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# Visualization Skills among Engineering Students Using Problem Based Learning Fogarty Model

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**Abstract:** Engineering Drawing subject's offered to all students who are enrolled in the civil engineering, electrical engineering or mechanical engineering. These subjects develop skills in geometry drawing more professional. For the concept in Engineering Drawing, students need to have good visualization skills. Visualization is needed to help students get a start before translating into a drawing. To train these skills, a Problem Based Learning (PBL) approach will be implemented. The problem solving process repeatedly attempts to help the student correctly and accurately interpret the drawings of the engineering drawing. The process of learning using PBL method are specifically follow PBL Fogarty Model. This study examined readiness of visualization skills among engineering students through PBL Fogarty Model approach. A total of 68 students of engineering from institutions in Malaysia are involved in this study. The instruments used are Space Ability Test adapted from Bennett, Seashore and Wesman (1972). The findings show that students have a good level of visualization skills. As a result, the more individual a person achieves a good visual cognitive level, the easier it is to master the knowledge, ideas and approaches of the new learning method

**Keywords:** PBL Fogarty Model, Engineering Drawing, Visualization

## 1. Introduction

Today's societies place challenging demand on teaching and learning process especially for Technical and Vocational Education. To provide a comprehensive learning environment, student need to have higher-order thinking skill, visualization skills and other abilities related to learning. Technical and Vocational Education are responsible on given a specific skills and competencies that prepared the young people and adults for work's life. With rapid transformation in economic, technology and education spheres, the adoption of new learning strategy can be change the nature of education in engineering field. Defining the transformation, Problem Based Learning can improve pedagogic realities and give indirect impact based on visualization skills, achievement and attitude of students. Furthermore, PBL also include many characteristics of problem solving which is an unknown outcome, multiple paths to a goal, construction of a problem context, collaboration and add on the elements of competition (Ruiz-Callardo et. al, 2011; Masek, Yamin and Aris, 2011; Masek and Yamin, 2012).

Teaching and learning is a fundamentally thought about in a terms of information and skill transfer (Sullivan, 2019). The learning process usually consist of knowledgeable educator who constructed, managed and transmitted knowledge on a particular topic to student using the instructional media with technologies. This process become effective when teacher sent information to student and student received the message wisely. On the other hand, when student apply the information, means that the communication between teacher and student have been done and the learning cycle have completed. In addition, Technical and Vocational Education have to develop students' abilities to apply their knowledge in complex and practical situations. We have to evaluate the strategies which possibly created an effective learning and generate something that involves broad problem solving skills and discovery information in learning. The main reason

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for the inability of traditional teaching methods to facilities the development of flexible and useful knowledge and skills is the lack of contextualising or anchoring the content being learned (Silverman, 2011). So that, PBL with animation and graphic mode can be used to answer these needs. Animation is dynamic picture or object there are manipulated to appear as movement images or moving graphic. Defining graphic is images there are illustrated in design on just surface such as graph, canvas and so on. Integrated animation and graphic in recognize PBL trigger can help student gain more information to solve the problem.

It is obvious to say that; the conjunction of this method provides meaningful paradigm as well as to increase the understanding among learners. This paper does little to promote the active learning in online PBL, or the acquisition of critical skills is necessary for analyse and selecting the key point among the wide array of competing information in learning environment. Finally, we point out the Problem-Based Learning Model Fogarty (1997) are involve in this research that essential for instructional strategy.

## 1.1 Problem-Based Learning

Problem-Based Learning Model Fogarty (1997) applied in this study as a systematic problem-solving process and the problem will be seen repeatedly. Figure 1 shows the eight main steps in the PBL model Fogarty using animation (PBL-Animation group) and graphic (PBL-Graphic group). For the first step, problem situations or trigger in graphics mode and animation mode are display for student in Engineering Drawing Blog. For animation, short video shows the storytelling about crash in building. However, for graphic mode, the problem shows in picture with text like a book in Engineering Drawing Blog. The issue resembles real life and unstructured problem (Rio, 2009). In the second step, students will define the problem based on fact and information from discussion in group.

Definition of the problem will be changing throughout every step in Problem-Based Learning Model Fogarty (1997). By exploring the information in internet, journal, newspaper and others, students will use their experience and existing knowledge to solve the problem. FILA table are used to facilitate students gather information and plan the next solution. FILA offers four separate tables that need to be filled by students of 'Fact', 'Idea', and ‘Learning issues ‘and’ Source needed. Lecturer guide student as facilitator to make sure student follow the step and in line to get findings.

Students will review the problem many times and build an objective to finding. Each information and ideas will be shared with members using forum or chat. In step seven, students are given any solution to generate a suitable alternative of the problems. For the next step, students will make final decision and discuss with group member and lecturer. They will present their finding and defend the solution of findings. The others group can ask them a question to make sure they are really understanding about the findings.

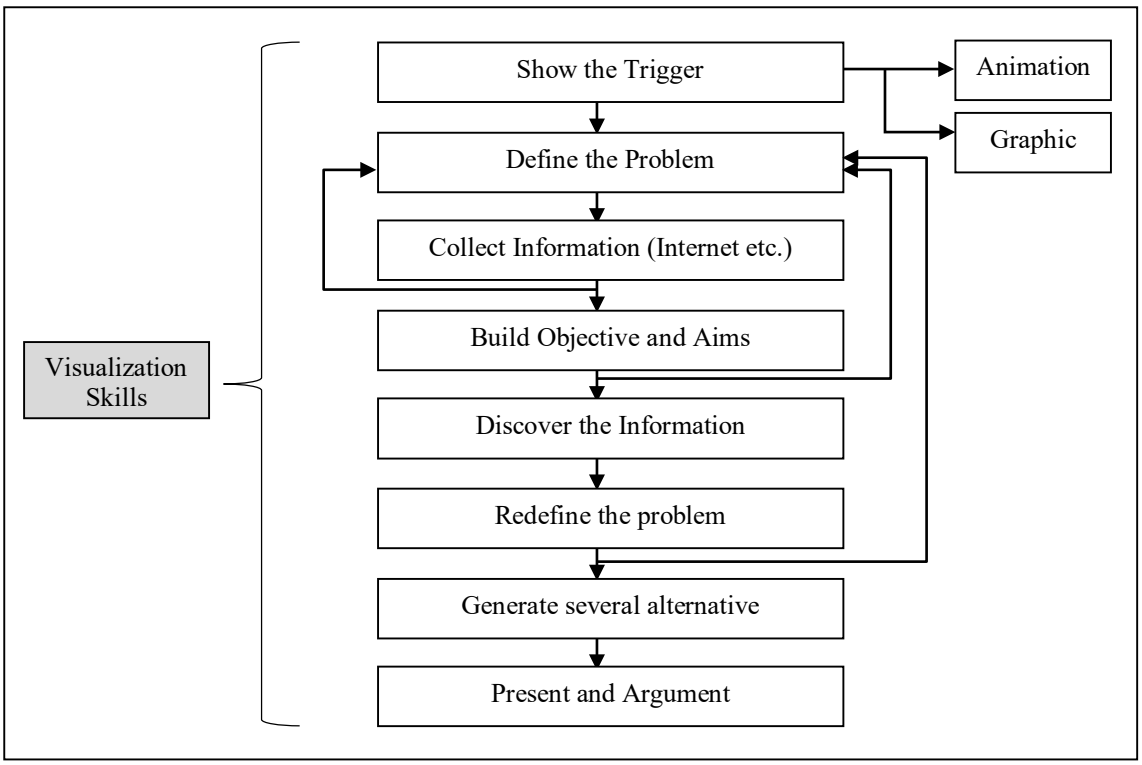


**Fig. 1 - Model Fogarty**

## 2. Methodology

This was a quasi-experimental research using quantitative methods to answer the questions of visualization skills readiness among engineering students. There are two group involve which is group of PBL-Graphic online (PBL-G) and group PBL-Animation online (PBL-A). Method of sampling in this study refers to a purposive random sampling using intact group. Sampling aims to refer to sampling procedures where a group of subjects with particular characteristics are selected as respondents of the study (Piaw, 2006). The selected research sample consists of students who have majored in Mechanical Engineering. A total of 68 students from institutions A in North Malaysia were involved. 32 students are from Class 1 are define as a PBL-G group while 36 students from Class 2 are define as a PBL-A group. The study focuses only on the topic of Isometric Views. The instrument used is visualization test adapted from Bennett, Seashore and Wesman (1972). The reliability coefficient was 0.91 for the entire item. There are 60 items and each one has a different figure. Each item in this test covers isometric, spreadsheets, reflection, sectional and combinations. Students will be given 30 minutes to answer all the questions above with A, B, C and D scales. This test is used to test the ability to fold 2D objects to 3D objects mentally (Mohd Salleh, 2011).

Hence, the interpretation of the data is based on the interpretation of visualization skills score by Sorby (2006) as in Table 1. The achievement level is three levels of 'average score', 'slightly below average score' and 'below average score'. However, to facilitate the interpretation of the findings, the 'average score' level is interpreted to 'Excellent' and 'Good' levels. Additionally, the 'slightly below average score' and 'bottom average score' levels are interpreted as 'Satisfactory' and 'Weak' levels of room capability.

**Table 1 - Visualization Skills Achievement Level**

| Score Mark (%) | Visualization Skills Score Level | Level |
|---|---|---|
| 81-100 | On average score | Excellent |
| 61-80 | | Good |
| 41-60 | Slightly below average score | Satisfactory |
| 0-40 | Below average scores | Weak |

## 3. Results

The results of the analysis on the achievement of the Space Ability Test score are shown in Table 2. The findings show that 50% of respondents (16 students) are at the level of good visual skill. While 25% of respondents (8 students) were in excellent level, 21.9% of respondents (7 students) were satisfied and the rest 3.1% of respondents (1 students) were at a weak level. In this preliminary study showed that engineering students did not face any problems in visual skills. Based on the previous study, engineering students face problems connecting objects in their environment with the concept of Engineering Drawing (Widad & Hatta, 2001).

**Table 2 - Student Visualization Skills Achievement Level**

| Visualization Skills Score Level | Frequency (f) | Percentage (%) |
|---|---|---|
| Excellent | 8 | 25.0 |
| Good | 16 | 50.0 |
| Satisfactory | 7 | 21.9 |
| Weak | 1 | 3.1 |
| | 32 | 100.0 |

Refer to Table 3, the findings of the analysis of the PBL-G found that post-test mean score (M = 36.69, SD = 8.483) were relatively higher than the pre-test mean score (M = 24.38, SD = 8.419).

**Table 3 - Description of the Mean, Standard Deviation, Minimum and Maximum of PBL-G**

| | Pre-test | Pos-test I |
|---|---|---|
| N | 32 | 32 |
| Mean | 24.38 | 36.69 |
| Standard deviation | 8.419 | 8.483 |
| Minimum | 15 | 17 |
| Maximum | 52 | 49 |

Refer to Table 4, available post-test mean score of the PBL-A (M = 42.36, SD = 7.453) were relatively higher than the pre-test mean score (M = 26.67, SD = 6.476).

**Table 4 - Description of the Mean, Standard Deviation, Minimum and Maximum of PBL-A**

| | Pre-test | Post-test I |
|---|---|---|
| N | 36 | 36 |
| Mean | 26.67 | 42.36 |
| Standard deviation | 6.476 | 7.453 |
| Minimum | 14 | 26 |
| Maximum | 43 | 57 |

The results of the analysis showed increased student achievement in engineering drawing course when they follow a treatment in PBL-A compared to PBL-G.

The results of this analysis are shown in Table 5. One-way ANCOVA analysis of the data showed that the F = 8348, mean squared error = 536.163 and $p < 0.05$. This shows that there are significant differences in post-test score between students who in group of PBL-Graphic online group is pursuing PBL-Animation online after effects of pre-test mean score is controlled.

**Table 5 - One-way ANCOVA to test mean score visualization skill**

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 545.612[a] | 2 | 272.806 | 4.247 | 0.018 |
| Intercept | 8209.057 | 1 | 8209.057 | 127.809 | 0.000 |
| Pre_visualization | 0.278 | 1 | 0.278 | 0.004 | 0.948 |
| Group | 536.163 | 1 | 536.163 | 8.348 | 0.005 |
| Error | 4174.903 | 65 | 64.229 | | |
| Total | 111847.000 | 68 | | | |
| Corrected Total | 4720.515 | 67 | | | |

## 4. Findings and Discussions

The results of this study show that there is a difference between PBL-Animation with PBL-Graphic. The results showed student visualization skills increased when they following treatment in PBL-Animation. Based on the sensory-modality approach in Baddeley Working Memory Model, PBL-Animation well-designed storytelling problem situations portrayed visually or auditory (narration) with sound. Little research shown the effect of visual content in conjunction in teaching principles more easily and effectively (Guerra, Martinez, Martin-Gutierrez & Lopez-Chao, 2020). Foo (2013), found

there is a significant relationship between visual cognitive achievements of students drawing. Therefore, the level of visual cognitive students needs to be emphasized and trained in the teaching and learning process drawing so that they can achieve excellent results. Next, Hori, Cherian, Mark and Hori (2019) studied the performance of student using multimodal fusion of audio, vision and text to demonstrate a different several tasks. The results showed that the approaches designed to tackle the task need multimodal fusion to improve response quality. This finding is not consistent with Mayer Theory that explains the use of graphics along with the text more effective than display animations with text. This is because the animation with the text to increase students' cognitive load and quickly confused. However, the use of animation with sound is better and helps students understand the situation problems as implemented in the PBL-Animation.

Based on the Mayer Theory, offering animation and sound to give better results compared the graphic presentation with the text. Thus, the findings also have the same result with assumptions Mayer Theory. This study also shows that students are more interested in when the situation storytelling problems using animation mode. Students more easily understand and have a passion for finding a solution of the problem of narrative situations depicted. Studies conducted by Luppy, Anwar, Linuhung, Agustina and Rahmawati (2020) found that the approach Animation-Based Learning can create classroom more interesting in learning and improve communication interaction between the teacher and students. It can also be seen in the students who attend PBL-Animation. They become more mature and more active than at the beginning of the intervention. This finding is also have the same result with the findings of a study done by Rosiadi (2009). They use of teaching aids using animation elements for the movement of electrons in addition to the support of elements of the text as well as voice-over that explains the process. The results clearly show increased student achievement and their visualization skills also improved. Students said that they better understand the movement of electrons. Use this element to help students structure knowledge, enhance student visualization and further understand the lessons conveyed more clearly. Based on Rahmawati, Jumadi and Astuti (2020) studies, they found that e-handout using animation with PBL model approach was appropriate to be used as teaching material and it is known that students' understanding of concepts in learning physics can be improved. Animation brings users closer to the material information and improve knowledge among students. Therefore, PBL with animation method will help student to build a meaningful experience in learning and help train them better visualization skills. Students will focus on the things that make these activities better (Sharifah & Aliza, 2011).

Integration of PBL-Animation in the process of teaching and learning in the institution can address the problem of visualization weaknesses in students. Online discussion space between group members and the question and answer session to help them further develop existing knowledge and improve their visualization skills. They realize that in PBL, they need to better understand the problem and how to solve them (Colliver, 2000). Sun and Hu (2019) said, dimension, geometry and drawings based on a realistic observation of the forms that implied. For example, in the construction of isometric, students need to associate the concept is seen as experience and have a very important relationship between the external input and the real behaviour. Fadhilah Maizatul (2011) found that students' performance is simple visualization. The final year students of Educational Technology and Engineering has a high level of visualization, particularly in the form of images, stretches stretch and rotate three-dimensional objects. A total of 118 students from majoring in Bachelor of Engineering (Mechanical Engineering and Electrical Engineering) was involved. The findings of this study also showed that visualization is the middle and high students. This finding is consistent with findings that reflect their visualization skills increased after the PBL-Animation. Therefore, PBL helps students get a better visualization skill as well as an understanding of the subject matter.

The study found that PBL-Animation have a positive effect compared than to PBL-Graphic online. In conclusion, the individual is able to achieve high visual cognitive level, they are easier to get knowledge, ideas and new experience. Students will continue to build new knowledge from the information obtained with existing knowledge of students and overarching goal (Sullivan, 2019). Curiosity among students has also increased and they will achieve a higher level of thinking as required. Students are no longer passive, but active in solving problems. They will realize that in this method, engineering student’s need to better understand the problems that appear in the animation and figure out a way to solve the case innovatively (Mann et. al, 2020). Problems created allows students to explore their own solutions while improving visualization skills and their academic achievement. Therefore, engineering students are able to achieve the desired educational goals.

## 5. Conclusion

Based on the result of research that has been done, study found that the use of PBL online using the animation can increase and sustained the student achievement in Engineering Drawing course. Issues that are designed use animation in PBL be able to cause better understanding, dramatic scene and easy to create connection concepts of Engineering Drawing course. This could be due to the influence of the learning media used animated source arouse the curiosity of students. Therefore, the students managed to play an active role in seeking information and problem solving.

In this regard, students apply the information in research to find the answer of any questions that arise based on the information to solve the problem in three situations Isometric Projection topic. Online discussions in small groups as the main driver to help student discuss and manipulated the information. Lecturer as a facilitator provides support in all times

to give a good consultation to student find the solution. Learning become more active when students expand their skill while process bring out future development of global people.

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