STEM-based physics multimedia design for stimulating HOTS on water and wind energy topic: Physics teacher perception

STEM-based physics multimedia design for stimulating HOTS on water and wind energy topic: Physics teacher perception

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Abstract. The aims of this research is to design a STEM-Based Physics Multimedia Design for stimulating HOTS on water and wind energy topic. The method in this research is Research and Development using the ADDIE model from Reiser and Mollenda, which consists of five stages, specifically: analysis, design, development, implementation, and evaluation stages. This study describes the results up to the Analyze and Design stages by descriptive qualitative analysis. Design Stage made with sheet validation by the practitioner using a Likert scale Validator product design consisting of ten professional physics teachers with qualifications Master of Physical Education. The research results obtained that it is needed the development of STEM-Based Multimedia Design for Stimulating HOTS on Water and Wind Energy topic. The multimedia design that has the potential to stimulate HOTS on the water and wind energy materes consists of videos and animation of water and wind energy power plants that contain all components of STEM. Because the design was obtained valid to used, so, further research to develop STEM-based multimedia for stimulating HOTS on water and wind energy materials is needed.

1. Introduction

The development of the Internet of Things, which was followed by the emergence of new technology in data science, artificial intelligence, robotic, cloud, three-dimensional printing, and nanotechnology are characteristics of the industrial revolution 4.0 [1]. This era requires every human being to prepare themselves to realize a quality golden generation of Indonesia. One form of self-development to create quality human resources is through education [2–4].

Education in the 21st century (4.0 industrial revolution era) requires students to have 4C skills (Creative, Critical Thiking, Communicative, and Collaborative) [5]. 4C skills lead to higher-level thinking skills (HOTS). HOTS is the ability to examine, connect, and evaluate all aspects of a problem including gathering, organizing, remembering and analyzing information [6,7]. Meanwhile, according to Anderson and Krathwoll, based on Bloom's taxonomic revision, HOTS is the ability to analyze, evaluate and create (the top three skills from the cognitive level) [8,9]. HOTS has an important role in learning, especially in learning physics which requires us to study physical events in everyday life, both real and abstract [10,11]. Therefore, to train HOTS in learning physics, we need stimulus in learning.

Stimulus in learning is needed to arouse and increase students' attention to the learning topic and provide opportunities for students to foster their curiosity and their ability to investigate information [12]. To realize HOTS as a result of learning, the stimulus presented must be contextual and interesting [13]. One stimulus that can be used in learning is the variation technique in the use of learning media. Learning media that might stimulate HOTS is multimedia.

Multimedia is a learning media that is able to present information factually, conceptually, effectively and efficiently, so that, learning becomes more interesting and can increase students' motivation in learning, because the learning topics presented are not only in the form of text but also contain pictures, audio, videos, and animation. [14–20] However, based on the results of the analysis of student needs, it is known that currently, multimedia in schools has not been designed to stimulate HOTS, especially on the topic of renewable energy, on the sub-topic of water and wind energy which is very abundant in Indonesia.

Renewable energy is a topic that is very important for students to learn in order to deal with resource problems in the environment. this is explained in a Joint Decree of the Minister of Environment and Forestry and the Minister of Education and Culture, No.07/MenLH/06/2005 No.05/VI/KB/2005 about fostering and developing environmental education. In this joint decree, it is emphasized that environmental education is integrated with existing subjects in school, and the integration rules are contained in the copy of attachment of the Regulation of the Minister of Education and Culture No. 69 of 2013, which stated that renewable energy in physics subject is expected to be able to present the idea of solving the problem of limited energy resources, alternative energy, and its impact on life [21]. Therefore to achieve these basic competencies, the right learning approach is needed to be applied in multimedia in the topic of renewable energy.

The learning approach that is considered suitable for multimedia and in accordance with 2013 curriculum is STEM approach [22,23]. STEM is a learning approach that uses the inter-science approach i.e. science, technology, engineering, and mathematics [24–26]. The application of STEM is done by active problem-based learning [27]. This approach is considered suitable for stimulating HOTS. Because through this approach, students will get used to thinking in different ways so that they will form their logic of thinking. This approach makes learning more meaningful through the systematic integration of knowledge, concepts and skills to solve everyday problems in various fields of science [28].

Therefore, in order to create a multimedia that can meet the needs of the 21st century education and in accordance with 2013 curriculum, an analysis of the needs of students and physics teachers must be done to develop STEM-based multimedia design to stimulate HOTS on the topic of water and wind energy which is valid based on teacher perceptions.

2. Methods

The method used in this research is the Research and Development (R&D) method with ADDIE (analysis, design, development, implementation, and evaluation) instructional media development model. The model can be seen in Figure 1.

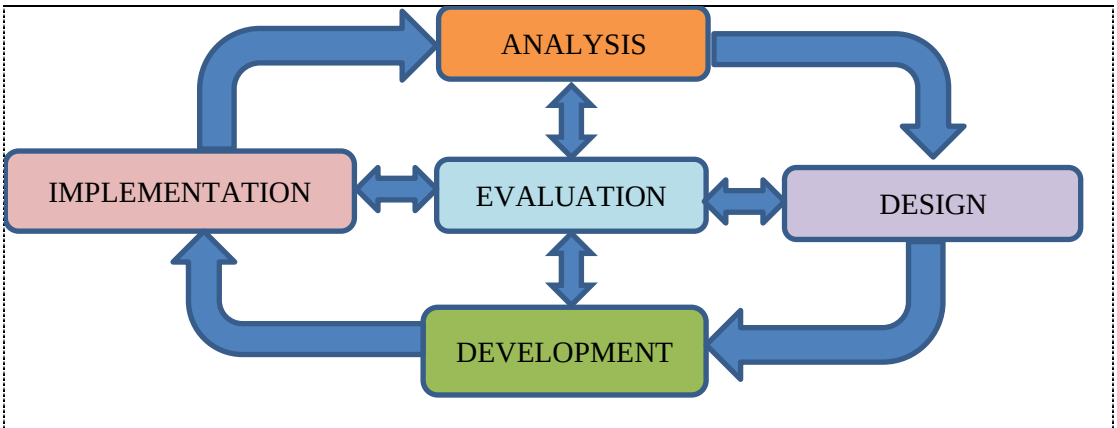


Figure 1. ADDIE Development Model[29].

However, this study only describes the development process up to the Analyze and Design stages through qualitative descriptive analysis. This research was only up to the design stage because this study aimed to develop a multimedia development design that is in accordance with the physics teacher's

perceptions of water and wind energy. This design will be used as a reference for the development of STEM-based multimedia to stimulate HOTS in water and wind energy materials. The scheme of this research procedure is illustrated in the following chart in Figure 2.

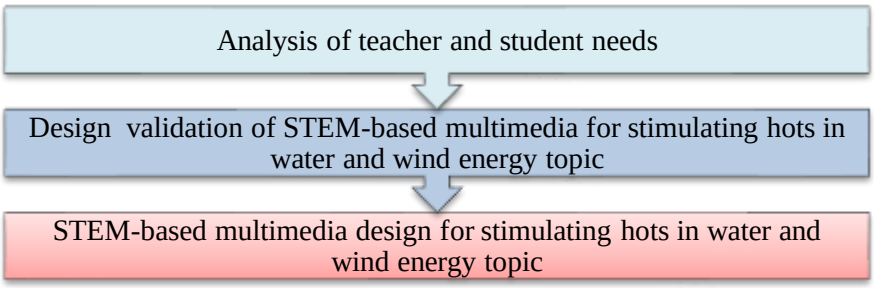


Figure 2. Research Procedure

In the analysis stage, we asked 43 students and 32 physics teachers in Lampung Province to fill out a needs analysis questionnaire consisting of 30 questions for teachers and 25 questions for students through a Google form. The analysis of needs aimed to get information about real conditions in the learning process. The data obtained were analyzed with quantitative descriptive using percentage technique.

In the Design stage, we asked 10 physics teachers to become multimedia design validators, then, we asked them to give an assessment through a validation sheets that used a Likert scale with five choices: (1) strongly disagree, (2) disagree, (3) undecided, (4) agree, and (5) strongly agree [30]. . Multimedia design in the form of tables, story boards and charts are attached in the validation sheets. Design assessment instruments are provided in Google Form. The feasibility interpretation test is listed in table 1:

Table 1. Feasibility Interpretation [31].

Average Score	Decision
4,20-5,00	Very suitable for stimulating HOTS
3,40-4,19	Suitable for stimulating HOTS
2,60-3,39	Quite suitable for stimulating HOTS
1,80-2,59	Not really suitable for stimulating HOTS
1,00-1,79	Not suitable for stimulating HOTS

3. Results And Discussion

Based on the results of physics teachers' and students' needs analysis, we get the results as shown in Table 2 and 3:

Table 2. Results of teachers' needs analysis

No	Statement Analysis
1.	93,8% of Physics teachers have implemented the 2013 curriculum revision in school.
2.	87,5% of Physics teachers have given higher-order thinking skills question to their students.
3.	87,6% of Physics teachers provide opportunities for students to discuss a problem with their group-mates.
4.	90,7% of Physics teachers give students the opportunity to exchange ideas and discuss them.
5.	93,73% of Physics teachers give students the opportunity to analyze the problems given during learning.
6.	90,8% of Physics teachers give students the opportunity to look for other sources to improve students' critical thinking ability.
7.	90,6% of Physics teachers give students the opportunity to discuss and present the topic.

No	Statement Analysis
8.	90,6% of Physics teachers give students the opportunity to solve problems in their own way.
9.	93,8% of Physics teachers give students the opportunity to do experiments.
10.	87,5% of Physics teachers give students the opportunity to present the results of their experiments in class (doing presentation).
11.	96,9% of Physics teachers give students the opportunity to complete experiments with physics concept.
12.	94,9% of Physics teachers use scientific approach in learning.
13.	96,9% of Physics teachers use media in learning.
14.	96,9% of Physics teachers apply fun physics learning.
15.	72,2% of Physics teachers have multimedia based learning resource.
16.	90,6% of Physics teachers have heard about multimedia based learning resources.
17.	90,6% of Physics teachers have used the STEM learning approach.
18.	37,5% of Physics teachers have developed *multimedia* learning resources with the STEM approach to stimulate HOTS.
19.	80,7% of Physics teachers need *multimedia* learning resources with the STEM approach to stimulate HOTS.
20.	84,45% of Physics teachers want to apply *multimedia* learning resources with the STEM approach to stimulate HOTS.
21.	81,5% of Physics teachers hope that STEM-based multimedia learning are effective to stimulate HOTS.
22.	87,5% of Physics teachers hope that STEM-based *multimedia* learning can be used in learning process.
23.	90,7% of Physics teachers hope that STEM-based multimedia could make students interested in learning physics.
24.	93,8% of Physics teachers are interested in using varied learning resources.
25.	84,4% of Physics teachers need STEM-based *multimedia* learning resources to stimulate HOTS.
26.	65,6% of Physics teachers feel they have not delivered the renewable energy topic completely
27.	84,4% of Physics teachers have not provided experiments on renewable energy
28.	83,3% of Physics teachers do not use multimedia when learning renewable energy.
29.	87,5% of Physics teachers provide questions related to higher-order thinking skills in renewable energy test.
30.	75% of Physics teachers have not stimulated higher-order thinking skills with the STEM approach in Static Fluid topic.

Table 3. Students' needs analysis

No	Statement Analysis
1.	67,4% of Students stated that they did not like Physics subject.
2.	51,2% of Students stated that physics is a difficult subject.
3.	79,1% of Students feel that physics is boring.
6.	48,8% of Students can work on higher-order thinking skills questions.
7.	95,3% of Students are given the opportunity to discuss the concept with group-mates.
8.	97,7% of Students are given the opportunity to exchange and discuss their ideas.
9.	95,4% of Students are given the opportunity to analyze the problems given by teachers while learning.
10.	97,7% of Students are given many opportunities by physics teachers to look for other sources.
11.	95,4% of Students are given the opportunity by physics teachers to present the results of the discussion.
12.	83,7% of Students are given the opportunity by physics teachers to solve problems in their own way.

No	Statement Analysis
13.	95,2% of Students are given the opportunity to do physics experiments.
14.	93% of Students are given the opportunity by physics teachers to present their work in the classroom.
15.	93% of Students are given the opportunity by physics teachers to complete experiments using physics concepts.
16.	88,3% of Physics teachers use a less attractive-physics learning media.
17.	86% of Students feel that their teachers are not good at conveying physics learning by applying a science, technology, engineering, and mathematical approach.
18.	86,1% of physics concepts they studied did not apply Science, Technology, Engineering, and Mathematics.
19.	86% of Physics concepts that I learned can be applied in everyday life.
20.	100% of Physics learning will be effective when using interesting *multimedia* learning.
21.	100% of Students are interested in the multimedia.
22.	93% of Students feel confident that learning Physics using *multimdia* learning will be interesting.
23.	76,7% of Students feel that Static Fluid topic is so boring.
24.	97,6% of Students agree that if physics -especially on the topic of renewable energy- is presented with multimedia learning will be more interesting.
25.	88,3% of Students think that they will understand the concept of renewable enegy if it presented by an interesting *multimedia*

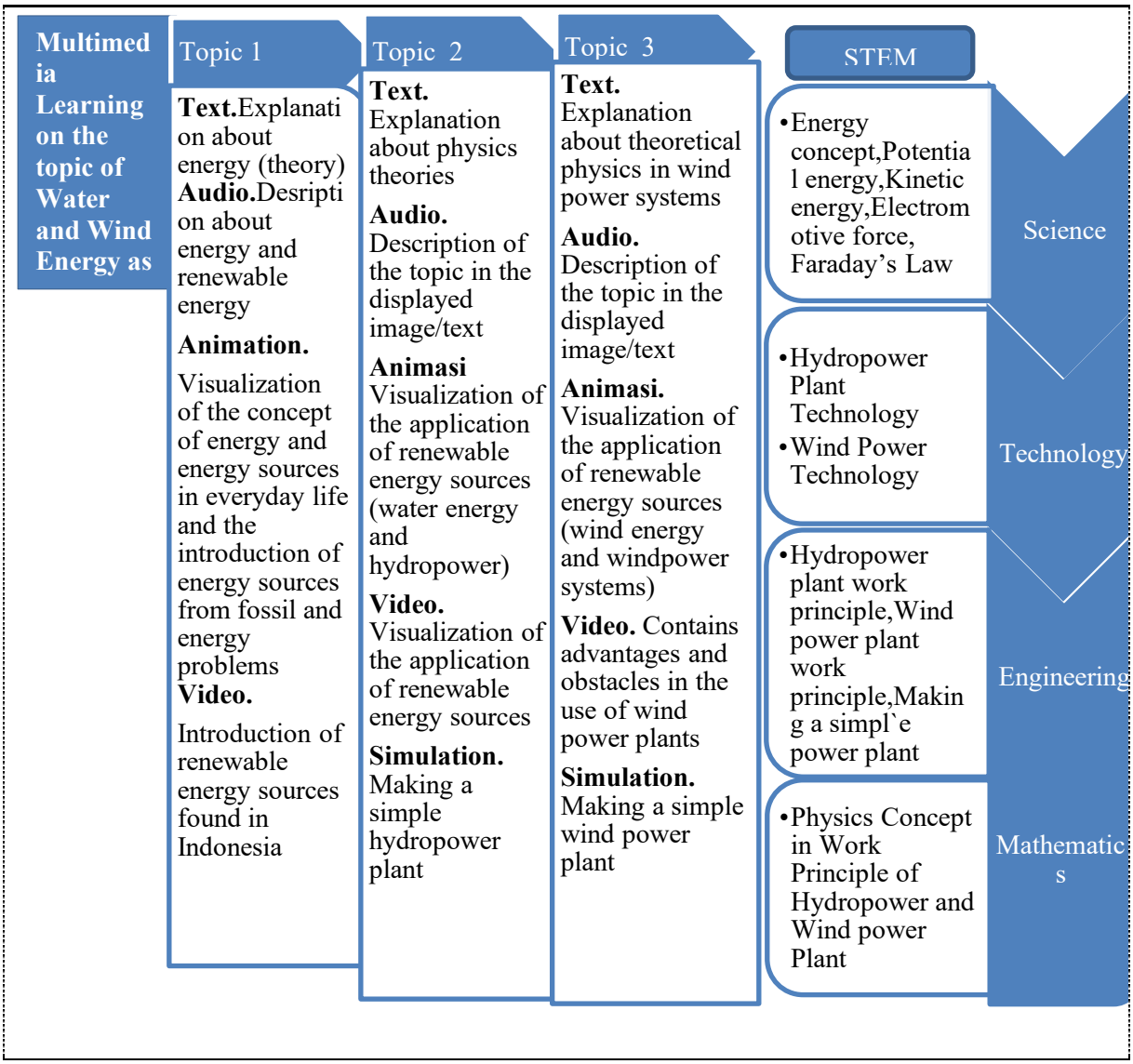
Based on the analysis of the statement in Table 3, we know that almost all physics teachers in Lampung have implemented the 2013 curriculum and have given HOTS questions to students, and most of the physics teachers have known the STEM learning approach. But, on the results of student questionnaires, students feel that the learning that they have received does not link science, technology, engineering and mathematics properly or learn to link the concepts of physics to everyday life. The teacher also did not develop special multimedia with the STEM approach to stimulate HOTS. Especially on the topic of renewable energy which most of the teachers claimed to have not done the learning on this material precisely and have not provided any experiments related to the topic of renewable energy. In fact, learning using multimedia is possible, because most schools have multimedia-based learning infrastructure. And based on the questionnaires regarding the needs of physics teachers, almost all of them want to apply STEM-based multimedia specifically to stimulate HOTS on the topic of renewable energy. The teacher also predicted that multimedia with STEM approach is effective for stimulating HOTS on the topic of renewable energy. And most students also think that using multimedia for learning on the topic of renewable energy will be very interesting. Because based on the results of student questionnaires, it is known that most students do not like physics. Students feel physics is difficult and boring because it is less interesting. This sort of thing was also expressed several times by previous studies. Esti's research stated that multimedia is effective to improve student learning outcomes [14]. Gunawan's research and Chen's research which stated that Multimedia was effective in increasing Physics concept understanding [15,19]. Therefore, based on the results of the analysis of teacher and student needs, as well as the results of previous research, we conclude that physics teachers in Lampung need STEM-based multimedia that is valid, effective, practical, and able to stimulate students' HOTS.

Based on the results of the needs assessment, we continue to develop into the design phase. At this stage, we made a research design in the form of a multimedia design chart, a multimedia story board, and a multimedia design table based on the analysis of teacher and student needs. Furthermore, the design is given to the design validators consisting of 10 professional teachers with a Masters in Physics Education qualification to be validated. The results of this validation are written in Table 4.

Table 4. Design validation results

Category	Topic 1	Topic 2	Topic 3
The content is compatible to stimulate HOTS	4,6	4,6	4,6
Content compatibility with STEM components	4,6	4,5	4,5
The Suitability of Features and Multimedia Content to STEM to Stimulate HOTS	4,5	4,6	4,7
Average	4,57	4,57	4,61

Based on the results of the validation in Table 4, it is known that all the criteria in the validation results are in the range of 4,20-5,00 with "Very suitable for stimulating HOTS" category. From the results of this validation also received positive support to immediately realize the development of this STEM-based multimedia to stimulate HOTS. Besides giving comments, the validator also gave advice to give attention in stimulating the ability to find ideas to design hydro and wind power plants, they also suggested to pay attention to the prerequisite knowledge about the concept of electricity in its application to the hydropower system and the availability of teachers to guide students. Design of this research is seen in figure 3.



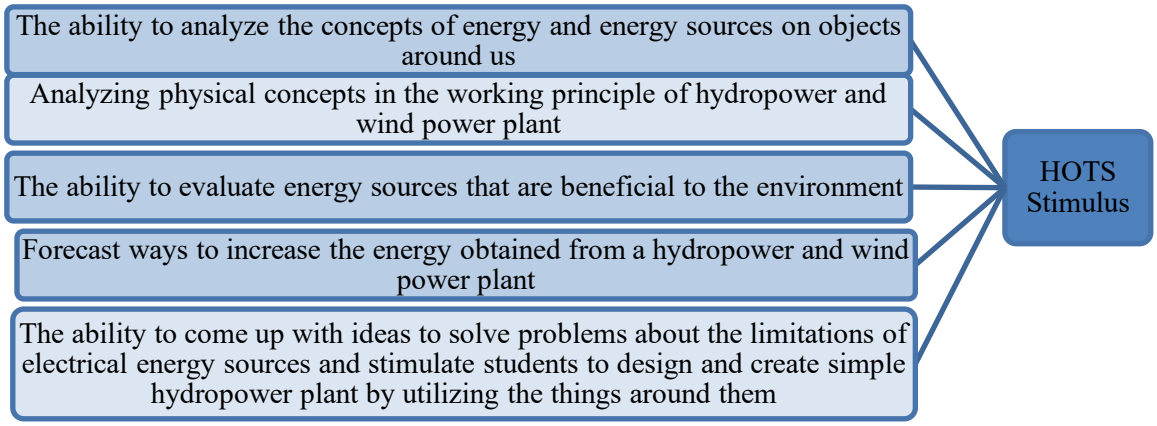


Figure 3. Multimedia Development Design

The chart illustrates that the topic of multimedia is divided into three: the concept of energy and renewable energy sources, hydropower and wind power plants. The research design chart illustrates that the features used in multimedia are text containing theoretical explanations and inducement questions to direct students' thinking. Audio which contains a description of the material from water and wind energy as electricity generation. Video introduction to abundant renewable energy sources in Indonesia and in the form of visualization of the advantages of using water and wind energy sources as power plants. Animated visualization of the concept of energy and energy sources in everyday life, the introduction of energy sources from fossil materials, energy problems and visualization of the application of renewable energy sources, namely water and wind energy and the work system of hydroelectric power. The simulation of making a simple power plant, and will be added with an interactive quiz as an enrichment. The use of these features in multimedia can help visualize abstract concepts, making it easier for students to understand learning topics[27]. In accordance with some previous studies which have revealed that the use of instructional videos is very effective because video help students to understand the concepts of physics[31,32]. The use of simulations in learning helps students visualize problems and the solutions, it can also foster a positive attitude towards physics [15]. the use of animation in learning physics also helps students to understand physics concept [33], and based on Andriani's research, the use of animation in learning has been proven to increase students' HOTS [34]. So that, the multimedia design depicted in the chart in Figure 2 uses these features to potentially stimulate HOTS in water and wind energy in the renewable energy topic. The multimedia design illustrated that the features used were integrated with STEM. STEM integrated multimedia based on this research has the potential to stimulate HOTS of students, namely the ability to analyze, evaluate and create. In accordance with previous research which states STEM improves higher order thinking skills [35].

4. Conclusion

Based on the research results, at the analysis stage, it is known that a STEM-based multimedia on the topic of water and wind energy is needed to stimulate HOTS. At the Design stage, it was found that the multimedia design that was developed was valid with high criteria, so, the design is feasible to proceed to the development stage.

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