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SHORT PAPER

Development of STEM-Based Learning Media FDS (Fire Detector System) Integrated with Blynk IoT to Improve Students' Creativity on Temperature Material

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ABSTRACT

The Society 5.0 era emphasizes the use of technology and innovation to address social challenges, such as the utilization of Internet of Things (IoT) technology. Creative thinking plays a vital role in generating new ideas and approaches to problem-solving. Science, technology, engineering, and mathematics (STEM)-based education can help individuals develop creative thinking skills by engaging in problem-solving and creating innovative solutions. This study aims to enhance the creative thinking abilities of junior high school students on the topic of temperature through the development of STEM-based instructional media. This is achieved by creating the fire detector system (FDS) educational kit and testing its validity and practicality in the learning process. The study model used in this study is the analysis, design, development, implementation, and evaluation (ADDIE) model. The ADDIE model consists of five stages: analysis, design, development, implementation, and evaluation. The research instruments utilized include structured questionnaires for expert validation and application testing. The participants involved in this study include several seventh-grade students and one science teacher from a junior high school. The collected data is then analyzed using qualitative and quantitative descriptive data analysis techniques. By utilizing the FDS educational kit, it is hoped that it can effectively foster creative thinking skills among junior high school students.

KEYWORDS

educational kit, Internet of Things (IoT), science, technology, engineering, and mathematics (STEM)

1 INTRODUCTION

The advancement of technology is an inevitable phenomenon. The progress of technology has had significant impacts on various aspects of life, including the field of education [1]. In the realm of education, technological advancements play

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a profoundly influential role. Educators and learners are compelled to incorporate technology in the application of knowledge. The ongoing rapid evolution of technology propels us into an era where everything is digitally driven. One of the renowned periods in technological advancement is the era of Society 5.0.

The Super Smart Society 5.0 era is a period in which society must address the social issues caused by the advancements of the Fourth Industrial Revolution, namely artificial intelligence (AI), the Internet of Things (IoT), robotic technology, and big data, which undoubtedly have the potential to replace human labor [2]. The Super Smart Society 5.0 era aims to create a technocentric human society that enables individuals to experience a high quality of life that is active and comfortable. The concept of Society 5.0 serves as a response to challenges posed by technological advancements, with goals of justice, equality, and shared prosperity, ultimately leading to the creation of a Super Smart Society [3]. The era of the Fifth Industrial Revolution is characterized by the emergence of AI, the development of digital systems, and heightened connectivity. This era's emergence allows technological advancements to profoundly influence various aspects of life as the boundaries between humans, machines, and information technology increasingly converge [4]. Consequently, demanding a more critical and creative way of thinking becomes essential for society's adaptability [5].

The transformation of this era is inevitable for everyone, thus requiring the preparation of adequate human resources (HR) to compete on a global scale. Enhancing the quality of HR through education, ranging from primary and secondary education to higher education, can be the key to keeping pace with the advancements of the Fifth Industrial Revolution. To confront the era of the Fifth Industrial Revolution, education is crucial in molding a generation that is creative, innovative, and competitive [6]. One way to achieve this is by optimizing the use of technology as an educational tool. This approach is expected to generate outcomes that can adapt to changing times and enhance them.

In the 21st century, challenges in the field of education are increasingly required to align with the times. As part of Society 5.0, educators must be capable of delivering instructional content that enlightens learners, while learners are required to master the four learning skills (4Cs): critical thinking and problem-solving, communication, collaboration, and creativity and innovation [7]. Creative thinking is one of the vital skills that must be cultivated in the present day. Creative thinking is the ability to generate novel ideas by tapping into one's imagination, providing students with opportunities that emphasize fluency, flexibility, originality, and elaboration [8]. This aligns with the four indicators proposed by Torrance, which include: (1) originality as the uniqueness of expressed ideas; (2) fluency as the capability to generate a multitude of ideas; (3) flexibility as the ability to overcome obstacles when generating ideas; and (4) elaboration as the addition of details to each idea, thus transforming simple stimuli into more complex forms.

However, in reality, the level of creative thinking skills among Indonesian students remains relatively low. According to the 2015 PISA results, Indonesia ranked 73rd out of 79 countries. Furthermore, based on the analysis of the global creativity index (CGI) in 2015, Indonesia was ranked 115th out of 139 countries [9]. Based on the acquired data, the low level of creative thinking ability among Indonesian students can be attributed to the lack of training in creative thinking skills during their learning process. Furthermore, the lack of collaborative teaching approaches is another factor contributing to the low level of creative thinking ability. The STEM (science, technology, engineering, and mathematics) teaching approach is one of the methods that provides students with opportunities to develop their creativity while assisting them in acquiring understanding and creativity as their creative thinking skills evolve [10].

The goal of STEM education is to enhance science skills, operate technology, develop problem-solving skills, and cultivate mathematical skills that are well-suited to address the challenges of the 21st century [11]. STEM-based learning is expected to uncover and enhance students' creative thinking potential. Furthermore, previous research indicates that the creative thinking skills of junior high school students in relation to temperature-related subjects are still relatively low. This underscores the need for STEM-based learning materials that can enhance students' creative thinking skills [13].

Based on the context, this research is conducted with the title "Development of STEM-based Learning Media FDS (Fire Detector System) Integrated with Blynk IoT to Improve Students' Creative Thinking Skills in Temperature Material." The purpose of this research is to develop a valid and practical STEM-based learning media FDS integrated with Blynk IoT to enhance students' creative thinking skills in temperature materials.

2 METHOD

This study falls under the category of research and development (R&D), utilizing the ADDIE development model, which consists of five stages: analysis, design, development, implementation, and evaluation. These five stages are interconnected, with the evaluation phase positioned between the others.

The data analysis techniques employed in this study encompass both qualitative and quantitative analyses. Qualitative data includes feedback and recommendations gathered during validity testing from subject matter experts and media specialists, as well as practicality testing with science teachers and students. On the other hand, quantitative data is collected during validity and practicality testing using a Likert-scale questionnaire. The questionnaire's response options range from 1 to 4, with labels as follows: strongly agree = 4, agree = 3, disagree = 2, and strongly disagree = 1.

Data analysis is conducted to assess the feasibility of the media-by-media experts and subject matter experts, as well as the practicality of both teachers and students. The collected data is then analyzed using equations to determine the overall effectiveness and efficiency of the developed media.

$$P = \frac{\sum x}{\sum xi} \times 100\%$$

Explanation:
P = eligibility percentage
$\sum x$ = the total score obtained
$\sum xi$ = highest total score

Based on these average results, subsequent decision-making is carried out for the validity and practicality tests, guided by the decision-making criteria outlined in the following Table 1.

Table 1. Percentage categories

Percentage	Criteria
81–100	Very valid/Very practical
61–80	Valid/Practical
41–60	Sufficiently valid/Sufficiently practical
21–40	Less valid/Less practical
0–20	Not valid/Not practical

3 RESULT AND DISCUSSION

The development of STEM-based FDS instructional media falls under the category of R&D. This study aims to develop instructional media in the form of a STEM-based FDS kit. The research is conducted through five stages, namely the analysis stage, design stage, development stage, implementation stage, and evaluation stage.

3.1 Analysis

During the analysis stage, the researcher plans the development of instructional media in the form of an educational kit. This analysis stage commences with a study analysis, which is initiated by conducting a literature review. The first aspect of this literature review involves curriculum analysis. The curriculum chosen for this study is the 'Kurikulum Merdeka' (Merdeka Curriculum). The selection of the Kurikulum Merdeka is motivated by its potential to enhance the quality of education in Indonesia. This curriculum can also be customized to meet the needs and characteristics of students, relieving them of the burden of traditional learning activities.

The second aspect of the literature review involves analyzing scientific content within the framework of different levels of creative thinking. This analysis involves selecting science content that is perceived as challenging for junior high school students based on their level of creative thinking.

During the analysis stage, a study is conducted to evaluate the extent of creative thinking among junior high school students in the context of temperature-related subjects. The research findings indicate that the creative thinking skills of junior high school students in relation to temperature-related subjects are still relatively low. As a result, the development of instructional media is considered necessary to enhance students' creative thinking abilities in this field.

3.2 Design

Based on the analysis stage conducted, the next step involves the design process, which entails crafting the design of the FDS media (see Figure 1). The design stage encompasses the creation of an overall design, including the design of the circuitry, packaging, kit components, user manual, student worksheets (LKPD), and handouts.

Fig. 1. FDS design

The components used in the FDS educational kit include NodeMCU ESP8266, a flame sensor, LED lights, an alarm buzzer, a mini water pump, a battery, resistors, USB cables, relays, and other supporting components. All hardware will be arranged according to the hardware design picture in Figure 2.

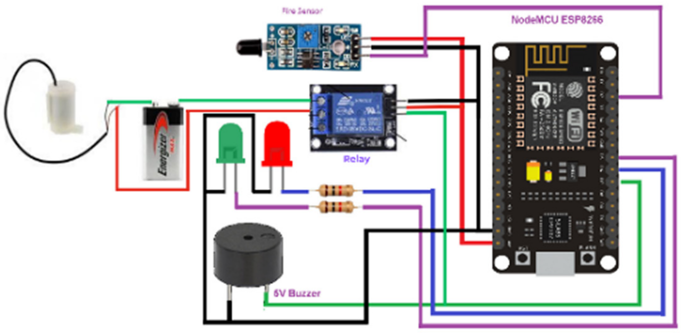

Fig. 2. Hardware design

The NodeMCU ESP8266 will function as the central processing unit responsible for sending and receiving data from all hardware devices. Data from the flame sensor will be received by the NodeMCU, and electrical signals will be sent to activate the lamp, alarm buzzer, and mini water pump. Additionally, the NodeMCU will send warning data to a smartphone or website using Blynk IoT, and notification alerts will be sent to the user's email. The user interface on the smartphone and website can be seen in Figure 3.

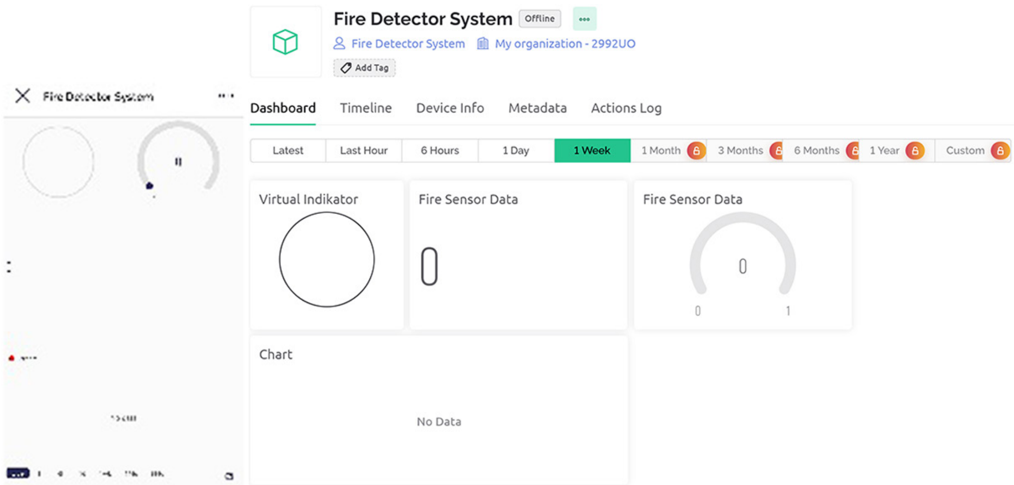

Fig. 3. The display of Blynk IoT app on smartphone (left) and website (right)

The virtual indicator will be green when the KIT is powered on. When the sensor detects fire, the virtual indicator will change its color to red. Furthermore, the fire sensor indicator will display a number indicating the intensity of the fire. As the fire intensity increases, the displayed number will also increase.

3.3 Development

During this stage, the previously designed FDS materializes into its physical form. Subsequently, a validation process is carried out, involving expert validation from both media specialists and subject matter experts. A questionnaire, previously prepared, is used to assess the validity of the media. The validation outcomes play a pivotal role in determining the media's viability, allowing for the progression to the subsequent stage.

The media validation process involves experts who are lecturers in the natural science education study program at Universitas Negeri Malang. Based on the content validation, a percentage of 83.03% is obtained. Similarly, a media validation score of 78.91% is achieved. Consequently, based on these results, a validity test score of 80.97% is obtained, categorizing it as 'valid.' Hence, the media is considered appropriate for further implementation in subsequent processes.

3.4 Implementation

During the implementation stage, the validated media developed by experts is put to practical use. The media is then subjected to practicality testing, involving both science teachers and junior high school students. The practicality testing involves one science teacher and 30 seventh-grade students from SMP Negeri 1 Singosari.

The outcomes of the practicality testing yielded a score of 98.61% based on the teacher's evaluation. Moreover, based on student evaluations, a score of 88% was obtained. Consequently, the overall result of the practicality testing amounts to 93.30%, falling within the "very practical" category. This underscores the media's effectiveness and utility in an educational setting, reaffirming its potential to enhance the learning experience for both teachers and students.

3.5 Evaluation

The evaluation stage is carried out between each of the other stages. This phase aims to refine the media based on the outcomes of the preceding stages before progressing to the next phase. The primary objective of this stage is to enhance the developed media, ensuring its validity and practicality for use by junior high school students. The refined media is designed to help cultivate creative thinking skills among students, particularly in the context of temperature-related subjects. This iterative evaluation process ensures that the final media product aligns with the intended objectives and effectively addresses any identified shortcomings or areas for improvement.

4 CONCLUSION

The STEM-based instructional media, integrated with Blynk IoT, known as the FDS, aims to enhance students' creative thinking skills in temperature-related subjects. It has been validated by subject matter and media experts, placing it in the 'valid' category. Additionally, for practicality testing, indicating that it falls under the 'very practical' category.

Based on these results, it can be concluded that the FDS instructional media is suitable for implementation in classroom learning. The media has met the criteria for validity and practicality, affirming its efficacy in enhancing students' creative thinking abilities in the context of temperature-related subjects.

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