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C-Thinking Game for Literacy Education: Computational Thinking Learning in Elementary School

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***Abstract*— The results of the PISA (Program for International Student Assessment) global study conducted by the OCED (Organization for Economic Cooperation and Development) in 2019 were attended by 78 countries, Indonesia ranked 74th in the reading category, 73rd in the math category, and 71st in the science category. In 2021 PISA incorporates computational thinking into its survey. So Indonesia must be able to introduce computational thinking in order to catch up with other countries. This research aims to develop an educational game that is an introduction to computational thinking for 5th grade elementary school children and can increase creativity and cantra in thinking processes in simplifying big problems into simple ones. The design methods that will be used in this study is the Multimedia Development Life Cycle (MDLC) of Sutopo (1994), applications are made using Unity and Adobe Illustrator to design application features. The results of the application trials are in the range of 81% - 100% which means "agree" to be used.**

***Keywords*— Game, C-Thinking, Multimedia Development Life Cycle, Unity**

I. INTRODUCTION

The role of Information Technology and Human Interaction are important aspects of human life today. The Program for International Student Assessment (PISA) organized by the Organization for Economic Cooperation and Development (OCED) is a global survey of literacy (reading), mathematics and knowledge (science) abilities. According to the results of the PISA survey in 2018 [1] Indonesia ranked 74 out of 78 countries, and according to the results of the survey in 2022, Indonesia ranked 68 out of 88 countries[2];[3]. The results of the survey show that Indonesia's literacy ranking was at 74 in 2018, which increased to 71 in 2022; the ranking in mathematics ability was at 71 in 2018 and increased to 70 in 2022; and in science, Indonesia's ranking was at 71 and increased to 67 in 2022.[2];[3]. The test given in this survey is to determine the level of students' ability to solve problems, think critically and communicate effectively[1];[3]. Considering at the survey results, Indonesia needs be able to develop a better education system. The results of the PISA analysis of change and relationship content where students are asked to identify information in a problem and present it in the form of a simple mathematical model are still low[4][5], this is related to teachers as educators in schools being able to develop learning concepts which are expected to improve student understanding in solving problems. One of the concepts offered is Computational Thinking (CT) or computational thinking is a concept of basic human abilities that are important to have in the 21st century, equivalent to the importance of knowing how to reading, writing and math.[6][7]. By practicing CT concepts, it is hoped that teachers can help students in solving problems [8].

Bebras Indonesia, Bumigora University (UBG) bureau, is one of the organizations appointed to implement computational thinking in the West Nusa Tenggara region[1].urrently, Bebras Indonesia UBG Bureau is catching up with literacy, mathematics and science with a computational thinking concept approach to schools in Lombok, West Nusa Tenggara. The Computational Thinking concept approach is not only given to teachers but also to students with various forms of approach. Along with technological developments, technology in the field of education and instructional media has experienced increasingly creative and innovative developments in models, types and supporting tools[4].One of the technology-based learning approaches is education-based games. Educational games are technology-based games designed to stimulate thinking power including increasing concentration and problem solving so that students can train their brains in creative thinking[9].With this problem, researchers developed research aimed at creating a C-Thinking educational game.

C-Thinking is the name of the game that will be developed, where this game is intended to increase students' understanding in learning CT concepts based on Android technology. The design of the game is presented with story problems with CT concepts and a computer algorithm

approach which is intended for elementary school (SD) students in grades 4, 5 and 6. This educational game is also one of the learning media which includes learning material for students in a fun learning process. The challenges in this game are in the form of locked stages and levels which are a challenge for students to be able to complete all existing stages and levels. So it is hoped that it can help students understand and understand computational thinking and can improve logical thinking skills, as well as train students to think creatively [5].The C-Thinking educational game is divided into 2 stages, each stage has 3 levels.

II. Literature Review

Multimedia is a combination of more than one media in a form of communication. According to Lancien, multimedia today refers to combining and integrating media, such as text, animation, graphics, sound, video into a computer system[10]. Research[11]defines games or games in general as an activity that has the aim of having fun and filling free time. Games are structured or semi-structured activities that are usually aimed at entertainment and can sometimes be used as a means of education and have become an inseparable part of Samuel's children's daily lives[11]. Educational games are designed for educational enrichment (supporting teaching and learning) using interactive multimedia technology[12]. Educational game technology can motivate learning and involve players, so that the learning process is more enjoyable. Individualization, active feedback, active learning, motovation, social, scaffolding, transfer and assessment are the principles applied in game design[13];[14];[15].

Computational thinking (CT) is seen as a way of understanding and solving complex problems using computer science techniques and concepts such as decomposition, pattern recognition, abstraction and algorithms. This concept is considered to support the dimensions of 21st century education where it can help students to have an idea of abstraction and the ability to various levels of abstraction, as well as think algorithmically and understand the consequences of large scale and fundamental data for CT[6];[16].

Adobe Illustrator is a graphics program used in game creation where this application is a powerful and popular vector-based application. Several features provided make it easier for users to form objects in 2 dimensions (2D) and 3 dimensions (3D) with the base display colors Cyan, Magenta, Yellow and Key (Black). The forms of illustration that can be produced through this application are vector-based, icons, typography and other designs[17].Meanwhile, Unity is an application used to develop multiplatform games that are designed to be easy to use. Unity Software Inc. is an American software development video game company based in San Francisco. The company was founded in Denmark in 2004 as Over the Edge Entertainment and changed its name in 2007[18];[19]. Meanwhile, Android is a platform used in games. Android is designed with various features that move with the touch screen. Initially, Google Inc. bought Android Inc. which is a newcomer that makes software for smart phones (smartphones)[20];[21];[22].

III. METODOLOGY

The methodology used in the research is the Multimedia Development Life Cycle with activity stages, namely: concept, design, material collecting, assembly, testing and distribution[23]. The methodology stages are displayed as shown in Figure 3.1.

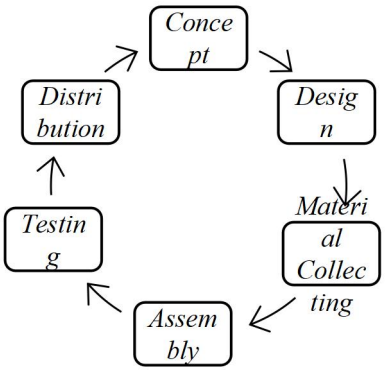

Fig. 3.1. Diagram Multimedia *Development Life Cycle*

3.1. Method of Data Collection

Data collection in this research was carried out by observation, interviews, literature studies and questionnaires which were used to design an educational game introducing mobile-based computational thinking called the "C-Thinking" application. Research was carried out at the Antonius Cakranegara Christian Elementary School (SDK) to find out and see how computational thinking is applied in schools. The data collection method using observation was applied to participants who carried out the Mini challenge and the Bebras Indonesia national challenge.

3.2. Method of Game Development

The design method used in this research is the Multimedia Development Life Cycle (MDLC), this method is a simple and sequential development so that it can facilitate the multimedia design process. Using this method will go through six stages, namely, concept, design, material collecting, assembly, testing and distribution[23].The navigation structure describes the relationship between menus in the application to be created. Initial development of the C-Thinking educational game by designing the game navigation structure. The results of designing the navigation structure of an introductory computational thinking game application can be seen in Figure 3.2.

In Figure 3.2. It can be seen that the navigation designed in this online game starts with the Splash Screen page, then the Main Menu which is divided into Material and Start, the Material section will go to the Material Page while the Start Page will navigate the features towards Start which goes to the Stage Page then the Level Page, then About will navigate to the About Page while How to Play will navigate to the How to Play Page.

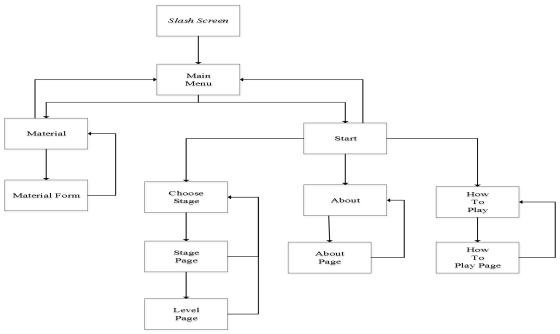

Figure 3.2. Navigation Structure

3.3. Method of *Material Collecting*

The materials in the C-Thinking educational game collected at this stage include: buttons, background, audio and others. The materials collected will be used in the next stage, namely creating a game application (assembly). Some of the preparation of ingredients is explained as follows:

a. Button

The buttons used in the educational game application introducing computational thinking are as shown in Figure 3.3.

Figure3.3. Design of Buttons

b. Shape

The shapes used in the educational game application introducing computational thinking have been created using Adobe Illustrator. The shape made as an example is the free mascot as in Figure 3.4.

Figure 3.4.Shape

All paragraphs must be indented. All paragraphs must be justified, i.e. both left-justified and right-justified.

c. Layout Background

Figure3.5. Background

To modify the background image, the researcher used Adobe Illustrator for modification. The background layout of the game can be seen in Figure 3.5.

3.4. Assembly

At the assembly stage, all objects that have been conceptualized and designed are implemented in Adobe and Unity tools. Several educational game application objects introducing computational thinking can be seen in Figure 3.6. related to the background that will be used in the game; Figure 3.7. related C-Thinking Games About Page; Figure 3.8. related to How to play; Figure 3.9. related to Stage and Figure 3.10. related to the Level in the Game.

Figure 3.6. *Background*

Figure 3.7. About the Game

Figure 3.8. How to Play

Figure3.9. *Stage* Button

Figure3.10. Level Button

4. Results and Discussion

4.1. Game Discussion

The splash screen is the start page of a program or application that appears when the application starts. The splash screen display can be seen in Figure 4.1 with the C-Thinking logo image making students interested in this game.

Figure 4.1. *Splash Screen*

Figure 4.2. Main Menu

After the splash screen page is run, you will immediately enter the Main Menu page. The Main Menu page will use a background with several tools displayed, namely the game logo, play button, content button, and music. The Play button is to start the game, the Material button is to read Computational thinking material, and the Music button is to turn the music off or on. The main menu displays as in Figure 4.2.

Figure 4.3. Play Page

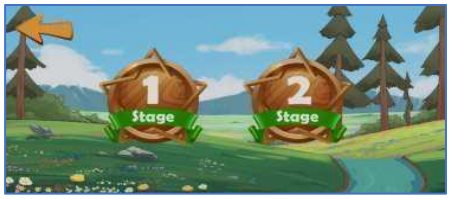

Figure 4.4.Start Page

Users who press the play button will enter the Play Page as shown in Figure 4.3. where this page will contain the Bebras logo, Start Button, About Button, How to Play Button and Back Button. Each button functions differently, the Start Button will lead to the Game menu, the About Button will lead to an explanation page related to the goals and objectives of the Game, the How to Play Button will lead to an explanation related to how to play the Game to be played and the Back Button will lead back to the Main Menu.

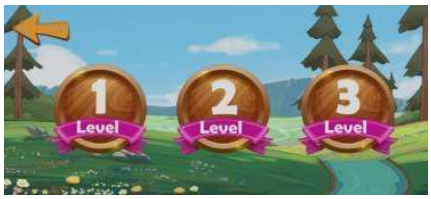

Figure 4. 6 Stages Page

Users who will press the Start Button will enter the Start Page as shown in Figure 4.4. where in this picture there are several tools including: Stage 1 and Stage 2 and the Back Button. The function of the Stage 1 button is to enter the Stage page and the function of the Stage 2 button is to enter the Stage 2 page. In this section the user can select Stage 1 or Stage 2 for playing options. Meanwhile, the back button will redirect you to the Play Page.

Figure 4. 7 Challenge 1

Each Stage Game prepared has a different storyline. The selected Stage 1 and Stage 2 pages will display the Stage Page where there are levels of difficulty (levels) in the game, namely: level 1, level 2 and level 3 as shown in Figure 4.6..In Figure 4.6. This page provides Level 1 Button, Level 2 Button, Level 3 Button and Back Button. If the user selects the Level 1 Button, he will enter the Game Stage 1 Page as shown in Figure 4.7. In Figure 4.7. shown the designed play page.

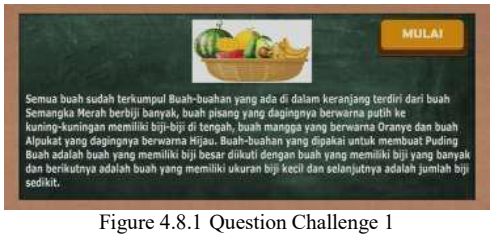

Figure 4.8.1 Question Challenge 1

Stage 1 in Figure 4.7.is a game where users are asked to collect fruit in a basket. The buttons provided are the Stop Button and Pause Button. The Stop button will stop the game being run and the Pause button will temporarily stop the game. At this stage the game can be played using a joystick with a game time feature and a score obtained for each successful fruit catch. Apart from that, in Stage 1 there is a button to start the challenge. When you start the challenge to answer a question you are given multiple choices to choose the correct answer. The Stage 1 page display can be seen in Figure 4.8.

Figure 4.9. Challenge Two

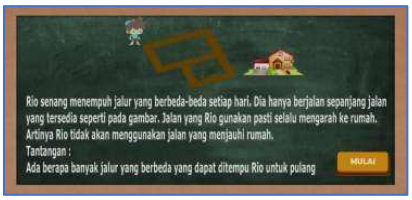

Figure 4.10.2 Question Challenge 2

Stage 2 can be seen in Figure 4.9. where in this stage the user will play the game by starting the game running towards the goal and collecting stars to get challenges. Some of the tools provided on the Stage 2 page are the navigation button to the player's object to the right with the right arrow button and the navigation button to the left with the left arrow button. In addition, the Up Arrow Navigation button is provided to jump up to capture the available stars above the provided object path. The rules in this game are that players cannot step on mines and players are asked to collect stars to enter the challenge. The form of challenge that will be given is shown in Figure 4.10.

4.2 Test Result

The purpose of the testing stage is to determine whether the game created is in accordance with the planned, designed concept and can produce output in accordance with the objectives of making the C-Thinking educational game. Apart from that, testing is carried out to find out errors in the game so that an evaluation can be carried out before distributing the product to target users. The testing method is carried out using the Blackbox and Whitebox methods.

4.2.1. Blackbox Testing

Testing was carried out by 2 experts who carried out the testing, namely, material experts and media experts. The form given by the questionnaire for measuring test responses is a Likert scale with the assessment ranges as follows:

- Response Value1 →Strongly Disagree (SD)
- Response Value2 →Disagree (D)
- Response Value3 →Quite Agree (QA)
- Response Value4 →Agree (A)
- Response Value5 →Strongly Agree (SA)

a. Instruments for Subject Matter Expert

The test items given to Subject Matter Expert can be seen in Table 4.2.1. related to the C-Thinking Game that has been created. Some of the questions asked were related to the correctness of the content of the material, the absence of errors in the game concept, the contemporary nature of the material, the scope and depth of the material, and the availability of references used in the C-Thinking Game concept. The results obtained were that all the answers given by the Material Expert were answers in the Strongly Agree category.

TABLE 4.2.1.
SUBJECT MATTER EXPERT QUESTIONNAIRE TABULATION

No	Assessment Aspects	Research Scale				
		1	2	3	4	5
1.	The truth of the content of the material					✔
2.	Free from conceptual errors					✔
3	Contemporary and up to date material					✔
4.	Coverage and depth of material					✔
5.	Adequacy of the references used					✔

b. Instruments for Learning Design Experts

The test items given to Learning Design Experts can be seen in Table 4.2.2. related to the C-Thinking Game that has been created. Several questions asked were related to the suitability of media delivery strategies with the characteristics of the relevant audience (students); accuracy of media delivery strategy so that the application is easy and quick to understand and the material, concepts and skills are able to be mastered; the level of application ability to encourage students to think critically and solve problems; the level of contextuality with application/application in real life that suits the characteristics of the relevant audience (students); and the accuracy of media selection in the C-Thinking Game. The results obtained were that all the answers given by the Learning Design Expert were answers in the Strongly Agree category.

TABLE 4.2.2.
LEARNING DESIGN EXPERT QUESTIONNAIRE TABULATION

No	Assessment Aspects	Research Scale				
		1	2	3	4	5
1.	Suitability of media delivery strategy with characteristics of the relevant audience (students).					✔
2.	The accuracy of the media delivery strategy allows for ease and speed of understanding and mastery of material, concepts or skills					✔
3	The level of possibility drives a					✔

No	Assessment Aspects	Research Scale				
		1	2	3	4	5
	student's abilitiesthink critically and solve problems					
4.	The level of contextuality with application/application in real life that suits the characteristics of the relevant audience (students).					✔
5.	Relative advantage, the accuracy of media selection compared to other media					✔

c. Testing by Developers

This test was carried out to determine the suitability of the C-Thinking educational game to the design that has been created. The C-Thinking Game application test scenario can be seen in Table 4.2.3. where there were 29 questions tested with the test results being 100%, namely 29 answers given were appropriate so it could be concluded that the C-Thinking Game application that was designed was in accordance with the assembly stages carried out. The results of testing by this developer can be a requirement for the next stage of testing on a sample of C-Thinking Game application users.

TABLE 4.2.3.
TEST APP FEATURES

No	Scenario	Expected Results	Test Results
1.	Open the application	Enter view Splash Screen	**Accord**
2.	Splash Screen	Loading can proceed and go to the main page	**Accord**
3.	Press the play button	Enter the play page	**Accord**
4.	Press the material button	Go to the material page	**Accord**
5.	Pressing the start button	Go to the stage page	**Accord**
6.	Select a stage	Enter the level page	**Accord**
7.	Select a level	Enter the game page	**Accord**
8.	Pressing the Back button	Enter the play page	**Accord**
9.	Pressing the about button	Go to the about page	**Accord**
10.	Pressing the button how to play play	Go to the how to play page	**Accord**
11.	Press the material button	Go to materials page	**Accord**
12.	Press the next button	Go to the next page	**Accord**
13.	Pressing Back	Return to main menu	**Accord**
14.	Take Fruit	Fruit taken	**Accord**
15.	Move the Joystick	Player moves	**Accord**
16.	Picking the wrong fruit	Score decreases	**Accord**
17.	Time runs out when the fruit has not been picked	Repeating the game	**Accord**
18.	Time runs out when the fruit is picked	Go to next page	**Accord**
19.	Hit the pause button	Displays a button to the main page and a continue button game	**Accord**
20.	Press the button to the left	Move left	**Accord**
21.	Press the button to the right	Move right	**Accord**
22.	Press the up button	Character jumps	**Accord**
23.	The character is hit by a mine	Score decreases	**Accord**
24.	The characters reach their destination	Displays the next page	**Accord**
25.	Hit the pause button	Displays a button to the main page and a button to continue the game	**Accord**
26.	Pressing the reset button	Repeating the game	**Accord**
27.	Pressing the Back button	Return to Main Page	**Accord**
28.	Press the next button	Go to the next page	**Accord**
29.	Push the Return Button	Return to Main Page	**Accord**

d. Testing by Users

The method used for user testing is the User Acceptance Test (UAT) method to determine the suitability of products that have been developed and designed according to user needs. The author gave 16 respondents the opportunity to try the application, then the author distributed a questionnaire to 16 respondents who were SDK Antonius Cakranegara students with the aim of providing an assessment of the application that had been created. Tabulation results can be seen in Table 4.2.4.

TABLE 4.2.4.
USER TESTING

No	Question	Assesment				
		SD	D	QA	A	SA
1	*This game is easy for you to play*	5	9	1	1	0

No	Question	Assesment				
		SD	D	QA	A	SA
2	*This game adds to your excitement in learning computational thinking*	7	5	3	1	0
3	*This game trains creativity*	10	4	2	0	0
4	*This game increases your interest and motivation in understanding computational thinking*	3	9	4	0	0
5	*You can use this game independently at home*	6	8	1	1	0
Total :		**31**	**35**	**11**	**3**	**0**

Calculation of Questionnaire Tabulation Results:

- Strongly Disagree (SD) = 1 x 0
  = 0
- Disagree (D) = 2 x 3
  = 6
- Quiet Agree (QA) = 3 x 11
  = 33
- Agree (A) = 4 x 35
  = 140
- Strongly Agree (SA) = 5 x 31
  = 155
- **Total Score** **= 334**

Calculation of X (highest score) and Y (lowest score):

- X = Highest score x (Number of questions x Number of respondents)
  = 5 x (5 x 16)
  = 5 x 80
  = 400
- Y = Lowest score x (Number of questions x Number of respondents)
  = 1 x (5 x 16)
  = 1 x 80
  = 80

Then a calculation is carried out to determine the percentage value obtained by the following formula equation:[4]

Information:

- P = Precentage
- f = Frequency of answers
- n = Number of highest scores

$$P = \frac{f}{n} x\ 100\%$$

$$= \frac{334}{4} x\ 100\%$$

$$= 83{,}5\ \%$$

Based on test evidence, conclusions can be drawn whether the system that has been tested is acceptable or not, which can be seen in Table 4.2.5.

TABLE 4.2.5.
RESPONSE PERCENTAGE VALUE

No.	Precentage	Information
1.	0% - 20%	Strongly Disagree
2.	21% - 40%	Disagree
3.	41% - 60%	Quite Agree
4.	61% - 80%	Agree
5.	81% - 100%	Strongly Agree

The percentage results are shown in Table 4.2.4. by adjusting the percentage values in Table 4.2.5. It can be concluded that the examiner's results reached a final result of 83.5% which is included in the "Strongly Agree" category. These results show that this educational game introducing computational thinking can be applied as a medium for introducing computational thinking.

e. Whitebox Testing

After making improvements based on expert suggestions at the Blackbox Testing stage, the author then carried out Whitebox Testing, namely application testing by the author. Testing in Whitebox Testing is carried out to determine whether there is an application code that has errors and is not functioning. After testing the application, the author came to the conclusion that the application was ready to be distributed to users, and no errors or bugs were found in the application that had been developed.

f. Distribution

From the results of the testing that has been carried out, this application is stored in storage media. Storing and installing this application is done by sending a file with the extension Android Package Kit (.apk) via the WhatsApp platform and the author uploads the application via Google Drive storage.

IV. CONCLUSIONS

Based on the results of the research that has been carried out, the author can draw the following conclusions:

1. C-Thinking can be used as a learning medium with the concept of Computational Thinking
2. Application system testing results that have been carried out on students and teachers and can be used by elementary school students starting from class.
3. From the User Acceptance Test, an assessment result of 83.5% was obtained, indicating the "Strongly Agree" category as a learning medium with the CT concept.

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