The 20th Commemoration of JICA Cooperation in Education

JICA Reflective Meeting
The 13th ICLS and 3rd ICLIm

Fostering Elementary School Students Engineering Skills Through Ethno STEM Approach

Fitri Nuraeni[1] , Hafiziani Eka Putri[1] , Wulandari[1] , Zhaza Nabila Zahra[1]

Abstract

Problem-solving will run well if there is an engineering activity. Thus, students engineering skills become essential in problem solving. This research aims to assess and analyze the engineering skills of elementary school students who experienced the Ethno-STEM approach through the pounding technique eco print compared to those with the conventional approach. This research uses a quasi-experiment research method with a non-equivalent pretest-posttest control group design. The lesson is implemented with a blended learning system by integrating several subjects: enviromental education, science, and mathematics. The sample of the research is 48 fourth-grade students in Purwakarta. The students engineering skills test instrument is used to obtain data before and after learning. Results show that the improvement of engineering skills of elementary school students who received the Ethno-STEM approach through the pounding eco print is better than those who experienced conventional lessons.

Keywords: Ethno · STEM · Engineering Skills · Elementary School

INTRODUCTION

Problem-solving activities related to problems in the environment around students are very important in learning to give students experience in meaningful learning. So that students can realize that the lessons they learn in class can be helpful for their lives. In addition, meaningful learning can also shape students into good problem solvers for their environment.

However, problem-solving will not go well if no engineering skills exist. According to Guzey, Moore, Harwell, and Moreno (2016), engineering is defined as the process of designing real solutions to solve problems. Like engineers who carry out design activities when they want to create a new technology or design problem-solving in everyday life (Nuraeni, 2020). Through engineering activities, it is also possible for the integration of various disciplines to occur. So that the solutions created are not only one-way solutions but solutions based on concepts related to other disciplines through critical thinking activities so that the solutions created will be exciting, effective, and efficient (Nurhikmayati, 2019).

Engineering skills can be applied early at the elementary school level. According to Lachapelle & Cunningham (2014), engineering skills can be applied in elementary schools because children are natural creators and thinkers. Engineering skills are also one of the skills needed in the 21st century (Katehi, Pearson & Feder, 2009). Therefore, engineering skills are indispensable in learning to equip students to follow the development of existing science and technology (Lestari, 2017). The idea is in line with Undang-Undang No. 20 of 2003 concerning the national education system, which states that national education functions to develop the capabilities and character of a dignified civilization in the context of the nation's intellectual life. In other words, the education system in Indonesia will make every effort to prepare students to compete and overcome problems in the world through their knowledge and skills.

✉ Corresponding Author
fitrinuraeni@upi.edu

Hafiziani Eka Putri
hafizianiekaputri@upi.edu

Wulandari
wulandari18@upi.edu

Zhaza Nabila Zahra
zhaza.nabila@upi.edu

[1] Primary School Teacher Education, Indonesia University of Education

How to Cite: Nuraeni, F., Putri, H. E., Wulandari, W., Zahra, Z. N. (2022). Fostering Elementary School Students Engineering Skills Through Ethno STEM Approach. *The 13th Indonesia Conference on Lesson Study (ICLS) Conference Proceeding*, 75-82

However, in reality, students' engineering skills, especially in elementary schools, have not been an aspect that has been considered. Research on engineering skills in elementary schools, especially in Indonesia, is rarely found. Most existing research is only available at the secondary education level (Lestari, 2017; Rukoyah, 2020). Both research results imply that STEM-based learning can improve engineering skills. This increase was obtained because engineering is one of the components of STEM learning. Engineering is at the heart of STEM activities, including designing, manufacturing and testing (Nuraeni, 2020). Another reason is that this approach has an engineering design process (EDP) in its learning. Engineering skills are skills produced through the engineering design process (Hoeruni, 2017).

However, a learning approach that hones engineering skills alone is not enough to allow students to follow the development of science and technology and become good problem solvers in their environment. There must be a link between the lesson and the surrounding environment to achieve this goal. One environment that is close to students is local wisdom. Moreover, learning related to local wisdom occupies a vital position in supporting the achievement of national education goals in Indonesia, which is directed to form students with the skills to maintain culture and national identity in the era of globalization (BNSP, 2011). Therefore, a STEM approach emerged along with local wisdom called the Ethno-STEM approach, namely project-based learning that integrates four STEM fields with local wisdom to develop critical, creative, innovative, and collaborative thinking skills (Sumarni & Kadarwati, 2020)

Each region has different local wisdom. As in Purwakarta Regency, there is a tradition that every citizen and community leader routinely carries out by bringing crops to their leaders in droves. This tradition is called the "Seba Nagri Tradition," local wisdom whose one goal is to express gratitude to God for abundant natural products (Nugraha, 2016). This tradition is the element of Ethno in this research. Considering the aforementioned background, this research aims to assess and analyze the engineering skills of elementary school students who experienced the Ethno-STEM approach.

METHODS

This study uses a quasi-experimental research method with a nonequivalent control group design. An experimental group experienced the Ethno-STEM approach through the eco-print pounding technique, and the control group with conventional learning. This learning group was not chosen randomly but based on specific criteria called the purposive sampling technique (Garaika & Darmanah, 2020). The sample of this study was 48 fourth-grade elementary school students at one of the public elementary schools in Purwakarta Regency. The research instruments used include 1) Engineering skills tests; 2) Observation sheets on the lesson implementation; and; 3) Documentation. The engineering skills test indicators used in this study are 5 of 9 engineering skills indicators (Crismond & Adams, 2012) which include; 1) Understanding the problem; 2) Building knowledge based on the results of the study of the problem; 3) Generating ideas; 4) Describe the idea; 5) Consider options and make decisions. The scores obtained from the results of the engineering skills test will be categorized into four categories of engineering skills according to Crismond & Adams (2012), namely; 1) Beginning Designer; 2) Emerging Designer; 3) Developing Designer; 4) Informed Designer. The flow of this research consists of 3 stages, namely:

1. Preparation stage
   At this stage, the researcher conducts a literature study, settles permission to the research site, and prepares instruments and learning resources. One of the research instruments used is the engineering skills test. After the engineering skills test was constructed, the researcher conducted a trial to assess its validity and reliability. Test items proven to be feasible will be used to obtain data before and after treatment.
2. Implementation stage
   This stage consists of several activities: 1) Selecting research samples for the experimental class and control class using purposive sampling technique; 2) The engineering skills pretest trial; 3) Give treatment in the experimental class using the Ethno-STEM approach through the ecoprint pounding technique while the conventional learning in the control class, and; 4) Giving engineering skills posttest to the experimental class and the control class.
3. Data analysis stage

The data obtained from the engineering skills test were processed and evaluated descriptively and inferentially using the help of SPSS version 25 and Microsoft Office Excel 2013. While the non-test data used were observation sheets, documentation was used to examine student activities in learning in the experimental and control groups, which are then recorded and evaluated.

RESULTS AND DISCUSSION

Learning with the Ethno-STEM approach through the pounding technique eco print in this study has been prepared and designed according to the Engineering Design Process (EDP). According to Mangold & Robinson (2013), EDP is a decision-making process with repeated activities. This means that basic science, mathematics, and engineering concepts are applied to develop optimal solutions to meet the stated objectives. The EDP carried out consists of 5 stages according to (Cunningham, 2009), namely: ask, imagine, plan, create and improve, which are divided into four learning meetings with a blended learning system. In this study, researchers provide learning with an Ethno-STEM approach through making eco prints with pounding techniques to improve engineering skills in elementary school students.

Eco print comes from the word eco, which means ecosystem (nature), and print (Irianingsih, 2018). Then, the pounding or hitting technique is one of the techniques for color appearance and pattern printing on eco print which is done by hitting the surface of the fabric and leaves (Sutianah, 2021). So eco print pounding technique is the giving of colors or patterns from natural materials by hitting the fabric's surface and natural materials used.

Learning through eco prints with pounding techniques can integrate several interrelated subjects, including; 1) Environmental Education on environmental pollution and environmental care attitudes associated with the "Seba Nagri Tradition". This Seba Nagri tradition is the element of Ethno; 2) Natural Sciences with the subject of plant parts and types of plants based on the leaf bones structure. Considering that one of the natural materials used in the pounding technique eco print is leaves, this topic was taken. So that at the imagine and plan stages, students were given a constraint: the natural materials used are leaves. 3) The use of natural materials as a substitute for artificial dyes to overcome the problems raised, and the tools used to make pounding technique eco prints such as roll meters and hammers as the technology element; 4) Implementation of EDP is a component of Engineering, and: 5) There is a role-playing activity for buying and selling tools and materials which is related to estimating the number, difference, product, and quotient of whole numbers as the elements of Mathematics.

Meeting 1 (Ask and Imagine)

Learning activities are carried out online through learning websites, WhatsApp class groups, and zoom meetings. However, before the implementation of this 1st meeting, the researcher gave a worksheet and assigned students to watch the video challenge on the learning website. The activities carried out at the 1st meeting includes: 1) introducing problems, namely "Environmental Pollution Due to Synthetic Dye Waste"; 2) explanations of material about environmental pollution and reliable sources of information; 3) making problem frameworks and finding information to solve problems. Through this ask stage, students can practice engineering skills on indicators of understanding problems and indicators of building knowledge based on the results of a study. Then, there is an activity for students to imagine themselves as fabric entrepreneurs who care about the environment, which is the imagine stage.

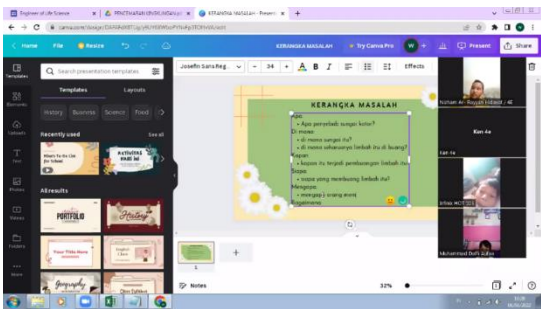


Figure 1. Meeting 1: Introducing problem

Meeting 2 (Imagine and Plan)

This activity is carried out face-to-face at the school. The learning activities consist of group-making activities, discussion of the task of finding problem-solving information at meeting 1, agreeing on problem solutions, planning tools and materials for making eco prints, selling and buying role-playing activities, and making eco print motif designs with pounding techniques and distribution tasks between group members. In this activity, students can also improve their engineering skills on indicators of considering options and making decisions because they have to choose several price options with purchase limits and make the most appropriate purchasing decisions.

Figure 2. Meeting 2: Role-play purchasing tools and materials for eco print

In making the eco print design with the pounding technique, the teacher guided students to create a complete design, namely a design that meets the following criteria:

Figure 3. Design making criteria

Through planning activities, you can hone your engineering skills on the indicators of generating ideas. While making a complete design, students will gain engineering skills indicators of describing good ideas because expressing ideas should result in designs that are not superficial but support in-depth investigations of how solutions can and will not work (Crismond & Adams, 2012).

Meeting 3 (Create)

The activity is carried out in class and is an implementation activity of the pounding technique eco print motif design that students have designed.

Figure 4. Meeting 3: Creating eco print using pounding technique

Meeting 4 (Improve)

At this stage, the teacher displays the impressions of "The Tradition of Seba Nagri Purwakarta". This show serves as a means of reflection on the learning activities carried out, namely reinforcing that nature is a blessing from God that we must protect and use wisely, such as in the manufacture of eco-prints with pounding techniques that can use natural materials. Thus it can minimize pollution due to synthetic materials commonly used in fabric factories.

Figure 5. Watching Seba Nagri Video

At the 4th meeting, there were other activities, such as presenting the results of the pounding technique eco print that each group had made and evaluating the work of other groups (Fig.6).

Figure 6. Product presentation

After treating the experimental and control groups, students took a posttest of engineering skills. The results of the engineering skills test were analyzed descriptively by comparing the average and N-gain of the two groups as seen o Table 1.

Table 1. N-Gain of engineering skills

Learning Approach	Test	$\overline{X}$	*N-Gain*	Category
Ethno-STEM	*Pretest* *Posttest*	7,79 14,21	0,401	Medium
Conventional	*Pretest* *Posttest*	7,08 7,50	0,025	Low

Descripion: Maximum Score is 24

Table 1 shows that the mean (X) pretest score of the learning group with the Ethno-STEM approach through the pounding technique eco print is greater than the mean (X) pretest score of the conventional learning group. Then, the mean (X) posttest score of the learning group using the Ethno-STEM approach through the pounding technique eco print is greater than the mean (X) posttest score of the conventional learning group. The increase shown by the N-Gain score for the learning group with the Ethno-STEM approach through the pounding technique eco print is greater (medium category) than the conventional learning group (low category). The N-Gain category is obtained based on the N-Gain criteria according to Hake (1999), which can be seen in Table 2.

Table 2. *N-Gain* criteria

Gain	Criteria
$g \geq 0,7$	High
$0,3 \leq g \leq 0,7$	Medium
$g < 0,3$	Low

Second, the improvement of engineering skills in this study was also analyzed inferentially using SPSS version 25. Because the data obtained were not normally distributed, this inferential test used the Mann Whitney U test. The hypotheses tested were as follows:

H_0: $\mu1 \leq \mu2$ The improvement of engineering skills of elementary school students who experienced the Ethno-STEM approach through eco print pounding techniques is not better than those who underwent conventional learning.

H_1: $\mu1 > \mu2$ The improvement of engineering skills of elementary school students who experienced the Ethno-STEM approach through eco print pounding techniques is better than those who underwent conventional learning.

Test criteria: if the p-value is less than 0.05 then H_0 is rejected. However, if it is greater than 0.05, then H_0 is accepted. The following is a recapitulation of the average test results for improving engineering skills, which are presented in Table 3 below:

Table 3. Average test results for improving engineering skills

Learning approach	***Mann-Whitney U***	***Z***	***p-value* (*Sig.* 1 tail)**	**Desc.**
Ethno-STEM Conventional	17,500	-5,630	0,000	H_0 rejected

Table 3 shows that the average increase in students' engineering skills has a p-value smaller than 0.05. The results of the engineering skills increase of students who experienced Ethno-STEM approach through eco print pounding technique is better than students who experienced conventional learning. Third, more specifically, the scores obtained from the results of the engineering skills test are grouped into four categories, which can be seen in Table 4 below:

Table 4. Engineering skills category

Score	**Category**
1	*Beginning Designer*
2	*Emerged Designer*
3	*Developing Designer*
4	*Informed Designer*

Description:

1) Obtained score is converted into range 1 to 4 as follow:

$$\text{Total Score: } \frac{\text{Score}}{\text{Maximum score}} \times 4$$

2) If, after the student's acquisition score is processed into the formula, it turns out that there are students who do not achieve a score of 1, then it can be said that these students do not have engineering skills.

The results of the engineering skills grouping in the experimental group can be seen in Figure 7 below:

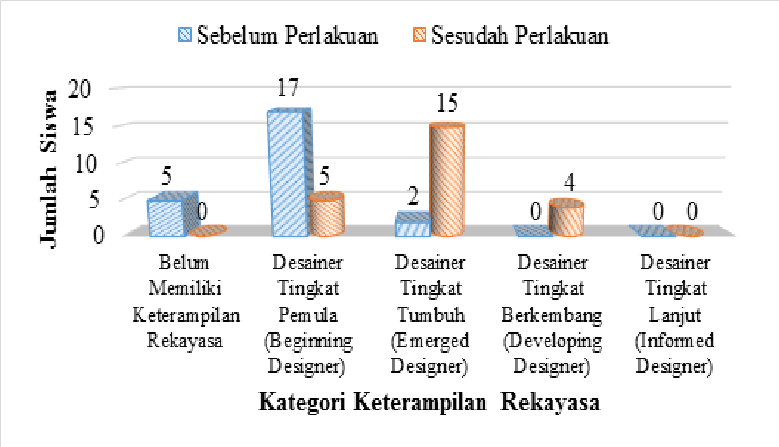
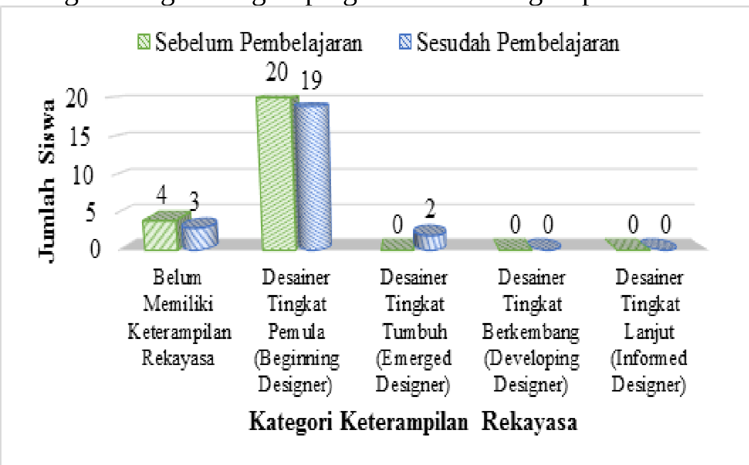


Figure 7. Engineering skill category improvement in experimental group

In Figure 7, it can be seen that there are several improvements in the category of engineering skills of students who receive Ethno-STEM learning through the pounding technique eco print. Engineering skills before treatment in the group that received this learning were in the beginning and emerged categories. Seventeen students have engineering skills in the Beginning Designer category, two students are in the Emerged Designer category, and five students do not have these skills. However, after the treatment, students in this group have engineering skills categorized as beginning (5), emerged (15), and developing (4) designers.

The results of engineering skills grouping in the control group can be seen in Figure 8 below:



Gambar 8. Engineering skill category improvement in control group

In Figure 8, it can be seen that there are several improvements in the category of engineering skills of students in the control group. Initially, there were 20 students as Beginning Designers, and four students did not have these skills. However, this group has engineering skills at the beginning (19) and emerged (2) categories after conventional learning activities. On the other hand, the rest of the students (3) still do not have these skills.

CONCLUSION

The engineering skills improvement of students who receive learning with the Ethno-STEM approach through eco print pounding techniques is better than those who experienced conventional learning. On average, students who get Ethno-STEM learning through the pounding technique eco print are Emerged Designers, and some have reached into Developing Designers. On the other hand, students with conventional learning, on average, were Beginning Designers, and some were Emerged Designers. However, this study only uses 5 of 9 engineering skills indicators according to Crismond and Adams (2012), thus hopefully, further research can examine deeper about the other three indicators, namely: 1)

Conducting experiments, 2) Identifying problems encountered during experiments, and; 3) Improve product manufacture.

REFERENCES

Crismond, D. P., & Adams, R. S. (2012). The informed design teaching & learning matrix. *Journal of Engineering Education-Washington*, *101*(4), 738-797.

Cunningham, C. M. (2009). Engineering is elementary. *The bridge*, *30*(3), 11-17.

Garaika., & Darmanah. (2020). *Metodologi Penelitian.* Lampung Selatan: CV. Hira Tech

Guzey, S. S., Moore, T.J., Harwell, M., & Moreno, M. (2016). STEM integration in middle school life science: Student learning and attitudes. *Journal of Science Education and Technology*, *25* (4), 550-560.

Hoeruni, Y. (2017). Pengaruh Pembelajaran IPA Berbasis STEM terhadap Keterampilan Rekayasa dan Keterampilan Berpikir Kreatif Siswa SMP (Doctoral dissertation, Universitas Pendidikan Indonesia).

Irianingsih, N. (2018). *Yuk Membuat ECO PRINT motif kain dari daun dan bunga*. Jakarta: Gramedia Pustaka Utama.

Lachapelle, C. P., & Cunningham, C. M. (2014). Engineering In Elementary Schools. In Ş. Purzer, J. Strobel, & M. E. Cardella (Eds.), Engineering in Pre-College Settings: Synthesizing Research, Policy, and Practices (pp. 61–88). Purdue University Press.

Katehi, L., Pearson, G., & Feder, M. (2009). Engineering in K-12 Education: Understanding the Status and Improving the Prospects. In Engineering in K12 Education: Understanding the Status and Improving the Prospects.

Lestari, D. (2017). *Pengaruh Pembelajaran Berbasis STEM terhadap Keterampilan Rekayasa dan Penguasaan Konsep Siswa pada Materi Pencemaran Udara* (Doctoral dissertation, Universitas Pendidikan Indonesia).

Mangold, J., & Robinson, S. (2013). The Engineering design process as a problem solving and learning tool in K-12 classrooms. In *2013 ASEE Annual Conference & Exposition* (pp. 23-1196).

Nuraeni, F. (2020). *Aktivitas Desain Rekayasa untuk Pembelajaran Berbasis STEM di Sekolah Dasar. Edisi 1*. Sumedang: UPI Sumedang Press.

Nurhikmayati, I. (2019). Implementasi STEAM dalam Pembelajaran Matematika. *Jurnal Didactical Mathematics*, *1*(2), 41-50.

Purnamasari, P., Annur, S., & Salam, A. (2016). Pengembangan bahan ajar melalui model pembelajaran REACT pada materi elastisitas. *Berkala Ilmiah Pendidikan Fisika*, *4*(3), 209-221.

Rukoyah, S. O. (2020). *Pembelajaran Berbasis STEM Untuk Membangun Keterampilan Rekayasa Dan Kemampuan Engineering Productivity Siswa* (Doctoral dissertation, Universitas Pendidikan Indonesia).

Sumarni, W., & Kadarwati, S. (2020). Ethno-STEM project-based learning: Its impact to Critical and creative thinking skills. *Jurnal Pendidikan IPA Indonesia*, *9*(1), 11-21.

Sutianah, C. (2021). Menumbuhkembangkan Wirausaha Berbasis Industri Kreatif Fesyen Bagi Warga Pedesaan Dengan Memanfaatkan Flora Pada Praktik Penyempurnaan Kain Dengan Teknik Eco Print. *Jurnal Ekonomi, Sosial & Humaniora*, *2*(06), 1-7.