east for 2s, and southeast for 2s. How to determine the vector size of the robot's movements? After students formulate problems, students will be directed to decomposition the problem and abstraction. Next, students propose a hypothesis and then collect data by creating a programming algorithm. The following is the programming algorithm of the above problem:

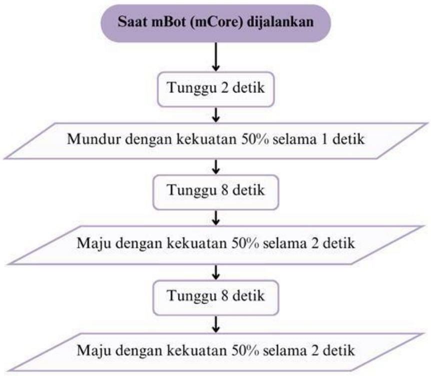

Figure 5. Activity Programming Algorithm 1

After students make the programming on mBlock, then students will carry out experiments using a robot that has been programmed. The center point of the robot will be given a marker so that when it moves, it will produce a line. After the robot moves to form vector lines, then students perform pattern recognition. After ensuring the patterns formed according to the programming, students can take measurements of the lines that have been formed. The results of the programming were obtained by vector towards the south with a time of 1s and a length of 0,21 m. The eastbound vector with a time of 2s has a length of 0,459 m. The southbound vector with a time of 3s is 0,46 m long. Basically, the length of the vector produced from the movement of the robot will be different even at the same time, this is because there is a power current from the battery used by the robot.

The following are the final validation results by the first and second subject experts in the educational robotic-based vector learning module after being revised 3 times each:

Table 3. Data Validated Results by the First Subject Expert

Aspects	Validation results	criterion
Content eligibility	75%	Quite valid
Presentation eligibility	78,57%	Quite valid
Language assessment	81,25%	Very valid
Total Average	78,27%	Quite valid

Table 4. Data Validated Results by Second Subject Matter Experts

Aspects	Validation results	Criterion
Content eligibility	95,83%	Very valid
Presentation eligibility	100%	Very valid
Language assessment	93,75%	Very valid
Total Average	96,53%	Very valid

Based on the data contained in the table above by the first material expert, it was obtained that the validation value of 78,27% was included in the criteria that were quite valid. Meanwhile, the second subject matter expert obtained a validation score of 96,53% which was declared very valid. This indicates that the module is worth using.

Table 5. Data Validated Results by Media Experts

Aspects	Validation results	Criterion
Presentation Design	85%	Very valid
Ease of Use	91,67%	Very valid
Ease of Access	100%	Very valid
Repeated Use	100%	Very valid
Meet Standards	87,5%	Very valid
Total Average	92,83%	Very valid

Based on the data contained in the table above by media experts, it was found that the validation value of 92,83% % was included in the very valid criteria. This shows that the module is feasible in terms of its media and technical use.

Conclusion

This study uses the ADDIE development model which produces an educational robotic- based vector learning module. Based on research that has been conducted, the educational robotic- based vector learning module using a structured inquiry model to improve students' computational thinking has been validated by the first subject expert by 78,27% with fairly valid criteria. The second material expert gave a score of 96,53 with very valid criteria and media experts got a validation score of 92,83% with very valid criteria. Based on the results of the validation above, the educational robotics-based vector learning module uses a structured inquiry model to improve computational thinking skills suitable for use in research schools.

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Curriculum Vitae

The writer is a student of the University of Jambi, Indonesia. This research has a focus on the field of educational science and technology. Where the author is directly involved in the writing and development of educational robotic- based vector learning modules using a structured inquiry model to improve students' computational thinking that has been aligned with the independent curriculum.