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STEM Learning Design with Literation-Based Pop-Up Book Media in Elementary Schools

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Abstract: This study aims to examine the stages of developing a STEM learning design with literacy-based Pop-Up Book media. Media-integrated instructional designs can facilitate students' mastery of the studied subject. The implementation of learning designs with creative media has not been widely applied during teaching and learning activities in class, especially in thematic learning with the 2013 curriculum. Pop-Up Book media is creative media applied to literacy-based STEM learning designs in school. This study used a design-based research method. Data were collected through interviews, expert assessments, and questionnaires. Pop-Up Book media based on literacy has been designed to be implemented through STEM learning designs in elementary schools. Therefore, this creative media can be applied by teachers in learning with the 2013 curriculum in elementary schools.
Keywords: stem learning design, media pop-up book-based literation, curriculum 2013

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Introduction

The STEM Learning Design is an alternative learning design that has the potential to be applied to build 4C skills through STEM learning with literacy-based Pop-Up Book media. STEM learning can be implemented in elementary schools by implementing the 2013 curriculum, which is prepared in a thematic, scientific and contextual manner. It is expected to build and create generations capable of developing their competencies. Currently, learning models do not provide meaningfulness in learning, and students are not directly involved in each learning process, resulting in unqualified competencies. STEM education applies to the 2013 curriculum because it combines four disciplines: Science, Technology, Engineering, and Mathematics. Therefore, the STEM learning design with literacy-based Pop-Up Book media in elementary schools is designed to create meaningfulness and student involvement in the learning process. Then, STEM learning with literacy-based Pop-Up Book media will integrate the four components capable of producing students' thinking activities that are useful for bringing out students' critical thinking patterns, which are characterized by the ability to solve problems, make decisions, analyze assumptions, evaluate, and conduct investigations. This research used STEM learning with literacy-based Pop-Up Book media in elementary schools. The results of learning in elementary schools show that STEM learning has become known in various elementary schools but has not been widely applied in the learning process. Then students are enthusiastic about learning STEM with literacy-based Pop-Up Book media in Elementary Schools. These results indicate that STEM learning is gaining popularity in various schools to build 4C capabilities and support the 2013 curriculum. STEM learning design with literacy-based Pop-Up Book media in elementary schools is the focus of preparing research articles.

By integrating its four components, STEM learning can generate thinking activities that help students develop critical thinking, which is the capacity to solve problems, make decisions, analyze assumptions, evaluate, and conduct investigations. STEM education is an interdisciplinary approach to learning in which students use science, technology, engineering, and mathematics in real contexts that connect schools, the workplace, and the global world to develop STEM literacy and prepare them for

the new economic era (Sapitri, 2018). One of the efforts that can be made to deal with economic challenges is to improve education according to national standards and how the education system conforms to internationally enforced standards such as science education standards. Therefore, STEM learning needs to be a reference for education in Indonesia.

When STEM is integrated with the environment, students acquire knowledge that reflects the real world they encounter daily (Herak, 2011). STEM learning is one way to increase human resources with a high level of knowledge, namely creating. In addition, STEM creates a generation that likes learning science and mathematics and improves student achievement because students are motivated and directly involved in the learning process. Through STEM, students are encouraged to become problem-solvers, inventors, and innovators, to develop independence, to think logically, to be technologically literate, and to be able to make connections between STEM education and the real world.

A teacher must have learning alternatives to increase the creativity of his students. One of the alternatives used is the use of the STEM learning approach. STEM learning applies Science, Technology, Engineering and Mathematics at once. STEM-based learning is expected to shape the character of students who can recognize and apply knowledge using their skills by creating and designing something based on mathematical calculations. STEM learning is an alternative in the world of education that will help with problems in the real world.

Integrated STEM education is an interdisciplinary approach to learning in which students apply science, technology, engineering, and mathematics in a real-world context that connects schools, the workplace, and the global world, fostering STEM literacy and preparing students to compete in the new economic era (Tsupros et al., 2009). Integrated STEM education as an approach to teaching two or more STEM fields by involving STEM practice in connecting each STEM discipline is integrated learning between science, technology, engineering, and mathematics to foster students' creativity through problem-solving (Kelley & Knowles, 2016).

From the opinion of several experts regarding STEM learning, it is known that STEM is learning that integrates four areas of learning to develop students' learning competencies. In addition, the four learning areas are interrelated, making it easier for teachers and students to understand each learning process. Students learning interest increases because they are directly involved in solving problems commonly encountered in everyday life. The description of STEM education at the elementary school level, according to Blackley & Howel in Lidinillah (2013), states *"...that engineering is not included in the material in the elementary school curriculum, although there are numerous problem-solving activities and innovations in science and mathematics education"*.

STEM learning can be developed in two ways, namely integrating context and content. Context integration applies an outline in learning that is considered a driving force or motivator for teaching mathematics and science material, while content integration applies techniques or ways of learning. The technical or methodical application emphasizes that engineering skills are part of the learning objectives, whereas mathematics and scientific concepts are acquired incidentally through learning activities. STEM is a strategy for implementing the learning process that applies knowledge, skills, and dispositions to solve everyday problems related to the natural and social environment.

There are several parts in the application of STEM, according to Kuenzi & Schminke (2009), which have three parts: knowledge, skills, and attitudes.

a. STEM Knowledge
   STEM knowledge is ideas, concepts, principles, theories, and understandings in the STEM field that are present in all STEM subject curricula. The curriculum created is designed to build and improve students' knowledge, skills and attitudes, which are carried out through activities that the teacher has designed. The progressive and dynamic acquisition of STEM knowledge is important so that students are always up to date with the latest knowledge and developments in the STEM field.
b. STEM Skills
   STEM skills are guessing, solving problems, and making a design or product. This skill can be acquired through activity. Activity skills will emerge when students understand a learning process.
c. STEM Learning Attitudes
   Attitudes in STEM are positive morals or morals that students must obey. Applying attitudes during STEM learning is very important to produce students who are proficient in their knowledge and skills and have strong personalities.

STEM learning has the potential to be used to improve 4C abilities. STEM in its learning integrates four fields of disciplines, namely science, technology, engineering, and mathematics, which are prepared to be able to produce students' thinking activities that are useful to help bring out students' critical thinking, which is characterized by the ability to solve problems, make decisions, analyze assumptions, evaluate, and carry out investigations (Artobatama, Hamdu and Giyartini, 2020). STEM learning design that utilizes literacy-based Pop-Up Book media to increase students' awareness of learning. Usually, literacy activities are implemented outside of class hours, but currently, literacy activities are very important to be integrated into the teaching and learning process.

Outbound Traditional Game-based STEM learning that is applied outdoors is appropriate for use in Elementary Schools. Because in this learning at every learning meeting, teaching will produce products or work from students. It can be concluded that this learning combines STEM, outbound, and traditional games (Artobatama, 2018). Based on this, STEM learning is flexible enough to be integrated with supporting media. Literacy-based Pop-Up Book media is an idea that can be implemented in STEM learning in elementary schools. Therefore, learning tools such as lesson plan, students' worksheet, teaching materials, learning videos and Media Pop-Up Books become one unit to be applied in class, especially in grade V of elementary school.

STEM-based thematic learning media on the sub-theme of energy change that integrates science and mathematics can be used in learning for fourth-grade students (Falentina, Lidinillah, and Mulyana, 2018). Various learning media support learning in the classroom. It can increase students' enthusiasm for learning. Learning material in grade V, semester 1, regarding ecosystems implemented in Pop-Up Book media, can be a medium that connects teacher explanations with students' understanding. Because currently the 2013 curriculum is still widely implemented, this STEM learning can be applied in elementary schools. However, STEM learning with literacy-based Pop-Up Book media in this school can be implemented using an independent curriculum with some adjustments to the learning tools prepared.

STEM learning is possible to be developed in the context of the elementary curriculum to assist students in fulfilling 21st-century skills, so efforts are needed to increase the understanding and readiness of elementary teachers in designing and implementing STEM learning in elementary schools (Haryati, Lidinillah, and Karlimah, 2020). The 4C skills implemented in STEM learning support the development of students. Teachers use Pop-Up Book media as learning media, which can also be used as a product that students will produce. Therefore, students will better understand learning when students see, hear, and carry out learning activities.

Research results from researchers indicate that there are difficulties faced by teachers in developing STEM that is integrated with the curriculum (Roehrig et al. 2021). In implementing creative and innovative learning designs, there will indeed be obstacles or obstacles from teachers, students, the environment, or the school. However, STEM learning design has a significant impact on increasing student creativity. Thus, teachers must be wise in implementing STEM learning with Pop-Up Book media, according to needs and paying attention to the situation and conditions of the school.

The study's results revealed significant differences between teachers who knew STEM and those who did not. Teachers who understand STEM pedagogy tend to have lower intrinsic challenges than those who don't. Therefore, training is needed to understand STEM (Dong et al. 2020). Implementing STEM learning provides broad benefits for students in terms of 21st-century skills, producing products as the output of the learning that has been implemented. Pop-Up Book media can generate student motivation and enthusiasm for learning. Literacy, integrated into Pop-Up Book learning media, then implemented in STEM learning, becomes a very good learning design when implemented in elementary schools. Thus, elementary school teachers can apply STEM learning with literacy-based Pop-Up Book media.

Methods

The research conducted in this research was design-based research or design research. Barab (2006) explains that Design-Based Research (DBR) is "a series of approaches used to produce new theories, artifacts, and practical models in explaining and potentially impacting learning in naturalistic conditions". DBR is an appropriate research method for enhancing the quality of instructional design because it can overcome the gap between theory and practice.

In this research procedure, there were several steps of DBR according to McKenney & Reeves (2013) as follows.

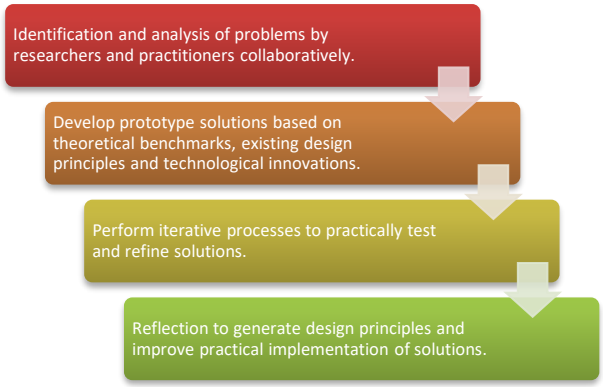

Figure 1. Research Objectives of DBR Research Steps

The research subjects for the development of STEM learning designs were elementary schools in the city of Bandung. In contrast, the sampling technique in this study used a purposive sampling technique. In this study, researchers used a sample of grade V at Cipaganti Elementary School, considering that Cipaganti Elementary School has qualified achievements from students and schools and has implemented the 2013 curriculum with a scientific approach.

This research was conducted in one elementary school that used the 2013 curriculum, Cipaganti Elementary School, located in Bandung City, West Java. The research was conducted for two months, namely October and November 2022.

The data collection technique used in this study was as follows.

a. Interview
   The interviews were conducted with fifth-grade teachers at Cipaganti Elementary School.
b. Documentation Study
   The documentation study carried out in this study was the lesson plan made by the teacher used as a guide for carrying out the learning process.
c. Observation
   The type of research used by researchers was non-participatory observation. Researchers did not participate in activities but only observed the activities. Observations were made during product trials at Cipaganti Elementary School. The observer observes the learning process using the learning design created by the researcher.
d. Questionnaire
   The questionnaire given in this study was an open questionnaire. Questionnaires were given to teachers as the subject of this research.

Results and Discussion

This study aims to produce a STEM learning design for fifth-grade elementary schools that use the 2013 curriculum on the sub-theme of ethnic and religious diversity in my country. This research is collaborative research consisting of learning design development research, developing student worksheets, developing learning media and teaching materials, and developing learning implementation videos. This research is a development on STEM learning on the theme of 5 ecosystems and sub-theme 1 of ecosystem components.

This study's identification and problem analysis steps were carried out using a literature study and a preliminary study of several elementary schools to identify existing problems. Researchers conducted a literature review on a variety of classroom-based learning processes. The literature review results suggest that the learning process is still conventional and that variations in learning methods cannot be developed. That optimal enjoyment of learning has not been attained. The lecture method continues to dominate education, which has implications for teacher-centered learning processes. It is in line with the statement (Nurlenasari et al., 2019) explaining that the learning process is still conventional and teacher-centered, and the dominant use of the lecture method is carried out in class.

From the results of interviews conducted with class teachers, namely Lamri, S.Pd., M.Pd., researchers obtained information that the learning design, in this case, the Learning Implementation Plan, is very important to be prepared before the learning process is carried out in class so that learning objectives can be achieved optimally. In designing a learning design, a teacher must pay attention to the components contained in the Ministry of Education and Culture (2016) regarding Process Standards. The lesson plan includes the following components: school identity, theme/sub-theme identity, class/semester, subject matter, time allocation, learning objectives, basic competencies and competency achievement indicators, learning materials, learning methods, learning media, learning resources, and steps for assessing learning outcomes. Apart from that, in preparing the lesson plan, one must pay attention to the principles of preparing the lesson plan. In making lesson plans, teachers usually follow these rules. Two factors cause teachers difficulties in designing a learning design. The first factor, namely internal factors, arises from the teacher, for example, the teacher's lack of curiosity to find out how to design learning designs that align with the 2013 curriculum and teachers are constrained by time. Meanwhile, external factors, namely the lack of available materials, make it difficult for teachers to develop learning designs. Whereas in the 2013 curriculum itself, the teacher must be able to further develop the material in the teacher's and student's books.

From the results of interviews conducted with the grade V teacher, Mrs. Putri, the researchers obtained information that this learning design was very important because it served as a reference for implementing learning. The standard of the learning process is in line with Permendikbud No. 65 of 2013. The implementation of the lesson plan in the 2013 curriculum places more emphasis on the activeness of students. Then the need for interesting learning. In elementary schools, STEM learning can be applied so students can learn while playing. When designing learning, the obstacles encountered were when determining competency achievement indicators and determining the use of operational verbs.

Creative learning is one of the nation's cultures and characteristics. Creative teaching and learning process is very important in meaningful learning. Thus, creativity in learning is competence in the learning process stage (Saputra et al., 2020). Stages of teaching and learning that apply STEM learning can implement literacy-based Pop-Up Book media as an alternative to improve the quality of learning. Thus, through STEM learning with Pop-Up Book media, it can increase the creativity of students.

The development of students is not a natural process but is influenced by how their environment interacts with them. When pupils enter the school milieu, their opportunities to interact increase. The teacher's stimulus effect significantly impacts the phases of child development. For him, being an effective teacher necessitates knowing and understanding his students (Particia & Zamzam, 2021). Students can grow and develop well because they have abilities that must be guided and directed by the teacher. Students can learn optimally because there is a link, namely, media, in learning. Pop-Up Book media can link teacher explanations and students' understanding.

To adapt to technological developments, teachers must prepare learning resources and learning media according to student's interests so that students can focus their attention on the learning stages and teachers can increase their focus on learning (Triwahyuningtyas et al., 2020). Pop-Up Book media implemented in STEM learning can foster creativity, creative thinking, collaboration, and communication skills. STEM learning integrates science, technology, engineering, and mathematics. Thus, literacy can be applied to Pop-Up Book media through STEM learning.

Through the use of materials and simple experimental activities, learning experiences are shaped. The science learning content can assist in formulating this learning experience (Aji & Pujiastuti, 2021). Teachers can design optimal learning for the success of learning in class. The STEM learning design tool includes lesson plans, worksheets, teaching materials, Pop-Up Book media, learning videos, and PowerPoint media. Based on these six aspects, literacy can be integrated into learning.

Teaching and practicing reading activities to students is not an easy thing but a challenging thing. Implementing literacy for students requires innovative learning media because each student has special characteristics (Dayu & Setyaningsih, 2022). Books are commonplace as learning media to increase literacy. Then, sometimes students are less interested in learning with books for a long time. Therefore, making learning media Pop-Up Books is an innovation to improve students' literacy skills. The Pop-Up Book media consists of various images that appear differently and is unique because these images can stand upright after opening the book.

Students are at a level where they require direct instruction from the instructor as a facilitator of learning. Students can solve various problems in their environment using their acquired knowledge. One of the requirements is critical thinking so that students can contribute original thoughts and solve a problem or provide a solution (Nawangsari et al., 2022). Teachers must facilitate students so that learning takes place optimally and creatively. The implementation of STEM learning is still not widely implemented in elementary schools. Through STEM learning, it is hoped that students will make projects at the end of learning as an output. Pop-Up Book media as learning media can also be made by students as a product.

Literacy activities in elementary schools are part of the school curriculum. This activity consists of planning, implementing, evaluating, and following up, directly supervised by the school principal. Besides being included in teaching and learning activities, literacy activities also have their own time - 15 minutes before or after learning activities. Before the pandemic, literacy activities were included in core learning activities and carried out as apperception and reflection (Rahayu & Mustadi, 2022).

Based on the identification and analysis conducted by researchers on the learning process in the classroom, it can be concluded that teaching and learning activities in elementary schools are still conventional. In contrast, the learning process requires engineering and technological processes to meet the demands of the 21st century, namely that students must possess 4C skills or abilities (critical thinking, communication, collaboration, and creativity). The need for engineering and technological activities that fifth-grade elementary school students must carry out is the activity of making a practical and simple product. Still, it includes the basic competencies that have been determined. The steps that students will carry out during the learning process need to be explained in detail and guidance from the teacher as a facilitator. So that students can carry out learning properly and can run as expected.

Based on trials, learning has been running smoothly. But deficiencies still need to be corrected to achieve more optimal learning. This study aims to produce STEM-based learning design products to achieve 4C capabilities in elementary schools. Therefore, the researcher will discuss the research finding data based on the formulation of the research problem. The discussion includes the results of preliminary studies conducted in elementary schools, the design of STEM-based learning designs using spring-powered cars in elementary schools, an overview of the STEM-based learning design product trials that have been developed and the final design of STEM-based learning to achieve 4C capabilities in elementary schools.

Figure 2. Pop-Up Book Media

According to the test results, overall, learning has been running smoothly. But there are still deficiencies, and some are not in line with the learning design that researchers have designed. It happened due to several things, including when the distribution of time allocations was not appropriate; the teacher added learning steps by greeting and clapping; lack of detail explaining the meaning of the song Indonesia Raya; forming groups before learning begins; the process of selecting tools and materials is not conducive; during the process of drawing tools and materials, students imitate the literacy-based Pop-Up Book media which is located on the table; and students do not follow the guidebook when making literacy-based Pop-Up Book media.

Conclusion

The results of research and development of STEM learning designs with Literacy-Based Pop-Up Book media conducted at Cipaganti Elementary School using the 2013 curriculum in Bandung City, in

grade V to be precise. The learning designs implemented in elementary schools in Bandung City have not led students to carry out engineering activities or make products that contain technology. In addition, generally, students have not developed critical thinking, communication, collaboration, and creativity skills. So learning is not in line with the demands of 21st-century education, which is better known as 4C skills.

STEM-based learning designs are structured so that the learning stages involve students in critical, creative thinking, communicating, and collaborating in line with the demands of 21st-century education. The learning design stage is based on the Reeves Design Based Research method. At this stage, a STEM-based learning design was produced (draft 1) as a lesson plan, students' worksheet, teaching materials, and Pop-Up Book media, combining the subjects of Science, Mathematics and Indonesian. After the STEM-based learning design (Draft 1) was drawn up, an expert validator performed product validation to validate the validity of the product that researchers would test. Next, a STEM-based learning design (draft 2) in the form of students' worksheet, lesson plan, teaching materials, and Pop-Up Book media will be revised or improved based on suggestions from expert validators, resulting in a ready-for-testing STEM-based learning design.

The trial phase was carried out twice. Based on the results of the trial implementation, there were still deficiencies and weaknesses. A revision was made to improve the learning design so that the learning process was more optimal and as expected. In trials, learning runs optimally and aligns with the learning design designed by researchers. The teacher's response to the learning design that has been designed gives very positive response by stating that this learning can activate students to think, and in line with the demands of the 21st century, students must have 4C skills.

According to the 2013 curriculum and the STEM (Science, Technology, Engineering and Mathematics) approach, STEM-based learning design is emphasized with a scientific approach. STEM-based learning with learning stages: (1) asking questions (defining problems and identifying boundaries); (2) imagining (exploring ideas and choosing the best); (3) planning (drawing diagrams and collecting materials); (4) creating (following the plan and testing it); and (5) improving (discussing possible improvements and repeating steps 1-5).

Furthermore, researchers proposed some suggestions. The stages of research using the DBR method are not simple and quite complicated. Therefore, everything that is needed regarding research requires thorough preparation and sufficient time to obtain optimal, ideal, precise, and effective results. This research and development should be carried out collaboratively under the research umbrella, considering that learning tools have several components so that the research results do not stand alone but consist of complete learning tools. This research and development should be further developed in other science and Indonesian learning materials. The development of STEM-based learning designs must consider using the correct tools and materials, adequate facilities, and classroom arrangement to conduct product trials.

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