KnE Social Sciences
ICMScE
International Conference On Mathematics And Science Education
Volume 2024

Research Article

The Needs Analysis for Secondary School Science Teachers in Delivering STEM Learning on Socio-scientific Issues

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Abstract.
This study aimed to obtain the analysis results of the needs for science teachers in STEM learning on socio-scientific issues. The study involved 135 respondents from various education stakeholders such as *Dinas Pendidikan* or education department, education and training institutions, and secondary school science teachers. This study utilized a descriptive method. The data were obtained using document analysis instruments, observation guidelines, questionnaires, interview guidelines, and field notes. Then, the data were analyzed descriptively. The results of this study showed that the implementation of STEM training programs was rated in the good category (76%). Teachers still find difficulties in integrating STEM into their teaching due to their lack of understanding of STEM, limited examples in STEM learning, and poor collaboration between teachers in setting learning objectives, scenarios, LKPD, and STEM assessments associated with SSI. Based on the findings through the selected research instruments, the needs of teachers in integrating STEM into their teaching are as follows: 95.5% of teachers stated that STEM integration training was needed, 76.5% of teachers thought that education and training should be sustainable, 77.3% of teachers stated that there was a need for collaboration in the MGMP community, and 72.7% of teachers think they need integrated examples of STEM learning. Furthermore, there are other things required in the training program, which are the utilization of ICT in training, teachers' active participation in preparing the training program, synchronous activities through online meetings and mentoring, and incorporating socio-scientific issues in STEM learning.

Keywords: science teachers, STEM learning, socio-scientific issues

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Published: 26 April 2024

Publishing services provided by Knowledge E

Selection and Peer-review under the responsibility of the ICMScE Conference Committee.

1. INTRODUCTION

The vision of science education is to prepare students to have a decent understanding of science and technology. Science subjects are supposed to be delivered by teachers through the development of thinking skills, attitudes and the ability to overcome environmental problems [1]. Science learning must prepare students and learners of all ages to

find solutions for present and future problems. In Schools, learning science in the context of socio-scientific issues (SSI) have emerged as an important educational framework. It allows a stronger emphasis on preparing students to be involved as active citizens, scientifically literate, and ready to achieve sustainable development goals [2], Education for Sustainable Development (ESD) that is recognized as an integral element of the Sustainable Development Goals (SDGs) 4 on quality education. The SDGs incorporate 17 development goals and 169 indicators. Meanwhile, SDG13 directly addresses climate change [3]. The use of fossil fuel energy by vehicles and factories generate carbon emissions that put a significant threat to the atmosphere and create global warming and climate change. The average temperature of the earth's surface has increased by 1.5^{o} to 4.5^{o} Celsius. Consequently, it increases sea levels by an average of 10 to 15 cm due to the Arctic ice melting in summer [4]. Through science education, related competencies namely knowledge, attitudes, and skills with respect to environmental conservation will be fostered and developed so that people are aware and change their behavior in relation to the importance of environmental conservation. Next Generation Science Standards (NGSS) recommends altering science learning from traditional inquiry to contemporary practical science within the scope of Science, Technology, Engineering, and Math (STEM) learning.

Scientific and engineering practices as a cognitive orientation activity in the effort to improve scientific literacy and appreciate the Nature of Science (NOS). Likewise, STEM has a focus on preparing a generation that is ready for the challenges presented by the future employment landscape. In terms of career opportunities, the STEM field would be a promising career in the future. The integration of STEM in learning today can equip students to face complex real-world problems in the future. Education stakeholders should focus on STEM as an effort to face global problems.

The implementation of STEM education must be integrated, one of the integration models is the Engineering Design Process/EDP [5]. The first stage in EDP is problem identification. One of the world's critical challenges today is related to the SDG's awareness. Therefore, STEM learning on socio-scientific sustainability issues needs to be implemented [6,7]. The second stage of EDP is research. At this stage, necessary information is carefully collected and utilised to identify the most appropriate technologies to solve the problem. STEM integration in learning has been widely used in various countries. STEM education develops the students' ability to identify problems, improve analytical and problem-solving skills, develop creativity, and ensure better engagement in their life. In the effort of educating students to become competitive innovators in the global economy, the addition of art in STEM is essential. STEM has become STEAM. The field of studies in STEM are taught in an integrated and holistic manner. The integration between STEM's field of studies is applied to compelling problems in actual

situations [8]. The prototype development in EDP STEM must consider holistically the transdisciplinary vision of ESD, namely environmental, economic, and social/cultural [9]. Consequently, teachers' creativity in conducting STEM learning needs to be improved.

The creativity of science teachers in conducting STEM learning is highly desirable [10 , 11]. The teacher's ability in preparing lesson plans is not the only ability that has a significant effect on student involvement in STEM learning, but also their ability to communicate, interact, and maintain positive teacher-student relationships [12]. In addition, TPACK capability of teachers is very important to prepare a digital native generation [13, 14, 15]. Teachers must have sufficient insights covering content (CK), Pedagogy (PK), Technology (TK), content pedagogy (PCK), and Technology in content pedagogy (TPACK) in delivering STEM academic disciplines.

Professional development and creativity of science teachers in the STEM field are important in order to prepare a generation of problem solvers who are able to solve complex real world challenges [16]. It is vital for teachers to master the STEM's field of studies through collaborative self-development [17]. Science teacher professional development (PD) programs can be accomplished through a series of workshops [18, 19]. Based on the descriptions above, it is necessary to conduct a field study entitled The Needs Analysis of Education and Creativity Training Program for Science Teachers in Delivering STEM Learning on Socio-Scientific Issues.

2. RESEARCH METHOD

The research subjects in this study consisted of 1 person from the Education Office, 3 people from the Education and Training Institution, and 132 science teachers who are also MGMP IPA active members. The study utilizes a descriptive research methodology. The study employed data collection instruments that consisted of: observation sheets, questionnaires, interview guidelines, and field notes. The data were carefully collected and analyzed descriptively.

3. RESULTS AND DISCUSSION

3.1. The Description of Policy Makers' Role in the Implementation STEM

The education office acts as a trusted administrator in the execution of policies made by the Ministry of Education and the Provincial Education Office. The role of the education office is vital in improving teacher professionalism. Moreover, the education office has a role and function in providing services to teachers in primary and secondary school.

However, the vast area of the district and the large number of teachers generated several obstacles and limitations in providing the expected services. Based on the results of these interviews, the data revealed that the district education office was unable to directly provide guidance to science teachers through education and training. This is because the district education office should not hold the training for more than two days, therefore the training is no longer the authority of the education office. Consequently, the district education office must form partnerships with education and training institutions to be able to organise longer training for teachers. Thus the training will be organised by the education and training institution.

In 2021, the District Education Office established a partnership with the Education and Training institution. As a result of this partnership, the Department of Education was able to organise 4 series of training for science teachers, including: science education and training for extracurricular science teachers, training for STEM learning batch 1 and 2, training for preparing AKM questions based on scientific literacy. In addition, the Sukabumi District Education Office has an important role in preparing the Teacher Professional Education Program. The District Education Office has the authority to determine PPG participants. For that reason, PPG participants were selected strictly by the education office. The first selection stage is paper screening. Teachers who are entitled to take part in PPG were the teachers who have an undergraduate academic qualification that is compatible with their teaching subjects. The teachers who have passed the selection are eligible to take part in the PPG pre-test. Teachers who have passed the pre-test will be appealed by the education office to re-do the paper screening process ensuring the submitted documents fulfil the requirements determined by the PPG LPTK.

The education office also has the authority to issue a decision letter (SK) to MGMP and KKG management. In addition, the education office provides guidance and direction to MGMP administrators so that MGMP is suitable to become a centre in the development of teacher professionalism. The education office will also coordinate with the MGMP and KKG to choose eligible participants who will take part in the training. MGMP has an important role in providing valid information related to teacher competence. Likewise, MGMP is a forum for teachers to develop learning tools, assess learning, and write scientific papers.

Based on the interviews with the education office, MGMP of science is the most active MGMP compared to the other subjects' MGMPs. The education office through the PTK Dikdas department has carried out intensive coordination to make the implementation of partnership with the education and training institutions successful. In addition, the education office is always involved in activities that have been organized by the IPA MGMP. Among them, there are three events in 2021 which were attended by the

education office, namely *Webinar penyusun soal PAS berbasis AKM, dan Webinar guru P3K IPA*. The relationship between the education office and the IPA MGMP is very good.

3.2. Stages in Organising Teacher Education and Training Programs

In order to obtain information related to the implementation of the training, interviews were conducted with two staff from the education and training institution. The interviews were conducted with *kepala staf bidang program* and *kepala staf bidang PTP*. The interview with *kepala staf bidang program* was conducted offline, while *kepala staf bidang PTP* was interviewed through a zoom meeting. Based on the interviews results with *kepala staf bidang PTP* and *kepala staf bidang program* PPPPTK IPA Bandung, there are some key information points related to the implementation of education and teacher creativity training in STEM learning were as follows:

1. The stages in the implementation of education and training include: preparation, implementation, and evaluation stages.
2. The development of training programmes is using ADDIE method
3. The education and training institution has three sub-sectors in managing the delivery of education and training programmes which are: planning, implementation and evaluation. The planning sub-sector contains the activities of analysis, designing, and development of the training programme. The implementation sub-sector contains implementation activities. The Evaluation sub-sector performs education and training evaluation activities.
4. More than 30 training courses were held in one fiscal year.
5. STEM education and training was held through DIDAMBA and regular training was organised in collaboration with other institutions such as Seameo Qitep In Science, and the Education Office.
6. Socioscientific issues have not been involved in STEM education and training

The study found some weaknesses and limitations in the implementation of the education and training programme which includes: education and training programme was not sustainable, there was no monitoring of STEM learning implementation by the teachers in the actual classroom, the programme did not have specific instruments to ascertain whether teachers are actually implementing STEM in their teaching activities, there is no information regarding the obstacles faced by the teachers when implementing STEM in their classroom, and no information on the students responses on their learning process with STEM approach.

3.3. Important Factors Required by the Teachers to Improve STEM Integration in Their Teaching Activities

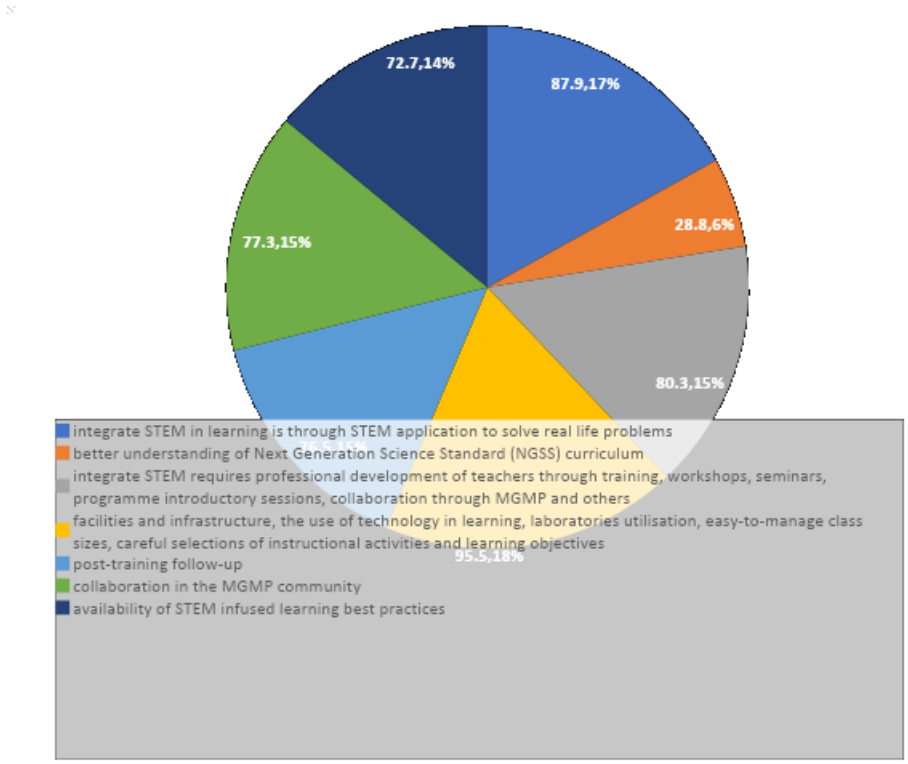

Figure 1: Teachers' needs in STEM education and training.

From the graph presented above, the data revealed that as much as 87.9% participants agreed that to be able to integrate STEM in learning is through STEM application to solve real life problems. Meanwhile, merely 28.8% stated that a better understanding of Next Generation Science Standard (NGSS) curriculum is necessary to be able to integrate STEM in learning. Approximately 80.3% of teachers agreed that to be able to integrate STEM requires professional development of teachers through training, workshops, seminars, programme introductory sessions, collaboration through MGMP and others. Moreover, there are also several things that must be considered: facilities and infrastructure, the use of technology in learning, laboratories utilisation, easy-to-manage class sizes, careful selections of instructional activities and learning objectives. STEM Integration Training (95.5%), post-training follow-up (76.5%), collaboration in the MGMP community (77.3%), and the availability of STEM infused learning best practices (72.7%).

The professional development (PD) of teachers is often constrained by time, geographical conditions, and costs. Technological support in PD is very meaningful. Teachers may explore to harness the power of technological advancement in their classrooms.

PD is transitioning to web-based remote instructions [4]. Thus, the professional development of teachers can be organised remotely through various online platforms [14], [20].

Several ways were identified to make participants feel more engaged in online workshops, including providing feedback by the facilitator at asynchronous times [21], mentoring [22], and involving teachers in constructing learning goals independently through *We Inspire Successful Educators* / WISE programme [18], and small groups discussion through breakout zoom in the community or *Community of Practice* [16]. The success of the PD program can be achieved when teachers are involved in the program development cycle. The PD program development cycle begins with aligning the education and training program with the problems faced by teachers in the classroom through research. These studies include lesson study and action research [23].

The innovation of education and training activities may incorporate some interventions where the teacher plays an active role in determining the content of teaching materials needed to solve daily learning problems [24]. Education and training facilitated teachers in providing active and inquiry-oriented learning activities, as well as professional learning communities [25]. Additionally, the education office provides permanent support through group collaboration and sustainable facilitation of teacher learning. Several studies showed the importance of the learning community [26].

Another important thing related to teachers' education and training is the training duration. Research showed that intellectual and pedagogical change requires training activities with sufficient time duration. A short-term intervention requires at least 14 hours up to 20 hours training to be considered as sufficient [27]. Estimated a minimum of 80 hours of training is adequate to facilitate teacher behavioural change [24]. A different aspect of duration is the continuity of the intervention [20]. One-time short-term interventions may be less effective than long-term interventions combined with ongoing follow-up support, such as follow-up interventions . Therefore, the training can be carried out throughout one semester through asynchronous use of the web, synchronous through online meetings and face-to-face sessions once a week without compromising on meeting the minimum 80 hour training duration requirement.

The creativity of science teachers in conducting STEM learning is highly desirable [11]. The teacher's ability in preparing lesson plans is not the only ability that has a significant effect on student involvement in STEM learning, but also their ability to communicate, interact, and maintain positive teacher-student relationships. In addition, teachers must have sufficient insights covering content (CK), Pedagogy (PK), Technology (TK), content pedagogy (PCK), and Technology in content pedagogy (TPACK) in delivering STEM academic disciplines. Teachers must also have creativity in using technology. Digital technologies were utilised by teachers in providing meaningful learning experiences

which includes powerpoints, youtube videos, flash simulations, the use of cameras to observe certain phenomena, photography and experimental videos, phet simulations, animations, equation-balancing applications, podcasts [28].

4. CONCLUSION

Based on the results of the field study, several conclusions can be drawn as follows: The role of the Education Office can be maximized through policies encouraging teachers to actively participate in self-development activities through MGMP. The stages in preparing teacher education and training programs include: Analysis of teacher needs (survey), Programme design, Programme development (expert judgment, limited trial), Implementation of education and training, and Evaluation of the training programme as a whole. The implementation of STEM training programs were organized in the good category (76%). By using the 5E approach. However, the study detected some obstacles and limitations which are the handouts for the participants, the selection of non-routine socio-scientific issues for STEM learning, insufficient length of training duration, unsustainable training activities, lack of active participation from the training participants, no micro teaching or teaching in actual classroom session, and the lack of collaboration between teachers in training activities. The theory development in the training program is related to several things including: utilization of ICT in training, increasing the training duration, asynchronous blended training activities with feedback, synchronous activities through online meetings and mentoring, incorporating socioscientific issues.

Acknowledgments

Thank you for The Indonesian Ministry of Education, Culture, Research, and Technology (Kemendikbud Ristek) provided financial support for this project through the Indonesian Educational Scholarship Program (BPI) and a Doctoral grant from the Education Financial Services Center (PUSLAPDIK). The Ministry of Education, Culture, Research, and Technology of the Republic of Indonesia (Kemendikbud Ristek) funded this research as part of a doctoral fellowship program in scientific education at Indonesian institutions of education's postgraduate schools. Dinas Pendidikan Kabupaten Sukabumi, Badan Diklat PPPPTK IPA Bandung, and MGMP IPA Kabupaten Sukabumi.

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