



# Assistance in designing STEM-based learning at the Muhammadiyah 1 Paiton research-based elementary school

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ARTICLE INFO	ABSTRACT
<p><b>Article history</b>            Received: 2023-02-15            Revised: 2023-02-27            Accepted: 2023-02-27            Published: 2023-02-28</p> <p><b>Keywords</b>            Lesson study            Research based school            STEM learning            STEM knowledge            Teacher competence</p>	<p>STEM learning has now become the main approach applied in various schools in many countries. One of the obstacles faced by various schools in Indonesia in implementing STEM is the lack of understanding and experience of teachers about STEM-based learning. The purpose of this service program was to assist SD Muhammadiyah 1 Paiton Probolinggo in preparing and implementing STEM learning. The solution to the problems offered is socialization and assistance in designing STEM learning. The order of these community service activities was: 1) Matching Perceptions between the Community Service Team and Partner Schools; 2) Presentation of Series 1 Material: Innovative and STEM Learning Models; 3) Presentation of Series 2 Material: Lesson Study and Learning Community; and 4) STEM learning workshops. After carrying out community service activities at SD Muhammadiyah 1 Paiton, there has been a significant and large increase in teacher knowledge regarding STEM learning from before (<math>M = 63.3, SD = 14.9</math>) to after the service program (<math>M = 95.6, SD = 6</math>), <math>t(11) = 6.6, p &lt; .001, d = 1.91</math>. Even though this service program has shown satisfactory results, this program needs to continue so that the learning community of teachers who able to optimize the design so that the implementation of STEM learning can be realized optimally.</p>
<p><b>Kata kunci</b>            Kompetensi guru            Lesson study            Pembelajaran STEM            Pengetahuan STEM            Sekolah berbasis riset</p>	<p><b>Pendampingan perancangan pembelajaran berbasis STEM di SD berbasis Riset Muhammadiyah 1 Paiton.</b> Pembelajaran STEM kini telah menjadi pendekatan utama yang diterapkan di berbagai sekolah di banyak negara. Salah satu kendala yang dihadapi oleh berbagai sekolah di Indonesia dalam menerapkan STEM adalah kurangnya pemahaman dan pengalaman para guru tentang pembelajaran berbasis STEM. Tujuan program pengabdian ini adalah untuk membantu SD Muhammadiyah 1 Paiton Probolinggo dalam mempersiapkan dan melaksanakan pembelajaran STEM. Solusi dari permasalahan yang ditawarkan adalah sosialisasi dan pendampingan dalam merancang pembelajaran STEM. Urutan kegiatan pengabdian masyarakat ini adalah: 1) Penyamaan Persepsi antara Tim Pengabdian dengan Sekolah Mitra; 2) Pemaparan Materi Seri 1: Model Pembelajaran Inovatif dan STEM; 3) Pemaparan Materi Seri 2: Lesson Study and Learning Community; dan 4) lokakarya pembelajaran STEM. Setelah melaksanakan kegiatan pengabdian kepada masyarakat di SD Muhammadiyah 1 Paiton, terjadi peningkatan pengetahuan guru yang signifikan dan besar mengenai pembelajaran STEM dari sebelum (<math>M = 63,3, SD = 14,9</math>) hingga setelah program pengabdian (<math>M = 95,6, SD = 6</math>), <math>t(11) = 6.6, p &lt; .001, d = 1.91</math>. Meskipun program pengabdian ini telah menunjukkan hasil yang memuaskan, namun program ini perlu dilanjutkan agar komunitas belajar para guru yang mampu mengoptimalkan desain sehingga implementasi pembelajaran STEM dapat terwujud secara optimal.</p> <p style="text-align: right;">Copyright © 2023, Fauzi et al            This is an open access article under the <a href="https://creativecommons.org/licenses/by-sa/4.0/">CC-BY-SA</a> license</p> <div style="text-align: right;"></div>

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## INTRODUCTION

Over the last decade, STEM (Science, Technology, Engineering, and Mathematics) is a learning form that has become a major topic of discussion in the education field. In STEM learning, teachers integrate content and empower specific skills related to science, technology, engineering, and mathematics (Martín - Páez et al., 2019). STEM was developed to answer the challenges of the 21st Century (Barcelona, 2014; Kennedy & Odell, 2014) which requires students to use their thinking skills (Reeve, 2016). In line with this statement, STEM is reported could to improve problem solving skills (Şahin, 2021; Topsakal et al., 2022) and students' critical thinking skills (Hacıoğlu & Gülhan, 2021; Rosana et al., 2021). The application of STEM also has a positive effect on student achievement at school (Yildirim, 2016) to their attitudes towards STEM-related disciplines (Baran et al., 2019; Hacıoğlu & Gülhan, 2021) and careers (Shahali et al., 2016). Not surprisingly, STEM education has become a priority in many countries (Freeman et al., 2019), in line with the increasing trend of research in the STEM field (Li et al., 2020).

Although the application of STEM is reported have a positive impact, various barriers in applying this learning also need to be considered. Some of these barriers are not only from curriculum aspects but to structural and pedagogical aspects (Margot & Kettler, 2019). The lack of available teachers with STEM education backgrounds is also a barrier to implementing STEM in schools (Ejiwale, 2013). One of the main challenges identified is the teacher's STEM knowledge. Integrating STEM in learning requires basic knowledge of how to contextualize and incorporate STEM concepts in learning (Nadelson & Seifert, 2017). Low knowledge related to STEM will reduce teacher confidence to apply this learning. Therefore, it is necessary to increase STEM-related knowledge because increased teacher confidence will increase the effectiveness of integrating STEM activities (Margot & Kettler, 2019).

In Indonesia, the application of STEM in Indonesia is also not optimal. Various obstacles and problems are factors causing the low implementation of STEM in various schools in Indonesia. One of the schools that has experienced this condition is SD Muhammadiyah 1 Paiton, Probolinggo Regency. In these schools, many teachers do not understand STEM-based learning. This is in line with previous researchers who reported that there are still many teachers who do not understand STEM in Indonesia (Diana & Turmudi, 2021). The lack of STEM training for teachers and schools is another factor that has hindered teachers at SD Muhammadiyah 1 Paiton from learning STEM. Furthermore, as a school that has only been established for four years, this SD still has several obstacles in developing its learning. Regardless of the obstacles faced, SD Muhammadiyah 1 Paiton remains motivated to be able to apply STEM learning. In addition, STEM is very appropriate to be developed at this elementary school because SD Muhammadiyah 1 Paiton is a research school. Therefore, related to the obstacles faced and the school's enthusiasm to develop better, assistance in designing and implementing STEM-based learning by academics from universities needs to be held.

Community service activities that focus on STEM learning have been reported in several previous publications. Some of these programs, such as the introduction of STEM learning (Izzati et al., 2019), training in developing STEM-based learning tools (Nugraheni et al., 2022) and teaching materials (Hamimah et al., 2022), to training in the application of STEM learning (Busyairi et al., 2022). However, a community service program involving the socialization of lesson study for learning communities as an effort to optimize STEM realization has never been carried out. In addition, many community service programs have not involved teachers to directly simulate project completion in STEM learning. Therefore, the purpose of the Community Service program reported in this paper is to increase the competence of teachers at SD Muhammadiyah 1 Paiton in designing STEM-based learning by involving the socialization of the learning community and direct experience implementing STEM projects.

The implementation of STEM learning in schools will support the achievement of the Sustainable Development Goals (SDG's), especially the fourth goal on quality education. If STEM learning at SD Muhammadiyah 1 Paiton can also be implemented optimally, students' knowledge and attitudes towards STEM will also increase (Baran et al., 2019; Hacıoğlu & Gülhan, 2021; Shahali et al., 2016). This condition will encourage them to increase career opportunities in the future which requires a person to have a positive attitude towards STEM and STEM-oriented thinking skills. Increased career opportunities will support economic growth in line with the eighth goal. In addition, good STEM learning is project-based STEM learning that raises contextual issues that are relevant to global issues (Ling et al., 2019). In this lesson, students will also be trained to solve various problems in the environment around them, such as environmental, health, and nutrition problems. Thus, in the long term, the benefits of this service program will also produce alumni who help achieve several other SDG's goals, such as the second goal (zero hunger), third (good health and well-being), and thirteenth (climate action) (Hák et al., 2016; Mitlin, 1992; Robert et al., 2005).

## METHOD

There are three main components involved in this community service program. First, the lecturer team consists of one chairman and one member. The team leader is a lecturer in the biology education study program who is an expert in the fields of education, methodology, and data analysis and has participated in an international short course on STEM held by the State University of Malang. One member of the team is a lecturer in the biology education study program who is an expert in the field of education who has attended short course activities on lesson study in Japan and STEM in Indonesia and Singapore. The second component is a student service team consisting of five biology education students. The third component is SD Muhammadiyah 1 Paiton as a partner for this community service program.

SD Muhammadiyah 1 Paiton is an educational unit with an elementary level in Sumberanyar, Kec. Paiton, Kab. Probolinggo, East Java. The location of the school is presented in Figure 1. In carrying out its activities, SD Muhammadiyah 1 is under the auspices of the Ministry of Education and Culture. SD Muhammadiyah 1 is located at Jl. Surabaya - Situbondo, Sumberanyar, Kec. Paiton, Kab. Probolinggo, East Java, with zip code 67291. This school designs its educational process on a research basis so that STEM implementation is in line with the school's vision. Participation of partners in this service activity, namely the provision of meeting rooms for the implementation of activities that are offline. In addition, the school will condition that each teacher is able to participate as the main subject in community service activities.

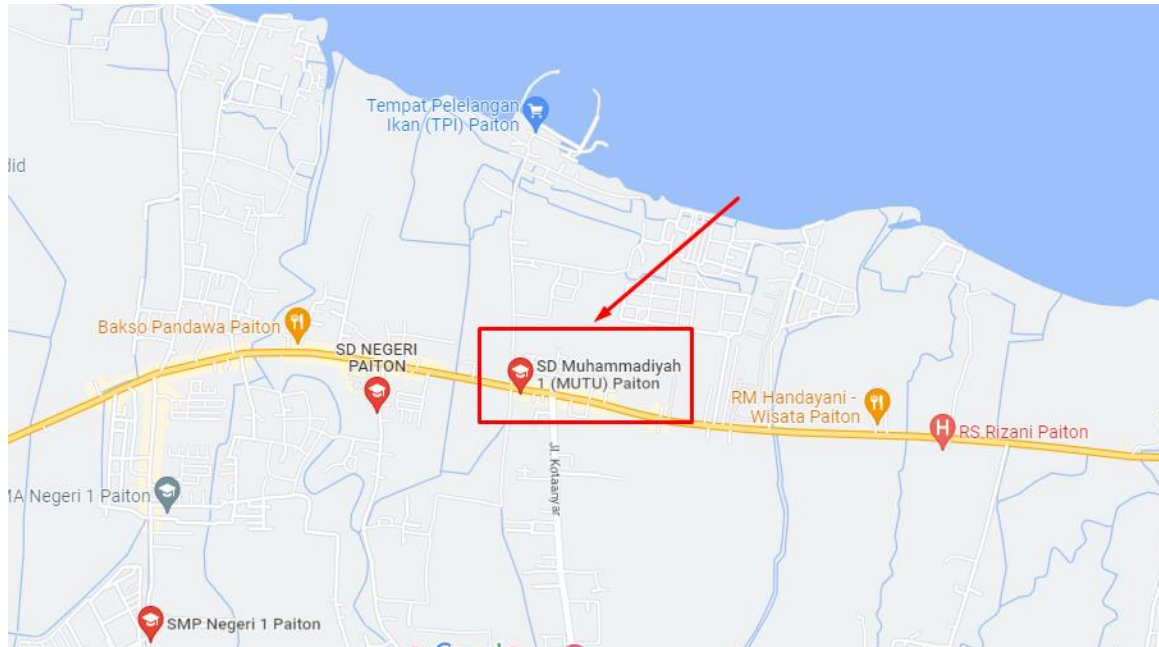


Figure 1. Map of SD Muhammadiyah 1 Paiton location

The school, which consists of teachers and principals as well as the service team agree that the problems that need to be prioritized to be resolved are 1) STEM-oriented learning socialization, and 2) STEM learning design. Based on the focus of these problems, the methods for implementing community service activities include discussion, outreach, and workshop methods. In detail, the sequence of community service activities is: 1) Equalization of Perceptions between the Community Service Team and Partner Schools; 2) Presentation of Series 1 Material: Innovative and STEM Learning Models; 3) Presentation of Series 2 Material: Lesson Study and Learning Community; and 4) STEM learning workshops.

Evaluation of program implementation is carried out periodically through phase 1 evaluation monitoring during implementation through observation activities. Data collection on teacher knowledge related to STEM was also carried out at the beginning (pretest) and at the end of the activity (posttest). The data collection instrument used was a questionnaire consisting of 10 items that access knowledge about innovative learning, higher-order thinking skills, lesson study, and the principles of STEM application in learning. The response choices for each statement were: really don't know, don't know, know a bit, and already know. The knowledge data was then analyzed using the mean and standard deviation to see a description of the teacher's level of knowledge about STEM. Furthermore, N-gain analysis is used to see the increase in knowledge. Finally, paired t-test analysis and effect size calculations were carried out to analyze whether there is a significant effect of the service program and how much influence this service program has on teacher knowledge.

## RESULTS AND DISCUSSION

The first activity carried out with partner schools was the equalization of perceptions of community service activities and the finalization of service schedules, both online and offline service schedules. Equalization of this perception is done online through the Google Meet platform. Furthermore, on August 13 2022 the first material presentation activity was carried out (Figure 2). The material presented in this activity is related to innovative and STEM learning models. Material presentation activities are carried out online using the Google Meet platform. Then, on September 9 2022 the second material presentation activity was carried out (Figure 3). The material presented in this activity is the importance of learning community. This material presentation activity was also carried out online using the Google Meet platform.



Figure 2. Documentation of the 1<sup>st</sup> series material presentation activities



Figure 3. Documentation of the 2<sup>nd</sup> series material presentation activities

Before carrying out face-to-face service activities in Probolinggo, the Community Service team conducted a leveling of perceptions and debriefing with the student service team who joined this community service program (Figure 4). After that, in November 2022, a STEM learning design workshop was held. This activity was carried out at SD Muhammadiyah 1 Paiton. The workshop was held face-to-face by involving a team of lecturers, student teams, as well as partner school teachers and administrative staff (Figure 5).



Figure 4. Documentation of debriefing activities with student teams



Figure 5. Documentation of STEM learning design workshop activities

To determine the usefulness of the community service activities that have been carried out, the Community Service team has collected data on teachers' knowledge about STEM learning, both before and after participating in community service activities. Table 1 presents the pretest and posttest scores of the teachers involved in this program. After the knowledge data before and after the community service activities are collected, a gain score analysis is carried out to find out how much the teacher's knowledge has increased. The score is also presented in Table 1.

**Table 1.** Teacher's pretest and posttest scores and their N-Gain scores

Teacher	Pretest	Posttest	Gain
1	72.5	100	1.00
2	62.5	90	0.73
3	87.5	100	1.00
4	52.5	90	0.79
5	55	95	0.89
6	57.5	100	1.00
7	62.5	100	1.00
8	80	82.5	0.13
9	30	100	1.00
10	65	90	0.71
11	75	100	1.00
12	60	100	1.00
<b>Gain</b>			<b>0.85</b>

In addition to analyzing the data using N-gain, a paired t test was also carried out to determine whether there was a significant increase in knowledge. The results of the paired t test showed that there was a significant difference between before ( $M = 63.3$ ,  $SD = 14.9$ ) and after the service program ( $M = 95.6$ ,  $SD = 6$ ),  $t(11) = 6.6$ ,  $p < .001$ . Furthermore, to ascertain how much influence the service program has, effect size calculations are also carried out. As a result, the resulting effect size is in the large category,  $d = 1.91$ . This shows that the magnitude of the difference between the average difference and the expected average difference is large.

Based on pretest data, at SD Muhammadiyah 1 Paiton, many teachers do not understand STEM properly. This is in line with previous researchers who reported that there are still many teachers who do not understand STEM in Indonesia (Diana & Turmudi, 2021). The experience of the teachers is also another obstacle that causes them difficulty designing STEM lessons. The lack of STEM training for teachers and schools is another factor that has hindered teachers at SD Muhammadiyah 1 Paiton from learning STEM. However, the results of the analysis show that community service activities can have a positive impact on teacher knowledge.

Teacher knowledge about STEM is a priority that needs attention. Knowledge will increase teacher confidence in implementing STEM learning. High self-confidence will increase the effectiveness of STEM learning applied by teachers (Margot & Kettler, 2019). With the effective application of STEM, it is hoped that the benefits of STEM learning can be obtained, such as increasing student achievement at school (Yildirim, 2016) to students' critical thinking skills (Hacıoğlu & Gülhan, 2021; Rosana et al., 2021). In addition, the application of STEM will also empower students' science process skills or research skills. These competencies will support the vision of SD Muhammadiyah 1 Paiton as a research-based elementary school.

Several publications indicate that the development of STEM learning needs to be done in stages and continuously. This statement is based on several community service activities aimed at providing STEM learning assistance, such as in Bandung Regency (Sukmana & Nurhayati, 2019), Yogyakarta (Richardo et al., 2021), Madiun (Setiawan et al., 2020), as well as Bojonegoro (Imaduddin et al., 2021). Learning planning needs to be carried out in stages and continuously because new learning designs such as STEM are challenges as well as problems that need to be addressed in a sustainable manner (Hill et al., 2020). Furthermore, STEM is not only related to lesson plans, but also its implementation and follow-up. The Community Service Team believes that optimizing STEM learning cannot develop if consistent and sustainable efforts are not made. On the other hand, the success of efforts and changes made need to be grown through an adaptive environment. Change efforts that are carried out partially often encounter various obstacles that will slow down the achievement of success. Conversely, efforts made collaboratively are indicated to be able to minimize the handicap faced. In this case, efforts need to be made collaboratively at the school level so as to create an atmosphere that teaches and strengthens one another. Therefore, it is deemed necessary to initiate learning communities and apply lesson study in subsequent programs at this school.

The existence of a learning community that aims to facilitate teachers to learn together is an urgent step to optimize the planning and implementation of learning (Owen, 2014). The existence of this learning community will also have a significant effect on increasing knowledge building among teachers (Popp & Goldman, 2016). It is hoped that this learning community will not only consist of teachers, but also university lecturers. In line with this statement, previous publications said that collaboration with peers, district support, to professional development programs will enhance teachers' efforts to implement STEM-based learning (Margot & Kettler, 2019). Furthermore, professional development programs are seen as important in facilitating teachers to follow trends in STEM implementation and training them to design effective STEM teaching (Ejiwale, 2013). In addition, with the application of lesson study, the quality of planning and implementation of learning will increase from one meeting to the next. Through collaborative activities in planning

lessons that pay attention to evaluation of previous learning, lesson study activities will be able to improve the quality of learning implemented by the teacher (Ming Cheung & Yee Wong, 2014).

## CONCLUSION

This paper has reported community service activities carried out at SD Muhammadiyah 1 Paiton, Probolinggo. Discussion, outreach, and workshop activities have been carried out to help these research-based schools understand and initiate STEM-based learning. After carrying out community service activities at Muhammadiyah 1 Paiton Elementary School, there has been a significant increase in teacher knowledge regarding STEM learning from before participating in community service activities to after participating in community service activities. In addition, the teacher learning community will begin to be initiated after this service activity runs. As a follow-up effort to the suggestion program to optimize service activities is to remain active in providing assistance at Muhammadiyah 1 Paiton Elementary School so that the design and implementation of STEM-based learning activities can continue. Assistance activities can also be carried out through online discussion forums or continuing offline activities to Paiton.

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