The Relationships of Spatial Experience, Previous Mathematics Achievement, and Gender with Perceived Ability in Learning Engineering Drawing

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Taking advantage of the convergence of technology and new insights of teaching and learning, the Ministry of Education of Malaysia has implemented a new educational reform primarily to revise the current curriculum, establish new learning standards, and incorporate the use of technology as an integral part of the learning process. This new educational reform suggests more of a focus on critical-thinking processes, problem solving, and student assessment deemed critical in academic curricula (Custer, Valesey, & Burke, 2001). One of the critical knowledge domains that received much attention is technical education. Several educational initiatives were drawn and implemented with special focus on the integration of computer technology in the curriculum of technical and vocational teaching and learning. Engineering Drawing for example, became one of the critical subjects that drew the Ministry's attention at the secondary education level due to the fact that overall performance began to decline after 1994 as more non-technical students enrolled in public schools and began taking the same course (Nor Fadila & Widad, 1999). Similar results were reported by Jayasree's (2003) study that indicated lower performance in Engineering Drawing compared to other technical courses. As a result, a thorough investigation is needed to identify the underlying factors that contribute to this problem and find the ways and means to address it. Research on the impact of engineering drawing learning in Malaysia has generally been scarce due to the relatively early adoption of the curricula. However, studies have begun to emerge that concentrate on Malaysian secondary schools and are shedding some light on the implementation of technology courses, particularly Engineering Drawing, focusing on the pedagogical, and socio-cultural aspects (Ismail, 2002; Nor Fadila & Widad, 1999; Tuan Zaidi 2002; Widad & Hatta, 2001; Yusri,

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1997). These researchers concurred that a basic understanding of fundamental concepts of projection theory, orthographic projection, isometric drawing, hidden views, and sectional views was problematic to most learners due to poor spatial ability. In addition, the ability to grasp these topics is critical as it represents the fundamentals of Engineering Drawing that deal with the construction of 2D and 3D geometry, and the creation of multi-view and pictorial representations (Bertoline & Wiebe, 2002; Olkun, 2003).

Apart from the spatial issue, gender and mathematics achievement were also found to be factors affecting students' performance in Engineering Drawing. Nur Fadila and Widad (1999) found male students performed significantly better than their female counterparts based on a research report of Engineering Drawing courses (LPMK: LK-1998). The same study revealed better performance of students with greater previous mathematics achievement over those with lower previous mathematics achievement. A strong positive correlation between mathematic achievement and spatial ability has been established in some research (Pallrand & Seber, 1984; Siemankowski & MacKnight, 1971; Tartre, 1990). Consistent and substantive gender differences favoring males have been found for spatial tests (Linn & Petersen, 1985; Voyer, Nolan, & Voyer, 2000). These gender differences pose potential threats to the success of female students in technical, scientific, and mathematics courses. A study by Scales (2000) indicated a slight relationship between gender and achievement in introductory engineering graphics, with females having lower final grades.

From the social-cognitive perspective, Hutchison, Follman, Sumpter and Bodner (2006) surveyed 1,387 first-year engineering students, studying their self-efficacy or perceived ability. They found that low self efficacy is related to learners' confidence, motivation, and persistence, thus affecting academic performance. In a related study, again of engineering students, a significant correlation was found between students' perceived ability (self-efficacy) and spatial ability (Towle, Mann, Kinsey, O'Brien, Bauer, & Champoux, 2005). In today's egalitarian society that advocates educational equality, it is expected that students enrolled in an engineering drawing course will be drawn from diverse cultural, educational and demographic background that may affect the learning and teaching process.

Purpose of Study

The purpose of this research was to examine factors that may influence students' perceived ability or self-efficacy to learn Engineering Drawing at the foundation year, namely in the Form Four level of the Malaysian secondary schools. The school system in Malaysia consists of primary and secondary levels: the former spans over a period of six years and the latter seven years. Students in Form Four of the secondary school level are equivalent to the tenth graders of the North American school system.

The Engineering Drawing course covers a two-year period, with fundamental concepts, theories, and techniques covered during the first year and advanced topics covered during the second year (11th grade). Several factors have been identified to be critical in shaping students' perceived ability to learn the subject matter. The first year of the Engineering Drawing course involved nine topics or units and for the purpose of this research it was divided into several categories in order to study the varying perceptions of students relative to the topics they were studying. Three hypotheses were formulated from prior research to address the issues mentioned above:

1. High spatial experience students will have higher perceived ability than low spatial experience students to learn Engineering Drawing.

2. High mathematics achievers will have higher perceived ability than low mathematics achievers to learn Engineering Drawing.

3. Male students will have higher perceived ability than female students to learn Engineering Drawing.

In addition to the above hypotheses, the study also sought to identify the factor(s) among the three variables that may have a strong predictive power to explain the variation in the perceived ability of students when learning the subject.

Method

Participants

A total of two hundred and twenty four (224) students, including 75 females and 149 males of Form Four level (10th graders) taking the Engineering Drawing course at the foundation year participated in the study. The average age for all the respondents was 15 years. The sample reflects typical gender distribution in schools, with males being the majority of those in taking technical subjects such as Engineering Drawing. The percentages of students based on geometrical location were 29.3%, 25.3%, 24.4%, and 21.0% drawn from northern, southern, central, and east coast states respectively in Peninsular Malaysia, providing a balanced representation in terms school geographic locations.

Instruments

A questionnaire designated as the Student Questionnaire (SQ) was designed by the authors to elicit information regarding students' demographics and background, including mathematics achievement at Form Three level (ninth grade) and their perceived ability to learn the nine topics of Engineering Drawing. One item for each of the nine topics was designed using a Likert-type scale with choices of extremely easy, easy, difficult, and extremely difficult, with numerical responses from 4 to 1 respectively. The summation of the scores across the nine items represented an index of the perceived ability of the student to learn the content of the Engineering Drawing course. The higher the score, the higher the perceived ability of the student.

The Cronbach Alpha was calculated to estimate internal consistency, resulting in coefficients of .79, .80, .71, and .67 for perceived ability to learn all topics, high spatial content topics, orthographic and isometric topics, and low spatial content topics respectively. The reliability coefficient for the low spatial content topics was slightly below the threshold of .70 it was deemed acceptable in accordance with psychometric theory (Nunnaly, 1978).

The spatial experience of the participants was measured using the Spatial Experience Questionnaire (SEQ)and was adapted from the English version designed by McDaniel, Guay, Ball, and Kolloff (1978). The SEQ consisted of a list of twenty-five spatial activities such as drawing, map reading, and playing chess. Students were asked to rate their participation in these spatial activities on a Likert-type scale of four options: "never," "occasionally," "often," and "very often." Values from 1 to 4 respectively were assigned to the four response possibilities. An index of spatial experience was thus determined by summing the responses, the higher the score, the higher the level of spatial experience. Internal consistency for the Spatial Experience Questionnaire (SEQ) was determined by the same procedure described above and resulted in a reliability coefficient of .89. The level of spatial experience reflects the degree of spatial visualization skills.

Data Collection

Application to conduct educational research study in public schools in Malaysia entails communication with the Education Ministry's agencies, namely the Education Planning and Research Department (EPRD) and State Educational Departments (SEDs). The former requires a draft of the research proposal prior to approving the study and the latter requires a formal letter of clearance from the former to allow such study at the selected schools. Principals of the selected schools were contacted by mail upon getting the approval letter from the SEDs. The administration of the survey questionnaires was carried out by visiting the schools during break sessions or free hours to prevent disruption of school activities. Normal school and co-curricular activities and other school priorities cropping up at the last minute hampered the effort to conduct the survey on a larger scale. Nonetheless, the sample adequately represented a balanced proportion in terms of gender and geographical distribution.

The administration of the questionnaires was carried out in the presence of the second author at the selected schools to enable the collection of first-hand information on the educational setting. All the participating schools possessed similar instructional materials, gender composition, teacher-to-student ratio, and teaching experience. The educational settings were deemed to be equivalent, thus minimizing the potential internal threats to the validity of the study.

This study employed a quantitative survey approach using two questionnaires. The first instrument was designed to collect demographic and background information of respondents. The second instrument included the nine items mentioned earlier to measure the students' perceptions about the difficulty of the Engineering Drawing course.

Prior to pilot testing, the questionnaire was reviewed by a panel of experts consisting of two lecturers from the same institution where the second author is working. These individuals have extensive experience in engineering graphics and computer-aided design (CAD) instruction. In addition, one of the experts was also the author of an Engineering Drawing textbook used by students at the secondary schools. These experts were consulted to categorize the nine topics of the Engineering Drawing course into two main groups: the topics that were deemed either high spatial or low spatial in their content. It was assumed that spatial content was directly related to the degree of effort students needed applying spatial visualization skills when learning the topics. No instrument was found that would measure this variable and the categorization was purely based on the panel's opinions.

Topics considered to have high spatial content were Sketching, Geometry, Orthographic Projection, Isometric Projection, Computer Aided-Design (I), Auxiliary Views and Oblique Drawing. Topics deemed having low spatial content were Introduction to Engineering Drawing, and Lettering and Lines. Because of their importance in the actual production of drawings, Isometric Projection and Orthographic Projection were treated separately. In the end, the categories included these two plus high spatial content topics and low spatial content topics. Thus four criterion variables were set for the regression analysis.

Analysis Procedures

Spearman rank-order correlations were computed between the variables of perceived ability to learn, gender, previous mathematics achievement, and spatial experience. Multiple regression was used to analyze the data using perceived ability to learn as criterion variable and gender, previous mathematics achievement, and spatial experience as the predictor variables. A stepwise regression procedure was also run using the same initial variables to identify critical factors(s) with significant predictive power that can explain the variation in the perceived ability.

Results

Perceived ability of students to learn each unit of the Engineering Drawing course at the foundation year is reported in Table 1 in descending order of rating. The higher the reported average rating the easier the respondents perceived their ability to learn a particular topic. Students were found to have the highest and lowest perceived ability to learn *Introduction to Engineering Drawing* and *Auxiliary Views* topics respectively.

The *Computer Aided Design* topic was perceived to be the second most difficult unit to learn. It was plausible that the low perceived ability was partly attributed to students having to work with the CAD software itself, which required familiarization with an environment completely different from the realm of the manual drafting practice that they normally encounter. This

Table 1
Rating of perceived ability to learn the topics of Engineering Drawing

Topics	Average Rating	Spatial Categorization	Learning Categorization
Intro. to Engineering. Drawing	3.41	Low	Easy
Lines and Lettering	3.23	Low	Easy
Sketching	3.22	High	Hard
Geometry	2.92	High	Hard
Oblique	2.60	High	Hard
Isometric projection	2.59	High	Hard
Orthographic projection	2.57	High	Hard
Computer Aided Design	2.54	High	Hard
Auxiliary views	2.40	High	Hard

Note: Higher rating implies higher perceived ability to learn the Engineering Drawing topics

particular topic is concerned with two-dimensional drafting using AutoCAD 2000. It requires students to learn basic commands and functions to produce 2D engineering drawings. Other topics that were categorized as highly spatial, namely *Orthographic projection, Isometric projection* and *Oblique Views* were perceived to be relatively difficult as expected. The first two topics were very important as they formed the basis of an engineering drawing (Bertoline & Wiebe, 2002; Olkun, 2003). Skills in this area were deemed highly pertinent by practitioners and educators (Barr, 2004) despite the current focus on computer-aided design based on 3D modeling over manual drafting practice. Table 2 presents Spearman rank-order correlations on perceived ability to learn the four levels of Engineering Drawing topics with gender, spatial experience, and previous mathematics achievement.

Table 2
Spearman rank correlations between perceived ability, spatial experience, previous mathematics achievement, and gender.

	Perceived ability to learn based on topics.			
	All topics	High Spatial Topics	Orthographic/ Isometric	Low Spatial Topics
Spatial Experience	.438**	.449**	.419**	.311**
Previous Mathematics Achievement	.285**	.278**	.272**	.226**
Gender	.140*	.218**	.187**	-.042

$^{**}p<.01$, $^{*}p<.05$

For all topics grouping, the correlation for perceived ability to learn and spatial experience was moderate and statistically significant, *r(222)*=.44, *p* =.002. High spatial experience respondents tended to have greater perceived ability to follow the engineering drawing instructions. A low correlation was found for perceived ability and previous mathematics achievement, *r(222)*=.29, *p* =.005. High mathematics achievers tended to have greater perceived ability to learn all topics in engineering drawing. A weak correlation was found between gender and perceived ability, *r(222)*=.14, *p* =.045.

For the high spatial content category, the correlation for perceived ability and spatial experience was moderate, *r(222)*=.45, *p* =.002. This indicates that the ability to learn these topics was positively perceived by those with high level of spatial experience. Previous mathematics achievement was slightly correlated with perceived ability to learn these topics, *r(222)*=.28, *p* =.007. The correlation for perceived ability and gender was also low, *r(222)*=.22, *p* =.009.

Similar pattern of associations was replicated for Orthographic and Isometric projection topics. A significantly moderate correlation was established for perceived ability and spatial experience, *r(222)*=.42, *p* =.005. Those with higher spatial experience tended to have greater perceived ability to learn these two important topics. The correlation for perceived ability and previous mathematics achievement was low, *r(222)*=.27, *p* =.009. A weak correlation was found for perceived ability to learn these two topics and gender, *r(222)*=.19, *p* =.009.

For low spatial content topics, the correlation between perceived ability and spatial experience was significantly small, *r(222)*=.31, *p* =.004. A significantly low correlation was detected for perceived ability and previous mathematics achievement, *r(222)*=.23, *p* =.007. The correlation of perceived ability and gender was observed to be negligible, *r(222)*=-.04, *p*>.05. The negative correlation is an indication that females had greater perceived ability than males in learning topics lacking in spatial contents although the correlation was not significant.

Inter-correlations between predictor variables were also investigated revealing a moderate correlation between spatial experience and previous mathematics achievement, *r(222)*=.38, *p* =.009. A moderate correlation was

Table 3
Inter-correlations between measures

Measures	1	2	3
1. Spatial experience	—	.376**	.339**
2. Previous mathematics achievement		—	.162*
3. Gender			—

***p*<.01, **p*<.05

found between spatial experience and gender, *r(222)*=.34, *p* =.009. The correlation of previous mathematics achievement and gender was weak, *r(222)*=.16, *p* =.041.

Multiple regressions with the three predictor variables were conducted and summarized in the following tables. The analysis of multiple regression for the statistical model employing the scores on perceived ability to learn all topics of Engineering Drawing as the criterion variable revealed a reasonable fit (R^2 = 27.5%) and the overall relationship was significant ($F_{3,220}$ = 27.77, p<.001) as shown in Table 4.

Table 4
ANOVA for model with independent variables regressed on all topics of Engineering Drawing

Source	*SS*	*df*	*MS*	*F*	*p-value*	R^2
Regression	864.896	3	288.299	27.770	.000	.275
Residual	2283.943	220	10.382			
Total	3148.839	223				

With other variables held constant, the scores on perceived ability to learn all topics of Engineering Drawing were positively related to spatial experience, and to previous mathematics achievement. Female students tended to have higher scores than their male counterparts on the perceived learning of all topics. The effect attributed to spatial experience was the highest (t_{220} = 7.17, *p* < .001) followed by marginal significant effect due to pervious mathematics scores (t_{220} = 2.07, *p* < .05) as shown in Table 5. The gender factor did not reveal any significant effect for this model of analysis.

Table 5
Regression analysis coefficient for model employing all topics of Engineering Drawing

	Non-standardized Coefficients		**Standard coefficients**		
	B	**Std. Error**		***t***	***p*-value**
Constant	13.446	1.888		7.121	.000
Spatial experience	.155	.022	.469	7.167	.000
Previous Mathematics Achievement	.056	.027	.129	2.070	.040
Gender	-.188	.485	-.024	-.387	.699

Subsequent examination using stepwise multiple regression confirmed that spatial experience and previous mathematics achievement were statistically significant in explaining the variation in the perceived ability to learn all topics of Engineering Drawing. The statistical model employing the perceived ability to learn topics of high spatial content as the criterion variable revealed a reasonable fit ($R^2 = 28.2\%$) with significant overall relationship ($F_{3, 220} = 28.84$, $p<.001$) as shown in Table 6.

Table 6
ANOVA for model with independent variables regressed on high spatial content topic

Source	*SS*	*df*	*MS*	*F*	*p*	R^2
Regression	495.281	3	165.094	28.842	.000	.282
Residual	1259.273	220	5.724			
Total	1754.554	223				

With other variables held constant, the scores on perceived ability to learn high spatial topics of Engineering Drawing were positively related to spatial experience and to previous mathematics achievement. Male students tended to have higher scores than their female counterparts on the perceived ability to learn these topics. Spatial experience was found to be the only factor with a significant effect ($t_{220} = 7.01$, $p < .001$) as shown in Table 7.

Table 7
Regression analysis coefficient for model employing high spatial content topics

	Non-standardized coefficients		Standard Coefficients		
	B	Std. Error		*t*	*p*
Constant	6.808	1.402		4.856	.001
Spatial experience	.133	.016	.456	7.014	.000
Previous Mathematics Achievement	.036	.020	.112	1.807	.072
Gender	.337	.360	.057	.936	.350

This was confirmed by a follow-up stepwise multiple regression revealing insignificant effects attributed to previous mathematics achievement and gender factors in explaining the variation in perceived ability. The statistical model employing perceived ability to learn orthographic and isometric demonstrated a reasonable fit ($R^2 = 25.1\%$) with a significant overall relationship ($F_{3,220} = 24.6$, $p<.001$) as illustrated in Table 8. It was clear that these two topics relied heavily on the spatial experience factor that produced the only statistically significant effect ($t_{220} = 6.6$, $p < .001$). Simple main effects attributed to previous mathematics achievement and gender were not found to be statistically significant as summarized in Table 9.

Table 8.
ANOVA for model with independent variables regressed on orthographic and isometric topics

Source	*SS*	*df*	*MS*	*F*	*p*	R^2
Regression	82.453	3	27.484	24.604	.000	.251
Residual	245.757	220	1.117			
Total	328.210	223				

Table 9
Regression analysis coefficient for model employing orthographic and isometric topics

	Non-standardized coefficients				
	B	Std. Error	Standard coefficients	*t*	*p*
Constant	1.291	.619		2.084	.038
Spatial experience	.047	.007	.438	6.599	.000
Previous Mathematics Achievement	.017	.009	.118	1.871	.063
Gender	.039	.159	.015	.248	.805

A follow-up stepwise multiple regression sustained the above finding where effects attributed to previous mathematics achievement and gender factors in explaining the variation in the perceived ability to learn these two topics were determined to be insignificant. A statistical model employing perceived ability to learn low spatial content topics as the criterion variable was analyzed by multiple regression. It revealed a poor fit (R^2 = 15.5%), but the overall relationship was significant ($F_{3,220}$ = 13.42, p<.001) as shown in Table 10 .

Table 10
ANOVA for model with independent variables regressed on low spatial content topics

Source	*SS*	*Df*	*MS*	*F*	*p*	R^2
Regression	65.198	3	21.733	13.424	.000	.155
Residual	356.159	220	1.619			
Total	421.357	223				

With other variables held constant, the scores on perceived ability of learning these topics of Engineering Drawing were positively related to spatial experience factor, and positively related to previous mathematics achievement.

Table 11
Regression analysis coefficient for model employing low spatial content topics

	Non-standardized coefficients		Standard coefficients		
	B	**Std. Error**		***t***	***p***
Constant	6.638	.746		8.902	.000
Spatial experience	.042	.009	.350	4.960	.000
Previous mathematics achievement	.020	.011	.124	1.846	.066
Gender	-.525	.191	-.180	-2.740	.007

Interestingly, female students tended to have higher scores than their male counterparts on the perceived ability to learn these topics. Effects attributed to spatial experience ($t_{220} = 4.96$, $p < .001$) and gender ($t_{220} = -2.74$, $p < .05$) were found to be highly significant. However, the effect of previous mathematics achievement was not significant at the .05 level. Follow-up analysis by stepwise multiple regression revealed similar results confirming the poor fit of this statistical model.

Discussion

Findings from the study have provided several insights concerning the perceived ability of students to learn the subject matter of engineering drawing. Spatial experience was found to be a significant factor, having a substantial relationship with students' perceived ability to learn Engineering Drawing for all four categories of topics, thus confirming the first hypothesis of the study. Students with more spatial experience perceive that they will be able to learn the content of the course.

Prior mathematics achievement was found to have a weak relationship in predicting students' perceptions on their ability to learn Engineering Drawing content overall. Thus the second hypothesis was only weakly supported.

The notion that males would have a higher perception about their success in Engineering Drawing, the third hypothesis, was not supported. Females were found to have a higher perception than males about learning the topics, especially the low spatial content group. One plausible explanation is the notion that, in general, females have greater ability to study content that requires a learning approach based on memorization and recall of facts rather than spatial skills. This is characteristic of verbal learners, and females have been shown to be the better verbal learners and males better spatial learners (see Gurian & Stevens, 2005).

Interrelations among the variables revealed that gender factor was moderately correlated with spatial experience factor and slightly correlated with previous mathematics achievement, favoring male subjects. Similarly, previous mathematics achievement showed a moderate relationship with the spatial experience factor. A person with a relatively higher level of mathematics achievement would likely reflect a corresponding higher level of spatial experience. No cause-effect relationship, of course, is implied.

Combining all the variables and their interactions together, a pattern emerged suggesting that, in general, male participants tended to have a spatial experience and mathematics background favorable to their perceived success in Engineering Drawing. Thus males felt more positive about their ability to learn Engineering Drawing compared to their female counterparts, especially for the high partial content topics.

Spatial experience was found to be the only factor showing a significant effect in the analysis for all four categories of the criterion variables. Little of the variance in perceived success of low spatial content was explained. This was not unexpected as the loading of the spatial factor in predicting perceived ability to learn engineering topics of low spatial content was too small to be accounted in the statistical analysis. Learning these topics normally requires rote learning and recall of facts and techniques and does not rely on cognitively processing spatial information.

The other two predictor variables, gender and previous mathematics achievement, minimally accounted for the variation in the perceived ability of students to be successful in Engineering Drawing. Stepwise regression further attested to the predictive power of spatial experience over the other two factors.

The above findings can help improve current instructional methods in Engineering Drawing by recognizing the potential differences in perceived ability to learn arising from several background factors, especially spatial experience. Teachers and instructors need to be aware of these differences among individuals or groups to undertake appropriate and necessary teaching strategies in their classrooms. Another important finding was the revelation of substantial gender difference in spatial experience. In general, female students were less spatially experienced than males, which may negatively experience their performance in Engineering Drawing in which high spatial visualization skills are required. Female students may come into the course disadvantaged because of their lack of spatial experience. These students may be highly vulnerable to threats to success caused by anxiety or fear. Teachers should be aware of these potential differences in their classrooms and take action to better assure that females have a potential for success that is equal to males.

Extreme care was taken to reduce any internal and external threats to the study following the administration of the questionnaire. As stated in the method section, one of the authors was present during the data collection process to assume consistency. Confidentiality and anonymity were assured to the students and it was made clear that their participation was voluntary. It was believed that the students felt more comfortable in reporting their experience without prejudice. Thereby, systematic bias and random variance was reduced. Nonetheless, it should be emphasized that the findings were purely based on self-reporting and they have to be interpreted with caution.

Conclusion

The research findings have highlighted that almost all topics of Engineering Drawing consist of highly spatial content that require greater spatial visualization ability. Teachers and instructors may have to prepare extra or extended classroom activities in the teaching process, especially in dealing topics that are considered difficult by some of the students. Interventional programs should be planned and readily implemented in classroom activities. These include providing remedial activities to allow struggling students to expand their spatial experience and thereby increase their spatial ability.

Several research studies in addressing students' lack of experience in spatial activities through interventional programs have been demonstrated to be considerably efficacious in enhancing spatial skills. These include mental rotation (Khairul & Azniah, 2004; Turos & Ervin, 2000) and spatial visualization (Rafi, Khairul, Abdul, Maizatul, & Mazlan, 2004; Olkun, 2003), both of which have been widely recognized to be important in learning in scientific and technical fields. These novel and innovative tools provide opportunities for learners to engage specific spatial tasks, focusing on spatial visualization skills and reasoning, making them more proficient in problem solving.

A broader implication of students' perceived ability to learn is linked to its important role in all cognitive theories of motivation involving constructs such as self-efficacy. Bandura (1986) described this construct as individuals' confidence in their ability to control their thoughts, feelings, and actions and thus influencing outcomes. The lower their perceived ability to learn, the higher the risk that their confidence and motivation in the learning process will be reduced. This, in turn, may translate into poor performance. In this context, it is critical that students' motivation in the process of learning Engineering Drawing be given due attention and monitored by teachers and instructors to ensure that they experience success.

The standard practice by Malaysia's school administrative bodies to impose relatively high previous mathematics achievement at Form Three level of secondary school system (i.e. ninth grade) for entry requirement may not adequately address the low passing rate in Engineering Drawing. In addition to this requirement, the spatial experience of students wishing to take the course may have to be measured as part of the selection process.

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