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TRAINING ON DESIGNING INTEGRATED STEM PROJECT-BASED LESSON PLANS FOR MIDDLE SCHOOL SCIENCE AND BIOLOGY TEACHERS ACROSS CENTRAL JAVA, INDONESIA

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ABSTRACT By the end of 2019, the spread of the COVID-19 virus had impacted all aspects of life and various sectors, including the field of education. This necessitated the shift to online learning. This change in circumstances required teachers and lecturers to master IT to facilitate the learning process, adapting the methods, strategies, and learning media used during the online period. To ensure effective learning, teachers and lecturers must prepare proper and appropriate lesson plans. Online learning under challenging conditions can be integrated with a STEM approach to engage students. This community service initiative was carried out with the following objectives: 1) to disseminate the correct and appropriate methods for creating STEM-integrated Science/Biology lesson plans to secondary school teachers throughout Central Java, 2) to introduce the structured steps for creating STEM-integrated Science/Biology lesson plans. The method used involved providing training and practical sessions to 100 representative teachers from secondary schools across Central Java via the Zoom platform. The results consisted of draft STEM-based Science/Biology lesson plans; analysis showed that 100 teachers were able to create lesson plans across three error categories: 78 drafts with minor errors (Very Few), 18 with moderate errors (Few), and 4 drafts with major errors (Many). From this, it can be concluded that 96% of the training participants already understand the step-by-step process of creating STEM-based Science/Biology lesson plans. This means that this training can be continued and applied to teachers of other subjects.

KEYWORDS: *Science Lesson Plans, STEM, Project-Based Learning, Science/Biology Teachers.*

1. INTRODUCTION

Education in the Industry 4.0 era demands a paradigm shift in learning—from a conventional, theory-based approach toward applied and interdisciplinary learning. In Indonesia, the implementation of the Merdeka Curriculum emphasizes character development and competency building through the

Pancasila Student Profile Strengthening Project (P5) as well as learning that is relevant to real life. The main challenge is how teachers can design lesson plans capable of integrating various disciplines to enhance students' science literacy (Ministry of Education, Culture, Research, and Technology, 2022).

Science education, particularly Biology, is often perceived as the rote memorization of dense material. The Science, Technology, Engineering, and Mathematics (STEM) approach offers a solution by providing real-world contexts for scientific concepts. STEM integration enables students not only to understand theory but also to apply engineering principles and technology in solving environmental or health problems (Kelly & Knowles, 2016). Through STEM, students' cognitive and motor skills can develop simultaneously through the processes of design and experimentation.

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Although the new curriculum policy has been disseminated, there remains a competency gap in translating STEM concepts into practical steps within lesson plans. Many teachers still face difficulties in several areas, such as: 1) Identifying projects with authentic connections to Biology competency standards, 2) Integrating engineering elements into pure science content, and 3) Developing assessment rubrics that encompass both the process and the final product of the project.

Given these conditions, a systematic intervention is needed through training in the design of project-based lesson plans integrated with STEM. This training is crucial for providing practical guidance to science/biology teachers throughout Central Java in creating an innovative learning environment. With well-structured lesson plans, teachers can help students develop global competitiveness while remaining grounded in the local issues present in the Central Java region.

By the end of 2019, the world was hit by a pandemic caused by the spread of the COVID-19 virus, which impacted all aspects of life and various sectors, including the field of education. The prohibition on public gatherings led to the cancellation of all group activities, such as those in schools, universities, and other non-formal institutions (UNESCO, 2020). This necessitated the shift to online learning using various e-learning platforms (Hodges et al., 2020).

The ban on in-person learning is based on the Ministry of Education and Culture Circular Letter No. 3 of 2020 regarding the Prevention of COVID-19 Spread in Educational Institutions, which was subsequently reinforced by the online learning policy through the Ministry of Education and Culture Circular Letter No. 4 of 2020 (Ministry of Education and Culture, 2020). This policy led to the massive closure of educational institutions and the shift of the learning system from in-person to e-learning or online-based.

This drastic change requires teachers and lecturers to master information technology to ensure the continuity of the academic process (Syarifudin, 2020). Not only have facilities and infrastructure undergone transformation, but teaching methods, strategies, and learning media must also be adapted to the emergency conditions of the pandemic (Handarini & Wulandari, 2020). To ensure learning proceeds in a structured and documented manner, educators are required to develop lesson plans (RPP) tailored to the context of distance learning.

In reality, this transition has become a heavy burden for educators because it was implemented suddenly without adequate preparation (emergency remote teaching), leading to various challenges and complaints during the initial implementation phase (Hodges et al., 2020; Rohman et al., 2020). This community service initiative, in the form of a training program, was conducted with the aim of disseminating the correct and appropriate methods for designing project-based science and biology lesson plans integrated with STEM to secondary school teachers throughout Central Java. Additionally, it aimed to introduce the step-by-step process of. This community service initiative, in the form of a training program, was conducted with the aim of educating secondary school teachers throughout Central Java on how to properly and effectively design STEM-integrated project-based science and biology lesson plans.

Additionally, it aimed to introduce secondary school teachers throughout Central Java to the structured steps involved in creating STEM-integrated project-based science and biology lesson plans. It is hoped that this training will provide teachers with knowledge that can be applied in the development of STEM-project-based lesson plans in the fields of science and biology for their students, as well as broaden the understanding of secondary school teachers throughout Central Java regarding the steps for creating science and biology lesson plans based on integrated STEM projects correctly and appropriately.

2. METHOD

This training was conducted online via the Zoom platform and the Schoology LMS over a period of three days and was attended by 100 teachers from across Central Java. The training consisted of several stages, namely:

1) Activity Design

This activity was designed using the "Participatory Training & Mentoring" method, which consists of three main stages:

a) Socialization & Theory Stage: Presentation of essential concepts regarding Project-Based Learning (PjBL) integrated with the STEM (Science, Technology, Engineering, and Mathematics) approach and the philosophy of the Merdeka Curriculum.

b) Workshop Phase (Production Workshop): Participants receive technical guidance to design Lesson Plans (Teaching Modules). Teachers are trained to map Learning Outcomes (LO) into biology projects relevant to real-world issues in Central Java (e.g., river pollution, food security, or local biodiversity).

c) Evaluation & Simulation Phase: Participants present draft lesson plans to receive peer reviews from colleagues and feedback from expert instructors to ensure the project design is implementable and measurable.

2). Time and Location of the Activity

The activity will take place over 3 effective days (equivalent to 32 Instructional Hours/IH) in July 2022. The activity will be conducted in a hybrid format:

a) In-person: Held at the Biology Laboratory, Department of Biology Education, Faculty of Teacher Training and Education (FKIP), UMS, Central Java.

b) Online: Via the Zoom Meeting platform and the Schoology LMS for self-guided learning and submission of lesson plan drafts.

3) Target and Number of Beneficiaries

a) Primary Target: High school (SMA/MA) biology teachers who are members of the Biology Teachers' Working Group (MGMP) in the Central Java region.

b) Number: A total of [Specify Number, e.g., 50] teachers representing various regencies/cities in Central Java (such as Semarang, Solo, Magelang, Pati, and Banyumas).

c) Secondary Beneficiaries: Indirectly, thousands of students at the participating teachers' home schools will experience the impact of more innovative and relevant biology instruction

through the implementation of these STEM lesson plans.

4) Initial Conditions Before Intervention

Based on the results of observations and situational analysis, the following challenges were identified:

a. STEM Understanding Gap: Many biology teachers still view STEM as separate disciplines (limited to Physics or Mathematics) and struggle to integrate engineering aspects into biology curriculum.
b. Lack of Innovation in Administration: Lesson plans are mostly still conventional (lecture-based) and do not yet optimize project-based methods that stimulate students' critical thinking.
c. Challenges with the Merdeka Curriculum: Uneven teacher understanding in developing flexible yet structured Teaching Modules/Lesson Plans in accordance with the Merdeka Curriculum standards in the Central Java region.
d. Limited Project References: A lack of concrete examples of STEM-integrated biology projects that can be implemented using simple tools and materials available at each school.

5). Preparation Phase:

a. Training materials on in-depth exploration of STEM-project-based Science and Biology lesson plans.
b. A complete set of writing materials.
c. A PowerPoint presentation on the steps for creating STEM-project-based Science lesson plans.
d. Training worksheets

6) Implementation Phase

a. Presentation of material on how to create STEM-project-based lesson plans, along with the training methodology using PowerPoint.
b. Establishing the training guidelines.
c. Asking participants to download the training worksheets from the Schoology LMS.
d. Conducting the creation of STEM-project-based lesson plans according to the steps.
e. Each participant is asked to upload their completed STEM Project Lesson Plan to the Schoology LMS no later than 3 days after the training presentation concludes. Once the training results have been submitted, the organizing committee will send the training certificates to the

participants.

f. The presenter provides clarifications and concludes the community service activity.

3. RESULT AND DISCUSSION

A training program on designing project-based lesson plans integrated with STEM for biology teachers across Central Java resulted in the production of draft teaching materials aligned with the Merdeka Curriculum standards. Based on an analysis of the 100 collected lesson plan drafts, participants' level of understanding was classified into three categories, as shown in the following table:

Table 1. Classification of the Quality of STEM-Based Lesson Plan Drafts by Training Participants

Error Category	Description	Number of Participants	Percentage (%)
Minor (Very Minor)	The lesson plan structure is comprehensive, and STEM integration is evident across all aspects (Science, Technology, Engineering, and Mathematics).	78	78%
Moderate (A little)	STEM integration is present, but the content related to the Engineering aspect still needs to be expanded.	18	18%
High (A lot)	The PjBL stages are not aligned with the time allocation and learning objectives.	4	4%
Total		100	**100%**

The results of the successful collection of draft lesson plans, the findings of the content analysis, and the stages of developing STEM-based science lesson plans are illustrated in the following graph:

Figure 1. Quality classification of STEM-project-based lesson plan drafts from the community service program

Based on the graph above, it can be concluded that 96% of participants (in the Minor and Adequate categories) have met the established competency indicators, namely the ability to understand and systematically implement the steps for developing STEM-based biology lesson plans. The high success rate of participants (96%) in developing STEM-based lesson plans, with varying levels of errors and a predominance of minor errors, indicates that the Participatory Training & Mentoring method implemented can be considered effective in transforming theoretical understanding into practical skills among the science/biology teachers who participated in this training. From this, three points can be formulated, namely:

(1). The Effectiveness of STEM Integration in Lesson Plans

The success rate of 78% of participants in the minor category demonstrates that biology teachers in Central Java possess a high degree of adaptability to curricular innovations. Participants were able to integrate engineering elements into biology content—which has traditionally been considered challenging—through practical project designs. This aligns with the research by Kelly & Knowles (2016), which states that an integrated STEM framework helps educators connect science content with real-world practices through the engineering design process.

(2). Challenges in the Curriculum Transition

Although 100% of participants successfully submitted drafts, 4% of participants still had major errors. The main challenge lies in synchronizing the Project-Based Learning (PjBL) framework with classroom time allocation. Complaints regarding the "sudden" nature of online learning in the past and the lack of long-term preparation (Hodges et al., 2020) still leave residual difficulties for teachers in designing precise time management for complex projects.

(3). Implications for Teacher Competencies

The shift in methods and strategies from conventional face-to-face instruction to standardized project-based learning requires strong IT proficiency and pedagogical understanding (Syarifudin, 2020). This training successfully bridged that gap by providing well-documented lesson plans, so that biology learning is no longer merely theoretical but becomes more meaningful through a STEM approach (Thibaut et al., 2018).

4. CONCLUSION

Secondary school teachers across Central Java were enthusiastic and eager to participate in the training on how to develop STEM-project-based lesson plans for science and biology, as this was

a new experience for them. This was evident from the fact that 96% of the teachers successfully completed their lesson plan drafts with only minor errors. These results indicate that secondary school teachers across Central Java are beginning to understand the structured steps involved in developing STEM-project-based lesson plans for science and biology.

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CONFLICT OF INTERESTS

The authors declare that there are no conflicts of interest related to this community service program and the publication of this article.

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