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Research Article

ENERGIA: Learning Media Programming Project As A Problem Solving Task For Students' Computational Thinking Training With Scratch

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ABSTRACT

Media is needed in learning to attract and make it easier for students to understand the material being taught. Interactive learning media for energy material with Scratch programming as a programming project assignment by applying block programming concepts for elementary school teacher education student training has never been researched. The research aims to develop valid and practical energy interactive learning media (energia) for elementary school teacher education students' computational thinking programming training as a final assignment for solving programming project problems and to determine their programming project competency level, using the Scratch application. The research carried out is of the research and development type using the ADDIE model. The research participants were 40 education students in Sumatra. Data was collected using observation techniques, interviews, artifact analysis, and questionnaires. The research instrument is a questionnaire with a Likert scale filled in by material experts, media experts, and research subject. Analysis of research data was carried out in a qualitative descriptive manner. From the research carried out, it was found that the final project of energy interactive learning media programming which was developed for computational thinking training for elementary school teacher education students received a valid score with a score of 0.7844 from material experts and 0.7918 from media experts validation, 86% for product practicality, and was suitable for use and made it quite difficult for students to be able to create their program because the level is at the advanced tier.

Keywords: interactive learning media, programming, problem-solving, computational thinking, training, scratch, energy

INTRODUCTION

National education that wants to progress must be responsive to the demands and progress of the times and technology of this century globally (Satria, 2016; Sudarsana et al., 2020). The progress of science and technology in the 21st century is so rapid that all aspects of human life, including the world of education, are affected by its existence. Science and technology are based on scientific thinking, critical thinking, and conducting new investigations and discoveries by scientists in solving problems to make human life easier and better (Wikandaru et al., 2020; Satria & Widodo, 2020; Satria & Sopandi, 2019; Satria, 2018; Zulkifli et al., 2022; Sugiarto Maulana et al., 2021; Ichsan et al., 2023). With the progress experienced in the fields of science and technology that can be applied to education and the learning process, the world of education is currently increasingly developing (Satria, 2015; Sudarsana et al., 2019; Satria & Sopandi, 2022), various kinds of reforms are being carried out to increasing the quality and quantity of education (Suharyat, et al., 2022; Satria et al., 2023; Haniko et al., 2023). Various breakthroughs in curriculum development, learning innovation, learning technology, and the fulfillment of educational facilities and infrastructure are needed to improve the quality of

education (Rahmat et al., 2021; Maruf et al., 2022; Satria, et al., 2023; Satria et al., 2024). When the world was hit by the Covid pandemic, much learning was done online (Ichsan et al., 2022), digital and online learning technology was developing rapidly and the world of education was required to use it (Sudarmo, Rasmita, 2021; Manullang & Satria, 2020; Sudarsana, et al., 2019; Suharyat et al., 2022). Mastery of digital technology is a must for teachers and students during the pandemic (Wahyuningtyas et al., 2022; Satria et al., 2023; Satria, et al., 2024).
Integrating technology and digital learning media is an absolute requirement for a teacher or lecturer today to teach (Satria, 2021; Sudarsana, et al., 2019; Arifin et al., 2023). Lecturers or teachers must be able to choose technology and media that can help pupils or students more easily understand the material being taught (Satria, 2017; Nurdin et al., 2019; Abidin et al., 2023). Learning media in general is a tool in the teaching and learning process (Satria & Sari, 2018; Satria et al., 2022). Everything that can be used to stimulate thoughts, feelings, attention, and learning abilities or skills to encourage the learning process can be called media (Abdullah et al., 2019; Satria, et al., 2023; Satria, et al., 2023). These boundaries are quite broad and deep, including understanding sources, environment, people, and methods used for learning purposes (Satria, 2019; Suharyat, et al., 2022). This also includes means of communication in the form of print, viewing, and hearing, as well as hardware or software technology (Sudrajat et al., 2018; Kurniasih et al., 2019; Sudarsana, et al., 2019; Morales-Obod et al., 2020; Satria, et al., 2022).

Factors that support the achievement of learning objectives are the selection of appropriate learning media and technology (Egline & Satria, 2014; Har et al., 2018; Sudarsana, et al., 2019). The right learning media is how it can create learning that suits student characteristics and learning materials to achieve learning goals (Satria, 2018; Agustin et al., 2019). Therefore, a teacher or lecturer must be able to choose the right learning media to support the learning process that can be adapted to their regional culture (Sudarsana, et al., 2020; Sudarsana, Suyanta, et al., 2020). Media creation by students can be done by teaching computational thinking skills through computer programming (Brennan & Resnick, 2012).

Computational thinking is a thought process involved in formulating problems and solutions so that the solutions are represented in a form that can be carried out effectively by information processing agents (Wing, 2011). So computational thinking is a thought process, which is independent of technology and computational thinking is a problem-solving method that is designed to be solved and carried out by humans, computers, or both (Akbar & Satria, 2019; Rahim et al., 2019; Maseleno et al., 2021). There are four main techniques (foundations) for computational thinking as a problem-solving strategy (Satria et al., 2023): decomposition - breaking down a complex problem or system into smaller, more manageable parts; pattern recognition – looking for similarities between and within problems; abstraction – focusing on important information only, ignoring irrelevant details; algorithm - develops a step-by-step solution to a problem or a rule that must be followed to solve the problem.

Computational thinking skills are important to learn even when students are in elementary school to solve various problems related to subject matter or everyday life problems. Computational thinking skills can make students think critically and creatively (Natali, 2022) in finding solutions to problems in learning materials provided by teachers or lecturers in addition to creating media.

Based on initial observations made by researchers, information was obtained that creating animated learning media using block programming which applies computational thinking concepts for science material has never been taught to students. Apart from that, science lecturers and students when presenting lecture material only use PowerPoint applications which are monotonous and less interesting even though they have downloaded material, videos, images, or learning media from the internet. This kind of learning process seems to be one-way, students only see and listen to the material being presented, and it does not enable students to actively interact directly with the material being presented. Furthermore, based on observations regarding the less interesting and monotonous learning process, it can be seen that many students pay less attention to lecturers when teaching or groups presenting material because they are busy looking at cell phones, social media, and playing games.

One way to overcome this problem is that it is necessary to introduce material and concepts of computational thinking using block programming through training by providing examples of programming projects in the form of energy interactive learning media that students can create so that later they can be used to create animated learning media in their lectures, especially for material Physics, so that the process of delivering lecture material is more interesting, enjoyable, and easy to understand, especially elementary school teacher education students will teach science material to elementary schools, where Physics science lecture material is material that is less interesting in presentation and the concepts are somewhat difficult to understand (Lusiani et al., 2021). Therefore, learning innovation is needed to make teaching science concepts more interesting and fun to learn by developing energy interactive learning multimedia that contains text, images, video, and sound that can be run and opened on cellphones and laptops. (Iskandar et al., 2019; Fatah et al., 2019; Saddhono et

al., 2019) which are easy to create with simple block-based programming which novice programmers can also create them.

Many other researchers have done research using the creation of interactive learning media without game, including using the PowerPoint or Powtoon application (Handayani & Dahlia, 2022; Chaerun et al., 2023), Macromedia Flash (Syaflin, 2022; Sidik et al., 2020), construct2 (Megawaty et al., 2021; Widyastuti & Puspita, 2020) or app inventor (Hanif, 2021; Firdaus & Hamdu, 2020). In contrast to these researchers, the researcher offers the creation of **en**ergy int**er**active learnin**g** med**ia** (**energia**) with game using block-based Scratch application programming as an example of a problem-solving final assignment project for elementary school teacher education students for computational thinking programming training material that hone programming concepts such as events, sequences, loops, parallelism, conditionals, operators & data, which have not been researched by other researchers in Indonesia. Educational games can be used as an option for learning media (Hamid et al., 2020). Students learn to play and learn through educational games. Additionally, using educational games as a teaching tool helps spark students' interest in the lessons they learn while playing (Erhel & Jamet, 2013).

In connection with this explanation, because there is no interactive learning media for energy material with block programming, the research aims to develop an interactive media project for learning energy with game using the Scratch application which is valid and practical and has a good level of programming competency which is useful as an example of a final assignment for solving programming problems in computational thinking training for elementary school teacher education students. The development of energia is also useful as a reference for applying computational thinking programming concepts learned in training and later can be used to create media material for lectures on Basic Concepts of Physics and others.

METHOD

Research and development (R & D) (Gall et al., 1996) are used as a type of development research carried out by researchers. Research and development is used to develop a product, in this case in the form of learning media, and later after the design and development process, a process of testing the practicality or effectiveness of the media as a product is carried out (Dick et al., 2015). The development model used in research is the ADDIE model, which consists of five process stages to produce interactive learning media products that comply with standards, namely: (1) Analyze, (2) Design, (3) Development, (4) Implement, (5)) Evaluation.

The analysis stage is related to analysis activities or identifying what problems are found in a particular environment so that ideas or thoughts emerge in determining the product to be developed. Analysis is carried out to determine user needs that are supported by the specifications/characteristics of the learning media being developed. Design is the stage for designing a product according to needs or analysis that has been carried out previously. This includes the activities of creating storyboards, and layouts and designing energy interactive media interfaces that are created. The third stage is development to create media using the Scratch application and testing the media developed, as well as revising or debugging the media so that it runs and is as desired. At the implementation stage, the media is ready to be applied to research subjects as users. Next, the fifth or final stage of the ADDIE model is evaluation, which is the activity of evaluating and assessing every step that has been taken to achieve a product that meets the specified specifications. The aim is to measure the quality of the products that have been developed.

Participants who participated in the research were three material experts and three media experts as well as 40 elementary school teacher education students from private universities located in Sumatra. Quantitative and qualitative data were collected through observation, Likert scales, artifacts, and interviews. This media is used for examples of final assignments for computational thinking training problem-solving projects and for science courses.

Data collection techniques were carried out employing observation, interviews, and questionnaires (Sudarmo, Muharlisiani, et al., 2021). A Likert scale questionnaire (Likert, 1932) with four types of choices was used to obtain data regarding the assessment of the interactive media being developed. The material and media expert validation questionnaire is shown in Table 1 and Table 2 as an instrument for collecting data for the research.

Table 1. Material Expert Questionnaire

Aspect	Indicator	Number of Items
Learning	Competency compatibility	3
	Providing Motivation	3
	Assessment	2
Material Content	Material Quality	3
	Material Selection	2
	Material Suitability	2
	Total	15

Table 2. Media Expert Questionnaire

Aspect	Indicator	Number of Items
Media Quality	Easy to use	3
	Background selection music/sound	2
Media Visual	Image quality	3
	Layout	2
	Suitability of illustration	1
Videos	Suitability of animation videos to material	1
Game	Suitability of game to material	3
	Total	15

These two questionnaires were distributed to experts in the energy interactive learning media product development stage.

Data obtained from questionnaires given to material experts, media, and users with the choice scale options are very good (4), good (3), fair (2), and not good (1). The validity test in this research used the Aiken formula (Aiken, 1985). The sum of selected data results for each statement obtained are divided by the maximum item. The average score results are then categorized into four categories; very valid or very practical, valid or practical, less valid or less practical, and invalid or impractical. The range of validity coefficient (V) is from 0 to 1.

For the assessment of created programming project artifacts or products, free and open source web applications, Dr. Scratch (http://www.drscratch.org/), is used to analyze Scratch code projects that researchers create automatically and assign CT scores to projects based on problem abstraction and decomposition, parallelism, logical thinking, synchronization, flow control, user interactivity, and data representation (Moreno-León et al., 2015). The total CT score is calculated by adding up the partial scores for each CT concept. Projects with a score of up to 7 points are considered to demonstrate a basic CT level, projects with a score between 8 and 14 points are evaluated as developing projects, and projects with more than 15 points are marked as advanced.

RESULTS AND DISCUSSION

This section presents the research results and discussions to answer the research questions.

1. Analysis Stage

At this stage, material learning problems are identified for the computational thinking training programming project assignment which can be used to create learning animation media on energy material. The programming materials that students need to learn as beginner programmers to be able to create interactive learning media are: How to start using the Scratch application, Motion & Drawing (Sequences), Looks & Sound, Variables (Operators & Data), Making Decisions (Conditionals), Repetition (Loops), which material has never been taught to elementary school teacher education students. The Scratch programming type was chosen because the block-based program form is not as difficult as programs in text form, which is easier to learn and suitable for elementary school children and elementary school teacher education students who are unfamiliar with programming languages.

From observations and interviews, it was found that computational thinking skills through programming with the Scratch application were not yet known and taught to students and the problem of the quality of learning media was still limited to PowerPoint slides whose use was still less interesting. Apart from that, the media used has not varied and not fun. Judging from the condition of the students, they have difficulty understanding the material and lecturers have to explain it repeatedly, and have difficulty finding reference sources. Meanwhile, the obstacles faced by lecturers in teaching are that students lack motivation to learn because the material is considered not easy to understand, students do not pay attention and are not serious about studying, and they are busy with their cell phones, social media, and playing games. Science lecturers also cannot create interactive animated media for teaching materials that can simulate the concepts being taught. For this reason, media is needed that can help, that can attract students' interest and attention, and contain material clearly, accompanied by videos to clarify the material, practice questions and game to increase insight and test retention of the material studied. It is also hoped that media can be used for independent learning at home. This interactive media can be created by lecturers and students through computational thinking programming training with the Scratch application.

2. Design Stage

Designed examples of programming project assignment materials that contain computational thinking concepts such as sequences, loops, conditionals, operators & data that can be used to create interactive animation media. For media, the results of the design stage are in the form of flowcharts and layouts for each

scene which describe the order and structure of the learning media, storyboards that contain template design plans, and interface designs. The flowchart that has been created is then used as a learning medium which can be depicted in Figure 1.

In the initial stages of opening and displaying or playing an interactive media programming project in the Scratch application, the user will enter a cover page that contains a welcome image of the energy lecture material. Next, after the user clicks the start button, the user is directed to enter the main menu of energy material, where there are various buttons on the page to go to other pages. This page includes material pages, video pages, practice questions pages, game, and user manual pages. The material page contains components of energy material. Video page containing animated videos enriching material of energy. The practice menu page contains questions about the material totaling 20 questions and the questions are randomized if there are repetitions of practice questions. The user manual page is a guide for interactive learning media user applications.

3. Development Stage

Development is the stage of product development and testing, where the results of analysis and design are developed into finished products. The following are the stages of product development and designs that have been created using Scratch software. The following are the results of product development and the form of programming projects for interactive energy learning animation media that were created (Figures 2, 3, 4, and 5). At this development stage, all computational thinking skills such as abstraction, decomposition, pattern recognition, and algorithms are applied along with all programming concepts that students learn in computational thinking training for programming problem-solving tasks.

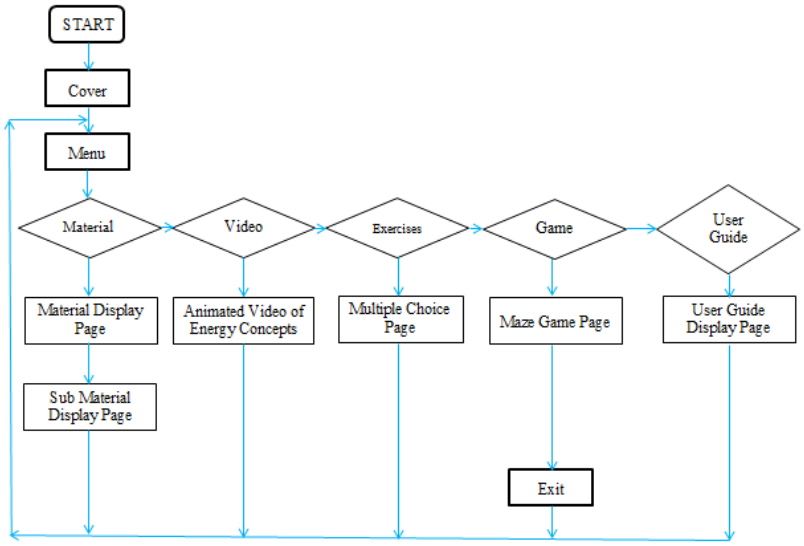

Figure 1. Media flow diagram

Figure 2. Energy cover and menu material page

Figure 3. Energy material page

Figure 4. Question practice page and block programming form in Scratch (which contains the concepts of events, sequences, parallelism, conditional, looks, variables, and loops)

Figure 5. Game and user guide page

Assessment of material, media, and student experts where the results of the learning media design were validated by three material experts, three media experts, and six students. Based on the results of material, and media experts, it was found that learning media was designed in the valid category with a score of 0.7844, as seen in Table 3. The design of learning media was improved by suggestions and comments from media and material experts, including the addition of examples of images. interesting and related to each concept of the material being studied, button layout, media, and image design improved, practice questions with more varied levels of difficulty, and programming projects that are more practical and cover all the computational thinking concepts taught. After improvements were made, the learning media was tested on six students. Input suggestions from students become material for further media improvements.

Table 3. Experts Assessment Results

Expert Validation	Value	Description
Material	0.7844	Valid. Can be tested in the field
Media	0.7918	Valid. Can be tested in the field
Average Score	0.7881	Valid. Can be tested in the field

Based on the assessment of material and media experts as well as the responses of several students, the energy interactive learning animation media developed is valid and can be tested on research subjects.
The difficulty level score for the Scratch programming project created is assessed based on Dr. Scratch is there, because it can't automatically check the web page because the system has an error. The online Dr. Scratch shared is still in the Beta version or testing, so it's not perfect. There are still many bugs that need to be fixed so that it can run well and provide input for improving the programming that we make to make it even better. For the difficulty score for the Scratch programming project created, the results can be seen in Table 4.

Table 4. Results of the Scratch project points assessed by Dr. Scratch rubric

No	CT Concept	Competence Score
1	Abstraction and problem decomposition	3
2	Paralelism	3
3	Logical thinking	2
4	Synchronization	2
5	Flow Control	2
6	User Interactivity	2
7	Data representation	1
Total point		15

The result of the media programming project assessment points for the concept of abstraction and problem decomposition is 3 because the learning media game script created uses of clones for two sprites. The concept of parallelism gets 3 points because the media programming project contains two scripts on when the backdrop switches to and the button is pressed. For the concept of logical thinking, it gets 2 points because, in the media program, there is an if-else command block in one of the sprites. The synchronization concept gets 2 points where in one of the media sprite scripts there is broadcast, when I receive message, stop all command block. The flow control concept also gets 2 points because, in the media, there are sprites with scripts that use repeat and forever command blocks. In the user interactivity gets 2 points because the media contains sprites with scripts that use key pressed, clicked sprite, ask and wait command blocks. In the concept of computational thinking, data representation gets 1 point because in sprite media only the attributes are modified. So the total score obtained from Dr Scratch's assessment is 15/21 or is classified as advanced level of difficulty for the programming project created. The level of difficulty of this program is due to the maze game program created which is related to energy materials.

4. Implementation Stage

The interactive media for energy programming with Scratch, which has gone through an expert validation process and small group trials, was revised until the final product, which was then tested for practicality on 40 students. Energy interactive media links are shared via WhatsApp groups. Interactive media for energy in the form of this application can be accessed via the internet by students via laptop or cellphone so that it can be seen and used by each student. Usage responses from students are recorded for further improvement processes.

5. Evaluation Stage

Evaluation activities are carried out at each stage. The purpose of the evaluation is to improve the product created before the final product is implemented. One of the evaluation stages is the improvement of interactive learning media resulting from the development stage, namely after testing by media experts, material experts, and small groups, at this stage the energy interactive learning media is revised according to the suggestions obtained to produce the final product better. Among the suggestions for improvement are animated videos made with examples of energy material that are easier for students to understand, as well as equipped with examples of practice questions that are easier to understand.
The response was "Very Practical" with a score of 86% (see Table 5) from users that the interactive learning media for energy with Scratch programming which was successfully developed in this development is an application that supports computational thinking training learning materials for problem-solving programming projects, which can also be used both in the classroom and for independent learning, by utilizing an Android-based smartphone and laptop computer.

Table 5. Practicality Assessment of Energia Interactive Media

Aspect	Value	Description
Aspects of CT programming concepts	85 %	Very Practical
Energy learning aspects	85 %	Very Practical
Visual aspects of media	85 %	Very Practical
Aspect level of programming problem-solving questions	85 %	Very Practical
Aspects of the benefits of CT skills	90 %	Very Practical
Aspect evaluation of game	80 %	Very Practical
Average Score	85 %	Very Practical

Regarding programming projects, 85% of students think they can be learned, are not that difficult, and can use examples to create them for other materials. The media and game is attractive, fun and motivating to learn energy material and computational thinking programming concepts with the Scratch application are quite easy to practice. The programming projects offered encourage students to think critically, creatively and imaginatively as well as hone their computational thinking skills.

From the results of data analysis and development of interactive media projects, and computational thinking with Scratch programming, the results are qualified as feasible or very practical for use. This is in line with research which states that interactive media is suitable for use as a learning medium and can improve the quality of student learning (Wulandari et al., 2017; Sugiyarto et al., 2021). The results of this research are supported by other research which states that interactive media is suitable for use at every level of education and can be an alternative learning resource in the classroom (Ketut Sinta et al., 2021; Kurnia et al., 2023; Satria, Sa'ud, Riyana, et al., 2024). The use of interactive media can improve students' understanding abilities (Suwiantini et al., 2021). The use of appropriate and good learning media will influence student learning outcomes, apart from helping teachers or lecturers in delivering material, learning media also makes it easier for students to receive material delivered by teachers or lecturers (Satria & Sari, 2018; Satria et al., 2023; Satria, Gusmaweti, Har, et al., 2024) as well as adding good assessment criteria from students to teachers who are the best at teaching (Abdullah, Hartono, et al., 2019). The results of several studies conducted by (Satria, 2013; Satria, 2015; Satria, 2020; Satria, 2019; Morales-Obod et al., 2020) also show that the use of learning media can help improve student learning outcomes. The use of educational games as a learning medium can also stimulate users to discover and improve their learning knowledge. Educational games are able to motivate students and also provide positive experiences (Lepper & Malone, 1987).

Apart from that, the development of this energy interactive learning media project hones students' computational thinking skills in developing programming concepts; events, sequences, parallelism, loops, conditionals, operators & data, and can be used by students and lecturers to recognize and develop computational thinking skills in the components of abstraction, decomposition, pattern recognition, and algorithms (Satria & Sopandi, 2022) in computational thinking training as one example of a final assignment for solving programming problems.

CONCLUSIONS AND RECOMMENDATIONS

From the data analysis of research and development results carried out on the development of an interactive learning media project for energy (energia) programming with Scratch software as an example of a final problem-solving assignment in computational thinking training for elementary school teacher education students, it can be concluded that the programming project application created is valid with an average score of 0.7881 and very practical with a score of 85% so it is suitable for learning energy material and computational thinking programming skill after validation by material experts, media experts, and user trials. The difficulty level of the programming projects created is at the advanced level, so it is quite difficult for students to create them. The interactive media created also can help students understand the material and computational thinking programming concepts taught. The interactive media created can also be modified (remixing) and used for independent learning to develop students' computational thinking skills. For future research, it is recommended to use programming concepts at a higher or more difficult level by using programming command blocks such as logic operation, operations on variables, and operations on list.

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