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# Designing lesson plan of Science, Technology, Engineering, Mathematics (STEM) education in science learning

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**Abstract.** Science learning has developed into the idea of connecting scientific science with the needs of the world of future work including; scientists, technologists, engineers, and mathematicians. STEM learning in science subjects can prepare future workers through increasing STEM literacy. However, STEM literacy of students is still low. There have been many studies that promote STEM learning in the classroom, but limited to proving STEM education in science learning with certain models can improve STEM literacy. No research has been found on how to plan STEM education in science learning in practical for use in the classroom. Therefore, this study intends to provide a contextual description of how STEM learning is planned primarily for science subjects in the classroom. This study is useful for teachers as an initial reference for planning STEM education in science learning in classroom.

## 1. Introduction

Science learning nowadays is not only about problem solving training in the classroom. Furthermore, students are required to be able to solve problems that are oriented to the real world [1]. Scientists and science teachers agree that science is a way of explaining the natural world [2]. In the United States, science learning in school is focused on connecting students with science-related jobs that can then support economic development [3]. Learning activating science that triggers students' interest in careers in the fields of science, technology, engineering and mathematics is important [4]. This is because the work that is needed for the future is scientists, technologists, engineers, and mathematicians who can be formed through STEM education [5]. One of the aims of STEM education is to build STEM literacy which is an ability to identify, apply, and integrate the concepts of science, technology, engineering, and mathematics to understand complex problems and make innovations to overcome them [6]. However, student STEM literacy is still low at an average of 55.28 from a range of 1-100 on science subjects on the subject of biotechnology [7]. This is not very good, because biotechnology is the application of science in the form of technology and is part of future work.

Several studies have been conducted to promote STEM education with project-based learning model in science learning that can improve STEM literacy and science performance, one of which is on the topic of discussion on energy, where STEM education is done with project-based learning model [8,9]. In addition, on electrical subjects, the use of STEM education with inquiry models can improve student



STEM literacy [10]. In magnetic learning material, STEM education with a project-based learning model can improve STEM literacy [11].

STEM education in learning Science in schools is very important to improve student STEM literacy. However, the research that has been conducted is still limited on promoting STEM education in one of science subjects in the classroom. Research is needed on technical processes in the field to design STEM learning plans in the classroom so that they can become a teacher's reference in starting the implementation of STEM learning in schools. This is because STEM education policy at school involves customization, which means it is tailored to the specific initial situation and context [12]. Therefore, this study discusses technically how the process to make lesson plan of STEM education in science learning in schools.

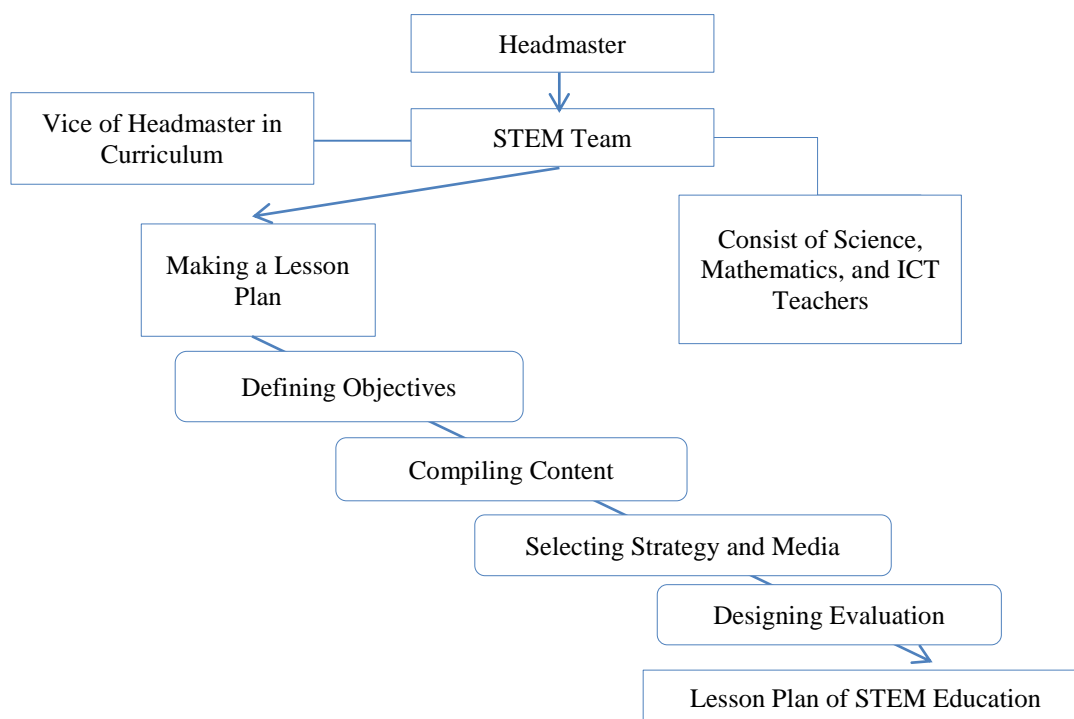
## **2. Methods**

The focus of the question to be answered in this study is how to make a lesson plan of STEM education in science learning at school? The author conducted a case study research by analyzing documents, observing, and conducting interviews with one of the junior high schools that had implemented STEM education in science learning. Document analysis is carried out one of the lesson plan document about "Force and Motion". The author also conducted observations in the school to find out more clearly how to make a lesson plan of STEM education for science learning. The interview was conducted three times with science teacher who had implemented STEM education from 2014 twice and the STEM expert at one of the universities in Indonesia once. Data analysis was carried out by the data analysis model of Miles and Huberman which was carried out through four stages, namely data collection, data presentation, reduction, and conclusion [13].

In the first step, the researchers interviewed how the initial stages of planning STEM education at school. The results of the interviews provide a general understanding of how to plan STEM education in science learning at school. To get more concrete data, the author asks for a lesson plan document for one subject to analyze the document. Next, the researcher observes the teacher discussion process in planning learning. The researcher conducted an interview to confirm the data that had been obtained previously for the science teacher who had been interviewed before and the STEM expert to obtain comparative data. In the final stage, data analysis is carried out to describe and draw conclusions.

## **3. Result and discussion**

Based on the results of data collection that has been reduced, the process of making lesson plans can be seen in figure 1.



**Figure 1.** The process of making lesson plans.

The earliest stage in designing STEM education in science learning was to make the STEM Team consisting of at least three teachers. STEM Team consist of Science, Mathematics, and Information and Communication Technology (ICT) teachers where science teachers should be team leaders. Interdisciplinary and innovative aspect of STEM also recurs fact that STEM is prepared, audited, and dealt with in team and STEM is all about teamwork [12]. The establishment of the STEM team was carried out by the Headmaster and coordinated with the Vice of Headmaster in Curriculum.

Before designing STEM education, the STEM team must be able to determine the approach to implementing STEM learning to be used. There are three approaches in implementing STEM namely silo, embedded, and integrated [14]. Silo is an approach that separates all STEM components and is the most traditional because it emphasizes teacher activity, not even seeing learning as a process of solving in the real world [15-17]. While the embedded approach is generally widely known as an approach that emphasizes knowledge gained through the study of problems in the real world and problem solving techniques in social, cultural and functional contexts [18]. The last approach is integrated where there are no boundaries between each subject so that all parts of S, T, E, and M are taught as a whole subject [19]. In the context of organizing curriculum content based on subjects, the most appropriate is the embedded approach [20].

The STEM team then coordinated with the Vice of Headmaster in Curriculum to determine when, where and how the implementation of STEM learning is conducted. Practically the learning planning process is carried out to answer four questions, including; 1) what are the objectives to be accomplished as the results of instruction? 2) What topics will we cover? 3) What procedures are best for directing the learning? and 4) How do we evaluate instruction? [21]. In school, the four questions are translated in the form of a learning planning component consisting of; defining objectives, compiling contents, selecting strategy and making media, and designing evaluation.

*First*, the planning process begins with defining of STEM education objectives. This activity begins with analyzing the competencies of a science material that students must understand. The competency then becomes the basis for making competency achievement indicators that are used as a reference to determine the achievement of a competency that has been written previously. *Second*, the teacher

analyzes the learning material that students need to understand before conducting the learning activities. Analysis of STEM material is based on predetermined learning objectives. The teacher must analyze the material from the point of view of the four component materials. *Third*, the selection of learning strategies and making media is based on the needs of the teacher in making the product, the availability of time, and the characteristics of the material being taught. In essence, STEM education in science learning is directed to provide space for students to make products. However, teachers are recommended to use three approaches, including project-based learning by Lucas, 5E by Bybee, and project-based learning by Laboy Rush [22].

At the stage of selecting the learning strategies, the teacher also makes media which as a product of the results of STEM education are carried out. This is because STEM learning is oriented towards making a problem-solving product. The product must be made in advance by the teacher to ensure that the product can indeed be made. In addition, to find out the time spent in making products. The thing that needs to be prepared by the teacher is the tools and materials for the media and student worksheets. Teacher should be able to use technology in making media because the learning activity they are presented with information during information technology-based learning, particularly when they restate the text that they have understood [23].

The teacher also makes the learning steps taken at each meeting in the class. The step is divided into three; these are preliminary, core and evaluation activities. Core activities are arranged based on the learning model used. The learning model is a pattern used by the teacher in compiling the learning steps.

*Fourth* teachers assess the process and learning outcomes that are used to measure the achievement of competences. In each of these assessments, the teacher makes the form and format of the assessment. The teacher must assess in accordance with the aspects assessed, for example aspects of knowledge, attitudes and skills. The form of assessment must be completed with the assessment techniques used whether done by observation, tests, project appraisals, presentations and reports. Each of these techniques has an assessment instrument to be able to assess authentically.

In evaluating STEM education in science learning, experts have not recommended a method that can be used. Evaluation can be done based on the needs to be evaluated. Therefore, we need the ability of the teacher to determine the evaluation method used in accordance with the assessment needs.

The difficulty that teachers get in school in making this learning plan is in analyzing STEM material and creating learning media that are products of the use of STEM components. In this regard, there are three dimensions of science learning to make it easier for teachers, especially in planning STEM education in science learning. These dimensions include scientific and engineering practices, crosscutting concepts, and disciplinary core ideas [24].

In scientific design practices, the teacher determines the material that students need to understand before carrying out the engineering process where students must make the product as an alternative to solving certain problems. Furthermore, in engineering design practices the material will then be used in making products for solving certain problems. In this case, learning planning can be divided into two meetings, namely the first meeting to provide understanding of the material and the second meeting to carry out the process of making product-solving problems. There are eight practices carried out in this case, among them; 1) asking question (for science) and defining problem, 2) developing and using models, 3) planning and carrying out investigations, 4) analyzing and interpreting data, 5) using mathematics, information and computer technology and computational thinking, 6) constructing explanations (for science) and designing solutions (for engineering), 7) engaging in argument from evidence, and 8) obtaining, evaluating, and communicating information.

Crosscutting concept is a process of describing the scientific thinking process of a subject that applies to many subjects of science and engineering. There are seven crosscutting concepts within the framework of which; 1) patterns, observed patterns of forms and events guide organization and classification, and they prompt questions about relationships and the factors that influence them. 2) Cause and effect: mechanism and explanation, events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanism by which they are mediated. Such mechanisms can then be tested across given contexts and

used to predict and explain in new context. 3) Scale, proportion, and quantity. In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance. 4) Systems and system models. Defining the system under study specifying its boundaries and making explicit a model of that system provides tools for understanding and testing ideas that are applicable throughout science and engineering. 5) Energy and matter: Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations. 6) Structure and function. The way in which an object or living thing is shaped and its substructure determine many of its properties and functions. 7) Stability and change. For natural and built systems alike, conditions of stability and determinants of rates of change or evolution of the system are critical elements of study.

The core ideas dimension is divided into four main discussions including; physical science, life science, earth and space science, and engineering and technology. Each core idea has sections that will make it easier to know concept ideas. This is to facilitate the planning of STEM education in science learning.

#### 4. Conclusion

Planning STEM education in science learning begins with the formation of the STEM team by the principal consisting of science, mathematics, ICT teachers and other teachers who need to be involved in coordination with the deputy headmaster of the curriculum section. Four components of learning planning are arranged, namely, determining learning objectives, compiling learning materials, choosing learning strategies, and making learning evaluations. The four components are directed to the achievement of competencies in a learning material based on the competency indicators that have been previously set. Three dimensions can facilitate the STEM team in implementing STEM education in science learning including; scientific and engineering practices, crosscutting concept, and disciplinary core idea.

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