Creativity of Junior High School’s Students in Designing Earthquake Resistant Buildings

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Abstract. This research was stimulated by the present the territory of Indonesia is largely an area prone to earthquakes and the issue that human resources and disaster response planning process is still less competent and not optimal. In addition, the construction of houses and public facilities has not been in accordance with earthquake-resistant building standards. This study aims to develop students’ creativity through earthquake resistant building model’s projects. The research method used is descriptive qualitative method. The sample is one of the 7th grades consisting of 32 students in one of the junior high schools, Indonesia. Data was collected using an observation sheets and student worksheet. Results showed that students’ creativity in designing earthquake resistant building models varies greatly and yields new solutions to solve problems.

1. Introduction

The development of science and technology requires individuals to be ready to compete in all fields. It affects the quality of human life and causes changes in all aspects of human life. The changing times in the 21st century have had a positive and negative impact, especially with regard to the issue of natural disasters. The issue of natural disasters such as earthquakes that became one of the disasters that often occur because the regions in Indonesia to be disaster-prone areas. The built infrastructure is not designed with natural conditions. Houses and buildings such as buildings have not been much adapted to natural conditions [1]. This makes the people of Indonesia began to realize the importance of seeking disaster risk prevention. One of the actions taken is to build earthquake resistant buildings. This action is still difficult to realize because the human resource capacity still does not meet the criteria of workers who are experts in the field of engineering, technology and science. Therefore, it needs qualified human resources that is human capable to apply relevant knowledge to solve the problem. Director General of the UNESCO Conference in 2006 with the theme Building Creative Competences for the 21st Century that creativity is a way to be able to provide solutions to global problems [2].

The results of Dyers, J. H. that 2/3 of the ability of one's creativity obtained through education, 1/3 students come from genetic. These findings confirm the important role of education in developing creativity [3]. Lou, S. J., et al studied the model of student behavioral behavior in project-based learning in the context of STEM, where students were assigned a project with the theme "Audio Speaker" which required students to integrate STEM knowledge in project learning. The project aims to develop students' skills in the future [4]. In addition, Teressa conducted research on engineering...
students, mathematics and science. The students were asked to create learning medium that describes dry land and wetland materials for the 5th graders of elementary school [5].

In this research, students will design earthquake resistant building model for earthquake prone area of Indonesia. The process of designing earthquake resistant buildings cannot be solved by using only one field of science, but rather integrating various scientific disciplines, such as science, math, technology and engineering to create creative and innovative problem solving. In this study, we facilitate students to work in the field of STEM. STEM facilitates students to hone their creativity through activities that require them to "think out of the box [6]. Bybee explains there are several perspectives in applying STEM, such as STEM as single discipline, STEM as multiple disciplines, STEM as integrated disciplines until STEM as trans disciplinary [7]. Science becomes the core of learning and will incorporate students' knowledge and skills in the technology, engineering, and mathematics.

This lesson introduces students to the importance of earthquake knowledge, earthquake disaster prevention through earthquake resistant buildings technology. In fairly dense residential areas, protection needs to be taken to reduce population mortality and heavy damage caused by earthquake shocks. By using correct engineering principles, good construction detail and practical hence losses can be reduced. Geographically, Indonesia is wedged by two major oceans of the world (Indian Ocean and Pacific Ocean); Indonesia's geological position at the meeting of three major plates of the world (Indo-Australian plate, Eurasian plate, and Pacific plate). Earthquakes are caused by the release of energy resulting from moving plate pressure. The longer the pressure becomes larger and eventually reaches the point where the pressure cannot be retained by the plate edges. Light earthquakes that occur do not result in a significant effect on the structure; the earthquake is in little effect on the structure but still safe; and for large earthquakes, has already caused damage to the structure, but the structure still stands and does not collapse. That is the importance of earthquake resistant building planning, so that the buildings we occupy are safe, stable, and not easily collapsed during an earthquake. The main steps to consider when designing earthquake resistant buildings are (1) the structure of the land to be used for development should be hard; (2) constructing the foundation using rocks so that the foundation of the building is sturdy in supporting the load and resistant to vibration. A good foundation is balanced or symmetrical. The adjacent foundation must be separated to prevent local collapse (Figure 1); (3) the columns must use continuous columns (the conical size / the smaller from floor to floor). In high rise buildings, to improve the ability of buildings to lateral forces due to earthquakes, usually vertical elements of the structure using a combination of column with shear wall (Figure 2); (4) Roof Structure. When there is no bracing on the roof structure that holds the earthquake load in a horizontal direction, the collapse will occur as shown in Figure 3 [8].

![Figure 1. Foundation design combined](image-url)
2. Research Methodology

This research is a qualitative descriptive research because it is studying or describing a situation according to fact. The sample in this study were 32 students of class VII consisting of 25 male students and 17 female students in one of Junior High School. Data collection technique used is observation of learning process through observation sheet and LKS. Data is analyzed by combining and generalizing the results of data in the form of descriptive sentences thoroughly and candidly. The study was conducted in two seasons by integrating a "design" process that could improve the design skills for the school to the next level and as a student stock in the world of work [9].

At the season 1, there are 3 activities that are (1) Identify problem and propose idea. Students are given earthquake phenomena and then asked to identify the problem and propose the idea / solution offered to solve the problem. Activity (2) Design the design and (3) choose the tools and materials. Students are given a list of tools and materials to make earthquake resistant building models, then students determine the tools and materials as needed, and students can determine their own as needed, economical and easily searchable. At the 2nd season, proceed with activity (4) Make the product and test the product. Students make products according to their design. When the product trial, if not functioning or there are weaknesses, the student must identify the weakness of the product then find a solution to anticipate the weakness. Students can change the design of the design or replace the tool components and materials on the activities (5) redesign the product.

The assessed aspects of creativity are fluency, flexibility, originality and elaboration [10]. The assessment was conducted by 8 observers for 8 groups. Each group consists of 4-5 students. Every aspect of creativity has assessment criteria with score range 1 to 4. Maximum score for each activity indicator is 16, while the maximum score of each aspect of creativity is 4. Instruments used are the observation sheet and the rubric of creativity.

3. Result and Discussion

3.1. Student’s creativity

Assessment is done during the students designing and building earthquake resistant model through the engineering process design stage. Table 1 shows that students' creativity in designing earthquake resistant building model is 72.34% with medium category. The highest creativity is shown in the activity of making and testing the product.
Table 1. Recapitulation of student creativity in PjBL-STEM learning through authentic assessment

| Engineering Process Design Steps | Activity                           | Creativity (%) |
|----------------------------------|------------------------------------|----------------|
| Discussion                       | Identify problems and propose ideas| 72.85          |
| Design                           | Draw the design sketch             | 67.39          |
|                                   | Selecting tools and materials      | 74.60          |
| Construct                        | Create and test products           | 75.78          |
| Re-Design                        | Redesigned after test the product  | 71.09          |

**Mean Category**

| Category | 72.34 |

Table 1 shows that of the five activities, activity 4 is to create and test the product into a "bridge" for students to participate actively using the ability and creativity during making and testing the product. The 4 aspects of creativity for each activity can be seen in Figure 4.

From Figure 4, it can be seen that from the five activities, the aspect of fluency (ability to generate many ideas) become the most visible creativity capabilities, followed by aspects of flexibility, elaboration and originality. In activity 1, the average student is able to identify the problem, propose the idea and determine the appropriate solution to solve the problem (See Figure 4). These activities will certainly train students' creativity on the fluency aspect. The design ideas provided by the students are quite unique but much in common with other group ideas and existing designs. This is due to many students who duplicate the design ideas obtained from the results of browsing. However, students are able to develop their ideas when students discuss with their groups even though they are not written in detail. In activity 2, the students made design sketches of earthquake resistant building models and most students drew 2 product designs as alternative solutions, then the students discussed with the group to select the design idea which will be the solution to solve the problem, determine the tools and materials. Selected tools and materials may be the same as other groups, provided that the students include descriptions of their usefulness in the design in detail, but in reality, students simply write down the tools and materials without explaining the usefulness of the tools and materials. Tools and materials specified by the students, generally design-friendly, economical and easy to find, making it easy to manifest. Based on observations, there are 2 groups that use the main ingredients that are different from other groups, for example using newsprint and potato cutters (See Figure 5 and 6). Unfortunately, the manufacturing process is not exposed. Obviously this also trains students' creativity especially on aspects of flexibility, originality and elaboration.

The aspect of flexibility in activity 2, designs made by students, on average not accompanied by size but only labelled. In addition, design drawings also have similarities with students and other groups, so the design needs to be developed again by adding detailed drawings, lines, or colours and labels. The results showed that the students' ability in detailing the design of the design is still lacking. This is because not all students feel able to pay attention to the details of the design. In general they
are still difficult in designing designs that want to be realized and students confused in describing the description of the image. This is consistent with the data in the student worksheet (See Figure 6). Therefore the aspect of originality and elaboration on activity 2 is less prominent.

When creating and testing products, students are fast enough and skilled at putting together tools and materials. The same thing happens when students fix weaknesses or mistakes when making a product, but there are some less skilled students. In the pilot activity, students identify the weaknesses and obstacles that are found, then look for various ways and develop ideas that will be pursued through the discussion process to correct weaknesses clearly but less detailed when delivering them. This is clarified by the existing document that is on the student worksheet, the average student writes down the constraints and weaknesses are less detailed and tend to directly fix when finding difficulties.

**Figure 5. Student’s answer**

![Figure 5](image)

**Figure 6. The list of tools and materials which students choice**

| No  | Tools          | Description          | Quantity |
|-----|----------------|----------------------|----------|
| 1   | Duplex bead    | Strong, safe         | 5        |
| 2   | Poly foam      | Interior             | 3        |
| 3   | Corrugated     | Structural            | 2        |
| 4   | Chalk          | Writing               | 1        |
| 5   | Ice cream stick| Decoration            | 10       |
| 6   | Glue           | Glue                 | 1        |
| 7   | Watercolors    | Coloring             | 1        |
| 8   | Bowls          | Storage              | 1        |

**Figure 7. Design of Earthquake-Resistant Building’s Model**

Figure 5 is the student's answer that proposes building earthquake resistant homes because earthquake resistant houses are one of the safest ways to prevent earthquake damage. Earthquake resistant houses have a strong building structure so that when hit by the earthquake, the building will be sturdy and not damaged. Figure 6 is information of 8 tools and materials and their functions, and the cost required to construct an earthquake resistant model. This example uses ice cream sticks, newspapers, duplex paper, glue, watercolors, and bowls. Newspapers are useful as a building frame, duplex as a building base and ice cream sticks as decorations, bowls as a building printing tool. Figure 7 shows the design of earthquake resistant building models.
In redesigning activities, when students find out the weaknesses of their products, the average student designs the design according to the identification of weaknesses along with the size, but not accompanied by the caption, as shown in Figure 7. Figure 7 shows that the design after passing the testing process tends to be better compared to before testing the product. Student creativity looks better when starting to make products, testing products, identifying the weaknesses of their products. This is because in the process of making and testing, students exchange ideas and develop ideas more and more widely. Through the process, many new ideas are emerging. In addition, students' interest in the earthquake-resistant earthquake relief effort made the first step to create creative ideas. Through this learning, students can think broadly and openly in accordance with their abilities, so that knowledge will be more widespread. Woolfolk revealed that extensive knowledge is the basis for creativity. The wider the knowledge, the more likely it is to generate new ideas [10].

Based on these findings, creativity will continue to grow when stimulated with fun learning activities and provide opportunities for students to perform activities in accordance with his wishes, then at that time the students will express his ideas. The term creativity by Treffinger that creativity is consisting of cognitive abilities, personality and past experience [11]. The development of individual creativity is influenced by internal factors, such as encouragement and motivation to dare to express the hidden abilities, because each individual has the potential to be creative humans. [12]

4. Conclusion
Results showed that students' creativity in designing earthquake resistant buildings became the activity that most influenced students' creativity development. From this research also explains that the creativity of students can be developed through the learning experience so that in the assessment must also involve the learning process.

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