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Visualization skills and learning style patterns among engineering students at Universiti Teknologi Malaysia

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Abstract

The objective of this study was to identify the learning styles and visualization skills practiced by engineering students in Universiti Teknologi Malaysia. A sample of 250 respondents was selected from six engineering faculties in the university. This comprised of year one to year four undergraduate engineering students in the faculties. The study used quantitative approach of data collection and has been analyzed using descriptive and inferential analysis. The instrument for data collected included questionnaires, visualization skills tests and learning style inventory which were used to determine the relationship between learning styles and visualization skills of students. The results showed that there was no relationship between visualization skills and learning style engineering students in UTM. From this study, patterns of visualization skills and learning styles among engineering students were constructed based-on area/field of specialization, years of study and gender.

Keywords: Visualization skills, learning style, engineering students, spatial ability, mental image;

1. Introduction

A visualization skill is considered to be important aspect in the world of technology especially people who have been working in the engineering field. According to Strong and Smith (2002), visualization skill is a success measurement in the fields of technology especially in engineering. Subjects like Graphic and Engineering Design is known as one of the core subjects that are being offered in the engineering programs. According to Miller (1996), visualization skills are one of the elements that are being applied in this subject and it is an important foundation in determining the success of students in the field of engineering (Sorby and Baartmans, 1996). Besides that, the use of graphic language to communicate in the engineering field, some engineers needs to acquire ability to visualize and interpret mental images in the form of either oral or graphic (Mohd Safarin and Muhammad Sukri, 2006). Therefore, the student’s level of visualization skills needs to be aligned with the learning program that they are in to make sure that the future engineers will achieve the quality that is needed in the job opportunities especially in the field of technical and engineering education.

This research is done to identify the level of visualization skills and learning style that is being practiced by the engineering students in UTM Skudai. Therefore, this research will lead us to achieve the following research objective, (a) to assess the engineering students’ visualization skills in UTM according to the specified field and

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level of study, (b) to determine types of visualization skills that is being mastered by the engineering students of UTM according to their specified field and level of study, (c) to find out the learning style that was being practiced among the engineering students of UTM according to their specified field and level of study, (d) to determine the relationship between learning style and visualization skills among students of UTM according to their specified field and level of study, (e) to evaluate the appropriateness of types of visualization skills that needed to be mastered and the specialization of engineering field among the students of UTM, and (f) to produce patterns of visualization skills and learning styles of UTM students based on the area of specialization, level of study and gender.

2. Literature review

The programs in the field of engineering need students’ ability to process visual information also the capability to develop a mental image, to draw diagrams or to develop a symbol to represent their imagination. Research has shown that the level of visualization skills has influence a lot in students’ results in their core engineering subject such as Structure Design (Alias et al., 2002), Mathematics (Tillotson, 1984), Problem Solving in Engineering (Hsi et al., 1997) and Chemistry (Pribyl and Bodner, 1987). Learning in the field of engineering needs the level of visualization skills that is suitable with the program that they are in. It is because some of the students have natural visual ability that is different for each individual (Lord, 1985; Piburn et al., 2002). From the perspective of educational psychology, visual ability is understood as one natural ability a person would have in describing certain things even though without formal training that has to do with space ability. In short, all human being has this ability since they were born (Mohd Safarin and Muhammad Sukri, 2007).

Researches have found out the level of visualization skills in women are a bit lower as compared to men due to hormonal influences. (Hier and Crowley, 1982). However, according to Fennema and Sherman (1977), the existence of the differences in the level of visualization skills between men and women was due to the environment factor. In the meta-analysis spatial ability research, Linn and Petersen (1985) have found out that men are more prominent from women in the task of mental rotation from the speed perspective in completing that given task. Men are more prone in using ‘holistic strategy’ while women are more of ‘analytical strategy’ in solving the problems. ‘Holistic strategy’ is based on the ability to visualize the whole object while ‘analytical strategy’ is more of a systematic and step by step approach. ‘Holistic strategy’ is found to be more effective in terms of speed in problem solving. However, they mention that factors for choice of strategy contribute to the differences of visualization skills between men and women. Moreover, Hsi et al. (1997) says that space ability strategy can be found through education.

In addition, age is also a factor that influences someone’s visualization skills. According to Piaget in Bishop (1978), the development of space ability for certain individual is through three stages. The first stage is where topological ability is usually found in children of the age three to five years old which involves two-dimensional picture. The second stage involves 3D object visualization and picturing that object from a different position or angle of view. Most individuals have this ability in their teenage years, however, problem in visualization occurs when picturing object in a more complex manner. In the third stage, the person is able to picture a concept of area, volume and distance in a combination with its interpretation, rotation and reflection. Furthermore in this stage, they are able to combine the measurement concept with all the skills that they have acquired from the previous project.

Learning style has to do with the ability of student’s learning, student’s progression, how to learn and field of study in college and university level (Rita and Sugata, 1988). Students who are specialized in the field of social science like literature, music, drama and others are considered students who learn based on concept. Meanwhile students who are specialized in Science, Mathematics and Engineering learn through application (Kolb, 1984). Research done by Kolb (1984) then has found that there is a positive correlation between learning style and students’ specialization in certain fields. Teachers, learning and media can form students’ learning style for learning that taken place in class.

3. Research methodology

This research on the level of visualization skills and students’ learning styles has taken place at Universiti Teknologi Malaysia, Skudai campus. The respondents were those students who are undergoing their Degree level in the engineering field which was offered here in Skudai campus. It is a quantitative study done on the level of
visualization skills including its component and learning styles among students of engineering course. The research
design that was conducted were through descriptive and inferential statistics.

The data collected was analysed using the Statistical Packages for Social Science (SPSS) software version 12.0.
This research is using descriptive statistics to find the central tendency especially mean value, frequency and
percentages of the data. According to Azizi Yahya et al. (2007), descriptive analysis is used to describe or
summarize the information or data that has been obtained for its population or samples. While inferential analysis is
used to show the relationship between the visualization skills and the learning styles among the engineering
students. This study is using inferential statistics which show the correlation test at the alpha level which equals to
0.05 and one-way ANOVA analysis.

4. Results of the study

4.1 Research Question 1

The first research question was to identify the level of visualization skills among students who are undergoing
engineering study in UTM Skudai in accordance to their specialization field and level of study. Referring to Figure
1, it has been found that engineering students in UTM have a high level of visualization skills which is to achieve
the score of over sixty percent in the visualization test conducted. Results from the data analysis showed that
engineering students who are specialized in Electrical Engineering -Telecommunication (SET), Mechanical
Engineering -Manufacturing (SMP) and Mechanical Engineering -Automotive (SMV) were among those groups of
students who have the highest visualization skills. Meanwhile from the faculty perspective, students from The
Faculty of Chemical Engineering and Real Sources Engineering (FKKKSA) and The Faculty of Mechanical
Engineering are among the group of students who have the highest visualization skills with an average score of over
70 percent.

![Figure 1: Average score of engineering students in visualization skills test according to faculty and field of specialization](image)

The results of data analysis of the level of visualization skills among engineering students in UTM according to
years of study. Students who are in the study program at undergraduate level in UTM will enrol for four years or
equals to eight semesters accordingly. With that, analysis on this part will involve four groups of students from year
one until year four. Referring to figure 2 below, research has found that the level of visualization skills of year four
students is higher compared to year three, two and one. Therefore, it can be concluded that visualization skills of
engineering students in UTM will rise higher according to their level or years of study.

4.2 Research Question 2

The second research question was to establish the types of visualization skills that are mastered by the students
who are undergoing the program of study in engineering field at UTM Skudai according to their field of
specialization.
It was found that the ability level of combining 2D object designs through the MPFBT test, students from FKKKSA, FKM and Faculty of Geoinformation Science and Engineering (FSKG) were at the highest level compared to other students from other faculties. From the aspect of the ability to fold an object mentally through DAT:SR test however, it was found that engineering students from all specialization fields were at their average level. While for the ability to transfer 3D object to 2D mentally through MTT test, it was found that only students from FKKKSA have the highest level. This study also found that the ability to rotate mentally (through PSVTR test), engineering students from all specialization fields are at their average level. Meanwhile, from the aspect of the ability to cut mentally (through MCT test), the engineering students in UTM have an average level of ability. Moreover, only students from Faculty of Health Science and Biomedical Engineering (FKBSK) have a low level of ability in cutting mentally. For the ability to present mentally through the PSVT:D test, it was found that engineering students from all specialization fields have an average level of ability.

The average score of engineering students in six types of visualization test according to years of study. Research has found out that students of year four and three have the ability to combine, fold and transfer mentally at a high level compared to students of year one and two. The aspect of the ability to rotate mentally, students from each year showed an above average or high level ability. Meanwhile, year four and three students were at the above average in the aspect of the ability to cut mentally. However, year two and one students were at the below average or low level for this ability. Results also showed that students of year four, three and two were at the above average level in the aspect of the ability to present mentally. However, students of year one was at below average level.

4.3. Research Question 3

The purpose of the third research question was to identify the learning style that has been practiced among engineering students in UTM Skudai according to their specialization fields and level of study.

A bar chart on the learning style among engineering students in UTM according to the specialization field. Referring to the figure, it was found that Converger learning style is considered the most dominant learning style that has been practiced by the engineering students in UTM especially in the field of electrical engineering, science and geoinformation engineering, mechanical engineering and chemistry and real source engineering. This is followed by Diverger, Accommodator and Assimilator learning styles. Therefore, it can be concluded that engineering students in UTM are considered students who like to learn through abstract conceptualization and information process and active experimentation. In other words, they have the strength and efficiency to solve problem with the exact correct answer. The students also were not emotional and prefer to interact with objects as compared to people.

Referring to figure 6, it was also found that Converger learning style is considered the learning style that has been practiced by many students in year one, two and three. Meanwhile, Diverger learning style is the least practiced by students of year one. Moreover, Assimilator learning style is the least learning style practiced by students of year two and three. For students of year four, most of them practiced Diverger learning style followed by Converger, Assimilator and Accommodator. Hence, it can be concluded that engineering students in UTM will change their learning style from one who like to learn through conceptual abstract and active experimentation to learning through concrete experience and reflective observation. According to Kolb (1985), someone who practiced
Diverger learning style has high imagination ability and likes to see situation through different perspectives. That theory has been proven in this research where it was found that engineering students who were in their fourth year mostly like to practice Diverger learning style and they have a high level of visualization skills compared to the rest of them.

4.4. Research Question 4

The fourth research question focus on determining the relationship between learning style and the level of visualization skills of engineering students in UTM. To answer this question, Spearman’s Rho (r) correlational analysis was used to find out the relationship between the level of visualization skills and learning style.

Table 1: Crosstab of learning style and level of visualization skills

<table>
<thead>
<tr>
<th>Learning Style</th>
<th>Level of Visualization Skills</th>
<th>Count</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low</td>
<td>8 (100%)</td>
<td></td>
</tr>
<tr>
<td>Accommodator</td>
<td>3 (37.5%)</td>
<td>17 (41.5%)</td>
<td>42 (20.9%)</td>
</tr>
<tr>
<td>Diverger</td>
<td>1 (12.5%)</td>
<td>9 (22.0%)</td>
<td>42 (20.9%)</td>
</tr>
<tr>
<td>Converger</td>
<td>0 (0.0%)</td>
<td>12 (29.3%)</td>
<td>79 (39.3%)</td>
</tr>
<tr>
<td>Assimilator</td>
<td>4 (50.0%)</td>
<td>3 (7.3%)</td>
<td>38 (18.9%)</td>
</tr>
<tr>
<td>Total</td>
<td>8 (100%)</td>
<td>41 (100%)</td>
<td>201 (100%)</td>
</tr>
</tbody>
</table>

\[ r = -0.3, p = .637 \]

Results of the correlation analysis revealed that the coefficient value of Spearman’s Rho (r) correlation is -0.3 and the coefficient value of probability \( p > .05 \) (see Table 1). This shows that there is no significant relationship between visualization skills and learning style of students in the engineering field in UTM Skudai. Referring to the frequency and percentage of engineering students according to the level of visualization skills categories which are between low, average and high level of visualization skills, it showed there was no specific pattern were exist. The only conclusion that can be made here was majority of engineering students in UTM (201 from 250 students) has a high level of visualization skills with most of them who practiced Converger learning style (39.3%) followed by Diverger learning style (20.9%), Accommodator (20.9%) and Assimilator (18.9%).

4.5. Research Question 5

The fifth research question was to identify whether there is a significant difference existed in the achievement of engineering students in UTM in the visualization skills test in accordance to their specialization field. The analysis that was being used in answering this research question is one-way ANOVA and LSD in determining the group of students’ specialization field that control the visualization skills component that was being tested.

Table 2: The comparison of engineering student’s achievement in visualization tests across field of study by one-way ANOVA analysis

<table>
<thead>
<tr>
<th>Type of visualization skill test</th>
<th>Group</th>
<th>Df</th>
<th>Mean</th>
<th>F</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPFBT</td>
<td>Between Group</td>
<td>22</td>
<td>87.3</td>
<td>1.048</td>
<td>0.407</td>
</tr>
<tr>
<td></td>
<td>Within Group</td>
<td>227</td>
<td>83.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DAT:SR</td>
<td>Between Group</td>
<td>22</td>
<td>114.3</td>
<td>1.107</td>
<td>0.340</td>
</tr>
<tr>
<td></td>
<td>Within Group</td>
<td>227</td>
<td>103.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MTT</td>
<td>Between Group</td>
<td>22</td>
<td>154.0</td>
<td>0.879</td>
<td>0.623</td>
</tr>
<tr>
<td></td>
<td>Within Group</td>
<td>227</td>
<td>175.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSVT:R</td>
<td>Between Group</td>
<td>22</td>
<td>228.4</td>
<td>1.288</td>
<td>0.181</td>
</tr>
<tr>
<td></td>
<td>Within Group</td>
<td>227</td>
<td>177.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSVT:D</td>
<td>Between Group</td>
<td>22</td>
<td>298.8</td>
<td>1.592</td>
<td>0.049*</td>
</tr>
<tr>
<td></td>
<td>Within Group</td>
<td>227</td>
<td>185.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCT</td>
<td>Between Group</td>
<td>22</td>
<td>377.1</td>
<td>1.605</td>
<td>0.046*</td>
</tr>
<tr>
<td></td>
<td>Within Group</td>
<td>227</td>
<td>234.9</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Significance at .05 levels
Results from ANOVA analysis (see Table 2) found out that there was no significant difference between the ability to combine, fold, transfer and rotate mentally with the specialization field of the students. However, there is a significant difference between the aspect of the ability to cut mentally and the ability to present mentally in accordance to students’ specialization field.

Research has found that engineering students from FKKKSA have the higher ability to cut mentally compared to students from other faculty followed by students from the faculty of FKM and FKE (see Table 3). Meanwhile, at the same time it was found that students from FKBSK have the lowest ability to cut mentally compared to students from other faculty of engineering. Furthermore, the same pattern showed that students from FKKKSA have the highest ability to present mentally followed by students from FKM, FKE and FKA.

Table 3: The comparison of engineering student’s achievement level in MCT & PSVT:D tests across field of study by LSD analysis

<table>
<thead>
<tr>
<th>Type of test</th>
<th>Field of study</th>
<th>Field of study</th>
<th>Mean</th>
<th>Significance (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCT</td>
<td>FKKKSA</td>
<td>FKE</td>
<td>7.310</td>
<td>.018*</td>
</tr>
<tr>
<td></td>
<td>FKM</td>
<td>FKE</td>
<td>6.272</td>
<td>.027*</td>
</tr>
<tr>
<td>PSVT:D</td>
<td>FKKKSA</td>
<td>FKE</td>
<td>5.861</td>
<td>.032*</td>
</tr>
<tr>
<td></td>
<td>FKKKSA</td>
<td>FKA</td>
<td>7.381</td>
<td>.007*</td>
</tr>
<tr>
<td></td>
<td>FKM</td>
<td>FKA</td>
<td>4.997</td>
<td>.048*</td>
</tr>
</tbody>
</table>

* Significance at .05 levels

4.6. Research Question 6

“What is the pattern of visualization skills and learning styles of engineering students in UTM according to their specific engineering field, years of study and gender?”

Visualization skills pattern according to students’ specialization field has been structured. It was found that engineering students in UTM from different engineering specialization area have an average-high level of visualization skills in almost all categories of visualization skills. Analysis has shown that only students from FKBSK have an average-low level of the ability to rotate mentally. Results of analysis on pattern of learning style according to student’s specialization field found that Converger learning style is considered the most dominant learning style among engineering students in UTM. Despite that, there are also some engineering students in UTM who practice other learning styles. For instance, research has found that students from FKBSK also practiced Accommodator and Assimilator learning style at one time. Meanwhile, results of analysis on pattern of visualization skills among engineering students in UTM in accordance to their years of study has found that students in every level of study have an average-high and high visualization skills according to visualization categories. However, there are also engineering students of year one and two who have an average-low in the level of visualization skills in terms of the visualization of cutting mentally. Apart from that, from the aspect of learning style it was found that Converger learning style is the most dominant learning style among students of year one, two and three. While students of year four are more prone to practice Diverger learning style.

Student’s visualization skills pattern across gender however showed that male students overtook female students in the achievement of each component in the visualization test except in the ability to combine. For male students, Converger learning style was the most practiced by them. It was then followed by Accommodator, Diverger and Assimilator learning styles.

5. Conclusion

The suitable learning style helps students in mastering their visualization skills. Therefore, many authorities have to work hard in helping these students to improve their level of visualization skills by practicing the suitable learning styles. Referring to the results, there are a few actions that can be done in order to achieve the meaning of improving engineering students’ visualization skills which are, (a) Ministry of Higher Education (MoHE) can revise their policy carefully where the entree requirements for students who are applying the field of engineering for Tertiary Education in Malaysia should stress on visualization skills as part of their needed qualification, (b) Ministry of Education (MoE) is encouraged to organize a training program for teachers and students in the field of technical and vocational education at the school level to expose them with models of learning styles that can help them in enhancing students’ visualization skills, (c) university authorities also are urged to organize courses on ways to improve students’ visualization skills, (d) lecturers especially those in the field of engineering have to adapt their
teaching style with students’ learning styles so that it can help students to develop their visualization skills, and (e) students also need to work harder in enhancing their visualization skills according to the suitable learning styles.

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