JPII 5 (1) (2016) 94-100

Jurnal Pendidikan IPA Indonesia

http://journal.unnes.ac.id/index.php/jpii

STEM LEARNING IN MATERIAL OF TEMPERATURE AND ITS CHANGE TO IMPROVE SCIENTIFIC LITERACY OF JUNIOR HIGH SCHOOL STUDENTS

N. Khaeroningtyas[1], A. Permanasari[2], I. Hamidah[3]

[1]SMP N 1 Bumiayu, Jawa Tengah, Indonesia
[2, 3] Universitas Pendidikan Indonesia, Bandung, Indonesia

DOI: 10.15294/jpii.v5i1.5797

Accepted: 18 January 2016. Approved: 27 March 2016. Published: April 2016

ABSTRACT

This research aims to determine the improvement of students' scientific literacy after STEM (Science, Technology, Engineering, and Mathematics) learning using 6E Learning by DesignTM Model on temperature and its changes material. The research was conducted in SMP Negeri (State Junior High School) 1 Bumiayu in the academic year 2015/2016. The method used was quasi-experimental design with The Matching Only - pretest posttest control group design. This study used two group of experiment group of students who learned the material with STEM learning using 6E Learning by DesignTM, while the control group students learned with non-STEM learning. The analysis showed that the students' scientific literacy in experiment group is better than control group. The conclusion that can be drawn is STEM learning using 6E Learning by DesignTM on temperature and its changes material can improve students' scientific literacy.

Keywords: 6E Learning by DesignTM Model, Scientific Literac, STEM, Temperature and Its Changes.

INTRODUCTION

Scientific literacy is an important thing to be mastered by students (Gucluer & Kesercioglu, 2012). This is because the individual achievement in science knowledge and skill implies on their readiness in the era of advanced technology use in the future (OECD, 2013). According to DeBoer (2000), scientific literacy term was first used in 1958 by Hurd, McCurdy and Rocklefeller Fund. Scientific literacy can be defined as an ability to understand the process of science and to engage with the available scientific information in daily life (Fives et al., 2014).

Science learning in Indonesia that leads to the formation of students' scientific literacy is still rarely to do. Most of the learning activity is still conducted conventionally and focus on students' conceptual mastery. One of them is shown by the data quality measurement of students' science learning outcomes internationally. Indonesian students' scientific literacy skill in science concepts included in low category in 2009, it was in the number of 57 of the 65 countries and in the number of 64 of 65 countries in 2012 (OECD, 2013).

The poor quality of students' science learning outcomes shows that the science learning process of schools in Indonesia is still ignoring the acquisition of students' scientific literacy (Toharudin et al., 2011). Therefore, the improvement of learning process of science that lead to the achievement of scientific literacy of students needs to be done to improve the quality of students' science learning outcomes.

One of the learning practices in Indonesia that can be developed is learning by integrating Science, Technology, Engineering, and Mathe-

***Alamat korespondensi:**
Email: nisakhaeroningtyas@yahoo.co.id

matics (STEM). National STEM Education Center (2014) in Firman (2015) stated that STEM learning does not only mean strengthening of practical education of STEM fields separately, but it is rather to develop an educational approach that integrates science, technology, engineering and math, by focusing on the educational process in daily life real solving. STEM education is able to form human resources' (HR) reasoning and thinking critically, logically, and systematically (Asmuniv, 2015). Learning through the integration of STEM can make students better prepared in the STEM field jobs (Brown et al., 2011), increase interest and achievement in mathematics and science (Stohlmann et al., 2012). OECD (2013) stated that an understanding of science and technology significantly contributes to the personal, social, professional and cultural lives of everyone.

STEM learning is related to the characteristics of science materials in junior high because some of them are closely related to technology, engineering and mathematics. Through STEM, learning process will be more meaningful so students' scientific literacy can be achieved.

The application of STEM learning can be done with various models (Carter, 2013), one of them is 6E Learning by Design™ model. This learning model combines inquiry learning and design. 6E Learning by Design™ model developed by the International Technology and Engineering Educators Association (ITEEA) by incorporating technology and engineering in learning process to become integrated STEM learning. Sanders (2009) in Burke & Barry (2014) stated that The ITEEA 6E Learning by Design™ models provides a student centered framework for instruction that leverages the T and E of STEM as integrates content in a purposeful and informed way.

This study aims to determine the improvement of students' scientific literacy after STEM learning using 6E Learning by Design™ on temperature and its changes material. Researchers chose temperature and its changes material because it is closely related to science, technology, engineering and mathematics in daily life.

METHOD

The method used in this study was quasi-experimental. In the experimental study, researchers give a different treatment between the two groups, and then study the effects of such treatment. The characteristic of quasi-experimental research is that researcher can not control all variables, except for some specific variables. The independent variable in this research is STEM learning using 6E Learning by Design™ on temperature material, and the dependent variable is students' scientific literacy.

Subjects were divided into two groups, they are experimental group obtained STEM learning using 6E Learning by Design™ and control group obtained non-STEM learning.

The research design was Matching Only – Pretest Posttest Control Group Design. In this design, pretest was conducted in both groups. Measurement or observation was performed at the same time for both groups (Fraenkel et al., 2011). Diagram of the design can be seen in Figure 1.

Experiment group	M	O	X	O
Control group	M	O	C	O

Figure 1. Matching Only – Pretest Posttest Control Group Design Design

Both groups were pretest with instrument of test material that has been tested for its validity and reliability. Pretest is intended to determine the initial ability of both groups. Then those groups were given different treatment. To determine whether there is the effect of treatment, posttest was given to both groups.

Research was conducted in SMP Negeri 1 Bumiayu with population of seventh grade students in odd semester academic year 2015/2016. Samples are two classes of class VII E (experimental group) and class VII G (control group). Sample selection was done by random sampling class technique.

The research was conducted in three steps consisting of planning, implementation and final. In the planning steps, literature study on scientific literacy and STEM learning using 6E Learning by Design™ was done then instruments of scientific literacy test was prepared and validated the by four expert lecturers. The instrument trial was also conducted to students who have received the learning material of temperature and its changes, to obtain the validity and reliability of scientific literacy test instrument. Valid means the instrument can be used to measure what should be measured (Sugiyono, 2015). Data analysis technique is test instrument validity, reliability, difficulty level and discrimination power using Anates ver 4.0.9 application. In the implementation step, researchers conducted STEM learning using 6E Learning by Design™ in the experimental group and non-STEM learning in the control group.

In the final steps, the data were analyzed using SPSS 16 and reported. Before conducting

the research, students' initial was measure to ensure there was no difference of ability between the experimental and control group. Initial ability test data were taken from pretest of both groups then analyzed using SPSS 16 software.

Tests of Normality using Shapiro-Wilk test showed that the control and experimental groups were normalyl distributed (Sig. of control group = 0.216> α = 0.05 and Sig. of experimental group = 0.153> α = 0.05). Meanwhile Test of homogenity using Lavene test also showed that pretest data of both groups varied homogeneously (Sig. Based of Mean = 0.475> α = 0.05). Hypothesis testing of students' initial ability was done using Independent Samples Test. Sig test Independent Samples Test = 0.388> α = 0.05 (H_0 was accepted) so that it can be concluded there was no difference in the initial students' scientific literacy ability both of control and experimental groups.

To see the improvement of students' scientific literacy after applying STEM learning using 6E Learning by Design™ on temperature and its changes material, then hypotheses were formulated; null hypothesis (H_0 = There is no significant difference of scientific literacy improvement between experimental and control group) and alternative hypothesis (Ha = There is significant difference of scientific literacy improvement between experimental and control group). To categorize the level of scientific literacy improvement, it used the data normalized gain (N-Gain). Interpretation (N-Gain) is (1) high = if $g \geq 0.7$; (2) average = if $0.7 > g \geq 0.3$; (3) low = if $g < 0.3$. (Hake, 1998).

RESULT AND DISCUSSION

STM learning on temperature and its chages material was divided into two parts, of STEM learning in temperature material and STEM learning in expansion material.

STEM learning using 6E learning by design™ on temperature material was conducted through six steps of learning. Step (1), Engage, aims to emerge students' interest so students would actively participate in learning process. In this step students paid attention to pictures and illustrations of story about the concept of tempe-

Kelompok : 1 (Genius)

JURNAL DESAIN *ENGINEERING*

Mendesain Pembuatan Skala Termometer

1. Identifikasi Pengetahuan yang dibutuhkan dalam desain Engineering :

Identifikasikan apa yang **telah** kalian ketahui!	Identifikasikan apa yang kalian **butuhkan** untuk diketahui!	Identifikasikan apa yang **ingin** kalian ketahui!
✓ Konsep partikel zat padat, zat cair, dan zat gas	✓ Pengertian tentang suhu	✓ Pengertian tentang suhu
✓ Energi panas (kalor)	✓ Cara mengetahui suhu benda	✓ Cara mengetahui suhu benda
✓ Bagaimana cara mengetahui suhu benda	✓ Cara menggunakan termometer dengan benar	✓ Cara menggunakan termometer dengan benar
✓ Pengertian tentang suhu.	✓ Prinsip kerja termometer	✓ Prinsip kerja termometer
○ Cara menggunakan termometer dengan benar	✓ Jenis - jenis termometer	✓ Jenis - jenis termometer
○ Prinsip kerja termometer	✓ Titik tetap atas dan titik tetap bawah dalam penentuan skala suhu.	✓ Titik tetap atas dan titik tetap bawah dalam penentuan skala suhu.
✓ Jenis - jenis termometer	✓ Menghitung konversi skala suhu.	✓ Menghitung konversi skala suhu.
○ Pengertian titik tetap atas dan titik tetap bawah dalam penentuan skala suhu.	✓ Cara membuat skala suhu.	✓ Cara membuat skala suhu.
○ Menghitung konversi skala suhu.		
○ Cara membuat skala suhu.		

Permasalahan penyelidikan yang akan kami lakukan adalah :
Bagaimana cara mendesain pembuatan skala termometer ?

Nilai – nilai kemanusiaan" yang dapat kami peroleh dengan mempelajari materi suhu dan perubahannya :
toleransi, sabar, bertanggung jawab, tolong menolong, teliti, dan hati-hati

Figure 2. Engineering Journal Design

rature shown by teacher, it was to explore memories of particles of matter concept. Furthermore, students used the engineering journal design to identify what they have already known, what they need to know and what they need. Students also identified problems of investigation of the and " the value of humanity" that can be obtained by studying temperature material (example of Engineering journal design is presented in Figure 2).

Step (2), Explore, aims to give students the opportunity to build their own understanding of the topics / materials. In this stage, student demonstrated an experiment to measure the temperature of water using sensory organs, then found out about the concept of thermometer and its types, making thermometer scale in Celsius thermometer, temperature scale conversion concepts from various sources, including the internet. In this case the teacher acted as facilitator by providing materials and guiding students to focus on learning. Students inquirí process was the guidance in exploration process. Stage (3), Explain, aims to give students the opportunity to clarify and improve on what they have learned and determined its meaning. Explain steps is where students communicate what they have learned. Stage (4), Engineer was in the fourth steps aimed to give students the opportunity to build a deeper understanding of material by applying the concept, practice and attitude. Students used the concepts that they have learned in the explore steps to design the thermometer scale manufacture.

The next is step (5), Enrich, which aims to provide students the opportunity to explore more deeply about what they have learned and to transfer the concept into more complex problem. During this steps, students enriched the knowledge of adaptation mechanisms oof humans, animals and plants in maintaining stable body temperature.

The last step is (6) Evaluate where students and teacher determined how much learning and understanding they got. Students used self-evaluation sheet to assess the understanding of material. In addition, students assessed attitudes through self-assessment and peer assessment.

The improvement of students' scientific can be seen through the Gain value data formulated from score minus. The data is presented in Figure 3.

Figure 3 shows the improvement score of experimental group is higher than control group. To see whether after applying STEM learning using 6E Learning by Design™ model in temperature and its changes material would be different significantly with non-STEM learning, the data pretest and posttest in both groups was analyzed using SPSS 16 with difference test of two independent samples. Before testing the hypotheses, normality and homogeneity test were performed. Normality test results based on the Shapiro-Wilk test showed the students' scientific literacy of control and experimental group were normally distributed because Sig. control group value = 0.317> α = 0.05 and Sig. experiment group value = 0.255> α = 0.05. Homogeneity test using Levene showed that the data varied homogeneously because Sig. = 0.728> α = 0.05.

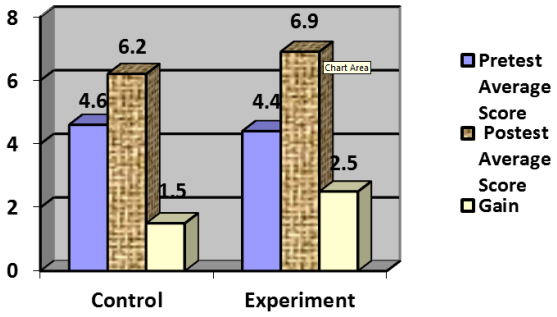

Figure 3. Pretest and posttest score of students in temperature material

Both data were normally distributed and homogeneously varied then test of independent samples of t test was performed. Independent Samples Test The test results showed the value of Sig. (2-tailed) = 0.003 <α = 0.05. Therfore it can be interpreted that the null hypothesis is rejected, which means there is significant difference of students' scientific literacy improvement in control and the experimental group. Average score of students' scientific literacy in experimental and control groups is presented in Table 1.

Table 1. N- Gain Average and Classification of Students' scientific literacy

Group	N-Gain Average	Classification
Control	0,27	Low
Experiment	0,44	Moderate

The improvement of students' scientific literacy who obtained STEM learning using 6E Learning by Design™ Model in temperatures material was higher than non-STEM learning. Scientific literacy is in line with STEM literacy, for example understanding the concepts and procedural skills and ability of the individual to demonstrate STEM relation to the personal, social and global issues (Bybee, 2010). Students who obtained STEM learning will be more literate in STEM aspects, so students' scientific literacy will

automatically increase. This improvement also shows that the junior high school students can receive STEM learning, as well as Verma et al. (2011 that has successfully engaged students in STEM learning through 5E Learning Cycle.

STEM learning using 6E Learning by Design™ Model is basically a blend of inquiry and design. At explore step, students are guided by the Students' Worksheet (LKS) to find its own concept of material and designi experiments to solve the problems. The discovery of the concept through this inquiry is believed to make learning more meaningfully and to increase students' achievement in science. This is in line with McCright (2012) that stated the project-based inquiry learning can improve knowledge, principle and science process. Learning strategy by linking professional practice (STEM) is also meaningful strategies (Dierdorp et al., 2014).

The improvement of students' scientific literacy can be happened because they are more motivated to be able to design a thermometer scale and given the chance to access information via internet (technology). Gutherie et al. (2000) in his research concluded that by integrating STEM learning can increase students' motivation in learning. Moreover, in Engineer step it showed that students were more creative in designing the thermometer scale. In this step, students created their own thermometer by using simple tools. It is unexpected plan to design their own thermometer scale from non scale thermometer in the laboratory school. This is in line with Stohlmann Morrison et al. (2012) that stated there are some advantages in STEM learning, including making students to be better at solving problems, innovator, inventor, confident, thinking logically and literate in technology; it also can improve students' creative thinking skills (Oktavia, 2015). Engineering design beyond the planning made the researcher must be fast and responsive in designing learning process so it can be continued smoothly.

STEM learning in expansion material was done through the same steps with temperature material. In expansion material, students were asked to design an investigation to prove that a matter can expand. Students did the same design of designing the investigation of gas expansion in a balloon.

Students' scientific literacy of experimental and control groups is presented in Figure 4.

The score improvement of experimental group was higher than control group. Normality test results based on the Shapiro-Wilk test showed that scientific literacy data of control and experimental groups was because normally distributed control because Sig. control group = 0.129> α = 0.05 and experimentation Sig. experimental group value = 0.092> α = 0.05. Homogeneity test using Levene test showed the data is not homogeneously varied because Sig. = 0,041 < α = 0.05.

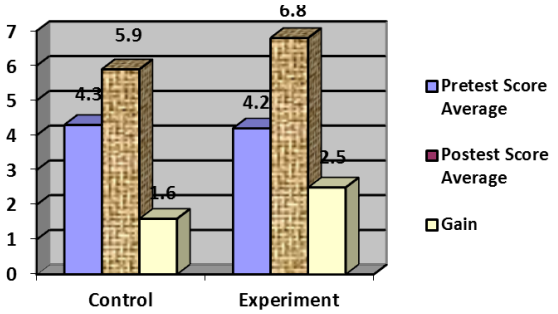

Figure 4. Pretest and posttest score of students in expansion material

Both data were normally distributed but not homogeneously varied so the test was conducted by using independent samples t test by see the data in equal variance not assumed. Value Sig. (2-Tailed) = 0.017 < α = 0,05 showed null hypothesis was rejected that implies there was a difference of students' scientific literacy improvement between control and experimental groups

Average score of students' scientfic literacy of control and experimental groups in expansion material is presented in Table 2.

Table 2. N- Gain Average and Classification of Students' scientific literacy

Group	N-Gain Average	Classification
Control	0,26	Low
Experiment	0,44	Moderate

Table 3. Research Result of Both Steps

Fase	Score Average	N-Gain Average	N-Gain Average	Category
1. STEM with 6E Learning by Design™ Model Temperature material	69	2,5	0,44	moderate
2. STEM with Model 6E Learning by Design™ Expansion material	68	2,55	0,44	moderate

The improvement of students' scientific literacy who obtained STEM learning using 6E Learning by Design™ Model in expansion material was higher than non-STEM learning.

The data of research from both steps are presented in Table 3.

The improvenment of scientific literacy in both steps resulted the same result. However, if look further the second material is harder than the first, this indicates that students' scientific literacy can be built and increased if the learning process keeps training the thinking skills as required in the implementation of the 6E learning by design™ model based on STEM , In line with Becker & Park (2011) that stated learning by integrating STEM will bring positive impact on students' learning process.

CONCLUSION

STEM learning using 6E Learning by Design™ Model in temperature and its changes can improve students' scientific literacy. The result indicates that scientific literacy can be improved if this model is applied continuously.

ACKNOWLEDGEMENTS

We would like to thank to Ucapan terima kasih diberikan kepada Directorate general of Higher Education through the Chairman of The Institute for Community Research and Service In Semarang State University who funded through Decentralization Program of Competitive Grants.

REFERENCES

Asmuniv. (2015). *Pendekatan Terpadu Pendidikan STEM Upaya Mempersiapkan Sumber Daya Manusia Indonesia yang Memiliki Pengetahuan Interdisipliner dalam Menyongsong Kebutuhan Bidang Karir Pekerjaan Masyarakat Ekonomi Asean (MEA)*. Published on Friday, 15 Mei 2015.

Becker, K & Park, K. (2011). Effects of integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students' learning: A preliminary meta-analysis. *Journal of STEM Education, 12*(6), 23-37.

Brown R, Brown J, Reardon K & Merrill C. (2011). Understanding STEM: Current Perceptions. *The Technology And Engineering Teacher, 70*(6), 5-9.

Burke, DTE & Barry N. (2014). 6E Learning byDesign™ Model. *The Technology And Engineering Teacher*, *70*(1), 14-19.

ByBee, R.W. (2010). Advancing STEM education: A 2020 vision. *The Technology And Engineering Teacher*, *70*(1), 30-35.

Carter, Vinson R. (2013). *Defining Characteristics of an Integrated STEM Curriculum in K-12 Education*. (Disertasi). Arkansas: University of Arkansas. Retrieved from: ProQuest Digital Dissertations. (UMI Number: 3566045).

DeBoer, GE. (2000). Scientific Literacy: Another Look at Its Historical and Contemporary Meanings and Its Relationship to Science Education Reform. *Journal of Research in Science Teaching*, 37(6), 582-601.

Diedrop A, Bakker A, Maanen, JAV & Eijkelhof, HMC . (2014). Meaningful Statistics in Professional Practices as a Bridge Between Mathematics and Science: An Evaluation of a Design Research Project. *International Journal of STEM Education*, 5*(1)*, 1-9.

Firman, Harry. (2015). *Pendidikan Sains Berbasis STEM: Konsep, Pengembangan, dan Peranan Riset Pascasarjana.* Seminar Nasional Pendidikan IPA dan PKLH, Universitas Pakuan Bogor, Indonesia.

Fives H., Birnbaum, AS. & Nicholich M. (2014). *Developing a Measure of Scientific Literacy for Middle School Student.* Published online 18 June 2014 in wileyonlinelibrary.com.DOI.10.1002/sce.21115.

Fraenkel JR, Wallen NE & Hyun HH. (2012). *How to Design and Evaluate Research in Education*. United States: Mc Graw Hill.

Gucluer, E & Kesercioglu, T. (2012). The Effect of Using Activities Improving Scientific Literacy on Students' Achievement in Science and Technology Lesson. *International Online Journal of Primary Education*, *1*(1), 3-10.

Gutherie, J.T., Wigfield A & VonSecker C. (2000). Effect of Integrated Instruction on Motivation and Strategy Use in Reading. *Journal of educational psychology*, *92*(1), 331-341, doi:10.1037/0022-0663.92.2.331.

Hake, R.R. (1998). Interactive-engagement vs traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics, 66*(1), 64-74.

McCright, Aaron M. (2012). Enhancing Students' Scientific and Quantitative Literacies through an Inquiry-Based Learning Project on Climate Change. *Journal of the Scholarship of Teaching and Learning*, *12*(4), 86-102.

Stohlmann M, Tamara J.M & Gillian H.R. (2012). Conciderations for Teaching Integrated STEM Education. *Journal of Pre-College Engineering Education Research (J-PEER),* 2(1), 22-29.

OECD. (2013). *PISA 2012: Assessment and Analytical Framework: Mathematics, Reading, Science, Problem Solving and Financial Literacy.* OECD Publishing. Retrieved from: http://dx.doi.org/10.1787/9789264190511-en.

Oktavia, Rani. (2015). *Penerapan Model Pembelajaran Model Proyek dengan Pendekatan Integrasi STEM dalam Meningkatkan Penguasaan Konsep dan Keterampilan Berpikir Kreatif Siswa SMP pada Materi*

Gelombang Bunyi. Thesis. Bandung : Universitas Pendidikan Indonesia.

Sugiyono. (2015). *Metode Penelitian Pendidikan (Pendekatan Kuantitatif, Kualitatif dan R&D).* Bandung: Alfabeta.

Toharudin, U., Hendrawati, S., & Rustaman, A. (2011). *Membangun Literasi Sains Peserta Didik*. Bandung: Humaniora

Verma, A. K, Dickerson, D., & McKinney, S. (2011). *Engaging Student in STEM Careers with Project—Based Learning-MarineTech Project*. *The Technology And Engineering Teacher, 70*(3), 19-26.