Attitudes towards Sketching and Drawing and the relationship with Spatial Visualisation Ability in Engineering Students

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The purpose of this study was to examine the attitude of engineering students towards sketching and drawing (S&D) and its relationship with spatial visualisation ability. Three aspects of attitude towards S&D were investigated namely, (a) the view of the professional role of S&D, (b) the personal value of S&D and (c) the usage tendency of S&D. Comparison was made between engineering and architecture students with respect to their attitude towards S&D. The engineering and architecture sample sizes were 57 and 19 respectively. Correlational research design was used to study the association between attitude and spatial visualisation ability. It was found that the mean scores of the engineering students’ were statistically less significant on all attitude aspects when compared to that of the architecture students’ and that there were statistically significant correlations between usage tendency of S&D and spatial visualisation ability. It was therefore concluded that engineering students had poorer attitude towards S&D compared to architecture students and that there was an association between the usage tendency aspect of attitude towards S&D with spatial visualisation ability.

Attitude, Correlation, Sketching and Drawing, Visualisation, Engineering.

INTRODUCTION

Spatial visualisation ability is “…the ability to mentally manipulate, rotate, twist, or invert pictorially presented stimulus objects.” (McGee, 1979, p. 893). Studies have shown that this ability influences academic achievements in engineering related subjects such as structural design (Alias, et al, 2001), integral calculus (Turner, 1982), mathematics (Tillotson, 1985), computer aided design (Sorby, 1999), engineering problem solving (His, et al, 1997) and chemistry (Pribyl and Bodner, 1987). Due to its relevance, ensuring high spatial visualisation ability among engineering students is therefore desirable.

Sketching and drawing (S&D) is one of the most commonly prescribed activities for developing spatial visualisation ability in engineering students, as inferred from course outlines for engineering graphics. S&D is a phrase used to describe all activities of making rough pictures (sketches) of something using pen or pencil and standardised drawings such as engineering drawing. In sketching, the proportions and lengths are simply judged by eye while in standardised drawing the proportions and lengths follow a specific scale. Association between S&D activities and spatial visualisation ability is supported by findings
from spatial ability studies. In two such studies, Fennema and Tate (1985) and Pribyl and Bodner (1987) show that problem solving employing S&D strategy is favoured by high spatial ability students.

Studies have also shown that, in general, positive attitudes towards prescribed learning activities and materials facilitate the achievement of the desired learning outcomes (Simpson, 1978; Young, 1998). Since S&D, as with learning activities and materials, is frequently employed by teachers in trying to develop spatial skills, a possible link between students’ attitudes towards S&D and spatial visualisation ability needs to be considered and investigated. Knowledge of the relationship could potentially provide a better understanding of spatial skills development in learners, which could help in the development of better teaching and learning materials and strategies (Yokomoto, et al, 1995).

**ATTITUDE THEORY**

Attitude is a social construct, which is not observable but can only be inferred from other human responses. However, there is no general agreement on a single definition of attitude. Nevertheless, there is a general agreement that attitude is a mental state that pre-disposes a person to act in a certain way towards the attitude object (Oppenheim, 1992; Sudman, and Bradburn, 1982; Oskamp, 1991).

Oppenheim goes further by conceptualising attitude as an entity comprising three attitude aspects, namely, the cognitive aspect, the affective aspect and the behavioural aspect (Oppenheim, 1992). According to Oppenheim, attitudes are reinforced by beliefs (cognitive component), often attracting strong feelings (affective component), that lead to a particular form of behaviour (the action tendency component). This viewpoint is known as the tri-componential viewpoint and is illustrated in Figure 1 where the three aspects are shown to constitute the concept of attitude.

![Components of attitude](Oppenheim in Oskamp, 1991)

The cognitive component consists of ideas and beliefs of the attitude holder about the attitude object. For example: 'Sketching and drawing is for draftsmen'.

The affective component consists of feelings and emotions of an attitude holder towards the attitude object. For example: 'I like drawing'.

The behavioural component consists of an attitude holder's action tendencies towards the attitude object. For example: 'I tend to use sketching and drawing to communicate'.

The three aspects may interact in the following way: an engineering student who believes that S&D is for draughtsmen will most probably have a low preference for S&D and will not voluntarily choose to use S&D.
THE RESEARCH PROBLEM

Civil engineering students in Malaysian polytechnics were found to have inadequate spatial visualisation ability as indicated by their average percentage score of 50 per cent on a spatial visualisation ability measure, the Spatial Visualisation Ability Test Instrument (SVATI) m(Alias, 2000). Although the development of spatial visualisation skills has been predominantly through drawing, students’ predisposition towards the use S&D has never been ascertained.

Studies have shown that students expressing a more positive attitude towards a subject area would endeavour to behave consistently with their attitudes, by investing more time and effort in that area or by seeking additional learning opportunities (Lindquist, 1980). Therefore, it is expected that students expressing a more positive attitude toward S&D would endeavour to behave consistently with their attitudes, by investing more time and effort in S&D activities or by seeking additional learning opportunities. These attitudes therefore, would be expected to predict subsequent performance on tasks related to S&D such as a task involving spatial visualisation ability.

The aims of this study are therefore (a) to evaluate the attitude strength of engineering students towards S&D by comparing theirs to that of architecture students and (b) to see if an association between attitudes towards S&D and spatial visualisation ability is supported by empirical evidence.

Due to the inherent difficulties of measuring attitude, it was not the intention in this study to gain an absolute measure of students’ attitude but rather only to gain a relative measure of this attitude. In order to assess this, the relative strength of the engineering students’ attitudes was compared to that of architecture students’ attitudes. It was expected that the engineering students would have a less positive attitude towards S&D. This hypothesis was based on the analysis of the respective engineering and architecture curriculum. It was observed that for problem solving, the emphasis of the engineering curriculum is on mathematical-analytical skills while that of the architecture curriculum is on S&D skill.

This study is part of a larger study that investigated the relationships of attitudes, teaching and learning, spatial visualisation ability and problem solving (Alias, 2000).

METHODOLOGY

Research questions and hypotheses

The two main research questions are as follows:

1. Are engineering students less positive in their attitude towards S&D as compared to architecture students?
2. Is there any association between attitude towards S&D and spatial visualisation ability?

The main null hypotheses (H₀) and their corresponding alternative hypotheses (Hₐ) can be stated.

H₀₁: There will not be a statistically significant difference between the mean scores on the Attitude Questionnaire of the engineering students’ and that of the architecture students.
H\(_a1\): There will be a statistically significant difference between the means scores on the Attitude Questionnaire of the engineering students’ and that of the architecture students.

H\(_o2\): There will not be a statistically significant correlation between the engineering students’ attitude towards S&D as measured by the Attitude Questionnaire and their spatial visualisation ability as measured by the Spatial Visualisation Ability Test Instrument.

H\(_a2\): There will be a statistically significant correlation between the engineering students’ attitude towards S&D as measured by the Attitude Questionnaire and their spatial visualisation ability as measured by the Spatial Visualisation Ability Test Instrument.

For the first H\(_o\), the attribute variable is civil engineering or architecture students and the active variable is the scores on the Attitude Questionnaire. For the second H\(_a\), the attribute variable is the scores on the Attitude Questionnaire and the active variable is the score on the SVATI.

**Research designs**

Two research designs were employed for resolving the two research questions: a two-group ex-post facto observation only for the study on the attitude strength and a correlational design for the study on the association between attitude and spatial visualisation ability. The two forms of research design require only one set of observations for each variable. The research designs employed eliminated the following sources of confounding namely, the maturation of subjects, sample instability and regression towards the mean.

In a study such as this, the most likely source of confounding is a non-representative sample. However, a non-representative sample is not expected to be a problem for reasons to be explained in the following section.

**Research population and background**

The immediate population to which the result of this study can be generalised to is civil engineering students in Malaysian polytechnics. Malaysian polytechnics are post-secondary institutions under the Ministry of Education, established to train secondary school leavers to be technical personnel. Malaysian polytechnics offer two and a half year certificate and three and a half year diploma programs in the various engineering disciplines. A few of the polytechnics do offer other disciplines such as architecture and business studies. Polytechnic programs are open to secondary school leavers who possess the minimum entry qualifications. The highest qualification conferred by polytechnics is the diploma. Upon graduation, students could continue their studies in universities for their degree qualifications.

Intakes into these polytechnics are managed by a central agency, the Department of Technical Education (DTE). Qualified candidates are placed into polytechnics in no particular order resulting in similar distribution of students, with respect to entry qualifications, in all polytechnics. There are currently 15 polytechnics throughout Malaysia. Although each polytechnic has its own director who is appointed by the DTE, the overall management of these polytechnics such as staff appointments, curriculum development, provision for infrastructures and educational facilities are under the DTE. For these reasons, it could be reasonably expected that students following a particular program in one polytechnic are similar to students following identical program in another polytechnic. Therefore, a sample taken from a civil engineering program in any polytechnic could be
reasonably assumed to be representative of the population of polytechnic civil engineering students.

To provide a clearer picture of the context of the study a simplified version of the Malaysian Education system leading to polytechnic education is presented here. Malaysians undergo six years of primary education followed by five years of secondary education. Secondary education consists of three years at the lower secondary (12 to 15 years old) and two years at the upper secondary level (16 to 18 years old). There are two public examinations at the end of each level, namely, the Penilaian Menengah Rendah (PMR) at the lower secondary level and the Sijil Pelajaran Malaysia (SPM) at the upper secondary level.

The PMR results provide the basis for the streaming of students into the upper secondary level. Students with good grades in mathematics and sciences are enrolled into the technical or science stream while those who are not, but who are good in arts subjects, are enrolled into the arts stream. Those students who are good in neither group of academic subjects are enrolled into the vocational stream at the upper secondary level.

The SPM results provide the basis for entering polytechnics and other higher institutions. The polytechnics’ entry requirement for architecture courses differs from the engineering courses. Good grades at the SPM level in technical drawing and art are the requirement for the architecture courses while good grades in mathematics are for the engineering courses.

Research samples

The engineering sample was made up of two intact classes of civil engineering diploma students (19 female and 38 male) from two Malaysian polytechnics, Ungku Omar Polytechnic (UOP) and Port Dickson Polytechnic (PDP). The sample is expected to be representative of the population for reasons explained previously.

The architecture sample consisted of 19 architecture students (6 female and 12 male) from both polytechnics who were in the final semester of the Architecture certificate program. The architecture sample was smaller reflecting their population in the Malaysian polytechnics, which is relatively small, compared to the engineering students population. For the purpose of the study, the architecture students from the two polytechnics were grouped into the high, the average and the low achievers. From the three groups, six high, seven average and six low achievers are randomly selected. Overall, 10 students were selected from UOP and six students from PDP.

There were approximately equal proportions of males to females in both groups, that is 67:33 in the engineering group and 68:32 in the architecture group. Therefore, non-equivalent gender proportions were not expected to be a source of confounding. The mean age of the architecture and engineering group was 21 years and 22.5 years respectively. The relatively small age difference was not, on its own, thought to have a large effect on the attitude difference, as both groups were matured students (above 20 years old).

Research instruments

Two research instruments were used in this study, the Attitude Questionnaire and the Spatial Visualisation Ability Instrument (SVATI). The Attitude Questionnaire is a 32-item instrument specifically designed for the study. The length of the instrument was mainly determined by cost and time constraints. Each item in the questionnaire was scored on a five point Likert scale. The Likert Technique was chosen as a measurement method because it is relatively easy to construct besides having a significantly high degree of validity and reliability (Thomas, 1978). With this measurement method, a set of attitude statements was
presented to which the subjects expressed their agreement or disagreement on a five-point scale. Each agreement or disagreement was given a numerical value from one to five. Therefore, a total numerical value could be calculated from the responses given. The attitude statements were in Bahasa Melayu.

The content of the Attitude Questionnaire was based on the tri-componential viewpoint. The three attitude aspects studied were (a) the view of the professional role of S&D, (b) the value of personal usage of S&D and (c) the tendency to use S&D, which corresponded to the cognitive, the affective and the action tendency aspects of attitude. The attitude statements were evaluated by three colleagues who were architecture and civil engineering lecturers from UOP. The three lecturers agreed that the statements were indicative of a person’s attitude towards S&D. Item analysis performed on the instrument showed that 29 out of 32 items had high item total correlations (ITC), namely, above 0.3, with only three items of lower ITC. Items with the low ITC were identified as double-barrelled items. The overall high ITC indicated that the instrument was uni-dimensional in nature. Table 1 gives examples of attitude statements (translations) corresponding to the three attitude aspects.

<table>
<thead>
<tr>
<th>Attitude aspects</th>
<th>Components of the Attitude Questionnaire</th>
<th>Attitude statements</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive</td>
<td>View of the professional role of S&amp;D</td>
<td>Sketching and drawing is for draftsman</td>
</tr>
<tr>
<td>Affective</td>
<td>Value of personal usage of S&amp;D</td>
<td>I like drawing</td>
</tr>
<tr>
<td>Action tendency</td>
<td>Tendency to use S&amp;D</td>
<td>I tend to use sketching and drawing to communicate</td>
</tr>
</tbody>
</table>

The Attitude Questionnaire was designed as two equivalent halves and therefore the Split-half reliability coefficient (r), was the measure used for estimating its reliability. Table 2 gives the reliability coefficients for each sub-scale based on data from the actual study. Two reliability coefficients are below 0.8, possibly caused by a combination of a low number of items and low item total correlations for some items. Some authors have recommended that an attitude measure should have an estimated reliability of at least +0.8 (Thomas, 1978) in order to be a reliable measure of attitude. However, a lower reliability of +0.70 has been argued to be acceptable (Davis in Dyer, 1979). The Attitude instrument and its sub-scales could therefore be said to be reliable.

<table>
<thead>
<tr>
<th>No. of items</th>
<th>Split-half rxx</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td>32</td>
</tr>
<tr>
<td>View of professional role of S&amp;D</td>
<td>12</td>
</tr>
<tr>
<td>Value of personal usage of S&amp;D</td>
<td>12</td>
</tr>
<tr>
<td>Tendency to use S&amp;D</td>
<td>8</td>
</tr>
</tbody>
</table>

The second research instrument, the SVATI was also specifically designed for this study and consisted of a paper and pencil test containing 28 items. Items consisting of three types of spatial tasks were used in the SVATI. Examples of the three types of items are shown in Figures, 2, 3 and 4. The construct validity of these tasks as measures of spatial visualisation ability has been established previously by Embretson (1997); Bartmans and Sorby (1996); Shepard and Cooper (1982) and McGee (1979). The SVATI scores were also highly correlated (rxx = 0.74) with the Vandenberg Mental Rotation Test (Alias, 2000), a frequently
used measure of spatial visualisation ability (Vandenberg and Kuse, 1971), lending further support for the validity of the SVATI.

The SVATI had been tried on a comparable group, namely, a group of 20 first year civil engineering students from the University of Surrey, United Kingdom, to ensure that the instrument was reliable. Items were analysed both quantitatively (statistically) and qualitatively and improvements were subsequently made to attain a Kuder Richardson 20 (KR20) reliability estimate of 0.70. Although not excellent, the reliability obtained was deemed sufficient for research purposes, in line with the recommendation by Fraenkel and Wallen (1990).

Figure 2. An example of a cube construction item

Figure 3. An example of an engineering drawing item

Figure 4. An example of a mental rotation item

DATA ANALYSIS AND RESULTS

Attitude towards S&D

In order to determine whether the engineering students’ attitude towards S&D was different from that of the architecture students, the mean scores on the attitude measure were compared to that of the architecture group. The scores on the three attitude aspects of the engineering students were also compared to that of the architecture students to provide a better understanding of the engineering students’ attitude towards S&D.

For these purposes two new null hypotheses were formulated.

H01: There will not be a statistically significant difference between engineering students and architecture students in their view of the professional role of S&D.

H02: There will not be a statistically significant difference between engineering students and architecture students in their personal value of S&D.

H03: There will be no a statistically significant difference between engineering students and architecture students in their tendency to use S&D.

The pooled t-test was used to test for statistical significance. The assumptions underlying this test were: normality of traits for the underlying population, homogeneity of variance, independence of measure and variances that were additive. Normality was reasonably
assumed and homogeneity of variance was assured as indicated by the results from the F-test. The rest of the assumptions were met through the design of the study. Table 3 displays the descriptive statistics and the results of the hypotheses testing.

Table 3. Results of data analysis on the Attitude Questionnaire

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=57</td>
<td>n=19</td>
<td>n=57</td>
<td>n=19</td>
<td>n=57</td>
<td>n=19</td>
</tr>
<tr>
<td></td>
<td>39.44</td>
<td>46.74</td>
<td>25.44</td>
<td>46.74</td>
<td>31.32</td>
<td>41.21</td>
</tr>
<tr>
<td></td>
<td>5.82</td>
<td>4.33</td>
<td>3.35</td>
<td>4.33</td>
<td>3.62</td>
<td>5.29</td>
</tr>
<tr>
<td></td>
<td>Power</td>
<td>0.998</td>
<td>Power</td>
<td>0.96</td>
<td>Power</td>
<td>0.998</td>
</tr>
<tr>
<td></td>
<td>4.02</td>
<td>1.99</td>
<td>3.79</td>
<td>1.99</td>
<td>6.49</td>
<td>1.99</td>
</tr>
<tr>
<td></td>
<td>t_(2-tail)</td>
<td>1.99</td>
<td>t_(2-tail)</td>
<td>1.99</td>
<td>t_critical</td>
<td>1.99</td>
</tr>
<tr>
<td></td>
<td>t_critical</td>
<td>1.99</td>
<td>t_critical</td>
<td>1.99</td>
<td>t_critical</td>
<td>1.99</td>
</tr>
</tbody>
</table>

Clearly, the scores for the civil engineering group were lower on all three measures, each by approximately one standard deviation. The results were identical for all three hypotheses tested, namely, the differences in means are statistically significantly different at the 5 per cent significant level with high statistical power (power ≥ 0.96).

It could therefore be concluded that compared to the architecture group, the civil engineering group was:

- less positive in their views of the professional role of S&D
- less likely to value S&D
- less likely to use S&D

Association between attitude and spatial visualisation ability

In order to determine whether there was any association between engineering students’ attitude towards S&D and spatial visualisation ability, Pearson correlation coefficients between the scores on the Attitude Questionnaire and the SVATI were calculated. Correlations between the three attitude aspects were also calculated. The results are displayed in Table 4, which generally shows that all attitude aspects were positively correlated to spatial visualisation ability. However, at the 5 per cent level of significance, only the tendency to use S&D is statistically significantly correlated to spatial visualisation ability (p < 0.5).

Table 4. Pearson correlation coefficients between the scores on the Attitude sub-scales and the SVATI

<table>
<thead>
<tr>
<th>Spatial visualisation ability</th>
<th>Views of the professional role of S&amp;D</th>
<th>Personal value of S&amp;D</th>
<th>Tendency to use S&amp;D</th>
</tr>
</thead>
<tbody>
<tr>
<td>n=57, df = 55, r_critical = 0.26</td>
<td>0.07</td>
<td>0.18</td>
<td>0.36 *</td>
</tr>
</tbody>
</table>

* p < 0.5

To have an overall understanding of the relationships between attitude towards S&D, view of the professional role of S&D, usage tendency and spatial visualisation ability, the above findings were integrated and presented in Table 5. Thus, students’ tendency to use S&D was statistically significantly correlated to students’ view of the professional role of S&D.
Furthermore, the students’ tendency to use S&D was statistically significantly correlated to spatial visualisation ability.

**Table 5. Correlations of the Questionnaire components and SV ability (n = 57)**

<table>
<thead>
<tr>
<th></th>
<th>Value of personal usage S&amp;D</th>
<th>Tendency to use S&amp;D</th>
<th>Spatial visualisation ability</th>
</tr>
</thead>
<tbody>
<tr>
<td>View of the professional role S&amp;D</td>
<td>0.07</td>
<td>0.44 *</td>
<td>0.07</td>
</tr>
<tr>
<td>Value of personal usage of S&amp;D</td>
<td>0.14</td>
<td></td>
<td>0.18</td>
</tr>
<tr>
<td>Usage tendency of S&amp;D</td>
<td></td>
<td>0.36 *</td>
<td></td>
</tr>
</tbody>
</table>

*p<.05

**DISCUSSION**

Of interest to the study was how the engineering students compared in their attitude towards S&D with a group that appreciated S&D. Consistent with the initial assumption it was found that the civil engineering students were less positive in their attitude towards S&D compared to the architecture students. Higher emphasis on S&D in the Architecture curriculum together with unsupportive educational practices are two factors that might explain the difference in attitude. One such practice is the streaming of students into science, arts and vocational stream after their PMR. It is possible that the decreasing academic requirements together with the increasing importance of S&D from science to vocational stream have strengthened the negative association between poor academic performances and S&D.

Another practice is the requirement for good grades in technical drawing and art for pursuing architecture courses in contrast to good grades in mathematics for pursuing engineering courses. This practice might have encouraged the belief that S&D are important to architects while mathematics are important to engineers. Negative perception of S&D is shown by the low score of the engineering students’ view of the professional role of S&D. Viewing S&D as being less important might have a negative effect on usage tendency of S&D although the low usage tendency could have been simply due to lack of skills. Further studies are necessary to determine the real cause of the problem.

The high correlation between students’ tendency to use S&D and their views of the professional role of S&D was expected, bearing in mind that the subjects are adult learners. According to Knowles (1989), a better career prospect was one the factors that motivated adult learners in their educational undertakings. A positive correlation was also found between the tendency to use S&D and spatial visualisation ability. It was possible that having a high spatial visualisation ability encourages frequent use of S&D which is supported by Fennema and Tarte (1985) and Pribyl and Bodner (1987) who found that subjects with high spatial ability tended to make use of drawing strategy more often in their problem solving. On the other hand, it was also possible that frequent use of S&D causes higher spatial visualisation ability, which was indirectly supported by the finding from a study by Alias, (2002) on spatial visualisation ability.

A model is suggested in Figure 5 for the relationships between attitude, view, usage tendency regarding S&D and spatial visualisation ability based on empirical evidence. In this figure, the engineering students’ view of the professional role of S&D is shown to be related to their tendency to use S&D. This figure also shows that students’ tendency to use S&D is related to spatial visualisation ability.
Evidence was found linking spatial visualisation ability directly to usage tendency aspect of S&D and indirectly to students’ view of the professional role of S&D. This finding could be interpreted as views of the professional role of S&D having a motivating effect on usage tendency of S&D, which may lead to higher spatial visualisation ability. If this interpretation was accepted, the poor view that students hold of the professional role of S&D as well as their low usage tendency of S&D would be inadequacies that needed to be dealt with especially if S&D were employed in the development of spatial visualisation ability. In other words, any attempt to improve spatial visualisation skills in engineering students through S&D has to consider the influence of students’ views of S&D. Adequate emphasis should be placed on developing awareness, understanding and acceptance of the important roles of S&D to their future profession. This acceptance is likely to increase usage of S&D and ultimately spatial visualisation ability. For teaching and learning in general, creating students’ awareness on the relevance of the learning materials to their future undertakings would surely be one way of motivating students in their studies.

REFERENCES


