

STEM Education for Prospective Teachers

Nisraeni^{*}, Ahmad Rustam, & Deni Iriyadi
^{*}brbungarampai@gmail.com
Universitas Cokroaminoto Palopo
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Abstract: The aim of this research is to determine the perception of prospective teachers, especially in the field of mathematics studies on STEM-based learning. The sample in this study were final students majoring in Mathematics Education at the Nineteenth University of November. This research was using a survey method. The research sample is prospective teachers especially in the field of mathematics studies. Research result show that the enthusiasm of perception teachers towards STEM education is very high. STEM education is able to improve the creativity of using learning media very well. Prospective teachers still have integrity in their knowledge. Thus, STEM education is very much needed in the world of education.

Keywords: STEM, mathematics education, prospective teachers

Introduction

Education has been in an era where various innovations about learning have grown to help and make things easier, especially in the learning process. These facilities have an impact on life, which is the world of education such as learning media will experience the change. With the development of the electronic world, the era of computer-based learning has replaced the forms of learning that have been applied all this time. These developments must be accompanied by developments in the learning process. STEM education is teaching and learning that refers to the fields of science, technology, engineering, and mathematics (Valerio, 2014). Therefore, STEM education is more important in preparing students to work in the technologically advanced world and is very important for the nation's competitiveness in the global economy (Wu & Anderson, 2015).

STEM as a form of teaching based on science, technology, engineering, and mathematics has received various attention and has been widely recognized as one of the contemporary forms of science that deserves to be improved. STEM is one of the solutions to problems in the world, especially in the field of education (Sheffield, Koul, Blackley, Fitriani, & Rahmawati, 2018). One of the STEM roles is as means to overcome student achievement both nationally and internationally and prepare students to be competitive in the global economy (English & King, 2015). STEM education has an important role in the development of education today. Therefore, students as the next generation who face complex problems in the future will no longer have problems and they are able to compete globally, especially as a workforce that tends towards the technological era.

The success or failure of STEM learning also lies in the teacher's ability. Not only students who will face these changes, but for prospective teachers must also be able to adjust to various changes that exist. STEM-based learning is expected to be applied by prospective teachers so that what has become the goal of education today can be fulfilled. The success of students in facing the global world today certainly has a teacher's role in it. The application of STEM can be supported by various learning methods. Integrative STEM allows various learning methods to be used to support its application (Ruiz-Gallardo, Castaño, Gómez-Alday, & Valdés, 2010; Jo & Ku, 2011; Wirkala & Kuhn, 2011; Mayer, Moeller, Kaliwata, Zweber, Stone, & Frank, 2012; Sandi, Cooper, & Stevans, 2012).

In education, STEM has been integrated into the curriculum using a holistic approach to teaching students to analyze and solve problems using technology and collaborative learning strategies. However, developed and developing countries, including Indonesia, face challenges in improving STEM education (Caprile, Palmen, Sanz, & Dente, 2015). In Indonesia, STEM is taught separately in science and math lessons (Sheffield et al., 2018). Although these subjects are considered important and highly valued, STEM as an integrated subject itself has not been well developed. STEM can be seen as the integration of subjects through a paradigm shift that focuses on mathematics and the development of



ICT literacy. Therefore, to successfully integrate STEM into the curriculum, adjustments are needed. STEM has been widely applied in learning. This situation is shown from the results of research that reveal that the application of STEM can improve students' academic and non-academic achievements (Cancilla, 2001; Bigelow, 2004; Gijbels, Dochy, Bossche, & Segers, 2005; Lam, Doverspike, Zhao, Zhe, & Menzemer, 2008; Lou, Iu, & Shih, 2011; Massa, Dischino, Donnelly, & Hanes, 2011; Reynolds, Yazdani, and Manzur, 2013).

In 2015, Australia established a "National STEM School Education Strategy 2016-2026" program on STEM education strategies to improve students' STEM abilities and aspirations (Murphy, MacDonald, Danaia, and Wang, 2019). The research explains about the capacity of educators in learning STEM. The results show that the STEM education strategy that has been applied has a great influence in building students' STEM abilities. Çalisici, Sümen (2018) conducted a study of the perceptions of prospective teachers about the STEM approach, showing that prospective teachers consider STEM to be a useful and necessary and highly valued approach that involves additional fields. In several categories, it was found that there were significant differences in the level of participants based on gender and grade level. In addition, Deveci (2019) conducted a study to examine reflections on STEM teacher teacher awareness. The results showed that STEM teacher candidates' awareness was greatly influenced by what they had done before. This explains that a person's understanding of something is influenced by what they learned before. From several studies that have been explained it is important to review the extent of STEM perceptions for prospective teachers, if viewed from the initial knowledge, readiness to their career path.

Research Method

This study uses descriptive analysis, to reveal the importance of STEM education. The instrument used is the Perception Instrument for Mathematics Teachers in STEM Education-Based Learning. This instrument consists of 20 questions that contain the views and knowledge of prospective teachers towards STEM. The item on the instrument contain several aspects including the initial knowledge of STEM, readiness in implementing STEM, and the effect of STEM on career paths. The sample in the study were the final semester students in the education department with 30 people. The sample selection aims to determine the extent of knowledge about STEM and their readiness in implementing STEM-based learning after graduation. Final semester students have gone through a whole series of lectures about the learning process in the classroom and microteaching, so that armed with that knowledge will make them understand about the application of STEM. The selection of this sample is in accordance with the initial objectives of the study, which is to determine the perceptions of prospective teachers who will later become teaching staff in various schools.

Discussion

The role of STEM education greatly contributes greatly to improving the quality of education. The following are the results of the research in the form of descriptions of the attitudes of prospective teachers towards STEM education.

Table 1.

Item	1	2	3	4	5	6	7	8	9	10
Statement	+	+	+	-	+	-	+	-	+	-
Median	3	3	4	2	3	2	4	2	3	2
Modus	3	3	4	2	3	2	4	2	3	2
Percentage	39%	55%	55%	71%	39%	71%	61%	52%	48%	61%

Table 2.

Item	11	12	13	14	15	16	17	18	19	20
Statement	+	-	+	+	+	-	+	+	+	+
Median	3	3	3	3	3	2	3	3	3	4

Modus	3	3	3	3	3	2	3	3	3	4
Percentage	45%	29%	42%	61%	68%	65%	68%	19%	35%	52%

More than 50% of prospective teachers agree that STEM education needs to be studied from the elementary to tertiary level. In addition, prospective teachers strongly agree that STEM education is an integrated learning between science, technology and mathematics. Prospective teachers do not agree that STEM education cannot develop students' creativity through a problem-solving process and prospective teachers agree that STEM education for students is expected to deliver students to fulfill 21st century abilities and skills. Prospective teachers do not agree that STEM education cannot provide learning and innovation skills that include critical, creative, innovative thinking and being able to collaborate. The next response, prospective teachers agreed that STEM education students will be able to use media, technology, information and communication.

From the results of the research conducted, around 98.8% of respondents knew the importance of STEM education. This shows that until now STEM has been widely known to the public and certainly has been applied. Thus, the problems that arise in the world of education and the global world can be solved and able to make changes, discover new things, understand themselves, and be able to master technology (Lantz, 2009). Awareness of the need for STEM education was also shown by respondents with a percentage of 96.7%. This shows that teachers in the future are expected to be able to become a pioneer for the development of science and technology that is more fundamental to the needs of the moment. In line with this, 73% answered strongly disagree if STEM education cannot develop students' creativity through problem solving processes. This shows that awareness of the importance of STEM education has grown in prospective educators. Thus, the hope of forming a generation that meets the capabilities and skills of the 21st century will be achieved.

The results of the research described above show that STEM education is very necessary to support the achievement of the goals of 21st century education. The assessment of 21st century education places more emphasis on active student learning in terms of education in schools. The process shifts the role of the teacher who used to be the center of learning now to become a student. Besides that, the forms of learning that are critical thinking and problem solving, communication, collaboration, creativity and innovation are also characteristics of 21st century learning. According to Koenig (2011) that the demands of work require a person to have broad cognitive and affective skills that often referred to as 21st century skills. These skills include the ability to solve complex problems, to think critically about tasks, to communicate effectively with people from different cultures and to use different techniques, to work together with others, to adapt to the environment and conditions that change quickly to do tasks, to effectively manage one's work, and to acquire new skills and information on their own. As we know that STEM education emphasizes students to be more active because the learning process that is initially teacher-centered is now centered on students who rely on the activeness and collaboration of students. This is in line with the 21st century education pattern which requires students to be more active in every learning.

Education in the 21st century demands a significant amount caused by the global economic climate that focuses on innovation and creativity. Creativity is an ability that has an important enough position to be owned by every person, organization, or a nation, this is a provision to be able to survive in competition in the 21st century. To create the ability of creativity, the mastery of concepts is needed as a basis for producing creative change. Mastery of the concept of knowledge in solving problems is the main prerequisite to produce creativity (Lubart & Sternberg, 1995) & Cropley, 2009). In addition, research results prove that mastery of the concept of knowledge is very important in realizing creativity, among others, Baer (2003) Then, the results of research by Amabile & Grysiewicz (1989) which states that it takes three variables for creativity to be formed: domain-relevant skills, creativity relevant skills, and task motivation.

Prospective teacher awareness about this makes the STEM-based education process easy to implement. Based on the results of research that has been done, almost all respondents showed agree on the importance of STEM education. A qualified teacher can help students achieve a higher level of

knowledge. Some researchers have proven this. Through his research shows that the readiness of an education will have a major impact on the progress of student achievement (Rule & Hallagan, 2006; Hibpshman in Ejiwale, 2013). The aim of STEM education is to prepare students to face 21st century competition.

For prospective teachers, provisions for STEM learning are needed. The current phenomenon shows the lack of development about teacher professionalism on this subject. Support from the leadership is also needed for the success of the program. The ability of teachers to manage classes is also one of the determinants of the success of STEM education. Teaching methods determine the extent to which students can understand teaching material well. The teacher as a facilitator in the class besides having to have knowledge of the content / material to be taught also must have the ability to deliver lessons. These two things are something that is “mandatory” owned by the teacher.

Conclusion

From the explanation that has been described shows that the importance of STEM education is to achieve the goals of 21st century education. Teacher’s ability is one of the determinants of student success. Nevertheless, it is not entirely the responsibility of teacher, environmental factors also have an important role. Support from sharing parties is also needed especially from stakeholders in order to issue policies that support STEM education including the provision of adequate facilities and infrastructure.

REFERENCES

- Amabile, T. M., & Grysiewicz, N. D. (1989). The creative environment scales: Work environment inventory. *Creativity research journal*, 2(4), 231-253.
- Baer, R. A. (2003). Mindfulness training as a clinical intervention: A conceptual and empirical review. *Clinical Psychology: Science and Practice*, 10(2), 125-143.
- Bigelow, J. D. (2004). Using problem-based learning to develop skills in solving unstructured problems. *Journal of Management Education*, 28(5), 591-609.
- Çalisici, H. & Sümen, Ö. Ö. (2018). Metaphorical perceptions of prospective teachers for STEM education. *Universal Journal of Educational Research*, 6(5), 871-880.
- Cancilla, D. A. (2001). Integration of environmental analytical chemistry with environmental law: The development of a problem-based laboratory. *Journal of Chemical Education*, 78(12), 1652-1660.
- Caprile, M., Palmén, R., Sanz, P., & Dente, G. (2015). Encouraging STEM studies for the labour market.
- Cropley, D. H. (2009). Fostering and measuring creativity and innovation: individuals, organisations and products. In E. Villalba (Ed.), *Measuring Creativity* (pp. 257-278). Luxembourg: OPOCE.
- Deveci, İ. (2019). Reflections of Rube Goldberg Machines on the Prospective Science Teachers’ STEM Awareness. *Contemporary Issues in Technology and Teacher Education*, 19(2), 195-217.
- Ejiwale, J. A. (2013). Barriers to successful implementation of STEM education. *Journal of Education and Learning*, 7(2), 63-74.
- English, L. D. & King, D. T. (2015). STEM learning through engineering design: Fourth-grade students’ investigations in aerospace. *International Journal of STEM Education*, 14(2), 1-18.
- Gijbels, D., Dochy, F., Bossche, P. V., & Segers, M. (2005). Effects of problem-based learning: A meta-analysis from the angle of assessment. *Review of Educational Research*, 75(1), 27-61.
- Jo, S. & Ku, J.-O. (2011). Problem based learning using real-time data in science education for the gifted. *Gifted Education International*, 27, 263-273.
- Koenig, J. A. (2011). *Assessing 21st Century Skills: Summary of a Workshop*. Washington, DC: The National Academy Press.
- Lam, P., Doverspike, D., Zhao, J., Zhe, J., & Menzemer, C. (2008). An evaluation of a STEM program for middle school students on learning disability related IEPs. *Journal of STEM Education*, 9(1), 21-29.
- Lantz, H. B. (2009). Science, Technology, Engineering, and Mathematics (STEM) Education What Form? What Function?

- Lou, S. J., Liu, Y. H., Shih, R. C., & Tseng, K. H. (2011). The senior high school students' learning behavioral model of STEM in PBL. *International Journal of Technology and Design Education*, *21*(2), 161-183.
- Lubart, T. I., & Sternberg, R. J. (1995). An investment approach to creativity: Theory and data. In S. M. Smith, T. B. Ward, & R. A. Finke (Eds.), *The Creative Cognition Approach* (pp. 269-302). Cambridge, MA: Massachusetts Institute of Technology.
- Massa, N., Dischino, M., Donnelly, J. F. & Hanes, F. D. (2011). Creating Real-World Problem-Based Learning Challenges in Sustainable Technologies to Increase the STEM Pipeline.
- Mayer, R., Moeller, B., Kaliwata, V., Zweber, B., Stone, R., & Frank, M. (2012). Educating engineering undergraduates: effects of scaffolding in a problem-based learning environment. In *Proceedings of the Human Factors and Ergonomics Society Annual Meeting* (Vol. 56, No. 1, pp. 2507-2511). Los Angeles, CA: SAGE Publications.
- Murphy, S., MacDonald, A., Danaia, L., & Wang, C. (2019). An analysis of Australian STEM education strategies. *Policy Futures in Education*, *17*(2), 122-139.
- Reynolds, D., Yazdani, N. & Manzur, T. (2013). STEM high school teaching enhancement through collaborative engineering research on extreme winds. *Journal of STEM Education*, *14*(1), 12-19.
- Ruiz-Gallardo, J. R., Castaño, S., Gómez-Alday, J. J., & Valdés, A. (2011). Assessing student workload in Problem Based Learning: Relationships among teaching method, student workload and achievement. A case study in Natural Sciences. *Teaching and teacher education*, *27*(3), 619-627.
- Rule, A. C. & Hallagan, J. E. (2006). *Preservice Elementary Teachers Use Drawings and Make Sets of Materials to Explain Multiplication and Division by Fractions*. A Research Study Presented at the 2nd Annual Preparing Mathematicians to Educate Teachers (PMET) Conference at Oswego, New York, June 6, 2006.
- Sandi-Urena, S., Cooper, M., & Stevens, R. (2012). Effect of cooperative problem-based lab instruction on metacognition and problem-solving skills. *Journal of Chemical Education*, *89*(6), 700-706.
- Sheffield, R., Koul, R., Blackley, S., Fitriani, E., & Rahmawati, Y. (2018). Transnational examination of STEM education. *International Journal of Innovation in Science and Mathematics Education*, *26*(8), 67-80.
- Valerio, J. (2014). *Attrition in science, technology, engineering, and mathematics (STEM) education: Data and analysis*. Nova Science Pub Inc: UK.
- Wirkala, C. & Kuhn, D. (2011). Problem-based learning in K-12 education: Is it effective and how does it achieve its effects? *American Educational Research Journal*, *48*(5), 1157-1186.
- Wu, Y. T., & Anderson, O. R. (2015). Technology-enhanced stem (science, technology, engineering, and mathematics) education. *Journal of Computers in Education*, *2*(3), 245-249.