Analysis of High School Students’ STEM Literacy and Problem-Solving Skills in Chemistry

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Abstract. In 21st century learning, most students are expected to have good critical thinking and problem-solving skills. According to this goal, the education system should have a learning method that results in improving critical thinking and problem-solving skills among students. The purpose of the study is to analyse the level of STEM literacy and problem solving of students in chemistry materials. This study involved seventy students in grade twelve of senior high school in Sragen Regency, Indonesia. The research design employed a qualitative method. The distribution of questions given in the form of open-ended question type consists of six cases in ten items. Such cases include three components of literacy: science literacy, mathematical literacy, technology-engineering literacy, and problem-solving. The findings show that most students are lacking STEM literacy skills and the ability to solve problems. The ability of STEM literacy and problem-solving is deficient. This research shows that students are unfamiliar with STEM literacy and problem-solving in chemistry. This result is not following the 21st-century learning. Therefore, it is critical to put a particular action in improving STEM literacy skills and problem-solving among students in the Indonesia education system.

1. Introduction

In the 21st century era, learning must be able to adjust students’ competencies for facing the challenges of their real and future life [1]. With the advent of change in society, economic, and ecological environment; education for future generations must be able to develop the skill required for student’s success as the citizen of the world such as creativity, critical thinking, cooperation, collaboration, knowledge, and media literacy, and entrepreneurship [2,3]. Hence, 21st-century learning encourages students to master content while producing, synthesizing, and evaluating information from various subjects and sources for diverse cultures [4].

Research conducted by PISA (Program for International Student Assessment) reveals that Indonesian students have low interest in learning science. Data provided by the OECD, Indonesian science students scores only reached 396 below the OECD average of around 496 [5]. The global challenge a new generation of STEM experts is to integrating of science, technology, engineering, and mathematics in the contexts of real learning in the life. Educational researchers indicate that teachers struggle to make connections across the STEM disciplines. As a result, students are often disinterested in science and mathematics when they learn in isolated and detacted ways. Students tend to lose
connections to cross-cutting concepts and real-world applications. [6]. STEM education can associate scientific inquiry, by formulating questions answered through investigation to inform the student, before they engage in the engineering design process to solve problems [7]. Improving STEM education may also increase the literacy of all people across the population in technological and scientific areas [8]. International concerns about advancing STEM education have escalated in recent years and show no signs of reduction. Educators, policy developers, business, and industry organizations, to name a few, and industries to highlight the importance for improving STEM skills to meet current and future social and economic challenges [9].

In-depth understanding of STEM literacy and problem solving is essential for building education in the classroom[11]. STEM literacy as “the conceptual understandings and procedural skills and abilities for individuals to address STEM-related personal, social, and global issues”[17]. Student who graduates possess 21st Century skills are sought out by employers [12]. In the environment of rapid advancements of technology, employees need to be flexible and perpetual learners in order to keep up with new developments [13,14]. There is a prerequisite to ensure that students who graduate the K-12 system are adept in 21st Century skills so that they can be successful in this new workforce landscape [13]. Therefore, students must have STEM literacy and problem solving skills to meet the challenges of the 21st century. The purpose of the study is to analyse the level of STEM literacy and problem solving of students in chemistry materials. STEM approach integration will help students analyse and solve real-life problems so they are ready to work.

2. Research methods
This study aims to know the STEM literacy and problem solving skills of high school students in chemistry learning. This study used the dissemination of open-ended assessment questions as data collection. Quantitative method consisted of six cases in ten items, the distribution of questions given in the form of open-ended assessment consists of six cases in ten items. The case included three components of literacy: science literacy, mathematics literacy, technological engineering literacy, and problem solving. This research involved seventy students in the-twelfth grade in Sragen Regency, Indonesia. Subject selection in this research was taken from twelfth grade students since they had already learned about the chemistry materials in tenth and eleventh grade as well. In addition, the chemistry materials tested in this research is a combination of chemistry material taught in tenth and eleventh grade. The number of research subject is seventy twelfth grade students consisting of 40 female students and 30 male students. Quantitative data collection was the dissemination of questions to students. The dissemination of questions was used to assess STEM literacy and problem solving skills integrated in chemistry learning.

Researchers investigated STEM literacy and problem solving skills in the form of the spread of open questions given to seventy students in the twelfth grade in Sragen District. The forms are given to students who have received chemistry material. The problem was distributed in the form of a cases question consisting of six cases in ten question items. The case presented in the question was a case based on indicators to know the level of science literacy, technology literacy, engineering literacy, mathematic literacy, and problem solving [6,15]. The analysis of the data obtained was processed using categories in the Likert scale rubric 1-5, then from seventy students in each question item in the average to be analysed as a whole. So, there was an average result score in each item to be discussed in the analysis of students’ STEM literacy levels and problem solving skills.

3. Result and Discussion
Researchers focused on two main areas, namely knowing students’ STEM literacy and problem solving skills. Analysis of STEM literacy and problem solving skills was taken from a sample of seventy students. The data obtained from the dissemination of open questions to the sample then drawn on average from the entire sample so that it is obtained point per score on each question. Analysis of STEM literacy and problem solving skills of seventy students has been shown in figure 1.
STEM literacy levels are presented on questions number one through nine. The nine questions presented are science literacy, mathematics literacy, and technology-engineering literacy. Science literacy is presented on questions number one through four. Successive scores obtained from number one to four are 2.4, 2.6, 2, and 2 out of a maximum score of 5. This shows that student literacy is based on indicators of scientific phenomena, scientific investigations, completion analysis, and interpreting data as well as low student scientific evidence. Mathematics literacy is presented on questions number five through six. In a row, the score obtained from question number five to six is 1.8, and 2 out of a maximum score of 5. This shows that student literacy on indicators mathematically formulates situations and uses low student concepts, facts, procedures, and reasoning. Technology-engineering literacy is presented on questions number seven through nine. In succession, the scores obtained from question number seven to nine are 2.6, 2, and 2.4 from a maximum score of 5. This shows that students’ literacy on indicators determines technological principles, analyses technological advantages and weaknesses, and develops solutions to achieve low student goals. The overall STEM literacy score is on average 2.2 out of a maximum score of 5. It can be concluded that student STEM literacy is low.

Figure 1. Analysis of STEM literacy and problem solving skills

The level of problem solving students is presented in question number 10 with the type of problem solving problem in a single case. The indicators included in the question are that students can define, examine, plan, implement, and evaluate problems in the cases presented in the question. The average score obtained in problem solving analysis is 2 out of a maximum score of 5. This indicates that the students’ problem solving skill is low. The results of students’ answers on STEM literacy and problem solving skills are selected among the seventy students to be presented. This aims to explore the knowledge of different students when answering the questions presented.

1. Exist 2. Water Pollution 3. Don’t Know 4. Sorry I don’t know how
   (Students answer questions number 1 to 4 about indicators in science literacy, 27 August 2020)

5. Don’t know how 6. Exist, blood is acidic
   (Students’ answer to questions number 5 through 6 about indicators in mathematics literacy, 27 August 2020)

7. Blood should be sterilized first 8. Hydrolysis 9. Iron pipes are inserted into the soil to prevent corrosion.
   (Students’ answer questions number 7 to 9 about indicators in technology-engineering literacy, 27 August 2020)
10. A hydrolysis  B. No  C. Given chalk  D. Living pipe smeared chalk  E. Very sure lillahi ta'ala The result is handed over to the Almighty

(Students’ answer to question number 10 about indicators on problem solving, 27 August 2020)

Based on the students’ answer in answering the question we can check that the answer given by the student shows the literacy and problem solving skills of the student is low reflected on the students’ answer. Students are lazy to think deeply in completing the given case. This is because students are not familiar with STEM literacy in learning. Therefore, students have a lazy pattern to read in detail the information presented and are lazy in providing solutions to solve problems in the given case. Overall STEM literacy and problem solving skills of students acquired have a low category. This shows that learning that can improve STEM literacy and problem solving skills is needed students. Moreover, the learning media is also needed on the project that can improve students’ STEM literacy and problem solving skills. The integration of STEM approaches will help students to analyze and solve problems in real life so that they are ready to work [10]. Cognitive and affective change strategies such as problem-based learning, student-centered, hands-on STEM related activities and projects, and cooperative learning are important for inclusion in positive dispositions toward STEM [16]. Therefore, students must have STEM literacy and problem solving skills to meet the challenges of the 21st century. The purpose of the study is to analyse the level of STEM literacy and problem solving of students in chemistry materials. STEM approach integration will help students analyze and solve real-life problems so they are ready to work. So it is necessary to have learning media and learning resources that can integrate the STEM approach and problem solving so that students’ STEM literacy and problem solving skills can increase in order to face the world of work in the future.

4. Conclusion

Based on data from seventy students of the twelfth grade science program, we examined students’ STEM literacy and problem solving skills in chemistry learning. From the results of the analysis obtained, data on students’ STEM literacy and problem solving skills are in the low category. This is because students are not familiar with STEM-integrated learning and students are not familiar with STEM literacy and problem solving skills in classroom learning. So it is necessary to have learning media and learning resources that can integrate the STEM approach and problem solving so that students’ STEM literacy and problem solving skills can increase in order to face the world of work in the future. STEM literacy and problem-solving skills among students are able to be enhanced by means of virtual laboratory learning media based on STEM approach. Therefore, students could upgrade STEM literacy and problem-solving skill through conducting experiments independently on practicum provided in virtual laboratory.

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References

[1] Rahmawati Y, Ridwan A, Hadinugrahaningsih T, Soeprijanto. Developing critical and creative thinking skills through STEAM integration in chemistry learning. J Phys Conf Ser. 2019;1156(1).

[2] Bati K, Yetişir MI, Çalışkan I, Güneş G, Saçan EG. Teaching the concept of time: A steam-based program on computational thinking in science education. Cogent Educ [Internet]. 2018;5(1):1–16. Available from: https://doi.org/10.1080/2331186X.2018.1507306

[3] Hong O. STEAM Education in Korea: Current Policies and Future Directions Science and Technology Trends Policy Trajectories and Initiatives in STEM Education STEAM
Education in Korea: Current Policies and Future Directions. Policy Trajectories and Initiatives in STEM Education [Internet]. 2016;90–102. Available from: https://www.researchgate.net/publication/328202165

[4] Ridwan A, Rahmawati Y. Steam I Integration I N C Hemistry L Earning F or D Eveloping 21 St Century SKills. 2017;7(2):184–94.

[5] OECD. Greece What 15-year-old students in Greece know and can do Figure 1. Snapshot of performance in reading, mathematics, and science. 2018.

[6] Todd R. Kelley1 and J. Geoff Knowles. International Journal of STEM Education (2016) 3:11 DOI 10.1186/s40594-016-0046-z

[7] Kennedy, T., & Odell, M. (2014). Engaging students in STEM education. Science Education International, 25(3), 246–258.

[8] National Research Council [NRC]. (2011). Successful K-12 STEM education: Identifying effective approaches in science, technology, engineering, and mathematics. Washington: National Academies Press.

[9] Lyn D. English. English International Journal of STEM Education (2016) 3:3 DOI 10.1186/s40594-016-0036-1

[10] I. Ismail I, Anna Permanasari , Wawan Setiawan . (2016). Jurnal Inovasi Pendidikan IPA, 2 (2), 2016, 190 – 201. /DOI: http://dx.doi.org/10.21831/jipi.v2i2.8570

[11] Erdogan I, Ciftci A. Investigating the Views of Pre-Service Science Teachers on STEM Education Practices. Int J Environ Sci Educ. 2017;12(5):1055–65.

[12] National Research Council. (2013). Monitoring progress toward successful K-12 STEM education: A nation advancing? Washington, DC: National Academies Press. https://doi.org/10.17226/13509

[13] Bybee, R. W. (2013). The case for STEM education. Arlington: NSTA press.

[14] Johnson, C. C., Peters-Burton, E. E., & Moore, T. J. (Eds.). (2016). STEM road map: A framework for integrated STEM education. New York: Routledge.

[15] Mourtos, N. J., Okamoto D & Rhee, J. (2004). Defining Teaching, and Assessing Problem Solving Skills. Prosiding.UICEE Annual Conference on Engineering Education. Mumbai, India, 9-13 Februari.

[16] Lee, K.-T., & Nason, R. (2012). Reforming the preparation of future STEM teachers. In Y. Shengquan (Ed.), 2nd International STEM in Education Conference (pp. 33–39). Retrieved from https://eprints.qut.edu.au/56850/

[17] Bybee, R. W. (2010). Advancing STEM education: A 2020 vision. Technology and Engineering Teacher, 70(1), 30–35.