Enhancing concept mastery of students through STEM-project in scientific inquiry learning

D A Rachmayati¹, *, I Kaniawati² and H Hernani³

¹Sekolah Pascasarjana Pendidikan IPA, Universitas Pendidikan Indonesia, Jl. Dr. Setia Budhi No. 229, Bandung 40154, Indonesia
²Departemen Pendidikan Fisika, Universitas Pendidikan Indonesia, Jl. Dr. Setia Budhi No. 229, Bandung 40154, Indonesia
³Departemen Pendidikan Kimia, Universitas Pendidikan Indonesia, Jl. Dr. Setia Budhi No. 229, Bandung 40154, Indonesia

*deviaulia@upi.edu

Abstract. This study aims to examine the effect of STEM project in scientific inquiry learning towards enhancing concept mastery of students. The research method used was a quasi-experiment with the one group pretest-posttest design. Quantitative data was obtained through instrument of concept mastery test using a two-tier multiple choice instrument and then analyzed using dependent t-test. Based on the result of dependent t-test was found that there was significance difference between the pretest and posttest scores of students with sig = 0.000 (p<0.05). The enhancing between pretest and posttest score was obtained from N-gain analysis, the value of gain index is 0.64 showed that the enhancing of students’ concept mastery is in medium category. Based on the results obtained from this study, it showed that STEM project in scientific inquiry learning had positive impact on concept mastery of students, therefore it can be used as an alternative learning model in science learning that integrates technology.

1. Introduction

Moving on from the demands of 4.0 era in the 21st century is needed the innovative and effective learning so it will be able to develop students’ skills needed for solving the real world problem. In this time science teachers are faced with the challenge of being able to integrate technology in learning, technology which is integrated in learning will probably support the teaching learning process [1].

STEM learning which has an acronym for science, technology, engineering, and mathematics become one of the leading international discourse in education field [2]. Learning that integrate STEM approach involves separate disciplines namely science, technology, engineering and mathematics become a cohesive unit [3]. The real world problem will not find problems in separate disciplines, so the challenge for teachers is to be able to teach STEM disciplines in an integrated manner [4]. The successful of STEM learning occurs when the students get a basic understanding concept and move from low cognitive level such as remembering and knowing to high level thinking [5]. Students can have skills in recognizing a concept or practice in integrated manner by integration of more than one disciplines in STEM learning such as scientific experiments and engineering design in solving problems or projects [6].
Concept mastery is one of important thing in science learning, especially in integrating technology in learning, concept mastery will avoid occurring misconceptions when students applying their knowledge in engineering design process. The integration of technology in science learning will provide many benefits, the interaction between technology, content, and pedagogy is important in supporting the successful integration of technology in learning [1].

The aims of this study were to enhance the concept mastery of students through STEM-project in scientific inquiry learning. In this study, students would be asked to do a simple hydraulic bridge project which is one of technology product that can solve real world problem. Students will find difficulty in designing and constructing a prototype without being equipped with good concept mastery, meaningful learning is provided by STEM project through mastering and applying concepts in a project [7]. The implementation of the scientific inquiry learning model as a basis for conducting STEM project is expected to facilitate the integration of technology in science learning become more effectively. The research question in this study is how enhancing of students’ mastery concept through implementation of STEM-project in scientific inquiry learning?

2. Method

2.1. Research design and participant
This study is a quasi-experimental research using the one group pretest-posttest design [8]. The design of the one group pretest-posttest design used one class that was given pretest in the beginning before treatment and posttest after treatment. The description of the design in this study can be shown in Table 1.

| Pretest | Treatment | Posttest |
|---------|-----------|----------|

Table 1. The one group pretest-posttest design.

The participants of this study were 19 students of eight grade in junior high school in the city of Banda Aceh, Aceh Province by involving 1 science teacher who guided the learning process and 3 science teachers who observed the engineering design process of the students in each group. The treatment given in this study is implementing the STEM-project in scientific inquiry learning. The flow of learning implementation can be shown in Figure 1. The learning process began with implementation of scientific inquiry learning model as the basis for conducting the STEM-project which consists of several syntaxes namely orientation, problem formulation, hypotheses formulation, data collection, hypotheses test, and conclusion formulation [9]. The results of scientific inquiry learning model implementation will be a guideline for students in doing engineering design activities in STEM-project which consists of several stages namely problem scoping, idea creation, designing & constructing, assessing design, and redesigning & reconstructing [10].

![Flow of learning implementation](image-url)

Figure 1. Flow of learning implementation.
2.2. Data source and analysis
Concept mastery of students were measured using 16 multiple choice two tier questions constructed based on the basic competencies in 2013 curriculum revised 2017 for Pascal’s law concept. The instrument of mastery concept consists of 2 levels of dimension of cognitive process, namely understand (C2) and apply (C3) [11]. The instrument was validated by 5 experts in science education and then tested on 23 students. The validity of each questions were valid and the reliability value obtained were 0.69. The difference between pretest and posttest scores of students was analyzed using dependent t-test, while the enhancing in students’ concept mastery was analyzed through the gain index [12].

3. Result and discussion
Enhancing of pretest and posttest scores of students analyzed based on the gain index showed that in the medium category with gain index value = 0.64. An overview of the students’ pretest and posttest scores is shown in table 2.

| Category | Average of Scores (X̄) | N-gain | Pretest | Posttest |
|----------|------------------------|--------|---------|----------|
| Medium   | 42.76                  | 79.28  | 0.64    |          |

The enhancing of students’ concept mastery can be seen from the average pretest score of 42.76 while the average posttest score had enhanced to 79.28. Based on the results of the N-gain analysis obtained index gain 0.64 which indicates the enhancing in students’ concept mastery after being given treatment is in the medium category [13]. This shows that there is a significant enhancing in the concept mastery of students after the implementation of the STEM project in scientific inquiry learning.

Students' pretest and posttest scores were also analyzed using the dependent t-test to see if there were significant differences in the two scores, before that the normality test was also conducted which showed the data were normally distributed both pretest and posttest scores. The results of the analysis using the dependent t-test also showed that there were significant differences between the students' pretest and posttest scores which were marked by the acquisition of sig = 0.000 (p <0.05). The sig value obtained indicates rejection of H0. The overview of the normality test and dependent t-test are shown in table 3.

| Dependent T-Test | Sig. | Inter. | Sig. | Inter. |
|------------------|------|--------|------|--------|
| Pretest          | 0.405| Normal | 0.000| Significant difference |
| Posttest         | 0.220| Normal |      |        |

The results showed that the implementation of STEM-project in scientific inquiry learning had a positive impact on students’ concept mastery. In this study scientific inquiry learning leads students' initial knowledge more deeply so that students can develop their skills in providing solutions to the problems given, because in STEM integrated learning students are given the opportunity to obtain more realistic learning in solving problems in daily life [14], students can also develop their abilities in connecting science, technology, engineering and mathematics that can improve students’ mastery of concepts to be better [15].

The results of scientific inquiry learning become the guideline for students in engineering design process when doing STEM projects. The success in implementing scientific learning inquiry greatly determines how the engineering design process takes place in the STEM project. In its implementation, STEM brings scientific inquiry and engineering design together through the four disciplines where scientific inquiry involves questions that can be answered through investigation, while engineering design involves formulating problems that can be solved by constructing and testing prototypes during

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Table 2. Enhancing of pretest and posttest scores.

Table 3. The results of students’ concept mastery statistical test.
the design process [16]. Design and scientific inquiry are routinely used together as engineering solutions in solving real-world problems [17], besides that, projects guided by inquiry questions will encourage students to conduct an experiment and allow students to integrate the knowledge they get into the project [18].

4. Conclusion
There is an enhancing in the results of students’ concept mastery test scores after the implementation of STEM-project learning in scientific inquiry learning. This means that the implementation of the STEM project in scientific learning inquiry has a positive impact on improving students’ concept mastery to be better so that it can be one of alternative learning model that can be used in science learning that integrates technology.

References
[1] Dinçer S 2018 Are preservice teachers really literate enough to integrate technology in their classroom practice? Determining the technology literacy level of preservice teachers. 
Education and Information Technologies 1-20.
[2] Marrero M E, Gunning A M and Germain-Williams T 2014 What is STEM Education? 
Global Education Review 1(4)
[3] Breiner J M, Harkness S S, Johnson C C and Kochler C M 2012 What is STEM? A discussion about conceptions of STEM in education and partnerships. School Science and Mathematics 112(1) 3-11
[4] DeCoito I, Steele A and Goodnough K 2016 Introduction to the Special Issue on Science, Technology, Engineering, and Mathematics (STEM) Education Canadian Journal of Science Mathematics and Technology Education 16 109-113
[5] Basham J D and Marino M T 2015 Understanding STEM Education and Supporting Students Through Universal Design for Learning Teaching Exceptional Children 45(4) 8-15
[6] National Academy of Engineering and National Research Council 2014 STEM Integration in K-12 education: Status, prospects, and an agenda for research (Washington, DC: The National Academies Press)
[7] Jauhariyyah F R A, Suwono H and Ibrohim I 2018 Science, Technology, Engineering and Mathematics Project Based Learning (STEM-PjBL) pada Pembelajaran Sains In Seminar Nasional Pendidikan IPA 2017 2
[8] Fraenkel, Wallen and Hyun 2012 How to Design and Evaluate Research in Education (Eight Edition) (New York: McGraw Hill International Edition)
[9] Hosnan M 2014 Pendekatan saintifik dan kontekstual dalam pembelajaran abad 21: Kunci sukses implementasi kurikulum 2013 (Bandung: Ghalia Indonesia)
[10] English L D, King D and Smeed J 2017 Advancing integrated STEM learning through engineering design: Sixth-grade students’ design and construction of earthquake resistant buildings The Journal of Educational Research 110(3) 255-271
[11] Anderson L W, Krathwohl D R, Airasian P W, Cruikshank K A, Mayer R E, Pintrich P R, Raths J. and Wittrock M C 2001 A taxonomy for learning, teaching, and assessing: A revision of Bloom’s taxonomy of educational objectives, abridged edition White Plains
[12] Hake R R 2002 Relationship of Individual Student Normalized Learning Gains in Mechanic with Gender, High-School Physics, and Pretest Scores on Mathematics and Spatial Visualization. Physics Education Research Conference
[13] Hake R R 1999 Analyzing Change/Gain Scores American Educational Research Association’s Division D, Measurement and Research Methodology 13 Maret 1999.
[14] Stohlmann M S, Moore T J and Cramer K 2013 Preservice elementary teachers’ mathematical content knowledge from an integrated STEM modelling activity Journal of Mathematical
Modelling and Application 1(8) 18-31
[15] Komarudin U, Rustaman N Y and Hasanah L 2017 Promoting students’ conceptual understanding using STEM-based e-book In AIP Conference Proceedings 1848(1) 060008
[16] Kennedy T J and Odell M R L 2014 Engaging students in STEM education Science Education International 25(3) 246-258
[17] Sanders M E 2008 Stem, stem education, stemmania.
[18] Bell S 2010 Project-based learning for the 21st century: Skills for the future The Clearing House, 83(2) 39-43