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Design Learning Media with an Open-Ended Problem Approach Using the Web to Improve Critical Thinking of Vocational Students

Renra Noviana*, Wawan Setiawan, Asep Wahyudin

Departemen Pendidikan Ilmu Komputer, Universitas Pendidikan Indonesia, Indonesia
*Correspondence: E-mail: renraleerning@student.upi.edu

A B S T R A C T

Critical thinking skills must be provided through education, by developing critical thinking skills to make them better trained in solving various kinds of problems both in learning and outside learning. To improve critical thinking skills, an appropriate learning approach is needed, learning must be student-centered. This study aims to develop instructional media with an open-ended approach measure the improvements on students from the application of media and student responses to the media. This study uses a Comprehensive Life Cycle (SHM) methodology to develop media. One-group pretest post-test was used for the research design. media with an open-ended problem approach have been developed and get a percentage score of 86% or "very good" by experts on media testing and get a percentage score of 85% or "very good" by experts on material testing. The use of media with an open-ended approach can improve critical thinking skills with the increase in students' cognitive tests with the High Order Thinking Skill (HOTS) category questions with an increase in the average N-gain of students by 0.46 (which is in the "medium" category). Student responses to learning media get a percentage score of 75%.

A R T I C L E I N F O

1. INTRODUCTION

This 21st century education focuses on the skills of creating and updating (Creativity and Innovation Skills) (Subekti, 2014). To cope with the demands of the 21st century, learners and teachers need to know how to use their knowledge and skills by thinking critically, analyzing information, understanding new ideas, communicating, collaborating, solving problems, and making decisions (Sahin, 2009). Therefore, the ability to think critically is very important in this 21st century.

One subject that requires critical thinking skills is programming lessons. Material on programming is material that is difficult for students to learn, because it requires considerable amounts of skills. The difficulty of programming subjects is due to the first when formulating real problems into a programming language. Both difficulties in making plans whether in making pseudocode, flowcharts, or natural language. The three errors in punctuation, writing variables, types, access variables, especially in this case are arrays and records are common mistakes made by student (Maryono, 2016).

To improve critical thinking skills, there are innovation efforts in the world of mathematics education, namely the emergence of approaches with open-ended problems. Open-ended method is presented with open problems that have many correct answers, and students can combine their own knowledge, skills or ways of thinking that have previously been learned (Novikasari, 2009). Programming and mathematics lessons are closely related in programming there are mathematical elements such as operations and algebra, and comparisons that exist in mathematics are also used in programming so that learning with an open-ended approach will be suitable for use in programming because previous research open-ended approaches have succeeded in training students' critical thinking.

Based on these problems, this study aims to design learning media with an open-ended problem approach to improve critical thinking of vocational students in basic programming subjects and implement learning media that will provide an analysis of whether learning media with open-ended problem approaches will affect the improvement of students' critical thinking skills. The results of the research are expected to be useful for further research, as well as for educators when teaching basic programming material, for students to make learning media a means to more easily understand basic programming material.

2. METHODS

The research method used in this study is an experimental research method, experimental research methods are included in quantitative research methods (Mulyadi, 2012) The steps of experimental quantitative research can be seen in **Figure 1**.
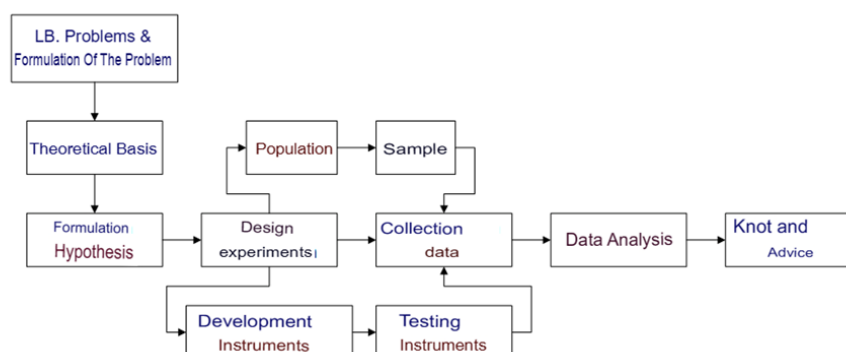
Figure 1. Quantitative research steps of an experiment.

The experimental research design used is a pre-experimental design one-group pretest-post-test design attached in **Equation 1**, this design contains pretests and post-test so that the effect of treatment can be calculated by comparing the value of post-test greater than pretests then the treatment has a positive effect.

In developing learning technology, using the learning media development method offered by Wijaya (2022), namely the overall life cycle (SHM). The SHM model consists of five stages such as analysis, design, development, implementation, and assessment (Wijaya, 2022). For media assessment instruments used based on Learning Object Review (LORI) conducted by experts. The formula for testing expert validation uses a rating scale.

$$O_1 \ X \ O_2$$

Eq 1. One-Group Pretest-Post-test Design.

Information:
O1   : Pretest scores (before training)
O2   : Post-test score (after training)
X   : Treatment

2.1. Population and Sample

The population in this study is one of the schools located in Bandung. The sampling technique used in this study was carried out with nonprobability sampling type purpsive sampling, which is a sampling technique with the following consideration that the selected sample is in accordance with the problems raised by the researcher (Nur & Utami, 2019).

2.2 Student Comprehension Instruments

This instrument is used to assess the extent of increased student understanding through student learning outcomes after using the learning media created. Because it uses a pre-experimental design in the form of one-group pretest-post-test, the effect of treatment can be calculated by comparing post-test and pretest values (Nainggolan, Sidabutar & Pasaribu 2022). The technique can be written as described in **Equation 2**. The technique used in the calculation of this data analysis is the normalized gain technique with the following formula:

$$g = \frac{skor \ posttest - skor \ pretest}{skor \ maksimum - skor \ pretest}$$

Eq 2. Determining N-Gain.

Information:
G   : Normalized gain value
post-test score: Percentage of post-test score
pretest score   : Pretest score percentage

The results of the gain value obtained can be classified as in **Table 1**.

Table 1 Gain index classification

Gain Index	Criteria
$g \geq 0.70$	High
$0,70 \geq g \geq 0.30$	Average
$g < 0.30$	Low

2.3 Student Response Instruments

Student response instruments consisted of 18 questions regarding the use of the learning media and student's understanding of the material provided in the learning media. The scoring uses Likert scale on a scale of 1 to 5.

3. RESULTS AND DISCUSSION
3.1. Media Development
3.1.1. Analysis

Based on the results of the analysis of learning media made web-based, for the selected material content is programming subjects data types, variables, constants, operators, and branching. The material content is based on Learning Objectives and Learning Outcome from the Directorate of Vocational Development for basic programming subjects, with the source referring to the w3school website.

3.1.2. Design

Flowchart for the learning media is described in **Figure 2**. **Figure 2** explains the stages presented to the user while using the learning media.
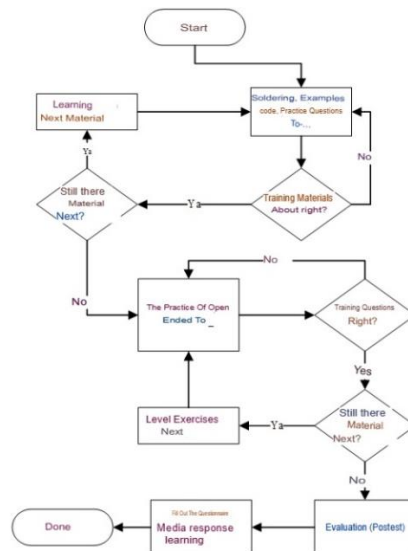
**Figure 2.** Open-Ended Learning Media Flow.

A storyboard is created to help with the visual development. According to the storyboard, there are three stages that student have to go through. The first stage is the learning session for Branching material, the second stage is the practice question session, and the third stage is an evaluation (post-test) and the learning media response questionnaire. The storyboard created can be seen in **Table 2**.

Table 2. Main Storyboard.

Figure	Description
	Login Menu Page Login using Student ID and password Login button: enter the dashboard menu Register button: exit pop up to register account

Pop up to register an account.
Register by filling out
Name, Student ID, email, and password
Register button: execute register account
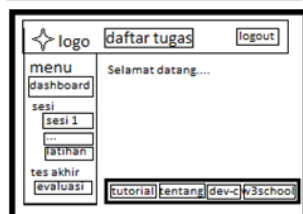
Dashboard menu
There is a top navigation that contains:
Task list button: view all tasks
There is a left navigation that contains:
Menu (dashboard button): button to the dashboard menu
Session
(session button) : towards a learning session
(training button) : go to the training session
There is a bottom navigation (footer) that contains:
(tutorial button) : go to learning media tutorial videos on YouTube
(About button) : Go to the menu about learning media :
(dev-c button) : go to the link to download the dev-c software
(w3school button) : go to the w3school website link
And the content of the menu contains a welcome greeting along with a tutorial on what to do.
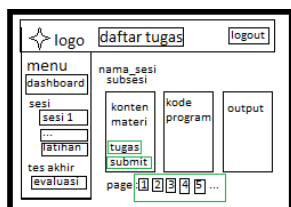

Learning sessions menu
There are 3 content columns that contain the content of program code material and output from the program code, then in the bottom material content column there is a task section and a submit button
(submit button): button that issues a pop up to submit the task
(assignment button): button containing a downloadable task description file
(page button 1,2,3...): navigation button to the next page

Training Session Menu
There are 3 columns of content containing practice tasks, clue 1 to make it easier for students to work, clue 2 to make it easier to do exercises, there are task and submit buttons along with the same page as in the learning session menu
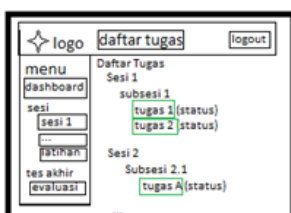
Task List menu
There is a list of task lists sequentially by session, and subsessions
Task button: a button that goes to the page of the session where the task is located
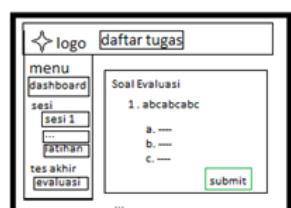

Evaluation Menu (Post-test)
There is a collection of post-test questions that must be done, after submitting the evaluation questions will change to a learning media response questionnaire that must be filled out
Submit button: to submit an answer

3.1.3. Development

For the assets used in the media, researchers use the css framework from bootstrap and template design from Architect UI, for icons from font awesome 4, and some additional image assets from freepik. The interface is made based on storyboards and made some adjustments to make it more attractive and easier to use, for the media interface display as follows:

3.1.3.1. Login Page

When the student first opened the website, the first page that will appear is the login page, as shown in **Figure 3**. Each student needs to register their own account before accessing the learning media using 'Register' link under the image.
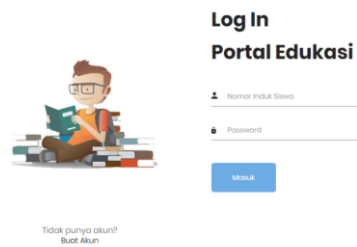

Figure 3. Learning Media Login Page.

After clicking the Register link, a pop-up menu in **Figure 4** will appear. This menu is used to create student accounts. The student must register their username, Student ID, email address and password.
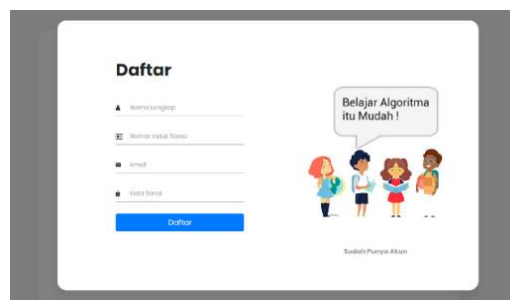
**Figure 4.** Account list pop up.

3.1.3.2. Dashboard Page

The dashboard page in **Figure 5** is the first page when students have logged in. The student can access other menus such as learning sessions, evaluations and assignment lists. There are also video tutorial links, about (learning media), W3School web, and download links for dev-c ++ software in the footer.
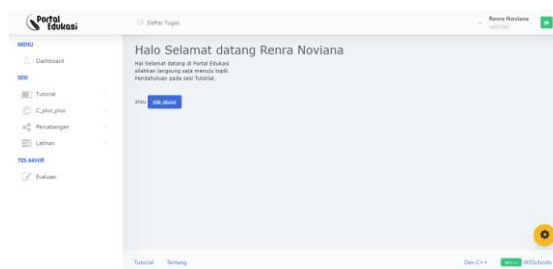
Figure 5. Dashboard Page.
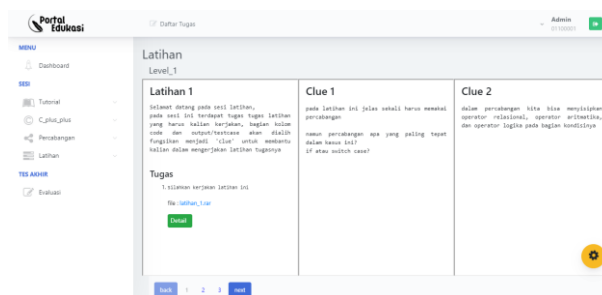
3.1.3.3. Learning Sessions Page

The learning session page in **Figure 6** is a page where students learn, there are 3 main columns in the learning session, the leftmost column is the content column which the student can read the material and the bottom is an assignment. The middle column is the example code column, and the rightmost column is the output column or can be a testcase of the code in the middle column.
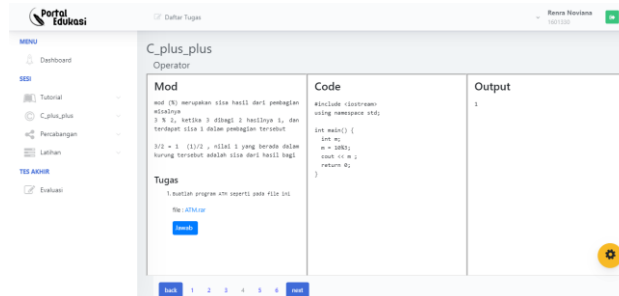
Figure 6. Learning Session Page.

### 3.1.3.4. Training Sessions Page

The page in **Figure 7** is the student learning session page that contains exercises with open-ended problem questions. In the practice session page, there are three main columns, the leftmost column contains practice tasks, in the middle column is the first clue if students have difficulty solving problems or doing assignments, and in the right column is the second clue column to help students in doing assignments, and in the rightmost column is the second clue column to help students with assignments.

Figure 7. Training Session Page.

3.1.3.5. Assignment Sessions Page

Figure 8 is a page that contains a list of tasks. There is an assignment file name that contains a link to the learning session where the task is located and on the side of the file name contains the status of the task whether it has been completed or not.
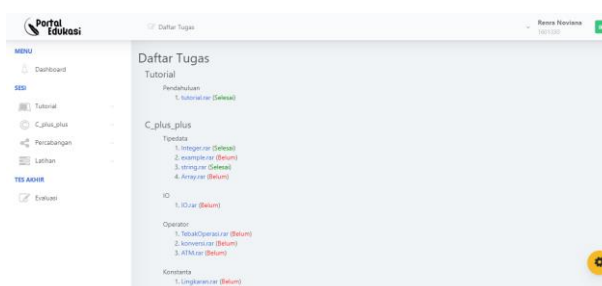
Figure 8. Task List page.

3.1.3.6. Evaluation Page

Figure 9 is a page containing post-test questions that must be done by students. If students have done the post-test questions, the questions on the evaluation page will turn into media response questionnaires as shown in **Figure 10**.
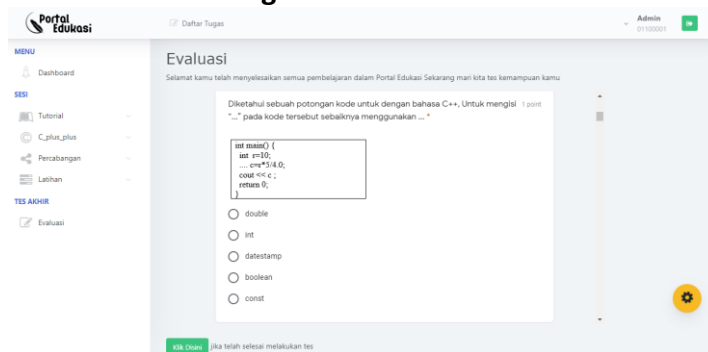

Figure 9. Evaluation Page.

Figure 10 is an evaluation page that contains a questionnaire of responses to learning media responses filled out by students after doing the post-test.

(i) Implementation. Learning media was tested by several students, in Blackbox testing learning media can functionally run without problems.

(ii) Rating. The assessment of learning media according to media experts gets an average percentage score of 86% included in the "very good" category, and according to material experts gets an average percentage score of 85% included in the "very good" category.
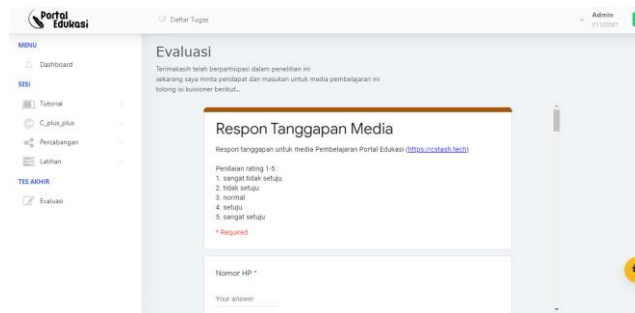
Figure 10. Evaluation Page after doing the post-test question.

3.2. Data Analysis

Pretest and post-test results by researchers are included in **Table 3**. Researchers gain gain from the pretest to the post-test. The following is a table of pretest and post-test gain results from learners.

Table 3. Pretest post-test gain results.

No Res.	Pretest Value	Post-test	N-Gain	Gain Average	Class
1	85	90	0.33		
2	80	95	0.75		
3	75	95	0.80	0.50	Upper
4	75	85	0.40		
5	75	80	0.20		
6	70	95	0.83	0.51	Middle
7	65	75	0.29		

8	55	75	0.44		
9	55	80	0.56		
10	55	70	0.33		
11	55	65	0.22		
12	50	90	0.80		
13	50	65	0.30		
14	40	95	0.92		
15	35	40	0.08		
16	35	90	0.85		
17	30	40	0.14		
18	25	50	0.33	0.28	Lower
19	15	45	0.35		
20	15	40	0.29		
Gain Average				**0.46**	

Based on **Table 3** the results of the pretest-post-test highest gain value was obtained by the middle class, which was 0.51 which was categorized as a moderate increase in gain, for the increase that occurred in the upper class was categorized as medium at 0.50, but in the lower class the increase in gain was categorized as low by 0.28. An increase in students' cognitive abilities in critical thinking was obtained from the results of the pretest and post-test with an average n-gain of 0.46 with the "medium" category.

3.3. Students Response

For student responses for the learning media can be seen from **table 4**. Responses have been implemented for upper, middle, and lower class groups. Based on **Table 4**, the upper class received the highest response to the media aspect and understanding aspect with a percentage of response to the media aspect 87% and response to the understanding aspect 85%, from the middle class received a response to the media aspect 80% and a response to the understanding aspect 77%, from the lower class received a response to the media aspect and the lowest understanding aspect, namely the response to the media aspect worth 54% and the response to the understanding aspect 58%. The total of all percentages is 75%.

Table 4. Learning media response results.

Class Group	Response to Media Aspects			Response to aspects of understanding			Percentage Total
	Score	Ideal Score	Percentage	Score	Ideal Score	Percentage	
Upper	152	175	87%	235	275	85%	86%
Middle	307	385	80%	463	605	77%	78%
Lower	77	140	55%	123	220	56%	56%
Percentage Total							75%

4. CONCLUSION

Learning media with an open-ended problem approach was developed using the SHM method which includes the analysis, design, development, implementation, and Evaluation stages. Based on the analysis, there is an increase in critical thinking seen from the increase in students' cognitive abilities, as evidenced by the average increase in the pretest by 52 to 73 on the post-test so that it has a gain value of 0.46 in the 'medium' category. The learning media designed also received a good response from the upper and middle class group students and received a less good response from the lower class group students.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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