Effects of Using Graphics and Animation Online Problem-Based Learning on Visualization Skills among Students

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Abstract. The Engineering Drawing subject develops skills in geometry drawing becoming 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. So that, Problem Based Learning (PBL) using animation mode (PBL-A) and graphics mode (PBL-G) will be implemented in class. Problem-solving process is repeatedly able to help students interpret engineering drawings step work correctly and accurately. This study examined the effects of PBL-A online and PBL-G online on visualization skills of students in polytechnics. Sixty eight mechanical engineering students have been involved in this study. The visualization test adapted from Bennett, Seashore and Wesman was used in this study. Results showed significant differences in mean scores post-test of visualization skills among the students enrolled in PBL-G with the group of students who attended PBL-A online after effects of pre-test mean score is controlled. Therefore, the effects of animation modes have a positive impact on increasing students' visualization skills.

1. Introduction
Visualization is a very important skill in the subjects related to engineering (Leopold et al., 2001). In the industry, one of the components of graduate employability is able to generate new ideas in developing a quality product (Polytechnic Graduate Executive Report, 2008). Engineering Drawing is a major problem in most of the students because they do not understand the concept clearly and they are weak on visualization skills (Mohd Khairulanwar, 2010; Widad &Lee, 2004). Students have difficulty to imagine a 3D object into 2D (Nazamuddin, 2003). The failure is caused by a complex theory in certain topics and students depend on the lecture-answer method (Abdul Aziz, 2008; Yue, 2006; Tang, 2005). Mohd Salleh et al. (2011) said that in the Engineering Drawing subject, students had difficulty in understanding Isometric drawing topic. Approaches or methods like Problem Based Learning (PBL) can create great ideas and encourage students to build knowledge more meaningful (Joseph & Razmah, 2006). Engineering Drawing promotes culture of innovation and the ability to think visually in the product creation process from the beginning to the end (Muhyiddin, 2010; Zain, 2010).

Integration of online PBL can provide a platform to stimulate active and student-centered learning (Bourne, Harris & Mayadas, 2005). Online learning is a learning environment that uses the Internet network environment that helps students get the information, knowledge and skills in cyberspace (Fauziah, Hanafi & Guan, 2010). This method supports the traditional practice of face-to-face interaction in the classroom. This research shows PBL online learning can promote the characteristics of collaborative and self-directed learning (Brodie & Porter, 2008). This method is more flexible and suitable for a variety of learning styles.

One of the reforms in the PBL method in this study is online learning. The addition of PBL online is a synchronous discussion where students will discuss through a chat room and forum (Fauziah, Hanafi & Guan, 2003; Bernard & Rubalcava, 2000). This method is more efficient whereby mature students explore the links to web based sources to look for information (Bol & Garner, 2011). The findings from Megat Shahrul Anuar and Zahiri Aman (2004) showed that online learning has received encouraging response and is able to support students in their learning minds. The efficient transfer of knowledge is a very difficult challenge to educators. This means that, an educator had to adapt to the development and application of electronic teaching media.
Problem-Based Learning Model by Fogarty (1997) is applied in this study as a systematic problem-solving process and the problem will be seen repeatedly in every step. Figure 1 shows the eight main steps in the PBL model adapted from Fogarty’s model.

![Diagram of Problem-Based Learning Model](image)

**Figure 1: Problem-Based Learning Model**

In the first step, the students will present their storytelling with a problem situation displayed in graphics mode and animation mode. The students will watch a short video and read the display on the e-engineering Drawing blog. The issue resembles real life and unstructured problem (Rio, 2008). Animation and graphic presentation help students to improve their visualization skills. The next step, students will define the problem based on existing information and experience. Various definitions of treatment will be given by the group. Definition of the problem will be changing throughout the process. In a step to collect information, students will use existing knowledge and experience. FILA table is used to facilitate in gathering information of students and their plan for the next solution. FILA offers four separate columns that need to be filled by students of a ‘fact’, an ‘Idea’, a ‘learning issues’ and a ‘source needed’. This table is reviewed together by a group of students and lecturers.

Information collected by the students will be reviewed on an ongoing basis. Students will review the problem and predict the solution to build a hypothesis. The search begins to focus on the study hypothesis. In the next step, students will undertake a study to explore the information through books, websites and making opinions. Students will ask for help if they need from lecturers. Information and ideas are shared with the members of the group. Again, the students are asked to define the problem. A collection of information will change the definition of the problem in each group. Lecturers will monitor the learning process. In step seven, students are given the command to generate a suitable alternative to the solution of the problem. There are three categories of alternative proposed possible solutions, and solutions that can be a better solution. Next, the students will conduct group discussion and make the final decision. They will present arguments to support their findings.
The PBL problem situation may be presented online via storytelling and visualized through animation mode and graphics mode as articulated by Mayer (2001). Table 1 shows the three assumptions in his theory which are dual-channels of information processing, limited capacity and active-processing (Abd. Hadi, 2005).

| Assumptions                  | Explanation                                                                 |
|------------------------------|-----------------------------------------------------------------------------|
| Dual-channel assumption      | The first assumption is the unproven but somewhat accepted theory that we process visual and verbal information differently and in two separate channels. Known as Paivio’s Dual Coding Theory, it states that we process and internally represent visual information in a different way than verbal information. |
| Limited capacity assumption  | The second assumption is that due to the capacity of working memory, we can only process a limited amount of information in each channel at one time.                                |
| Active-processing assumption | The final assumption is that in order to make something meaningful, people actively process information by paying attention and organizing and integrating the information. |

Mayer’s theoretical assumptions were developed based on Sweller’s Cognitive Load Theory, Paivio’s Dual Coding Theory and Baddeley’s Working Memory Model (Fatimah, 2006). Based on the sensory-modality approach in Baddeley’s Working Memory Model, instructional materials can be in the visual display (animation, graphics, text) or auditory (narration or sound). With reference to Paivio’s Dual Coding Theory, Mayer (2001) divides the channel into two types of information presentation of verbal and visual. This theory proposes that verbal and visual materials are processed in different processing system of the auditory canal/verbal and visual channels/pictorial (Abd. Hadi, 2005). Figure 2 shows the Mayer’s theory on the auditory/verbal canal and visual/pictorial channels.

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Bertoline (1998) defines visualization as a person’s ability to create, manipulate and interpret the images in the mind. Based on this definition, a person who is imagining a design, pattern or certain objects have never even seen physically is said to have some visualization capabilities. Similarly, a person who is able to imagine a shape, pattern and object to customize the environment and the time varies from place and time of original so have some abilities.

In engineering, a turning abilities, transform (Sorby et al., 2005), folding and stretching (Engineering Drawing, 2003), and deleting objects mentally (Field, 1999), is part of spatial ability. This capability is not easy, especially involving the thought of an object that has not been seen in front of the eye and something that has not yet physically exist. Psychological aspects of education, skills, visualization are understood as a natural ability in describing a person even without formal training or correlates with spatial ability (Sorby, 1999). In the other words, all human beings have this ability since they were born. However, the level of visualization skills may vary from person to person as with other skills.
1.1 PBL-A and PBL-G Based on Theory and Model

In this phase, researchers adapt Constructivist Theory, Cognitive theory of multimedia learning (2001) and Problem-Based Learning Model by Fogarty (1997) as the main essence in PBL-A and PBL-G online. PBL-A and PBL-G online consist of eight main steps: (1) identify the problem, (2) define the problem, (3) collect information, (4) creates a hypothesis, (5) do research, (6) redefine the problem, (7) generate some alternatives and (8) suggest solutions. Narrative design problems using animation mode and graphics mode were developed based on the Cognitive theory of multimedia learning (2001). Media content learning aims to produce narrative problems using text, graphics, audio, and video animation. The typeface used is a sans serif typeface, in Arial 12. The graph is loaded in JPEG format while the audio recordings in MP3 format. Video animation learning materials were developed in FLV format, while PBL teaching materials were developed using Blendspace website, Wiki, Blog, Mind Mapping, Poll, Dropbox, Glogster and pirate pad. In this study, design and website development of e-Engineering Drawing is based on Constructivist Theory and Problem-Based Learning Model by Fogarty (1997). Metacognitive process will start if new information can be understood by students. Therefore, researchers should take into account the learning process that is more efficient and can enhance students' understanding of the issues highlighted in the PBL-A and PBL-G. Integration of animation and graphic storytelling problem with the situation is a major step to help the students' develops metacognitive processes. Next, students can build knowledge, new ideas and concepts in learning in Engineering Drawing. Problem-Based Learning Model by Fogarty (1997) was adapted in the website e-Engineering Drawing.

Problem-Based Learning Model by Fogarty (1997) was adapted to design the website to facilitate the students’ visualization through the process of PBL-A and PBL-G. Cognitive theory of multimedia learning (2001) was used to clarify the situation in storytelling problem for PBL online using graphics mode and animation mode. This theory provides a theoretical support for the use of visuals, whether dynamic or static in a learning offering (Paivio, 1986). Mayer’s theory affects the information presented visually or auditorily. Mayer (2001) divides the channel into two types of information presentation, verbal and visual. This theory proposes verbal and visual materials processed in different processing systems of the auditory canal / channel verbal and visual / pictorial (Abd. Hadi, 2005). Based on this theory, researchers design problems connecting narrative information in verbal and visual,

i. PBL-G: Graphic with text
ii. PBL-A: Animation with audio

Strategies and approaches in verbal and visual information presentation are also important to ensure the effective application of information in long-term memory. Animation and graphic designs use Adobe Photoshop CS2, Illustrator CS and Macromedia Flash 8. Some of Cognitive theory of multimedia learning (2001) principles serve as a guide in designing PBL-A and PBL-G. Here are the principles underlying the Cognitive theory of multimedia learning (2001),

i. Multimedia principles
Students can learn better through the use of text and images of text only. Therefore, researchers combine the use of text along with pictures to enhance the effects of better learning.

ii. The principle of proximity space
Students can learn better if the text associated with the image is placed closer together than apart. In PBL-G, travelled graphics along with the related text to enable students to understand the situation of the problems raised.

iii. The Principles of time
Students can learn better if the text with images is displayed simultaneously compared to turns.

iv. The principle of coherence
Student learning will be disrupted if the text and pictures are interesting but not relevant to the content of the lesson. Similarly for a multimedia presentation with audio interrupted if unrelated. A better way is to get rid of the text and audio researchers which are irrelevant to enhance the learning effect.
v. Modality principle
Students can learn better if there is an animation with audio along with the text. PBL-A is based on the use of animated elements and associated audio.

vi. The Principles redundancies
Students can learn better if there is an animation with audio of along with text. This increases the cognitive load when combined together. The researcher did not incorporate animation, audio and text to avoid confusion when the intervention was implemented.

2. Methodology
The objective of this study is to compare the effects of PBL-A online and PBL-G online on visualization skills of students in polytechnics. In this study, the selected design is quasi-experimental study in the form of pre-test and post-test of the two treatment groups. PBL group online through trigger in graphic mode is called PBL-G and the PBL online through problems in the mode of animation storytelling is called PBL-A. Further, these groups took a post-test II to identify the retention of new learning methods (Table 2).

Table 2: Group Experiment Design

| Group  | Intervention |
|--------|--------------|
| PBL-G  | $O_1x_1$     | $O_2$           |
| PBL-A  | $O_1$        | $x_2$           | $O_2$           |
Which is:
\[ x_1 = \text{PBL-G} \]
\[ x_2 = \text{PBL-A} \]
\[ O_1 = \text{Pre Test} \]
\[ O_2 = \text{Post Test I} \]
\[ O_3 = \text{Post Test II} \]

Purposive sampling is used in this study. This refers to a sampling procedure in which a group of subjects has certain characteristics as respondents in the study (Piaw, 2006). Sixty-eight Mechanical Engineering students from polytechnic were selected. This study only focused on the Isometric Drawing topic which covering a three month period. The instrument used is visualization test adapted from Bennett, Seashore and Wesman. The reliability coefficient was 0.91 for the entire item. Training in aptitude tests was selected because each item is built on the concepts of Engineering Drawing. There were 60 items and each one has a different figure. Each item in the test covers isometric, spreadsheets, reflection, sectional and combinations. Students were given 25 minutes to answer all the questions. The test is used to determine the ability of students to fold 2D objects to 3D objects mentally (Mohd Salleh, 2011).

3. Result and Discussion
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 for graphic visualization (\( M = 24.38, \ SD = 8.419 \)). Please refer to Table 3.

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

Table 4 show the post-test mean score of the PBL-A (\( M = 42.36, \ SD = 7.453 \)) were relatively higher than the pre-test mean score on animation visualization (\( M = 26.67, \ SD = 6.476 \)).

|                  | Pre-test | Post-test |
|------------------|----------|-----------|
| N                | 36       | 36        |
| Mean             | 26.67    | 42.36     |
| Standard deviation | 6.476    | 7.453     |
| Minimum          | 14       | 26        |
| Maximum          | 43       | 57        |
The analysis showed that there was an increase on visualization skills for the groups which used animation mode PBL-A compared to graphics mode in PBL-G. This finding is consistent with studies of Norhayati, Shaferul and Mohd Fauzi (2013) who found that the use of animation helps students apply the information provided. PBL-A is designed to emphasize PBL Fogarty’s Model (1997) in repeated trigger. Every step of the PBL may have to be reconsidered. The situation of storytelling problems is displayed in animation mode. As a result, students will be able to create and manipulate information of storytelling in animation problems. This helps improve their visualization skills compared to the use of graphics. Based on the theory of Mayer, graphics gives less impact as compared to the use of animation. Indirectly, PBL also promotes learning through problem solving through the application of information effectively (Harris & Briscoe-Andrews, 2008).

Arumugam (2006) found that this approach can improve students learning through animation and increase their curiosity. PBL scenario is focused to use students’ curiosity so that problems can be solved (Hmelo-Silver, 2004). Through PBL-A, visualization abilities of students can be developed through computer animation, internet, website and online learning (Abdul Hadi, 2005). It also coincides with the views of Jamaluddin and Zaidatun (2003) who found that animation helps accelerate the process of understanding and maintaining information within a long time in the student’s memory.

Through a one-way ANCOVA analysis, the impact of PBL is applied to the values of mean visualization which skills test can be determined. The results of this analysis are shown in Table 5. One-way ANCOVA analysis of the data showed that the F=8348. It means squared error=536 163 and p<0.05. This shows that there are significant differences in post-test which means score visualization skills between students who attended PBL-G online group was pursuing PBL-A online and after effects of pre-test mean score of controlled visualization skills.

| Source              | Type III Sum of Squares | df | Mean Square | F      | Sig. |
|---------------------|-------------------------|----|-------------|--------|------|
| Corrected Model     | 545.612                 | 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 |             |        |      |

Visualization is a technique used in creating the image or animation that communicates with a message to be conveyed (Knight, 2000). This finding is also supported by Ahmad Zamzuri (2012). In his study, it is found that animation can cause teaching and learning process to be more efficient rather than the use of graphics. He added that animated presentation techniques can move the channels in verbal and visual memory and is an effective strategy for acquiring, processing, store and recall information. In this study, the effects of animation in the Mat Bond story could explain the problems that arise when building a house is not planned well. Mat Bond’s movements and his expressions can describe Mat Bond’s character in real situations. Problems arise when the size is not in accordance with the standards and the plans are not in accordance with the requirements. Problem situation helps to improve students' skills in visualization. In addition, the use of animation augmented with audio assistance can improve students’ learning effects. This is in line with the principle of Mayer’s theory where animation and sound presentation give a better impression than the graphical presentation along with text (Mayer, 2001). The relationship between input visual or verbal input or a combination of both gives the opportunity to build understanding through visual depiction income in the minds of students.

This finding is also consistent with studies of Rosiadi et. al. (2009) who designs teaching aids by using animation and sound element’s background that explains the process of learning. Lindstrom (1994) argued that the animations bring users closer to material information. The results of the study clearly show that their visualization skills will also increase. Students will also generate new ideas through their minds with the impression generated in the form of graphs or drawings. Infused storytelling animation problems are repeatedly used at every step of Fogarty’s PBL Model. This is to reinforce information to be conveyed. This helps students to structure the knowledge, and further understand the teaching content presented more clearly. PBL approach
for online students gives access information quickly and facilitates collaboration among online communities (She & Emy, 2007). This strategy can enhance students' knowledge and skills to contribute to the improvement of visualization. Therefore, students who attend PBL-A can build a very meaningful experience in learning and help train the skills to become a better visualization.

Through a one-way ANCOVA analysis, the impact of PBL is applied to the values of the mean post-test II visualization skills can be determined. The results of this analysis are shown in Table 6. One-way ANCOVA analysis of the data showed that the value of F=11.969, mean squared error=376 862 and p<0.05.

Table 6: One-way ANCOVA to test mean score visualization skill

| Source          | Type III Sum of Squares | df | Mean Square | F     | Sig.  |
|-----------------|-------------------------|----|-------------|-------|-------|
| Corrected Model | 378.228                 | 2  | 189.114     | 6.006 | 0.004 |
| Intercept       | 12325.831               | 1  | 12325.831   | 391.461| 0.000 |
| Pre_visualization| 42.541                  | 1  | 42.541      | 1.351 | 0.249 |
| Group           | 376.862                 | 1  | 376.862     | 11.969| 0.001 |
| Error           | 2046.640                | 65 | 31.487      |       |       |
| Total           | 169339.000              | 68 |             |       |       |
| Corrected Total | 2424.868                | 67 |             |       |       |

Integration of PBL-A in the process of teaching and learning in polytechnics can tackle weaknesses in students' visualization. The findings are also consistent with studies of Fong, Kong and Fauzy (2001) which found that the use of text with animated shows a positive trend compared to the use of static text with graphics. Based on Mayer’s theoretical principle, PBL-A is designed for the situation of storytelling problems that are displayed visually or auditorily (speech) along with the sound. It allows something rather difficult to explain with words or static images more easily and effectively (Jamalludin & Zaidatun, 2003). Mayer (2001) found that the first information which will be directed is then followed by animated images, text and so on. Animation also affects how students use information clearly in software (She & Chen, 2009). Therefore, it is clear that the potential in animation stimulate students’ focus on such information. Wang (2012) states that integration problems in a realistic animation contribute in a more meaningful experience than the group of students who use the help text only. Integration of animation modes in PBL-A is more dynamic and interactive features to help students sharpen their problem-solving process better.

Mohd Salleh (2011) found that students like to sketch drawing and moving images by using animation. Teaching aids which are built using animated elements also have a positive impact in the process of teaching and learning and visualization skills to maintain them in the long run. Online discussion space between team members and question-answer session in forums helps them to expand existing knowledge and improve their visualization skills. They realize that with PBL, they need to have a better understanding of the problem and how to solve it (Colliver, 2000). Mohd Khairulanwar (2010) added that plane geometry and painting based on a realistic visual contributes to the observation of implicit forms. For example, in the construction of isometric, students need to associate the concept of perceived experiences and draw a visual representation of the real (Abu Bakar, 1991). Observation of a problem needs to be done to get a more in-depth input and it is considered important. Indirectly, knowledge and problem-solving skills of students will help increase the visualization.

4. Conclusion
The study found that PBL-A line had a positive effect compared to PBL-G online. In conclusion, the individual is able to achieve good visual cognitive level. They master the knowledge, ideas and new approaches easily. Students will continue to build new knowledge from the information obtained with existing knowledge of students (Rio Sumarni, 2006). 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. A PBL helps students master skills, especially related to visual or shadow. They will realize that in this method, they need to understand the problems better by using animation and figures as a solution to the problem. (Colliver, 2000). Problems created to allow 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.
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