JPPIPA 9(3) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Secondary Science Teachers Perception on STEM Learning for Sustainable Development

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Received: December 29, 2022
Revised: March 22, 2023
Accepted: March 25, 2023
Published: March 31, 2023

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DOI: 10.29303/jppipa.v9i3.2776

Abstract: The aim of study is to analysis secondary science teachers' perception on STEM learning for sustainable development (STEM for SD). Data collected by online questionnaires instrument with 96 teachers as respondent. The data analyzed descriptively. Research finding is 36,5% knowing the ESD and only 26% (low) knowing without misconception and accurate explanation about it. Only 19 % (low) science teacher ever to implement ESD in their schools' program. School program on ESD such us renewable energy, waste management, environmental education, nature laboratory, and etc. The conclusion is science teacher perceptions increasing public understanding and awareness on ESD are still low. Because that teachers training program on ESD need to be implemented.

Keywords: Education for Sustainable Development; Science teachers' perception; STEM

Introduction

Education as a key to face the challenge global issues. Global issues such as climate change, poverty, loss of biodiversity, and etc. (Rico et al., 2021). Education for sustainable development (ESD) is a transformative education to empowerment of citizens for construction alternative sustainable futures, development of systemic, critical, and creative thinking (UNESCO, 2017).

The development of a sustainable society should be seen as a continuous process of learning. Its Involving a variety of actor in formal, non-formal, and informal learning. Science teacher come to be leader to drive all stakeholder in schools knowing ESD. Science teacher are important agents for change within education systems (Sander, 1998).

The various studies have pointed the difficulty science and technology teachers to embedding sustainability in curricula (Richmond et al., 2017). Mismatch between the essential significance and responsibilities of ESD and the existing qualified teacher are able to carry out ESD (Liu & Qi, 2021). Difficulty of practical ways of bringing sustainable development into science, technology, engineering, and mathematics (STEM) related subject (Hopkinson & James, 2010).

A generation that is prepared for the difficulties offered by the future job environment is the main objective of STEM. The STEM fields would be a promising job in the future in terms of employment chances. Students may be better prepared to deal with difficult real-world situations in the future because to the incorporation of STEM in the classroom now. STEM should be the focus of education stakeholders in an attempt to address global issues. The Engineering Design Process (EDP) is one of the integrative methods for the implementation of STEM education. It is necessary to apply STEM education on socioscientific sustainability challenges. In many nations, STEM

How to Cite:
Rahman, A.A., Kaniawati, I., Riandi, R., & Hendayana, S. (2023). Secondary Science Teachers Perception on STEM Learning for Sustainable Development. *Jurnal Penelitian Pendidikan IPA*, *9*(3), 1297–1303. https://doi.org/10.29303/jppipa.v9i3.2776

integration in education is extensively practiced. Students' problem-solving abilities, analytical skills, creativity, and level of interest in their lives are all improved by STEM education.

The creativity of science teachers in conducting STEM learning is highly desirable (Tan, 2014). The teacher's ability in preparing lesson plans is not the only ability has a significant effect on student involvement in STEM learning, but also their ability to communicate, interact, and maintain positive teacher-student relationships (Awad et al., 2019). In addition, TPACK capability of teachers is very important to prepare a digital native generation (Al-Harthi et al., 2018). 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. The prototype development in EDP STEM must consider holistically the transdisciplinary vision of ESD, namely environmental, economic, and social/cultural (Desimone, 2009).

Teacher understanding about ESD effect to teacher perception and action in ESD. For many years the search for causal connection between infant' action and their perceptual and cognitive advance (Fraser et al., 2007). This article goal is to analysis science teacher perception on ESD. This study is preliminary research for develop teacher training program creativity and TPACK on STEM for Sustainable Development. Through this research, researchers can determine the training program, how many target participants, and the stages of the activity so that it becomes meaningful learning for participants. Another important benefit of this research is that it provides an overview of the extent to which teachers' conceptions are related to ESD, the extent to which the implementation of learning is related to ESD, and what are the challenges faced in organizing ESD-laden learning.

Method

The methodology is qualitative research method by survey. Data collection instrument consist of online questionnaires. Subject in this study is 96 secondary science teachers in various district In Indonesia such as Bandung, Gunung Kidul, Sukabumi, Sambas, Sumedang, and Tarakan. The data were carefully collected and analyzed descriptively**.** Data analysis was done in a descriptive manner**.** The research flow is depicted in the following Figure 1.

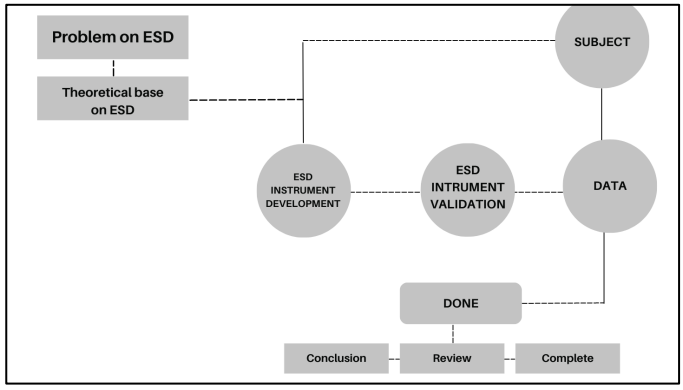

Figure 1. Research flow

Based on the methodology suggested by Ridwan (2010), the acquisition of these categories is a percentage, and the scores received by subject were then divided into low, medium, and high categories.

Table 1. Categorization of ESD perception

Teacher answer	Category
100 – 68	High
67 – 35	Currently
34 – 0	Low

Result and Discussion

One of the nation's taking part in the goal of integrating sustainable development principles into education is Indonesia. The Kemdiknas Strategic Plan (Renstra) Year 2010-2014 Chapter II Section 2.3 on Challenges Education and development demonstrate Indonesia's dedication. Meeting the world's commitment to achieving the Millennium Development Goals (MDGs), Education for All (EFA), and Education for Sustainable Development is 2010-2014 point 2. (Listiawati, 2011). For this study we develop indicator for perception science teachers on sustainability questionnaires. The indicator presents in Table 1.

Table 1. Indicator questioners instrument perception science teachers on ESD

Indicator	Item
Teacher knowledge related to ESD from the point of view of the individual part of the community	1-11
Teachers' knowledge of ESD from the point of view of teachers in schools	12-23
Principal Support for ESD implementation	24-29
Barriers to ESD implementation in schools	30

Question characteristics divided into two type such as: close question and open question. Open question type to find understanding science teacher on ESD. Only 36.5% (Cureently) have comprehensive understanding about ESD. In line with the results of the study Listiawati (2010) Based on data gathered via the implementation of education in the field, it is known that the majority of teacher had never heard of the development idea of sustainable development. Teacher answer on understanding about ESD have categories in five keyword: sustainability competence, future thinking, global warming, environment education, and 21st Century S.ills. The teacher answer percentage present in Table 2.

Table 2. Science teachers' percentage understanding about ESD

Teacher answer	Percentage %
Education that encourages change in knowledge, skills, values and to enable a more sustainable and equitable one for all	52
Education whose main target is students who aim so that they can play an active role in advancing development in the present and in the future	16
One way to reduce the impact of global warming	8
Efforts made to survive the challenges that exist for environment education	16
ESD equips students with knowledge, skills, and global life values that refer to 21st century skills. In addition, in ESD-oriented KBM, it is usually student-centered accompanied by the application of innovative learning typical of the 21st century.	8

Data on Table 2 present that teacher much importance to the sustainability issues of global warming and environmental education. According to Goleman et al. (2012), "green conduct" refers to how people behave in order to preserve and protect their local environment. Human conscience to love the universe gives birth to green conduct.

Environment and school initiatives (ENSI) provide what student or teacher should be involved with environment issues in three levels: The level of personal (experience the environment), interdisciplinary (study the environment), and socially (shape the environment) (Fraser et al., 2007). Handayani (2015) argued that children need to be taught environmentally friendly habits from an early age in order to develop into people who value the natural world. "Green conduct" is a representation of the environmental responsibility and care that each and every person must possess. Human attitudes and values regarding the environment are influenced by knowledge, emotions, and propensities to take action (Yulianto et al., 2022).

As said, by adding fresh information concerning extracurricular subjects, environmental and social concerns may be included into the curriculum. However, there is another intriguing approach that makes advantage of the contextual elements of students' everyday STEM learning experiences (Hopkinson & James, 2010). To be more precise, it does so by relating what they are learning to the realities of their field of study, as well as their personal and professional lives, in order to inspire them to develop an understanding of global citizenship, social justice, environmental protection, and sustainable economic development (Liu & Qi, 2021).

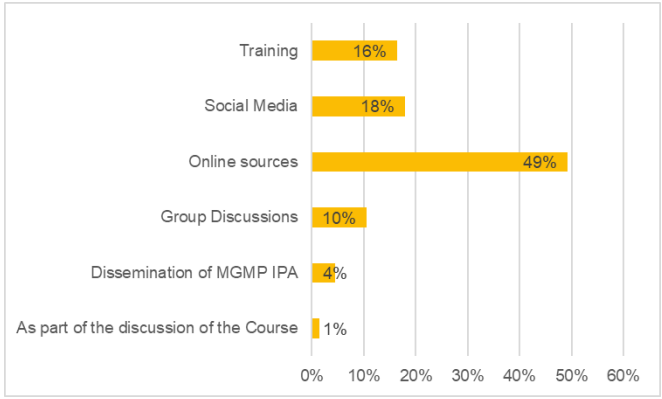

Figure 2. Sources of information used by teacher on ESD.

The sources of information used by teachers on ESD are shown in Figure 2. 49% (high) Science teacher choose the online sources. Its more accessible for teacher. Science teachers can access with their smart devices independent of time and space. Today, teachers who are basically socialized in the cyber-life and in a cooperative ICT environment in a Human ICT combo way of life. The integration of disruptive technologies soon after their appearance in the teaching material of the higher education disrupts the traditional environment of the education in many aspects (Horvath, 2017). Since the advent of the Internet, technology has changed the way that people learn. Around two million kids registered in K–12 virtual schools to attend all or some of their coursework online instead of in traditional classrooms (Wang, 2016).

The entire range of curriculum-based learning activities, projects, and techniques that educators may utilize with the aid of various educational technology is

simply not known by many educators. To far, technology-related professional development has placed an emphasis on understanding hardware and software affordances and their full potential rather than on practical, adaptable methods for curriculum-based applications of educational technologies (Harris & Hofer, 2011). In order to fully understand any potential constraints and be able to build lines of improvement that support the rectification of these challenging competence gaps, it is critical to determine the level of digital competence of the teaching body that supplies these resources (Artacho et al., 2020). Information from training program is still low only 16%. From the other data in figure 2 show that only 19,8% science teacher have already join on ESD training.

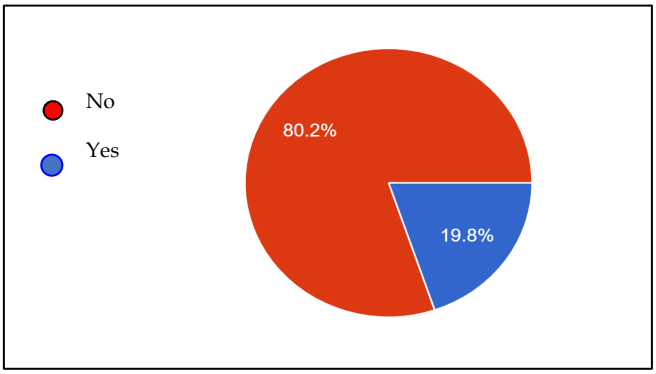

Figure 3. Teacher participation in ESD training

Data from interview show the ESD training that teachers have attended is not a specific training for ESD. ESD is not the core material on the training. ESD materials are complementary on the training STEM and environment education. Implementation on ESD training in secondary school teachers are still low. As research Wulandari that ESD training in Indonesia more implemented in higher education (Silva et al., 2020). Data questionnaire about the effect Teacher training to teacher competence show on Table 3.

Majority of teacher agree that teacher training in environment education can increase their competence in understanding of the content of the material, Environmental awareness, associating with different disciplines, teaching skills, student hands on activities, and ability to conduct assessments. Form the data show 57,3% teacher strongly agree teacher training program can improve teacher skills and increase teacher motivation to innovate the teaching and learning in their class. But the number of applications to the context of daily life (economic, social, cultural aspect) is still low. Teacher Difficulty of practical ways of bringing sustainable development into science, technology, engineering, and mathematics (STEM) related subject (Hopkinson & James, 2010).

Numerous academics have used the framework for various purposes since it was created as a framework to help instructors learn how to integrate ICT across the curriculum in the Technological Pedagogical Content Knowledge. Pre-service teachers are the focus of the majority of the study on TPACK development; however, some research is available to shed light on in-service teachers and their TPACK (Ndongfack, 2015).

Table 3. The effect teacher training to teacher competence

Teacher answer	Percentage Strongly agree %
Increase understanding of the content of the material	42.7
Environmental awareness	49.0
Applying to the context of daily life (economic, social, cultural aspects)	41.7
Associating with different disciplines	45.8
Improve teaching skills	57.3
Increase motivation to innovate	52.1
Increase student hands on activities	43.8
Improve the ability to conduct assessments	44.8

The TPACK levels may be useful to teacher educators in assessing and organizing their preservice and in-service students' technological readiness. The Teacher TPACK Developmental Model creates standard concepts and terminology that should make it easier for researchers to connect their work to that of others and to a wider context (Niess et al., 2009). Science teachers have understanding about ESD and connection in several subject areas. Teacher chooses subject area on ESD show in Figure 4.

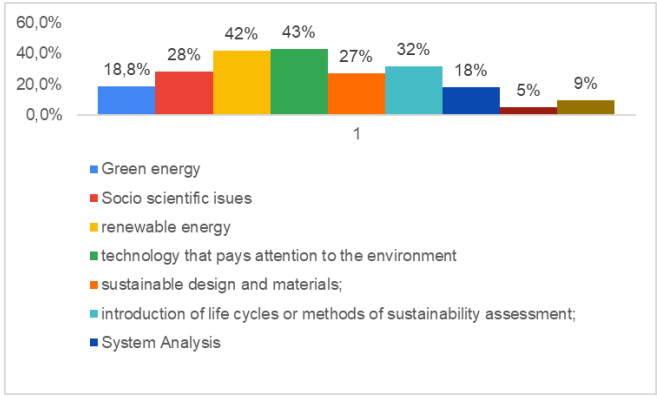

Figure 4. Subject area related on ESD

43% teacher agree that technology must pay attention to the environment. Nowadays technology breakthrough in many fields and every aspect of our life.

Disruptive technological development is created with long research. Science, Technology, Engineering and Mathematics (STEM) integration in learning has been widely used in various countries. 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 realworld challenges (Silva et al., 2020).

Renewable energy (RE) is a relevant subject area on ESD. 42% science teachers agree for this statement. It's a sustainable goals (SDGs) number seven. Use the five targets to create action to ensure universal access to sustainable energy. Ensure universal access to affordable, reliable and modern energy services. Double the global rate of improvement in energy efficiency. Increase substantially the share of renewable energy in the global energy mix. enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology (UNESCO, 2017).

Resource waste and other careless human actions are the causes of almost all environmental issues. People who are unaware of the issues brought on by irresponsible behavior are indifferent to occurrences that do not directly touch them. Interest in investigating the use of clean, renewable energy sources has increased due to worries about resources running out, particularly coal and oil, as well as worries about the environmental and atmospheric pollution they generate (Çakirlar Altuntaş & Turan, 2018).

The absence of secondary-level RE-targeted instruction or courses is one of these flaws. The unfavorable spread of RE technologies, design, and concepts, particularly among common people, is due to a lack of education in RE disciplines and technologies in secondary education (age 11–18). Due to the inadequate transmission of RE technology education, various variables, including socio-cultural, institutional, and technological hurdles, continue to exist among the general population. Another impediment is the lack of innovative ways to harvest different RE sources and the high cost of doing so using technologies accessible to the general public. Additionally, some of the available technologies are not cost-effective because they cannot meet the entire public's energy needs (Hoque et al., 2022).

By using cost-effective technology, it is possible to break down the boundaries and harness energy from new sources, making a significant contribution to addressing the world's energy needs. The inclusion of RE concepts in the educational curriculum starting in secondary school is one way to achieve this goal. This will teach many future holistic citizens of the critical need for RE technologies and inspire them to develop new creative and technological advancements in this area (Hoque et al., 2022).

From Figure 2 show only 19,8 % (low category) science teacher ever to already to join ESD training and implement ESD in their schools' program. The program such as: integrated ESD in school curricula in or extracurricular, project in STEM learning, waste management, environmental education, nature laboratory, and green school program.

A variety of techniques and instructional strategies are needed for the development of sustainability skills. Experiments, games, interactions with animals and the natural world, and other external learning contexts may all be used as examples of how to foster networked, alternative thinking. The following techniques also adhere to ESD standards: environmental investigation and project work, free work and open lessons, role-playing and simulation games, discussion and collaboration techniques, future workshops, and assessment techniques. The investigation of alternate viewpoints and contemplation on various worldviews may be made possible through the creation of intercultural environments. Flexibility of understanding is enhanced by using information in various situations and approaching issues from various angles. The learning that arises from this, among other things, stimulates pupils and is focused by ESD's emphasis on competence acquisition. It is also crucial that students evaluate their own learning methods and tactics (Scherak & Rieckmann, 2020).

Conclusion

The majority of science teacher had little understanding about concept of sustainable development. Only 26% teacher have ability to explain ESD concept clearly without misconception. Only 19 % science teacher ever to implement ESD in their schools' program. School program on ESD such us waste management, environmental education, nature laboratory, and etc. Recommendations for further study is: The teacher need to be fully prepared to address ESD concept and teaching skill on ESD through teacher training program. Integrated ESD concept in curricula. Baseline for further project to develop teacher creativity and TPACK training program on STEM for SD.

Acknowledgements

Thank you for Post graduate Science Education University Indonesia of Edcuation.

References

Al-Harthi, A. S. A., Campbell, C., & Karimi, A. (2018). Teachers' Cloud-Based Learning Designs: The Development of a Guiding Rubric Using the TPACK Framework. *Computers in the Schools*, 35(2), 134–151. https://doi.org/10.1080/07380569.2018.1463033

Artacho, E. G., Martínez, T. S., Ortega Martín, J. L., Marín Marín, J. A., & García, G. G. (2020). Teacher training in lifelong learning-the importance of digital competence in the encouragement of teaching innovation. *Sustainability (Switzerland)*, 12(7). https://doi.org/10.3390/su12072852

Awad, N. A., Salman, E., & Barak, M. (2019). Integrating Teachers to Teach an Interdisciplinary STEM-Focused Program about Sound, Waves and Communication Systems. *European Journal of STEM Education*, 4(1), 1–12. https://doi.org/10.20897/ejsteme/5756

Çakirlar Altuntaş, E., & Turan, S. L. (2018). Awareness of secondary school students about renewable energy sources∗. *Renewable Energy*, 116, 741–748. https://doi.org/10.1016/j.renene.2017.09.034

Desimone, L. M. (2009). Improving impact studies of teachers' professional development: Toward better conceptualizations and measures. *Educational Researcher*, 38(3), 181–199. https://doi.org/10.3102/0013189X08331140

Fraser, C., Kennedy, A., Reid, L., & McKinney, S. (2007). Teachers' continuing professional development: Contested concepts, understandings and models. *Journal of In-Service Education*, 33(2), 153–169. https://doi.org/10.1080/13674580701292913

Harris, J. B., & Hofer, M. J. (2011). Technological pedagogical content knowledge (TPACK) in action: A descriptive study of secondary teachers' curriculum-based, technology-related lnstructional planning. *Journal of Research on Technology in Education*, 43(3), 211–229. https://doi.org/10.1080/15391523.2011.10782570

Hopkinson, P., & James, P. (2010). Practical pedagogy for embedding ESD in science, technology, engineering and mathematics curricula. *International Journal of Sustainability in Higher Education*, 11(4), 365–379. https://doi.org/10.1108/14676371011077586

Hoque, F., Yasin, R. M., & Sopian, K. (2022). Revisiting Education for Sustainable Development: Methods to Inspire Secondary School Students toward Renewable Energy. *Sustainability (Switzerland)*, 14(14), 1–18. https://doi.org/10.3390/su14148296

Horvath, I. (2017). Disruptive technologies in higher education. *7th IEEE International Conference on Cognitive Infocommunications, CogInfoCom 2016 - Proceedings*, *CogInfoCom*, 347–352. https://doi.org/10.1109/CogInfoCom.2016.7804574

Listiawati, N. (2011). Relevansi Nilai-Nilai ESD dan Kesiapan Guru Dalam Mengimplementasikannya di Sekolah. *Jurnal Pendidikan Dan Kebudayaan*, 17(2), 135–152. https://doi.org/10.24832/jpnk.v17i2.13

Liu, Y., & Qi, W. (2021). Construction of language teachers' professional competence in education for sustainable development in higher education for post-pandemic era. *Journal of Language Teaching and Research*, 12(2), 304–311. https://doi.org/10.17507/jltr.1202.12

Ndongfack, M. N. (2015). TPACK Constructs: A Sustainable Pathway for Teachers Professional Development on Technology Adoption. *Creative Education*, 6(16), 1697–1709. https://doi.org/10.4236/ce.2015.616171

Niess, M. L., Ronau, R. N., Shafer, K. G., & Driskell, S. O. (2009). Mathematics Teacher TPACK Standards and Development Model. *Contemporary issues in technology and teacher education, 9*(1), 4-24. https://doi.org/10.1016/0014-2999(88)90271-3

Richmond, G., Dershimer, R. C., Ferreira, M., Maylone, N., Kubitskey, B., & Meriweather, A. (2017). Developing and sustaining an educative mentoring model of STEM teacher professional development through collaborative partnership. *Mentoring and Tutoring: Partnership in Learning*, 25(1), 5–26. https://doi.org/10.1080/13611267.2017.1308097

Rico, A., Agirre-Basurko, E., Ruiz-González, A., Palacios-Agundez, I., & Zuazagoitia, D. (2021). Integrating mathematics and science teaching in the context of education for sustainable development: Design and pilot implementation of a teaching-learning sequence about air quality with pre-service primary teachers. *Sustainability (Switzerland)*, 13(8). https://doi.org/10.3390/su13084500

Sander, R. (1998). Learning for the future. *Nursing Standard (through 2013)*, 13(4), 58. https://doi.org/10.7748/ns.13.4.58.s49

Scherak, L., & Rieckmann, M. (2020). Developing ESD competences in higher education institutions—Staff training at the University of Vechta. *Sustainability (Switzerland)*, 12(24), 1–19. https://doi.org/10.3390/su122410336

Silva, J. B., Silva, I. N., & Bilessimo, S. M. S. (2020). Technological structure for technology integration in the classroom, inspired by the maker culture. *Journal of Information Technology Education: Research*, 19, 167-204. https://doi.org/10.28945/4532

Tan, C. L. (2014). The curricular and pedagogic creativity of summerhill school, and related reflection on the

teaching in Singapore. *Journal of Education and Human Development*, 3(2), 541-557. Retrieved from http://jehdnet.com/journals/jehd/Vol_3_No_2_June_2014/31.pdf

UNESCO. (2017). *Education for Sustainable Development Goals Learning Objectives*. United Nations Educational, Scientific and Cultural Organization

Wang, Y. (2016). Big Opportunities and Big Concerns of Big Data in Education. *TechTrends*, *60*(4), 381–384. https://doi.org/10.1007/s11528-016-0072-1

Yulianto, A., Widodo, A., & Syaodih, E. (2022). Disclosure of Sustainability Consciousness in Elementary School Students: Application of Education for Sustainable Development through the Introduction of Green Behavior. In *International Conference on Elementary Education*, 4(1), 10-17.