Teams affect the outcomes in problem based learning, but how should they be formed?

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Abstract

RMIT University Bachelor of Chemical Engineering has a stream of project based learning courses. Students work in small groups on an open ended project. The current research examines how formation of teams for group activities affects group outcomes and satisfaction with group member contributions. Teams were formed by three different methods (free choice, constrained choice, random allocation). Group member contribution was assessed using a peer assessment survey. The teams with higher marks tended to be more satisfied with equity of team contribution. The teams designed on principles of role compatibility were rated more equitable than teams where students had chosen the members themselves. These courses were in different year levels, so this may also show that the higher year students are more skilled in teamwork, and so their teams work better. In conclusion, helping students to develop teamwork skills is likely to increase their group outcomes.

Keywords: problem based learning; project based learning; team formation

1. Introduction

There is a growing body of evidence that students learn best when they are active and have choice about when and what they learn. One example of a teaching pedagogy that builds on this evidence is problem based learning (PBL). The RMIT University discipline of Chemical Engineering has recently introduced a stream of PBL courses into its program. The four year bachelor program has two semesters per year, and four courses per semester. One course per semester is taught in PBL mode.

Group work is excellent for developing students' generic skills such as leadership, teamwork, report writing and presentations. However, group work can be problematic. The course manager may have difficulty managing the different groups equitably and efficiently: group work can be demanding and labour intensive for the academics involved. Student members may feel that one or other members are not contributing fully. Some students under-perform throughout the semester but benefit by collecting the "group mark" at the end of semester. This may be countered by asking students to carry out "peer assessment" on their group members. The group mark can then be moderated by the "peer assessment" factor calculated for each group member, and some individual's marks will go up, and some down. However, in general, some groups will function better than others.

Group members may be picked in a variety of ways. When students are allowed to pick the members of their group, they generally pick their friends. Such groups foster a social network among peers. Another common method is for the course manager to allocate students to groups at random. This is common in RMIT engineering courses and has the benefit that it reflects the way the real world works. Another way to form groups is to identify team member skills and form groups from members with complementary skill sets. Multi-disciplinary teams are often formed in this way.

This paper considers three methods for forming groups and discusses the effect of group formation on group function and outcomes as well as the students rating of the course.

2. Literature Review

Engineers need skills in dealing with continual changes in technology and organisation in the work place. In addition to being technically competent, professional engineers also require skills of collaboration, communication and ability to work in teams [1]. In a recent study, engineering graduates pointed out that the ability to contribute in team-based projects is one of the important reasons for their success in their job [2]. Although technical competency is recognised to be important in this study, it was ranked low (29th) among the 49 possible reasons for their success. There are other papers in the literature which report the large gaps between the teamwork skills required by the employers and the teamwork skills developed by the graduates during the engineering program [3, 4]. There have been a number of studies which have demonstrated the benefits of teamwork and

collaborative learning in higher education [5, 6]. These studies show clearly that cooperative learning has strong and positive effects on many possible learning outcomes.

Team based or cooperative learning has been widely used in developing the teamwork skills using a number of student-centred learning methods such as project-based learning and problem-based learning. There have been many publications in the literature which describe the effectiveness of project- and problem-based learning. Problem-based learning begins when students are facing an open-ended, ill-structured, real-world problem. Students usually work in teams to identify the learning needs and develop viable solution [7]. On the other hand, project-based learning begins with a project statement or assignment which directs the students to carry out a number of tasks in order to produce a final product which could be a design model or a computer simulation [7]. The findings of the project work are usually presented in a written report and/or presented orally. In summary, project-based learning emphasizes application or integration of acquired knowledge while problem-based learning is more directed to the acquisition of knowledge [7, 8].

Both project- and problem-based learning methods are complex to implement due to many reasons. One of them is the interpersonal problems that arise when students work in teams. These problems have been recognized widely and many studies have suggested effective strategies for overcoming them [9, 10]. It has been pointed out that in a co-operative learning arrangement, the instructor should hold all team members accountable for the entire project contents [10].

The benefits of collaborative learning to the students are many. Some of them are: higher grades, deeper understanding of course concepts, longer retention of information, greater communication and team works skills, and gaining a better understanding of the professional work environment. But these benefits will not be gained automatically if the teams formed are ineffective or dysfunctional [10]. Simply putting students in groups to work on projects will not help to achieve the above mentioned benefits. There are good books on team work and project management [11, 12]. However there are not many guidelines to form teams. Oakley et al [10] have proposed the following three simple guidelines for team formation:

1) Unless the class setting or the nature of the assignments dictates otherwise, use three- and four-person teams.
2) Form the teams yourself, and make them heterogeneous in ability. In other words, members must be diverse in ability levels with common blocks of time to meet outside class.
3) In the first- and second-years of a curriculum, avoid isolating at-risk minority students, such as women-in-engineering, in teams

They also suggest that the team formation in the first and second years of the program should focus on reducing the attrition and from third year onwards the focus on team formation should be in preparing the students for workplace.

3. Methodology

Approval to carry out the project was obtained from the RMIT Ethics Committee. Three cohorts of students enrolled into PBL courses in 1st, 2nd and 4th year of Chemical Engineering were invited to join the research project. All three courses have similar structures based around PBL. A technical description of the project is written by the course teaching team at the start of semester. Assessments are defined and outlined in the course description. Groups are picked or created. Each group must submit progress and final reports, progress and final presentations, and a design file. In the first and second year groups generally work on the same project concerning one process. In fourth year groups are given a choice of four processes. The students carry out research about the main commercial processes. They then design a plant with a capacity or feedstock quality defined by the course manager. An example of a project is “design an effective de-sulphurisation process for a brown coal power station”.

In this study three courses are compared where students work in groups and where the groups are formed in different ways. In this paper the courses are referred to as Course A, B and C.

In course A, students were allowed to chose their groups. Criticisms of this method include the groups are less heterogeneous in ability than if they had been formed at random; minorities tend to join the same groups.

In course B, each student analyzed his or her preferences for group work roles using Belbin’s self perception questionnaire [13]. Belbin studied teams during nine years of research at the Administrative Staff College at Henley in the UK, and identified 9 roles that team members play. He found that a team member typically has 3 preferred roles that he or she plays well and 3 roles that he or she can play reasonably well if no one else in the team can undertake these roles. The remaining 3 roles are best left to other team members. He found the most effective teams had members with complementary role sets. The students in Course B identified their top 2 preferred roles and then formed teams of five students from members with complementary preferred roles. Some role types were more prevalent than others, and some were very scarce (plant and resource investigators) so not all teams could be completely balanced. Students could select some friends but were limited to friends or peers with complementary roles. Criticisms of this method are: the students may be stereotyped into a particular role such as “leader” and not practice taking other roles;

the groups may be more homogeneous in ability than groups formed at random (e.g. the top students tend to form teams together); minorities tend to join the same groups (e.g. international students form groups together).

In course C, students were allocated at random to groups after nominating their preference among four projects. This achieves heterogeneity of abilities but fails to achieve a set of complementary skills.

Group size in each course was similar, varying from 4 to 6. These team sizes are larger than those advised in the literature, but were chosen for convenience because of the large class size (110 in Course A, 50 in Course B, and 100 in Course C). Course A runs in first semester of first year, Course B in first semester of second year, and Course C in second semester of fourth year.

Groups are asked at mid-semester and end of semester to analyse ("peer assess") the performance of themselves and each other group member. This coincides with submission of the progress and final report, when each member's contribution is keenly felt. It is evaluated using a Peer Assessment Proforma. The peer assessment criteria are: Knowledge of the subject, Initiative, Dependability and integrity, Participation in activities, Attendance and punctuality. The data for each member of the group is aggregated. Each average is normalised (to allow for "hard markers" as well as "soft markers"). Then each member of the group is given a peer factor based on an average of all the scores (including their self score). The course co-ordinator uses this factor to moderate the marks of each member in that group, by a linear or similar proportion (for example, to the square root of the factor). If all members were equally rated, all group members receive the same mark. If most members rated another member lower, that person receives a lower mark and all the others a higher mark: the average mark remains the same. The standard deviation of peer factors was calculated for each group, and an average standard deviation for all groups was calculated.

The lecturers observed the students during informal project review classes as well as formal presentation assessments.

Each course is surveyed each semester using a survey instrument developed by RMIT. The surveys are anonymous. Questions cover a variety of topics, including good teaching. The good teaching questions are the same as those used in the national Graduate Destination Survey (GDS) of all tertiary graduates to calculate the Good Teaching Scale (GTS) for each course/program. These questions are:

1. The staffs are extremely good at explaining things.
2. The teaching staff normally gives me helpful feedback on how I am going in this course.
3. The teaching staff in this course motivates me to do my best work.
4. The teaching staff works hard to make this course interesting.
5. The staff makes a real effort to understand difficulties I might be having with my work.
6. The staff put a lot of time into commenting on my work.

The surveys are collected by someone other than the lecturer and returned to a central statistics data processing group. This group compiles reports for each course and calculates the GTS. In addition to the standard questions, students in Course B were asked to comment on the group formation and how this affected their learning.

4. Results and discussion

4.1. Qualitative Data

The students in Course B were asked to comment on the group formation and how this affected their learning. They made positive and negative comments. 37 students answered the survey and 7 made comments on the groups. Examples of positive comments were:

"My group was the best aspect of the course"
"The group work we are doing broadens my knowledge. I learned how to do teamwork"
"I liked the way groups were selected at the beginning"
"Getting to work in a team with different people having different skills".

Examples of negative comments were:

"The teams should have been smaller"
"Nothing worked well this semester in our group, due to workload & useless team members"
"Belbin principles weren't really utilised well, we all did our own thing and it eventually came together in the end. The best group is one with your friends.."
"The Belbin roles were not even considered in our group. We committed ourselves to topics that interested us only."
"Our team had multiples of the types of worker but our team still worked well".

These comments suggest the students had a broad range of good and bad experiences, in about equal measure. Interestingly, two negative comments indicated one or more groups worked well "despite" use of Belbin principles: members chose topics of interest and these choices were complimentary. These groups failed to understand that those are the characteristics of a Belbin designed team. The negative comments suggest students need more assistance to develop teamwork skills.

Observations of the groups were made during workshops and presentations. Most workshops were well attended and the (assessed) presentations had 100% attendance. In public most groups appeared happy, productive and easy going. This may be more related to the Australian teenage culture of acting "cool", rather than an accurate reflection on how group members were feeling. In private, confidentially, some team members complained

vehemently about their groups or group members, especially around the submission date for reports.

42. Quantitative Data

The courses were evaluated using RMIT's survey based on the national Graduate Destination Survey questions. The results for the last two years are given in Table 1.

Table 1. Results for Good Teaching Scale (GTS)

Course	GTS 2007	GTS 2006
A	43%	45%
B	46%	58%
C	Not available	Not available

Table 1 shows that students rated course B slightly higher than course A. No data was available for course C. The repeatability of the data is unknown. It is expected to be around ± 5%.

Table 2. Average Results and Peer Factor

Course	Average Group mark	Average peer factor standard deviation
A (6 groups)	71%	0.333
B (7 groups)	64%	0.138
C (2 groups)	90%	0.087

Table 2 shows that students performed better in Course A than B but the average peer factor standard deviation was much higher. It is likely that the average group mark is affected by many factors such as how the course is assessed, who assesses the course, as well as how well the teams worked together. A functional team should perform better than a dysfunctional team, other things being equal. The peer factor standard deviation is a direct reflection on how well the groups worked together. A team with members who contribute equally has a standard deviation of zero, while a team with members who contributed very unevenly would have a high standard deviation (approaching 1). So the data in Table 2 suggest that the students in Course A were less satisfied with the equity of group member contributions than in Course B. Data for Course C is too limited to draw conclusions.

Fig. 1 shows the standard deviation of peer factors for each group as a function of that group's mark for Courses A and B. The limited data for Course C falls very close to the Course B trend. The students in teams that performed well (i.e. had higher marks) were more likely to rate the contribution by members as equitable (i.e. had a low peer factor standard deviation) in both courses. This was most evident in Course A groups. Course A groups also had a higher peer factor standard deviation than Course B or C groups across the whole range of performance. Course A students were less satisfied with the equity of contributions than students in Course B or C.

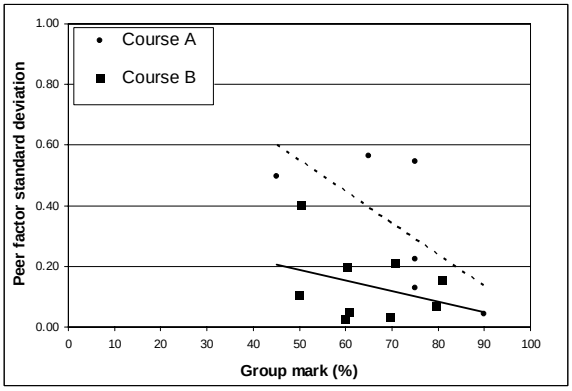

Fig.1. Individual Group Results and Peer Factor

This suggests the Belbin designed teams in Course B worked together better than "friend picked" teams in Course A. Alternatively, as Course A is a first year course and B a second and C a fourth year course, in later years where the students have developed better team skills (or more realistic expectations of team members) the teams worked together better. Interviews with the a few teams from each year would help identify causes of these differences. However, interviews were not carried out in this particular study. A goal of future work would be to identify how to help especially first year students develop better teamwork skills, as this is likely to help them achieve better group outcomes.

5. Conclusion

Strong generic skills are vital to engineers in today's workplaces. Team based or co-operative learning such as problem based learning (PBL) is recognized as an effective way to develop such skills, especially teamwork. How teams are formed influences team effectiveness: small diverse teams are better than large homogenous teams. Management theories such as those developed by Belbin can be used to pick team members with complementary preferences for roles. Peer assessment can be used to gauge whether a team works well. The group marks as well as peer assessment standard deviation were compared for students in 3 PBL courses. There was some correlation between these two indicators: high achieving teams were more satisfied with their peers. The course where students picked teams (from their friends) showed the highest level of dissatisfaction with their peers, while the course with members picked on the basis of preferences for Belbin team roles showed a lower standard deviation. Students praised team work as the best thing about the course as well as the worst. The data trends also suggest that students with more team skills (i.e. those in later

years) form teams that function better. More work is needed to optimize the way groups are picked for different year levels, and to develop students teamwork skills, especially in first year.

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Development of Effective Communication Skills in Undergraduate Engineering Students

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Abstract

The need for development of communication skills in undergraduate engineering students is recognised by professional accrediting bodies and employers internationally. In an Engineering Communication course at The University of Adelaide specific communication skills are developed by undergraduate students in a scaffolded-learning environment. Detailed feedback on students' draft written assignments and practice oral presentations is provided by lecturers with relevant expertise in language. Average marks for the final written assignments indicate that the 3 stage process of draft and practice, followed by feedback prior to final submission, is valuable to students in terms of improving their skills for written communication of a clearly structured analysis of evidence related to environmental sustainability.

Keywords: undergraduate engineering; communication skills; scaffolded-learning

1. Introduction

The purpose of this paper is to report on the effectiveness of the written analytical skills development aspect of the Design and Communication course in the School of Mechanical Engineering at The University of Adelaide. Students' communication skills are seen to improve in a learning environment that includes lecturer's feedback on practice oral presentations and draft papers. Firstly, background is given about the skills required of graduate engineers in professional practice. The discussion then focuses on development of effective communication skills in undergraduate Mechanical Engineering students. An indication of proposed future work follows in the Conclusion section.

1.1. Skills required of graduate engineers

Apart from technical expertise, both effective communication skills and an understanding of contemporary issues, such as environmental sustainability are widely acknowledged as vital for graduate engineers. Engineering graduates who demonstrate effective communication skills can reach leadership positions earlier in their careers [2], [3], [4]. The need for development of communication skills in undergraduate students is recognised by the professional accrediting bodies, and employers in Malaysia [1], Australia, UK, and USA [5]. Accreditation criteria for engineering degrees in Australia [6] require programs to develop students' ability 'to communicate with the engineering team and the community at large'. Secondly, an understanding of contemporary issues is important for modern engineers. Broad agreement on the need to develop students' awareness of social, environmental, economic and legal issues, which feature in engineering practice was reported in Mills and Treagust's [5] survey of engineering education in USA, UK and Australia. Australian [6] and similarly Malaysian accreditation criteria [1] require students to understand the broad social and environmental responsibilities of the professional engineer, plus the need for and the principles of sustainable design and development. Graduate engineers are widely expected to be effective communicators, well-informed about their responsibilities, including sustainable development.

1.2. Oral communication skills in professional practice

Oral communication characterises the daily work of engineers in small groups, and teams, as well as in formal settings. Formal presentations at public seminars have been identified as professionally important by 50% of a diverse group of engineers surveyed by Darling and Dannels [4], whereas 41% of responses in the same survey indicated that meetings and informal interpersonal oral communication were the most important type of oral communication, and occurred more frequently in a working week than formal presentations. Construction of a clear, concise and logical message, and effective interaction, were rated the most important skills by the engineers surveyed [5]. The importance of these oral communication skills for

professional engineers renders their development in undergraduate study as valuable preparation for an engineering career.

1.3. Written communication skills in professional practice

In professional practice, colleagues interact in providing feedback, and revising the draft text of a concept proposal, for example. Feedback on the draft text of a comprehensive energy concept for a German municipal council described in a case study by Pogner [7], was applied in conjunction with reading documents, visiting sites, and participating in meetings. Pogner's analysis of the process is that written interaction is 'negotiatory'. Furthermore, revision and rewriting operate as problem-solving strategies, and include agreement about the strategic value of a particular argument in a technical report. Thus, in the workplace written interaction is both a reflection of the decision-making process, and a means of demonstrating alignment in a professional community [7]. Valuable preparation for professional practice can potentially be found in the experience of applying feedback to draft texts during an undergraduate course.

1.4. Preparation for professional practice

Oral and written communication skills are part of engineering courses at many Australian and US universities, with a focus on sustainable development found to be particularly prevalent in Australian universities [5], including the Design and Communication course at The University of Adelaide. The design of these courses typically reflects items on the universities' list of graduate attributes for their students who are emerging from university to the workplace. Most communication curricula aim to develop in students the highly desired graduate attributes of skills in critical thinking and interpretation [8]. The production of well-structured analysis in written and oral text helps to prepare graduates for the demands of professional practice.

2. Developing effective communication skills in undergraduate Mechanical Engineering students at The University of Adelaide

This section of the paper focuses on the Communication component of the Design and Communication course, in which students learn skills for effective oral and written communication, focussing on issues of sustainability. Specifically discussion in this section encompasses curriculum, teaching method, assessment and feedback, plus outcomes and discussion of the effectiveness of the course.

2.1. Curriculum

The Design and Communication course in the School of Mechanical Engineering is compulsory for all students at third year level, and combines elements of both design and communication skills. Design projects in the course focus on lightweight, low net carbon-emission aircraft or commuter vehicles, for example. Environmental sustainability features of the design project are the focus of the Communication assignments. The task requires students to:

Identify how environmentally sustainable features can be incorporated in the design of your project. In addition, you could compare the effects of these features to a traditionally designed version of your project. You are not expected to justify sustainability. Your research must focus on the specific design features of sustainable transport.

The Communication curriculum is designed to develop effective communication skills, with the goal of presentation of structured analysis of literature sources in oral and written assignments, based on research about sustainability features of the design project. Throughout the course, skills and strategies are explained and modelled in the following areas:

1. Structure of a seminar presentation, discussion paper, paragraph
2. Developing a point of view based on analysis of published evidence
3. Appropriate formal language
4. Logical cohesion of text
5. Referencing conventions

2.2. Teaching Method

The heuristic teaching method where students attempt drafts and apply feedback in their subsequent assignments, was integrated into the original design of the curriculum by Wake [8] and is based on a 'scaffolded-learning' approach. A scaffold [9] describes the support available to students as they attempt to master the target skills. In this Communication course, students are assisted in their learning with model texts; exercises and explicit instructions; limited choices in structure, cohesive writing strategies, and referencing strategies, for example; as well as detailed individual feedback on draft texts by way of written comments and individual consultations with lecturers. For the students, the process of analysis begins with a literature search, guided initially by a librarian. Students are expected to compare statements about environmental sustainability features from scholarly source texts, and elaborate on an idea by means of an inference, example or reason [11]. Through comparison of claims about sustainability features and applying the interpretation of source literature to his or her design project, a student can begin to see evidence-based claims as conditional [11]. Consistent with the scaffolded process, assistance from a

lecturer is available at a level corresponding with a student's level of expertise, and 'fades' as a student approaches the target [13]. Through feedback on draft attempts the scaffolded-learning environment fosters students' achievement of the skills required for effective communication of their analysis.

Students are expected to take responsibility for their own learning in the Design and Communication course. The expectation of independent learning in a large class in conjunction with implementation of the scaffolded process means that whereas the appropriate resources are available to students, and feedback provided where the draft falls short of the target skills, it is the student's responsibility to practise the target skills in the class exercises, and apply the feedback. Students' motivation for achieving target skills as independent learners is commonly a high grade for Communication, with the view to employment prospects. An independent learning approach is compatible with a scaffolded-learning environment.

2.3. Assessment and feedback

The students' analyses are assessed according to specific criteria (Appendix 1), which are the basis for detailed feedback provided by language specialist lecturers on practice oral presentations and draft papers (Assignment A), for application in final assignments. Feedback on specific features of the practice oral presentation and draft discussion paper (Assignment A) is given according to the assessment criteria provided, and application of the feedback is required in the final paper (Assignment B). Feedback on practice oral presentations is provided on the content and the delivery style. Comments on the content of oral presentations, relating to 'focus of research', 'structure of analysis', 'integration of sources', and 'appropriate language formality', are used by students in preparation of subsequent written, as well as oral assignments. Feedback on the draft written paper comments is detailed, eg. *'outline of key issues in Introduction stage as logical framework for your discussion'*; *'compose topic sentence/s to introduce each key finding and outline subtopics of paragraph'*; *'evaluate key issue at end of paragraph'*, and '*avoid stating your point of view for the first time in the Conclusion stage'*. Thus, students' attention is drawn to specific features of their analysis where more work is required to satisfy the assessment criteria appropriately. Students review the relevant sections of course material, and may consult lecturers for advice on applying the feedback in Assignment B. Marks are awarded in the final assignment for the application of feedback comments. The application of feedback is a vital stage of the scaffolded-learning process, and development of undergraduate students' communication skills.

2.4. Outcomes and Discussion

The effectiveness of the scaffolded-learning process in this course is indicated by the improved average achievement of students in their final written assignment (Assignment B). In draft assignments (Assignment A), students' attempts at analysis of evidence may resemble an uncritical 'cut and paste' collection of information, due to lack of familiarity with the functions and conventions of integrating source literature. Subsequent assignments (Assignment B) incorporating the detailed feedback typically show improvement in structure and analysis for the majority of students, as shown in Figure 1. In 2006 the average mark for the draft paper (Assignment A) was 67%, and the average mark for the final paper (Assignment B) was 74%. In the class of 150 students the most significant improvement in marks occurred largely where students had done relatively poorly in their draft assignment (Assignment A). Marks improved by 12% - 45% between Assignments A and B for approximately one third of the class. The majority of these students were **below** the average mark for Assignment A. Conversely, many of the students who showed no improvement or achieved lower marks in their final paper (Assignment B) had achieved **above** the average mark in the draft paper (Assignment A).

Student perceptions of the course are positive. A high degree of satisfaction with the course is evident in student evaluations conducted by the University. Sprcific comments from students include: *'… encourages us to learn and to challenge ourselves'*, *'…provides good feedback'*. Comments from students about the explicit nature of the course include: *'Explains exactly what is required'; 'Good explanations for structure for academic writing. I now have a better understanding of how to write an academic paper'*. Another student wrote of the Engineering Communication course during her subsequent internship in the European Space Policy Institute (ESPI): *'Truthfully, I've always thought I was pretty good at writing and was rather offended initially at criticisms, but taking them on board has boosted my work ability so much. At the moment I'm writing another report for ESPI … again, several thoughts came into my head about the skills we learnt in Engineering Communication lectures.'* The value of developing the effective communication skills is recognised by students.

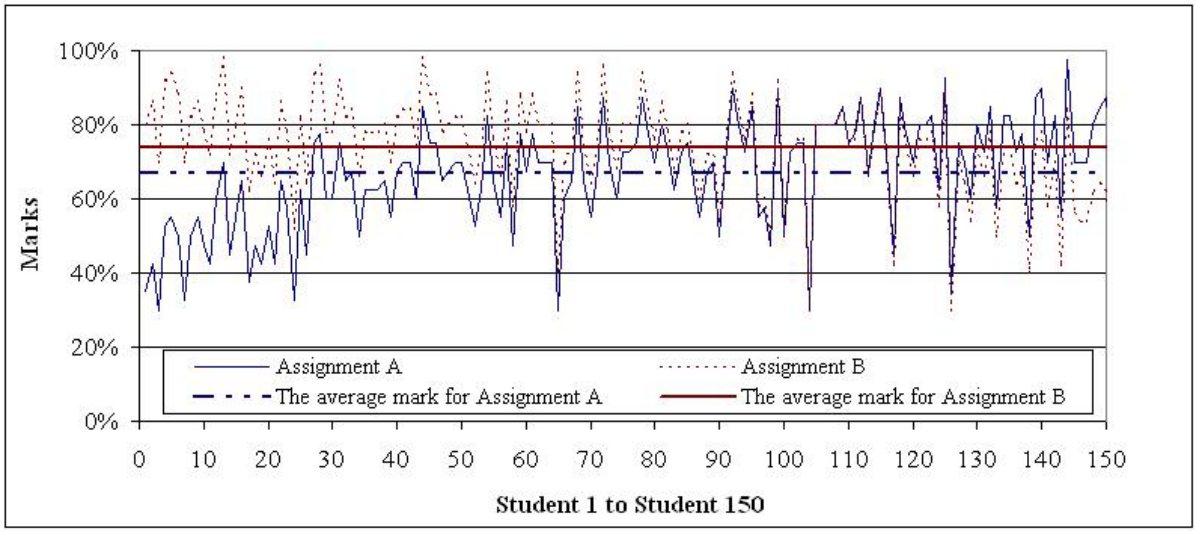

Fig. 1. Comparison of marks for Assignments A and B in the class of 2006

3. Conclusion

Average marks for subsequent assignments indicate that the 3 stage process of draft followed by feedback prior to final submission, is valuable to students in terms of improving their written communication skills. Future work is planned to investigate the reason for many of the students who had achieved above the average mark in the draft paper (Assignment A) showing no improvement or achieving lower marks in their final paper (Assignment B). Future work is also planned to evaluate the effect of a change in the timing of the practice oral presentation assignments.

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APPENDIX 1 - Assessment Criteria for Assignments

Practice oral presentation **10%**

Content of presentation *5 marks*

- Topic presented clearly
- Brief and relevant background provided
- Speaker's point of view/proposition/focus of research
- Key findings to date
- Speaker integrated relevant sources into presentation
- Appropriate use of semi formal language (eg. slang, colloquialisms, and unnecessarily technical language avoided)
- Appropriate conclusion

Style of presentation *5 marks*

- Natural delivery style, volume and pace appropriate
- Speaker maintained eye contact with whole audience (didn't read from notes)
- Text on slides word processed and legible with a large font 20+, neat format and correct spelling
- Text on slides is succinct, not too detailed
- Presentation was within appropriate length of time
- References shown on slides throughout, and diagrams appropriately labelled and acknowledged

Assignment A: Short Discussion Paper **20%**

Introduction *5 marks*

- topic and focus of research is clearly stated
- outline of key issues given as logical framework for discussion
- scope of research is stated (if appropriate)

Middle/Discussion *9 marks*

- each paragraph presents writer's analysis as a logically structured discussion
- topic sentence/s introduce each key finding
- topic sentence/s provide outline of sub-topics to be discussed
- discussion in each paragraph develops from general to specific
- ideas, topics and information are fore grounded in sentences
- appropriate use of register (eg use of slang, colloquialisms or spoken language avoided)
- source information is appropriate
- source information is interpreted accurately, not copied or plagiarised
- source information is accurately referenced in-text
- brief evaluation of key issue is provided at conclusion of each paragraph

Conclusion *2 marks*

- summary of key issues which link to research question
- student has avoided stating point of view for the first time in the Conclusion

References *3 marks*

- publication details are accurately set out in list of References

Appropriate formatting and presentation of paper *1 mark*

APPENDIX 1 - Assessment Criteria for Assignments

Assignment B: Research Discussion Paper (1000 - 1200 words) 30%

Please attach a copy of Assignment A with the mark sheet to this paper. Markers will take into account how well you have applied feedback from Assignment A into your discussion.

Introduction 7 marks

- topic and focus of research is clearly stated
- background/orientation to topic is clearly set out
- point of view/proposition/focus of research is clearly stated
- outline of key issues given as logical framework for discussion is clearly stated
- scope of research is stated (if appropriate)

Middle/Discussion 17 marks

- each paragraph present writer's analysis as a logically structured discussion
- topic sentence/s introduce each key finding
- topic sentence/s provide outline of sub-topics to be discussed
- discussion in each paragraph develops from general to specific
- ideas, topics and information are foregrounded in sentences
- information is linked between sentences by means such as repetition, development of information from one sentence to another, or through related and referred meaning
- appropriate use of register (eg use of slang, colloquialisms or spoken language avoided)
- source information is appropriate
- source information interpreted accurately, not copied or plagiarised
- source information is accurately referenced in-text
- brief evaluation of key issue at conclusion of each paragraph

Conclusion 3 marks

- summary of key issues which link to research question
- student has avoided stating point of view for first time in the conclusion

References 2 marks

- publication details are accurately set out in list of References

Appropriate formatting and presentation of paper plus attached copy of assessed Assignment A 1 mark

A Survey on Academic Ethics among the University Students

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Abstract

The purpose of this study is to examine the practice, tendency and awareness of university students towards academic ethics. A questionnaire on academic ethics had been administered to 167 engineering students in the Universiti Teknologi Malaysia, Skudai. It was revealed that the students did not really exhibit positive ethical behaviour when dealing with lecturers. The level of academic dishonesty was found to be at a moderate level, although the tendency to cheat during examinations was very low. In general the students had a high awareness of the university dress code and also dressed accordingly. The issue of academic ethics should be taken seriously by all parties involved so that the integrity of an academic institution could be strengthened.

Keywords: academic ethics; academic dishonesty; engineering students; dress code

1. Introduction

Ethic is the moral system that governs one's behaviour and influences the person's attitude towards something. Individual who has positive ethical values is said to exhibit positive attitude and behaviour. The importance of ethic has also been emphasised by our country, Malaysia, as outlined by the fourth challenge in the Malaysia's Vision 2020, which is "to form a community that has high morale, ethics and religious strength". Nonetheless, with the advent of technology, coupled with the fast changing pace in the environment, more negative ethical values have been surfacing, including among the university students. For example, researches on academic dishonesty among the university students have generally shown that cheating during examinations and plagiarism are worldwide problems [1], [2], [3]. This is something to worry about since these students will be the future leaders, either in an organisation or even in the society. It is assumed that students with low ethical values may exhibit the same attitudes when they start working in the future.

Realising the importance of academic ethics, the Department of Students Affair and Alumni of Universiti Teknologi Malaysia (UTM) has developed five principles to be carried out in order to produce competent and responsible graduates. One of the principles is selected culture, which aims to produce students with praiseworthy attitudes such as politeness, neatness and tidiness, helpful and responsible.

Being polite is an attitude that everyone should exhibit in everyday life. As for students, being polite includes respecting the lecturers and showing good ethics when dealing with the lecturers. As for neatness and tidiness, the university had also launch the "Smart Day" programme whereby students have to wear certain smart and proper attire on Monday. They are also encouraged to continue dressing in the same manner on other days as well. Besides that, UTM also has a dress code which students should abide by.

The university also views five offenses as serious offenses, which are: (i) cheating during examination, (ii) drug abuse, (iii) vandalism, (iv) gangsterism, and (v) stealing. Those caught doing these offenses may be expelled from the university.

Nevertheless, how far students abide by these rules and principle is something that should be looked into. In addition, although there are quite a number of studies done on academic dishonesty (cheating) not much study has been done on other academic ethical aspects. In addition, Gbadamosi [4] believed that most universities do not like to admit that academic dishonesty does exist in their universities due to the fact that it will ruin their reputation. However, by ignoring the problem, it may result in the universities producing unethical graduates which may lead to a greater problem to the society in the future.

Due to this notion, this study tries to:

(a) Investigate the practice and awareness towards academic ethics among the engineering students in UTM.
(b) Compare the practice and awareness towards academic ethics among these students based on demographic factors.

2. Literature review

A lot of research on academic ethics has mostly focus on academic dishonesty or cheating. So far, no

research on ethical behaviours dealing with lecturers and on dress ethics was found by the researchers of this study. Thus, this section will mainly focus on past findings on academic dishonesty.

2.1. Ethics

In general, ethics refer to the moral behaviour system, which guide someone in determining what is right or wrong and what constitute as good or bad behaviours. According to Mohd Janib [5], an ethical person is someone with good attitudes and acts in good manner. Recently, due to globalization, economic integration and internationalisation of trades which has increased the global networking around the world, the issue of cross cultural values has become somewhat significant since the influence of different cultural values may result in ethical conflict in a certain society [4].

2.2. Ethical behaviours when dealing with lecturers

As a person who is responsible in teaching, shaping the personality and making sure students gain certain knowledge, lecturer plays an important role in developing the leaders of tomorrow. Therefore, it is important that students value and respect their lecturers as well as behave ethically when dealing with them.

According to Hasan [6], a student should always greet his or her lecturers, talk politely and show respect when talking or dealing with them. In addition, he or she should always pay attention during lectures or discussions with his or her lecturers and should not forget to thank their lecturers after each lecture and discussion. A student should also not hold any grudge against his or her lecturers and always be humble when asking for help from his or her lecturers. Students who behave ethically when dealing with their lecturers will result in their lecturers being more sincere in teaching them and also makes the learning process easier.

2.3. Academic dishonesty

Academic dishonesty or generally known as cheating, is not something new in the academic field. In fact, the problem of students cheating in university has shown a worrying trend [7]. A study by Ameen *et al*. [8] showed that more than half (56%) of the respondents admitted having cheated during the examination and in doing their assignments. Nevertheless, only six percent admitted ever being caught for cheating. According to them, the reason why the percentage of students being caught was small compared to those who cheated is because the lecturers did not really play their role in emphasizing the academic rules and ethics. They knew that the lecturers did not want to be involved in the case of persecuting students who cheat because it will be a burden to them. In addition, the students also believe that the risk of being caught due to academic dishonesty was minimal.

Although several studies [9], [10], [11] found out that there was no difference between the male and female students in engaging academic dishonesty, O'leary and Radich [12] found out that male acted unethically four times more than their female counterparts. On top of that, Borkowski and Ugras [13] also found out that the female students are more ethical than the male students. Since the results are mixed, there is no concrete evidence to say that there really is a difference in the level of academic dishonesty based on sex.

In terms of race, it was revealed that Asian students were more prone to consider misconduct not as ethical misconduct compared to the students in New Zealand and European countries [7]. Moreover, Teoh et al. [3] found out that students with different background cultural beliefs had different perspectives on what were considered as unethical practice. Students who were more religious were also found to have higher ethical awareness [14].

An analysis done by Crown and Spiller [15] concluded that academic dishonesty is negatively correlated with student's grade. Other studies also found out that students with low academic grades had higher tendency to cheat during examinations [16], [17].

3. Methodology

A convenient sample of undergraduate engineering students was utilized for the purpose of this study. The respondents consisted of 167 engineering students from the Universiti Teknologi Malaysia, Skudai. The data was collected through self-administered questionnaire. The questionnaire contained seven sections. The first section sought demographic information. The second section measured the level of ethical behaviour when dealing with lecturers; the third and fourth sections measured the practice of and tendency towards academic dishonesty; the fifth and sixth sections gauged the awareness towards and conformity of the university dress code; and the last section was an open ended section to gain the respondent's perception on general ethical conduct among students.

In order to measure the level of ethical behaviour when dealing with lecturers, practice of academic dishonesty and conformity to the university dress code, the respondents were asked to rate on a scale ranging from 1, "Never", 2, "Sometimes" and 3, "Always". A five-point Likert scale ranging from 1, "Strongly Disagree" to 5, "Strongly Agree" was used to measure the respondent's tendency towards academic dishonesty. A scale ranging from 1, "Yes", 2, "Not Sure" and 3, "No" was utilized to gauge the respondents awareness towards the university dress code. The levels were divided into five levels ranging from "Very low ethics" to "Very high ethics".

The demographic data were analyzed to provide frequencies. The levels of ethical behaviour when dealing with lecturers, academic dishonesty and tendency to cheat during examinations, awareness towards the university dress code and conformity to the dress code were measured using frequencies. The Pearson Chi-Square tests, T-Test and ANOVA were utilized to find the differences of these levels according to demographic factors.

4. Results and discussion

4.1. Profiles of respondents

Majority of the respondents in this research were males (58.7%). About 37 percent of them were in the fourth year of their study, 33.7 percent in the third year and nearly 29 percent were in their second year. Most of them were Malays (82.6%) and Muslims (83.8%) while only 17.4 percent non-Malays and 16.2 percent were non-Muslims. In terms of the cumulative grade points average (CGPA) obtained by the respondents, more than half of the respondents (61.6%) obtained a CGPA of 3.01 and above (See Table 1).

Table 1. Profiles of the respondents

Factor	Number	Percentage
Sex		
Male	98	58.7
Female	69	41.3
Year		
2nd year	49	29.5
3rd year	56	33.7
4th year	61	36.7
Race		
Malay	138	82.6
Non-Malay	29	17.4
Religion		
Muslim	140	83.8
Non-Muslim	27	16.2
CGPA		
3.00 and below	63	38.4
3.01 and above	101	61.6

4.2. Level of academic ethics

Five categories of academic ethics were addressed in this study. They are ethical behaviours when dealing with lecturers, academic dishonesty, tendency to cheat in examinations, awareness towards the university dress code and conformity to the university dress code.

It was found that the engineering students did not really exhibit positive ethical behaviour when dealing with lecturers. Nearly half (44.9%) of the respondents exhibited a low level of ethics in this category while only 3.6% exhibited a very high level ethics. Although a majority (65.9%) of the respondents sometimes greeted their lecturers, there was still a handful (6.6%) who admitted that they had never greeted their lecturers. The same goes to thanking their lecturers when the classes were over. Even though, a majority (62.9%) sometimes thanked their lecturers, and about 16 percent always did, there were still those (21%) who did not show appreciation to their lecturers. In addition, when asked whether or not they asked permission before asking questions and apologized if they were late to class, half (50%) of the students said that they only sometimes did them. However, it was found that nearly half (49%) of the respondents admitted that they had always paid attention in class and 48.2 percent said that they had never slept during lectures.

In terms of academic dishonesty, about 40 percent of the respondents had a moderate level of ethics and 38.3 percent had a low level of ethics. Only 10.2 percent showed a very high level of ethics. This shows that the problem of cheating is still widespread. The most prevailing form of academic dishonesty among the respondents was asking friends regarding the test or examination questions where majorities admitted they always asked their friends about questions during the tests (60.5%) and during the examinations (61.7%). Nevertheless, the number of students who always cheated during the tests and examinations was very small, at 0.6 percent for both situations. Although more than half of the respondents (53.9%) sometimes allowed their friends to copy their answers during the tests, the same cannot be said for examinations. This is because most (57.5%) of them said that they had never let their friends copied their answers during the examinations. In terms of bringing notes to the examination halls and also during the tests, around 80 percent said they had never done that.

When asked whether or not they will be likely to involve in academic dishonesty in the future, the study revealed that 35.9 percent of the respondents had a very high level of ethics in this aspect. This shows that the respondents did not really intend to cheat but may do so in the real situation. Except for the tendency to ask answers from their neighbours if they face difficulty during the examinations or tests, where nearly 31 percent of the respondents agreed that they may do so, in all other situations, most (more than 30%) respondents strongly disagree that they will conduct non-ethical behaviours such as copying their friends answer, bringing notes to the examination halls or letting friends copy their answers in the future.

In terms of dress code, a majority (40.7%) of the respondents had a very high level of awareness towards the university dress code. In addition, the respondents were also found to dress accordingly where 43.4 percent were found to have a high level of ethics in conforming to the university dress code. Nevertheless, only 25.1 percent of the respondents were aware that they may be warned or fined (not more than RM50.00) for not abiding to the university dress code. In addition, although Monday has been announced as "Smart Day" for Universiti Teknologi Malaysia, only 13.2 percent admitted they always dressed as outlined in the university dress code. Most of them (46.1%) had never follow the "Smart Day" rule and while 40.7 percent sometimes dressed accordingly.

4.3. Differences based on demographic factors

A mixed findings were revealed when the level of academic ethics were compared according to the demographic profiles. It was found that for ethical behaviour when dealing with lecturers, the chi-square test showed that there was a significant difference between the male and the female students ($p < 0.05$). About 45 percent of the female respondents had a moderate to a very high level of ethics in this aspect compared to only 31.6 percent of their male counterparts. Half of the male respondent (50%) had a low level of ethics compared to 37.7 percent of females in this level. It can be assumed that the female students had more respect and appreciated their lecturers more than their male counterparts. However, for other demographic factors, none of the differences was statistically significant by the chi-square (Refer Table 2).

Table 2. Differences in ethical behaviour when dealing with lecturers

Factors	Significance Level
Sex	0.035*
Year	0.075
Race	0.206
Religion	0.230
CGPA	0.625

*Chi-square significant at $p < 0.05$

In terms of academic dishonesty, significant differences were found between different years of study, race and religion (See Table 3).

Table 3. Differences in academic dishonesty

Factors	Significance Level
Sex	0.109
Year	0.015*
Race	0.020*
Religion	0.008*
CGPA	0.171

*Chi-square significant at $p < 0.05$

Half (50%) of the third year students exhibited low ethical level in this aspect. Most of the second year (44.9%) and the fourth year (44.3%) students had a moderate level of ethics in terms of academic dishonesty. Surprisingly, none of the third year students showed a high level of ethics for this aspect while those who had very high level of ethics is very minimal (7.1%). The second year students had the most percentage (16.3%) of very high level of ethics with none having very low level of ethics for academic dishonesty. Although the findings of this study partly supports the findings of Sierles *et al.* [18] and Moffat [19] who found out that younger students were less likely to cheat compared to the older students, it also contradicts with their studies since the fourth year students were found to cheat less compared to the third year students. This may be due to the fact that they were more matured or since they were closer to their graduation year, they may fear that there will be some repercussions of being caught for cheating on their chances to graduate on time.

As for race, more Malays (42%) had lower level of ethics for academic dishonesty compared to the non-Malays (20.7%). In addition, 27.6 percent of the non-Malays had a very high level of ethics while only 6.5 percent of the Malay students had the same level of ethics. Not surprisingly, the same pattern can be found for religion factor. This is because, in Malaysia, race and religion are highly interrelated. Majorities of Malays are Muslims and vice versa. The non-Muslims exhibited better ethics compared to the Muslims in terms of academic dishonesty. One main factor that can be attributed to this finding is that the distribution of respondents based on race and religion was not equally distributed. As have been discussed in the demographic profiles of the respondents, the Malays and Muslims made up more than 80 percent of the sample studied. Therefore, the chances of them cheating were also higher than the smaller group of respondents. In addition, it cannot be said that the non-Muslim were more religious than the Muslim since this study did not measure of the religiousness of the students. Moreover, several studies had found out that the level of academic dishonesty was higher in the religious school than in the secular school [20], [21], [22].

Nevertheless, using T-test and ANOVA, no significant difference was found among all demographic factors in terms of tendency to cheat in the future. Since the overall level of tendency to cheat in the future was found to be only around 15 percent, this shows that although there was a difference in terms of actual cheating based on different years of study, races and religion, but on the whole, the students did not intend to cheat in the future regardless of demographic factors.

The Chi-square test also revealed that there was a significant difference in terms of awareness towards the university dress code between the male and female students, the Malays and non-Malays and

the Muslim and non-Muslim students (Refer Table 4).

Table 4. Differences in awareness towards the university dress code

Factors	Significance Level
Sex	0.047*
Year	0.845
Race	0.000*
Religion	0.004*
CGPA	0.699

*Chi-square significant at $p < 0.05$

Nonetheless, when it comes to actual dressing, significant differences were only found between sex and race (See Table 5).

Table 5. Differences in academic dishonesty

Factors	Significance Level
Sex	0.001*
Year	0.648
Race	0.008*
Religion	0.147
CGPA	0.214

*Chi-square significant at $p < 0.05$

The female students (73.9%) were found to have higher level of awareness towards the university dress code compared to 52.5 percent of the male students. Similarly, the female students also dressed more appropriately than the male students. More than half (58%) of the female students had a very high level of ethics in conforming to the university dress code while only 28.6 percent of the male students were in the same level. This shows a consistency between awareness and actual dressing. In addition, 64.2 percent of the Malays were highly aware of the university dress code while less than half (48%) of the non-Malays were highly aware of it. As a result, it was found that 77.6 percent of the Malay students dressed according to the dress code required while only just slightly more than half (51.7%) of the non-Malay respondents did the same. However, a significant difference was only found in terms of awareness toward the university dress code between the Muslims and non-Muslims but not in the actual dressing. This was found to be quite interesting because it was expected that the result would follow the same trend as for the difference between race since most Muslims are Malays and vice versa. What can be concluded here is that most probably there are some non-Malay respondents who are Muslims.

5. Conclusion

Violations in academic ethics will have serious impact in the workplace. This is because, it is likely that students' ethics and values on the campus will be brought along when they graduate and move into the workplace. Thus, it is assume that graduates with low level of ethics may create a lot of ethical problems when they started working. Realizing the importance of being ethical, UTM has listed ethics and integrity as one of the graduate attributes that this university graduates should possess.

However, this study revealed that the problem of academic ethics still existed in UTM. On the whole, the engineering students of UTM only had a moderate level of academic ethics. This proves that the university has to increase its effort in making sure that it will be able to produce graduates who are highly ethical and have high integrity.

In order for that to happen, everybody in this academic institution, from the upper level management to the lower level staff; the academic and the supporting staff, should play their parts in instilling more positive ethical values. In addition, besides setting good examples, the lecturers especially, should be firm in taking action against students who violate the academic ethics. Ignoring the existence of academic dishonesty, for instance, will lead to the problem becoming more rampant.

Furthermore, students should also be given more knowledge and exposure towards, not only academic ethics but also professional ethics which can really help them become a better employee in the future. Students should be taught that "the end does not justify the means". They should know that they should be responsible on any action they take. By having more knowledge and awareness on what are considered as unethical and immoral behaviors, it is hope that the we will have a more professional and ethical workforce in times to come.

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Assessing and Evaluating Life Long Learning Skills through Research Methodology Course at Faculty of Civil Engineering, Universiti Teknologi MARA, Malaysia

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Abstract

The training of engineers at undergraduate level requires that they acquire minimum a of eleven (11) generic attributes stipulated by the Engineering Accreditation Council (EAC). One of these attributes is the skill of life long learning. Traditionally, the skill is deemed to be implicitly acquired by graduates after having gone through the engineering degree programme. However, with the implementation of the outcome based education (OBE) there is a pressing need for an explicit assessment and evaluation of this generic skill. This paper presents the experience at the Faculty of Civil Engineering, Universiti Teknologi MARA (UiTM) in assessing and evaluating students achievement in acquiring the skills of life long learning. Specific examples of assignment and test will be presented to illustrate how this particular skill can be assessed and evaluated.

Keywords: engineering education; life-long learning skills; outcome-based education; research methodology

1. Introduction

The introduction of the outcome-based education (OBE) by the Ministry of Higher Education (MOHE) and the Engineering Accreditation Council (EAC) in Feb 2005 has triggered changes in the running of the Bachelor of Engineering Programme at the Faculty of Civil Engineering, Universiti Teknologi MARA (UiTM) [1]. A series of activities was conducted to create awareness within the Faculty; to develop programme objectives and programme outcomes and to critically review the curriculum and syllabi. The new curriculum and syllabus based on the OBE approach, approved by the Senate were implemented in July 2006. A summary of enabling activities conducted by the Faculty is shown in Table 1 [2].

One of the major challenges in implementing the OBE curriculum is in assessing and evaluating the programme outcomes associate with a particular course, especially those addressing "soft skills" [3,4]. One of these skills includes the need to undertake lifelong learning and capacity to do so. Traditionally, it is widely believed that once students had undergone the four year training programme, this skill or attribute will be implicitly acquired.
However, the OBE approach demands that evidence on student ability to acquire this attribute be quantified in terms of grade be documented. This paper presents the experience at Faculty of Civil Engineering at UiTM in assessing the attribute of acquiring lifelong learning skills through the course on Research Methodology.

2. Overview of course on Research Methodology

Research Methodology, designated by the code KJC 517 is a two credit hour course offered in semester six (6) of the eight- (8) semester Bachelor of Engineering programme at Faculty of Civil Engineering, UiTM. Students were required to attend two hours of lecture and one hour of tutorial per week.

Table 2 summarizes the course outcomes (CO) and shows how they contribute to the programme outcomes (PO). The assessment methods to be adopted in assessing students are also shown. It is evident from Table 2 that the course is capable of addressing four programme outcomes, namely PO2, PO3, PO7 and PO11. However, at the programme level, this course is expected to contribute significantly to the achievement of PO7 and PO11 [5].

Students were evaluated through a series of assignments, a series of tests and a mini report, which is a brief research proposal. The relative weightage of the various tools used is given in Table 3.

Table 1. Summary of Activities at Faculty of Civil Engineering UiTM towards implementing the OBE approach [2]

Dates	Event	Outcome
Mac 2005	Introduction to OBE during Faculty Meeting by Dean and Deputy Dean	Staff gained initial awareness on OBE
10-11 May 2005	Workshop on OBE for Academic Managers, FKA	P. Obj and P. Outcomes Formulated
16-18 May 2005	Workshop on Curriculum and Syllabus Review towards OBE	CO - P. Outcomes Matrix formulated
24-26 May 2006	Workshop on Implementing OBE in UiTM	Attempt to agree on P. Obj and P. Outcomes for all Faculties not very successful
May - July 2006	FKA panel of Academic Advisors and UiTM Senate approved the new curriculum and syllabi.	New curriculum implemented in July 2006 session on Semester 1 and Semester 3 students
17 October 2006	FKA meeting – Forward Based accreditation; EAC to visit in Nov/Dec 2009; OBE to be implemented in the old and new curriculum.	Staff to take immediate action – to ensure evidence are documented in course files
14-15 Dec 2006	Workshop on assessment and Evaluation of P. Obj and P. Outcomes.	Established dominant domains (Blooms) for P.Outcomes; tools for assessment and Performance criteria. Identified at least two CO for each course that will contribute to the P/ Outcomes
3-4 January 2007	Workshop on Assessment and Evaluation Toward full implementation of OBE for EC220.	Establish Assessment Tools and Performance Criteria for all courses

Table 2. Summary of course outcomes – programme outcomes matrix, including assessment tools for KJC517- Research Methodology [6]

Course Outcome (CO)	PO2	PO3	PO7	PO11	Assessment
1. To understand the technique of literature search and reviewing of literature.			3	2	Test, Assignments, Proposal (Written)
2. To identify research problem and writing problem statement	2	3	3	2	Test, Assignments, Proposal (Written & Oral)
3. To familiarize with the different types of research methods and designs		3	3	3	Test, Assignments, Proposal (Written)
4. To know how to prepare a research proposal and writing research report	3	3	3	3	Test, Assignments, Proposal (Written & Oral)
PO2 - Ability to communicate effectively, not only with engineer but also with the public PO3 - Ability to identify, formulate, and solve engineering problems PO7 - Acquiring the need to undertake lifelong learning and capacity to do so. PO11 - Having the knowledge of contemporary issues					

Table 3: Assessment weightage for KJC517- Research Methodology [6]

Assessment Tool	Number	Weightage
Assignments	2	30%
Progress Tests	2	20%
Comprehensive Test	1	30%
Brief Proposal	1	20%

3. Assignments as an Assessment Tool to evaluate Programme Outcome (PO) No. 7

For the purpose of illustrating how the Programme Outcome No.7 (PO7), that is acquiring the need to undertake lifelong learning, is evaluated in this course, discussions will be limited to the use of an assignment. A typical assignment is shown in Fig. 1. The assignment clearly identifies four (4) learning outcomes that students will acquire, the tasks required of them, including five (5) key elements that must be provided in their report. Furthermore, students are made aware of how completing the assignment helps them in achieving both course outcomes and selected programme outcomes. For example, in providing background facts related to the problem, students would be developing their ability to fulfill Course Outcome no. 1 and Programme Outcomes no. 7 and no. 11 (CO1-PO7; CO1-PO11).

Students have to search for related material. The material may be text-based; electronic-based (CDs and internet), visual-based (videos and photos) or even mind-based (seeking opinion from experts). In searching related material and writing up the background of the problem being studied, students will fulfill Course Outcome no.1, which is to understand the technique of literature search and reviewing of literature. Furthermore, skills acquired in this part of the assignment can also be used as evidence of students' achievement in developing Programme Outcome no. 7 (PO7), which is acquiring the need to undertake lifelong learning and Programme Outcome no. 11 (PO11), which is acquiring knowledge of contemporary issues. The analysis of the problem situation, by using the research tree technique, leading to the research topic and the writing of the problem statement though strongly emphasize on students' ability to acquire Programme Outcome no.3 (PO3), that is to identify, formulate, and solve engineering problems, they nevertheless significantly reinforce PO7 and PO11.

The marking scheme used for this assignment is given in Table 4. Though the overall weightage contributing to PO7 is only 15%, it proves that it is possible to use such an assignment to measure PO7, which is the attribute that is related to life-long learning skill. It is worth noting that, this assignment is capable of measuring students' ability in achieving three other programme outcomes, namely, PO2, PO3 and PO11.

4. Performance Criteria Matrix to evaluate Programme Outcome (PO) No. 7

Further efforts were made to quantify the evaluation of students' submissions in terms of grades associated with a particular course outcome and programme outcome pair. A series of performance criteria matrix were developed to evaluate the various CO-PO pairs. In total, four (4) performance criteria matrices were developed to evaluate PO7. A typical performance criteria matrix for the evaluation of CO1-PO7 is shown in Table 5.

This matrix enables the life long learning skill of students to be graded. The matrix assigns marks ranging from 1 to 5 based on quantitative and qualitative criteria shown. Quantitatively, PO7 can be evaluated through the number and variety of reference sources cited. Higher number of references cited and higher variety of reference sources indicate that the students have high capacity for life long learning. Qualitatively, the instructor will have to evaluate on the relevance on material cited and presented in the assignment. Though this may vary from instructor to instructor, the performance criteria matrix will ensure that this variation is minimal.

Successful assessment and evaluation of this assignment can be documented as evidence that student have or have not acquired the Course Outcomes and the Programme Outcomes associated with this course. Based on the assessment of the five key elements, the instructor will be able to identify the strength and weaknesses of the students, thus may initiate measure to improve delivery system that will address weaknesses identified.

5. Concluding Remarks

The use of an assignment, when properly designed can be effective in assessing and evaluating students' achievement in acquiring knowledge skills and attitude that are expected of an engineering graduate, i.e. the Programme Outcomes, in this particular case the attribute of life long learning skill. A performance criteria matrix is essential in making quantitative and quality evaluations of assignments. These matrices enable programme outcomes to be objectively evaluated.

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KJC517 - RESEARCH METHODOLOGY
ASSIGNMENT NO.1

Learning Outcomes:
This assignment is designed to assess students' ability on
a. awareness on current and contemporary issues.
b. developing life long learning skills, through search of relevant material and discussions
c. problem identification and problem formation
d. making an effective presentation

Task/Activities
Table A shows several events that had occurred in the last 3 years that are very much related to Civil Engineering.

Table A: Events of failures related to various disciplines of civil engineering

Hydrology/Water Engineering	Geotechnical Engineering	Traffic Engineering	Construction Management	Structural Engineering
Massive Floods in Southern Parts of Peninsular Malaysia.	Massive Landslide at Bukit Lanjan	Very High Fatalities on Malaysian Road during Festive Seasons	High Fatalities in the Construction Industry – Casualties on- and off-sites.	MRR2 closed to traffic due to serious cracking of the columns

You are to select one of the events given in Table A and provide the following **key elements** in your report.

1. A background of the event with facts reported in the media or any other sources (not more than a page; **CO1-PO7**; **CO1-PO11**).

2. An analysis on possible causes of the problem, in the form of a Problem Tree (one full page; CO2-PO2; **CO2-PO7**)

3. A possible research title. (**CO2-PO7**)

4. A concise problem statement and at least two objectives for the research. (not more than a page; **CO2-PO3**; **CO2-PO7**; **CO2-PO11**)

5. A presentation of not more than 5 slides. (CO2-PO2)

This assignment constitutes 15% of the course assessment.
Your submission should not exceed three (3) pages, including the Problem Tree.
Use: Times New Roman, Font 12 and 1.5 spacing.

Fig. 1. Typical Assignment for KJC517 – Research Methodology [6].

Table 4. Marking scheme used for Assignment No.1, shown in Figure 1

Tasks	Criteria	PO 2	PO3	PO7	PO11
1 (15%)	Some facts needs to be presented and sources should be acknowledged			5	10
2 (30%)	Reasonable problem tree showing all possible sources and focus on the main cause to be pursued. "Breadth and depth" must be addressed		25	5	
3 (05%)	A research title that is well defined		5		
4 (40%)	Problem Statement: 3 elements must be present Objectives: SMART and "evidence of attainment" e.g. the objective can be manifested in a graph or a table, etc.		30	5	5
5 (10%)	Slides should cover – background; problem tree; problem statement and objectives.	10			
Total weightage for each PO		10	60	15	15

Table 5. Performance criteria matrix for evaluating CO1-PO7 [6]

	Tools	E, F	D, D+, C-	C, C+	B-, B, B+	A-, A, A+
		Bad	Poor	Average	Good	Outstanding
Course Outcome **No.1** (To understand the technique of literature search and reviewing of literature) addressing **PO7**	(Assignments / Proposals)	**1**	**2**	**3**	**4**	**5**
Quantity of references used		Less than 3 references	3 to 5 references	5 to 7 references	7 to 10 references	> 10 references
Variability in references used (books; journals; mags.; thesis; websites; pers. comm.; proceedings)		1 type of reference	2 to 3 types of references	3 to 4 types of references	4 to 5 types of references	More than 5 types of references
Relevance of references used		The student is aware of the right reference materials	Ability to communicate and relate reference to the task at hand	Ability to adopt reference materials through paraphrasing	Ability to arrange materials in a clear and logical sequence	Ability to provide justification or to defend his findings

Enhancing Thinking through Active Learning in Engineering Mathematics

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Abstract

Research findings indicated that students must actively participate in their learning for effective cognitive and affective development. In this paper, we will present a model of active learning that we had developed and implemented in the teaching of Engineering Mathematics at UTM. We based our model on various approaches designed to invoke students' ability to use their own thinking powers, enhance their problem solving skills and promote soft (generic) skills that can contribute towards students' acquirement of necessary attributes as an engineer. This model incorporates and emphasizes the various possibilities of learning that we wish students to achieve and experience. In particular, we focus on three major aspects of learning; the construction of mathematical knowledge, competency in mathematical techniques and procedures as well as the appropriate soft skills.

Keywords: active learning; mathematical thinking; knowledge construction

1. Introduction

The aims of mathematics learning for engineering students should include the ability to formulate problems mathematically, to work with several mathematical ideas and various representations and to select and use multiple procedures. Consequently, it is expected that they could make connections between relevant mathematical concepts and to transfer as well as use these knowledge in their engineering fields. It is clear that to do these, they will need a strong understanding of basic concepts and the ability to adapt, modify and extend their mathematical knowledge appropriate to the problem situation.

However, we have encountered students who had difficulties in manipulating concepts, coordinating multiple procedures, manipulating symbols in a flexible way and in answering non-routine questions. Corroborative research further supports our observations (Tall & Razali, 1993; Anthony, 2000; Croft & Ward, 2001; Townend, 2001, Roselainy, Yudariah & Mason, 2002; Hoch & Dreyfus, 2005).

We believe that students can develop the ability to understand various related mathematical concepts, learn to reconstruct these concepts as parts of a whole and to make the connections between the parts. By designing appropriate methods, we can support students during their struggle with mathematical ideas and enhance their awareness of how to acquire efficient strategies in constructing knowledge. Consequently, we hope that they would be empowered with more successful ways of thinking about mathematics.

2. Our Models

2.1. Focus of Learning

Taking into consideration these issues, we had developed some strategies to encourage students to participate and to take charge of their own learning. We had focus on three major aspects of learning: the construction of mathematical knowledge, competency in mathematical techniques and procedures as well as the appropriate soft skills. See Fig. 1. The emphases were on students' development of higher order thinking skills, knowledge construction and soft skills, particularly, communication, teamwork and self-directed learning. The theoretical foundations of how to develop strategies for knowledge construction and to enhance students' mathematical thinking were based on the works of Tall (1995) and Gray, et al (1999). We used frameworks from Mason, Burton, & Stacey (1985) and Watson & Mason (1998) to design classroom activities and tasks. In particular, we adopted and modified the use of prompts and questions in engaging students with the subject matter as well as to initiate and support students' communication.

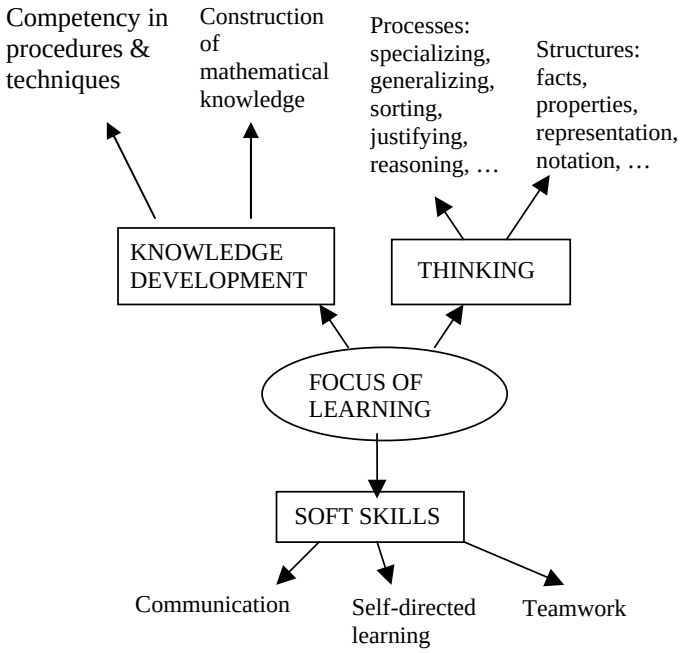


Fig. 1. Focus of Mathematical Learning.

What tasks and classroom activities would ensure that we could realize our focus of learning? How do we provide and promote a learning culture in which students could be active participants?

2.2. Active Learning

In order to achieve our focus of learning, we had chosen active learning, as it would give students the opportunities to be interactive with the subject matter. The important elements to support effective active learning were talking, listening, reading, writing and reflecting (Meyers & Jones, 1993). In preparing to implement active learning for our classroom, we had identified the following aspects.

(i) Designing classroom tasks – in designing the tasks, we had created, selected, and modified existing tasks to focus students' attention on the mathematical processes and structures that we wished them to learn. This was done by changing a bit of the question, removing some of the information from the question, replacing part of the question and adding a bit to the question that will require students to provide explanations and justification for the solutions found (Prestage & Perks, 2001). This led to the use of various powers such as specializing, generalizing, conjecturing and convincing as desirable mathematical behaviour. The tasks were categorized as *illustrations* and *structured examples* with *prompts and questions*. The prompts and questions were intended to direct and guide students' awareness of the fundamentals of *doing* a problem. There was also a section on *reflection*, for students to recapture important ideas and concepts. We had compiled all these tasks as a workbook so that students could refer to their work easily.

(ii) Determining approaches – throughout the teaching, the students worked either as a team or individually. For example, they would work as team when doing the structured examples and individually for reflection. Teamwork was carried out by students working in pairs or in small groups of 3 to 4 persons depending on the complexity of the problems, to elicit quick feedback or the suitability of the physical environment.

(iii) Encouraging communication – we had design prompts and questions to initiate mathematical communication. By working as a team, we encouraged discussion and sharing of ideas among the students. Students were also expected to hand in written work and to share their reflection in the classroom.

(iv) Supporting self-directed learning – the structured questions were created to strengthen the students' understanding of mathematical concepts and techniques. The examples and problems would provide the learning experiences where certain mathematical powers and themes were used specifically and explicitly. This should increase students' awareness of their own mathematical thinking powers and the mathematical structures studied. In addition, reading assignments were also given for students to explore certain concepts for themselves.

(v) Identifying types of assessment – we had incorporated both summative and formative types of assessment. These were, quizzes and tests, quick classroom feedback and written assignments. The objects of assessment were students' understanding of mathematical facts, standard methods and techniques, standard application of the concepts, problem solving, logical and analytical reasoning.

Fig. 2 below gives a summary of our model for active learning.

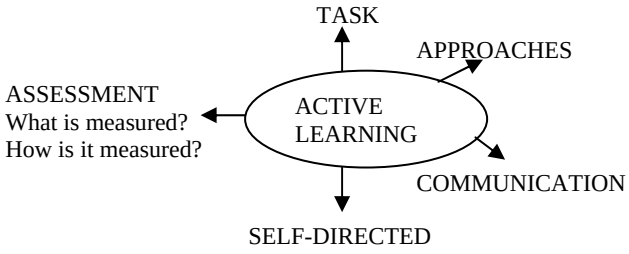


Fig. 2. Model of Active Learningl

We have implemented our model in the teaching of Engineering Mathematics for two semesters and below we will share some of the examples and responses of our students.

3. Examples of Mathematical Tasks and Activities

3.1. Mathematical Tasks

The mathematical tasks that were set for the students were categorized under Illustrations, Reflection, Structured Examples, Review Exercises and Further Exercises. Illustrations were 'worked out' examples to show how a particular concept was developed and what were the important structures and processes that were central to them.

Here, we will present two examples of exercises that we categorized under Illustrations and highlight what should the students attend to in the question. In the following example, the focus should be on the meaning of the symbolic representation. The prompts and questions were designed to direct the students' attention to the interpretation of the double integral over a non-rectangular region of integration.

Illustrations: Example 3.5

Evaluate the integral by reversing the order of integration.

$$\int_0^1 \int_x^1 y^2 e^{xy}\, dy\, dx$$

Prompts/Questions

- Which part of the integral informs you about the region of integration?
  - Find and sketch the region.
  - Can you determine the limits of integration for the reversed order?

We also asked students to construct their own questions, so that they would learn to recognize the essential features of the questions and thus, gain awareness over the class of questions, and hence over the technique. This type of task induces students to notice the roles of the integrand and the limits of integration thus recognizing the dimensions of variations under which the technique remains essentially the same.

Illustrations: Example 3.7

Construct TWO examples of double integrals that are readily evaluated by integrating in one order but not in the reverse order.

Why is it worthwhile to reverse the order of integration?

Questions asked in the section on Reflection were to help students to recapture and consider the important ideas and concepts that they have learnt. Students were encouraged to learn how to write mathematical ideas. This section was placed before the Structured Examples to ensure students took time to contemplate on what they have learnt before solving more challenging questions.

Reflection

- How do you evaluate double integrals?

  ……
- How do you choose the preferable order of integration?

  ……
- How are the limits of integration determined?

  ……
- What do you do to evaluate double integrals by reversing the order of integration?

  ……

Structured examples were questions designed in a manner that the degree of complexity was increased gradually until the whole set of examples brought about the understanding of the mathematical concepts and techniques. An example is given below.

Question 3

Sketch the region of integration. Compute the integral in two ways: (a) with the given order of integration and (b) with the order reversed.

i. $\int_0^4 \int_{x^2}^{4x} dy dx$ ii. $\int_0^p \int_0^x x \sin y\, dy dx$

iii. $\int_0^1 \int_0^{y^2} 3y^3 e^{xy}\, dx dy$

Prompts/Questions

- Which part of the integral informs you about the region of integration?
  - Find and sketch the region.
- How do you determine the limits of integration for the reversed order?
- Compare (a) and (b).
  - Does the order of integration matter?
  - What do you notice about the limits?

In presenting the contents, the lecturer would work together with the students for the Illustrations and Reflection whilst students work together in groups for the Structured Examples.

3.2. Classroom Activities

The mathematical tasks that have been prepared were carried out in the classroom within activities that would include the following.

(i) Working in pairs – this activity was usually chosen when the physical environment was not conducive for group discussion, for example, working in a tiered lecture theatre. It was also

suitable for quick discussion and feedback to the class.

(ii) Small group – these may be formal or informal and suitable to encourage team working. The group should produce a group paper or response. The group may work for a short term or throughout the semester. We also monitored the process of group work to enhance the realization of soft skills such as interpersonal communication, time management, leadership and ethics.

(iii) Quick feedbacks – could be graded or ungraded. The main purpose was to inform students of their current progress and to increase students' awareness of their own learning behaviour thus enabling them to make changes. Some of the tools used to gather quick feedback were: the 'minute paper', muddy points. 'turn to your partner' (Huba, & Freed., 2000) and impromptu quiz.

(iv) Students' own examples – could be used to monitor what students were attending to in the topics taught. When students could construct their own questions, then they gain control and ownership over the class of questions, and hence over the technique.

(v) Assignments – group or individual was used to support self-directed learning and allow for more complex or non-routine questions to be answered.

(vi) Discuss and share – questions were given for students to discuss their ideas, either in pairs or small groups, and then share these ideas with the class.

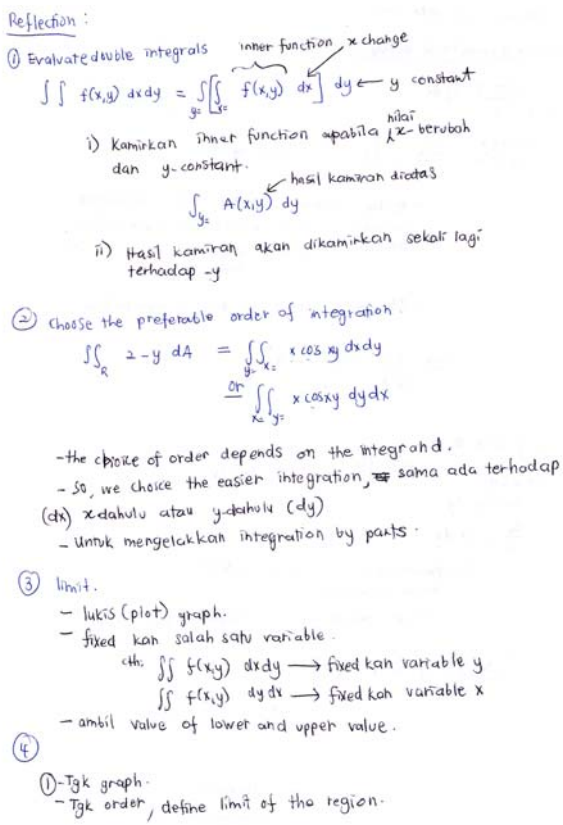
(vii) Reading and writing – extra reading assignments may be given to support self-directed learning and students were expected to hand a written form of the task.

The lecturer could select the classroom activities most suitable for the mathematical tasks at hand.

4. Students' Responses

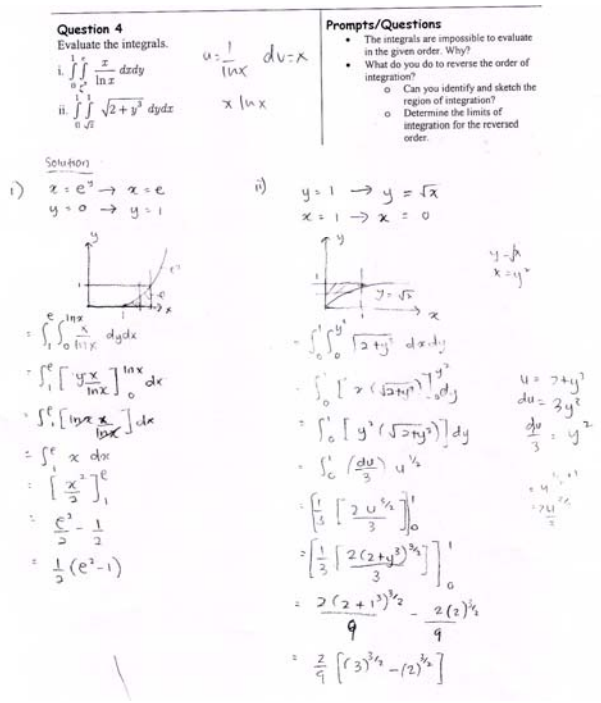
We had compiled all the mathematical tasks in a workbook. From our own experience, we found out that students prefer having some documentation at hand when they are working in the class. As we mention above, the prompts and questions that we have developed were also placed at the relevant problems so as to guide students in their thinking and to make explicit the processes and structures that they were learning. Here, we will share some of the students' responses to the learning environment, mathematical tasks and the workbook.

(i) Active learning environment – students enjoyed the opportunities to participate in their own learning. However, there were students who were not able to work in groups and usually end up working on their own and later discussed their work with the group. Many had difficulties to communicate mathematically. They claimed that they understood the concepts but could not articulate their knowledge very well to their friends. However, they enjoyed the various activities that were implemented. See example below.



(ii) To the mathematical tasks – we shall use the Structured Example: Question 4, given above, to highlight a student's work.

For Question 4 (i), he had correctly identified that the integrand was not easily solved using the given order of integration and had drawn the region of integration in order to find the new limits. He had at first, wrote the new limits incorrectly and could not solve the resulting integral. However, when prompted to check his notation, he realized that the limits were wrong and changed the limit for the inner integral correctly. This particular student admitted that he would refer to prompts and questions when he was stuck. Below is an excerpt of the student's work.



Other students commented that they found the gradual increase in the levels of difficulties in the tasks given was very helpful. It gave them the chance to follow the conceptual development. We were pleased that they were aware of the different levels of complexity. This indicated that students were able to appreciate what was the same and what was different in the tasks given thus recognized what was invariant among the changes in the class of questions.

(ii) To the workbook – we have reproduced some excerpts of students' comments from feedback questionnaire that we had given out at the beginning and at the end of one of the semester. Some of the students did not find the prompts and questions useful and usually ignore them. However, we found that when students were stuck with a problem, they would be asking us questions similar to the prompts and questions we had provided. At the end of the semester, the comments were more favourable and many saw the usefulness of the prompts and questions. Students also liked the different levels of difficulties found in the examples given and that they had to do the Structured Examples for themselves in the class.

Students' Comments

Beginning of the Semester

Student A

This workbook is very useful for me. I can understand what is the some topic about and ~~&~~ this workbook build myself confidence to take Engineering Mathematics subject. This workbook also ~~help~~ guide me to understand the topic.

Student B

I found this workbook is useful for students who studied engineering mathematics

Student C

The question and prompts would be unnessary. As for mathematic subject, is not about theory! Is about practise and pratical. I think illustration should be included and not question and prompts.

Student D

More examples, more solution results in high mark

At the end of the Semester

Student E

~~Well at first I was not~~ Well, at first when I was ~~doing~~ doing this work book I totally neglected the prompt and question because I was able to understand the content through my lecturer and I did not need to depend on the prompt to ~~do~~ solve my problems. But lately I miss a few class but yet I was able to understand and proceed with the help from the prompt.

Student F

Our lecturer have done her job very well.
Other than diagrams, she uses alot of realistic graphics example.
For this book, it helps alot especially in when we need to recall back what we've learned in a short period of time

Student G

The workbook is very useful for engineering student. It can induce our thinking skill and get well organized

Student H

For me, this book ~~for~~ to help me with challenge question. Even the book is the best among the world, the important is the teacher (lecturer)

5. Conclusion

In this paper, we had highlighted some of the strategies that we used in helping students to empower themselves with their own powers of mathematical thinking and help them in constructing new mathematical knowledge. The mathematical tasks were designed so that students could experience for themselves the process of identifying the general class of problems they were working on. We had provided and promoted an active learning environment so that the diverse activities would be more interesting for the students as well as providing them with opportunities to take charge of their learning. At the beginning, students were uncomfortable with the activities as they were different from their usual learning experiences. However, after a while, they gradually liked the new environment particularly, working in groups, sharing of ideas and working out the mathematics for them. We found our classes were also livelier.

Acknowledgements

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Training of Creative Thinking in Visual Literacy for Engineering Undergraduates

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Abstract

As with most, if not all, countries on the road to development, Singapore paid scant attention to the 'soft' literacy skills during its early stage of development. The focus had been on the 'hard' skills and, in particular, the training of large numbers of engineers to power its industries. This has been a major contributing factor in the "Singapore miracle", the transformation of the city state from "Third World to First" in just four decades. However, the next stage of its development will need more than just the 'hard' engineering skills in its engineering manpower. This paper explores some of the 'soft' creative skills that are needed as Singapore strives to move from among the bottom to among the top in the First World. It then studies, based on an elective visual literacy course introduced at Nanyang Technological University (NTU), the need for visual literacy in the training of creative thinking for engineering and business undergraduates. It highlights the rationale, structure and approaches taken in nurturing creative thinking in visual communication and in the creation of brand identities. Also presented and discussed are the learning outcomes and creative performance of the students. This is done through analysis of their exercises using creative thinking techniques and project works. It also poses the challenges faced in nurturing creative thinking in its engineering undergraduates.

Keywords: visual literacy; creative thinking; elective for engineering undergraduates

1. Why was Art Education sidelined in Singapore's past

When Singapore became independent in 1965, the critical challenge that its leaders had to face was national survival. Being a small nation with limited natural resources and high unemployment, rapid industrialization was seen as the only path to economic survival [1]. Another major consideration was the fact that only a small minority of its population was educated beyond the secondary level, not to mention education in the technical field which was essential for its industrialization needs. National education policies in the 60s and 70s were thus focused intensively at developing the necessary technical and scientific expertise for employment in the industries [2]. "The Government's education policy is designed to equip the youth of the State with requisite skills, aptitudes and attitudes for employment in industry" [3]. The public school curriculum was geared primarily towards national and economic priorities with focus only on mathematics, science and technical subjects. Scant attention was paid to art which was considered extracurricular or "outer" subjects taught after school or on Saturdays.

In order to maximize the potential of students and to reduce drop-out rates, an *ability-streaming* system was introduced in 1979. Under this system, students in Primary 3 and after PSLE (Primary School Leaving Examinations) were streamed according to their examination results. The rationale for ability streaming was to "provide for less capable pupils to develop at a pace slower than for the more capable pupils. In addition, it would allow every child every opportunity to go as far as he can" [4]. Students in Secondary 2 who achieved good examination results were further streamed to the science and mathematics stream while those who achieved less in their examination were generally streamed to the arts and commerce stream. At the tertiary level, science and engineering disciplines were very much favoured, primarily because of much better job prospects after graduation.

The pragmatic approach with a strong emphasis on science and mathematics in its education system served Singapore very well in the early years of its nation building. It nurtured and provided the Singapore economy with a large and suitably trained workforce to meet its industrialization needs. By the 1970s and into the 1980s, economic survival and unemployment was no longer a concern. In fact, Singapore's industrialization was so successful that the unemployment problem became a more pleasant manpower shortage problem.

In order to solve the labour shortage problem, an economic re-structuring initiative was launched in the early 1980s to transform its industries from being mostly labour-intensive to being capital-intensive. With this re-structuring and the increasing cost of labour, labour-hungry industries were forced to re-locate to other less developed regional countries where labour cost is lower. Efforts were made to have these replaced by attracting more capital-intensive industries to its shores. This approach transformed Singapore from a developing nation to one of the most dynamic economies in the world by the 1990s. During this second phase of Singapore's development, art education still took a back seat even though some attempts were made to have this introduced into its education system.

In the early 80s, an Art Elective Programme (AEP) was introduced to develop students' artistic skills as well as their understanding and appreciation of art. Students taking AEP can sit for the General Certificate of Examination (GCE) art examinations at both the 'O' (Ordinary) and the 'A' (Advanced) levels [5]. However, not every secondary school offered AEP. Those which offered this programme attracted only a small enrolment. This was mainly because science and mathematics subjects were still preferred as they led to better academic and career opportunities. As competition among students and among schools was very keen, partly due to streaming and to the ranking system on schools introduced in 1992 by the Ministry of Education, students, parents and schools preferred to focus their efforts on the core subjects to achieve better results, and subsequent better employment prospects, rather than on an elective subject like visual art.

Although visual art was introduced into the school programme, it was still very much "extra-curricular" and the emphasis was still on Science and Technology. Brother Joseph McNally, Director of the La Salle College of the Arts, one of the three post-secondary colleges in the 90s offering full-time design courses leading to diploma level, felt that Singapore lacks a design culture. "Singapore is a highly cultured society, but not in design. Everyone needs to be educated about design. There is a lingering feeling that it has to do with wallpaper," he said [6].

The problems of developing good art programmes and of attracting students to these were compounded by the lack of well-trained art teachers. The stated aims of the AEP were thus not completely realized. The arts and craft courses offered in the secondary schools then were more suitable as vocational training for those who were not so academically inclined.

2. The turning point for Art Education

With rapid globalization and as Singapore became a developed economy and moved to a more knowledge-based economy in the 1990s, it had again to transform itself to meet the increasing competition from not only the other rapidly developing countries including the economic giants China and India, but also the developed countries of the West.

The strong emphasis on science and technology during its early nation-building days successfully produced a workforce that was "highly proficient, clinically precise, but lacking in personal autonomy and afraid to take risks" [7]. In the 1990s, as the Asia Pacific became the world's most dynamic economic region, the need for Singapore to shift from an economy that relied on industrial labour to one that can capitalize on creativity and entrepreneurship became apparent. By the mid-1990s, it became obvious that, to meet the challenges of the knowledge-based economy where the service sector increasingly replaced the manufacturing sector as the mainstay of its economy, more "soft skills" need to be introduced into its education system. More serious planning and efforts were then made as its leaders increasingly spoke out for introducing relevant arts education into Singapore's education system.

To keep itself ahead of the rapidly developing regional competitors, Singapore embarked on the challenge to transform itself into the artistic and international business hub of the region. It aimed to become a vibrant cosmopolitan centre which, because of its strategic geographic location, excellent infrastructure and superior services and capabilities, can punch above its weight and support and influence markets beyond its natural boundaries [8]. To realize its goal and to ensure continued economic progress, it needs to cultivate a creative and thinking society and educate its young to reach their maximum potential. Arts thus need to play a more significant role in a broad-based education aimed at developing the "whole person" [9].

In 1996, in his address entitled "Our Future Depends on Creative Minds" at the Creative Arts Seminar, Deputy Prime Minister Lee Hsien Loong stressed the need for Singapore to recognize and nurture creativity and for the education system to develop students to the fullest of their abilities. "Our pupils have considerable creative talent in various artistic fields… We should encourage pupils who have a flair for the arts to develop their talents. Rather than focus only on academic achievements, we should treat excellence in the arts as another important indicator of all-round creative ability" [10].

In March 2002, arts educators, policymakers, and cultural agencies met for the first time at national level at the National Arts Education Conference to discuss the challenges of arts education within the Singapore schools system. Singapore's then Minister of State for Education, Dr Ng Eng Hen, highlighted at the Conference that the world economic landscape had changed and that, in a "post industrial" knowledge-based economy, "creativity and innovations" will be the driving force for economic progress. He pointed out that experts in the field of arts education have consistently advocated that the arts are essential components of education for the twenty-first century. This is "because the arts offer

multiple ways by which our students can perceive-and-understand-the-world… Arts Education should be seen as part of the broad-based holistic education we give to every Singaporean child. An ability education nurtures every child's talents and equips him with the skills and confidence to excel in the Knowledge-Based Economy." He urged schools to develop an arts friendly atmosphere conducive to art learning and innovation [11].

Following up on this, Singapore's Senior Parliamentary Secretary in the Ministries of Education & of Manpower, Hawazi Daipi, articulated in 2004 that "the creation of art forms is not limited to students who are artistically talented, students from various disciplines can benefit from their participation in the arts as well" [12]. He too encouraged the schools to build up the enthusiasm and interest among students for arts education so as to change their attitudes towards the arts.

In 2005, niche programmes were introduced to encourage primary and secondary schools to strive for distinctive strengths outside the traditional academic subjects and to enable students to excel in a variety of specialized areas. As a result, schools with different expertise and specializations start to emerge, for example, CHIJ Toa Payoh Primary was selected for the Arts. Since October 2006, upper secondary students also have a wider range of arts subjects to choose from. This is the response of the schools to the introduction of new arts-related courses by the five polytechnics. These electives, like Media and Design, can earn the upper secondary students advance-standing credits in some poly courses. Singapore's Minister for Education, Tharman Shanmugaratnam, stressed, in a report carried by the Straits Times newspaper [13], that these new subjects are more than just to prepare students for the polytechnics. They are aimed at developing inventive minds "able to look for problems, invent solutions and make them happen".

At The Teachers' Day Rally in 2006, Singapore's Prime Minister, Lee Hsien Loong, pledged that "every child would have his talents developed to the full" and stressed that "Education is the most critical investment and most effective success strategy for a changing world". He further encouraged the Singapore education system to "provide many paths for our students to grow and develop and to build up this whole mountain range of excellence, so that individually they are strong, but as a team we are invincible" [14].

3. Changes made at the Tertiary level

At the tertiary level, one of the steps taken to meet the demands of the knowledge economy is the broadening of the undergraduate curriculum. This was recommended by the International Academic Advisory Panel (IAAP) in 1999, a 12-member international panel of experts advising the Singapore government on how Singapore can build a world-class education system and enable it to cope with the demands of a fast changing, globalized system that require people with multi-disciplinary knowledge skills and work attitudes. The recommendation was to move towards a more flexible and diverse education system, one aimed at providing students with greater choice and ownership in their learning. Students should be given a more broad-based education to help develop them holistically, in and out of the classroom.

The universities responded by offering diverse sets of free electives which their undergraduates can select to supplement modules in their Major and Minor disciplines. As the President of Nanyang Technological University or NTU, Dr Su Guaning, put it, "NTU does not intend to produce just one-dimensional engineers and accountants" [15]. As 65% of the undergraduate population at NTU consists of Engineering students, free electives including visual art education help to enrich and broaden the intellectual growth and cultural development of the students beyond their immediate disciplines. With a broader curriculum, students become exposed to more areas and are expected to be able to develop competencies necessary for productive membership in the new economy. As Singapore's Senior Minister Lee Kuan Yew said, "Americans are not interested in making goods. They see their future in a world where wealth is generated not by making widgets or cars or whatever, but by brain power, by imagination, artistry, art, knowledge, intellectual property" [16].

In a knowledge-based economy, Singapore needs creative people who are multi-disciplinary, who can create new knowledge, and are risk takers who can venture into new territories. Professor Hong Hai, Dean of the Nanyang Business School at NTU, saw education as the "elevating of the mind…the ability to come up with something new while the other side of education is the lifting of the spirit. This comes from an immersion in art, literature, philosophy or deep science that opens up new vistas to life and existence…Without this, education is barren and clinical" [17].

In 2005, the School of Art, Design & Media at NTU was established offering Bachelor of Fine Arts Degree programmes in Digital Animation, Digital Filmmaking, Photography and Digital Imaging, Interactive Media, Product Design and Visual Communication. This is the first time in Singapore history that a creative art school is being established at a local university. In addition to offering its own undergraduate degree programmes, this school also plays a vital role in providing visual literary modules as free electives for undergraduates from Engineering, Business and other disciplines. The objective is to inculcate in these students multi-dimensional thinking skills and to enable them to be more adventurous, imaginative, inventive and innovative.

4. Developing Visual Literacy in Engineering Students

Engineering students, by and large, by the focus of their training will possess literacy skills far exceeding the basic skills of language and numeracy needed "to solve problems at levels of proficiency necessary to function on the job and in society, to achieve one's goals, and develop one's knowledge and potential" as defined in the National Literacy Act of 1991 [18] enacted by the US Congress. While most of these undergraduates may have latent talents for the arts, these are often not properly developed and sharpened because scant attention had been paid to this in their normal curriculum.

To give its engineering students that extra competitive advantage in the knowledge-based economy, a course on *Creative Design in Communication and Marketing* was offered by the School of Art, Design & Media at NTU. The objectives of this course are to develop an awareness in the students to understand the conceptual process of design that incorporates creative thinking, planning and strategy; to comprehend content and form and how these can be used effectively to inform and persuade; and to understand and apply the fundamentals and processes in developing brand identity. This course has been running for six semesters since July 2004. It is a free elective offered to all NTU undergraduates. The majority of those who have taken this course are Engineering and Business students.

This paper reflects on the experience gained during the past few years in the teaching of this course, its modes of delivery and the extent to which the objective has been met in inculcating an appreciation of visual literacy and in nurturing creative thinking in the engineering students.

4.1 The Teaching Implications of Creative Thinking in Visual Communication

Visual communication involves solving a design problem with a creative solution and delivering this effectively to the target audience. In order to conceptualise the idea for the creative solution, one needs to come up with a creative, original and fresh approach to a new improved situation. Creative thinking is the process of getting this 'big' idea that fits perfectly. Creativity, the ability to produce the original ideas or thoughts is necessary. According to Albert Szent-Gyorgi, winner of the Nobel Prize in Physiology, "Creativity is looking at what everybody else is looking, but thinking of what nobody has thought of."

The teaching implications of creative thinking in visual communication thus include the need to:

- develop the ability to rapidly produce ideas (Fluency); produce original, divergent solutions (Flexibility) and be able to frequently come up with original ideas (Originality). These are the three types of traits common in people of high creative ability according to Guilford [19];
- enhance visual literacy skills which involve the ability to interpret, use, appreciate, and create images and video using both conventional and 21st century media in ways that advance thinking, decision making, communication, and learning [20].

4.2 Rationale, Structure and Approaches in nurturing Creative Thinking in Visual Communication

Students attend a 3-hour lecture-cum-tutorial per week for twelve weeks. As indicated in the learning model in Fig. 1, students are firstly introduced to various ways of thinking to generate ideas. These include divergent thinking (Guilford) [21], associative thinking (Young) [22], lateral thinking (de Bono) [23], analogical thinking (Gordon) [24] and visual thinking, together with creative thinking techniques using words and visual association and brainstorming. This "open-ended" mode of inquiry is encouraged in order to get a free flow of original and novel ideas for divergent solutions. In solving a design problem, students learn the how and why of doing background research, and developing the creative strategy and creative approach. They also learn design basics (e.g. design elements and principles) to achieve creative results. The stress is on cognitive growth, on comprehension of knowledge learnt and on perception of visual images, and on verbal and written analysis using the design basics in order that students can reconstruct and organize their personal knowledge and understanding.

Secondly, while understanding design basics can help students to see and perceive visual images, and to decipher the meaning intended in the visual message, it also helps viewers to engage sensory interaction, and subsequently express feelings when conceptualizing ideas.

Thirdly, students are given as much opportunity as possible during this course to apply what they have learnt. During class, students form themselves into small groups after the lecture for each topic to work on an exercise which involves discussing and applying the concepts learnt. This develops in them, through actual practice, their fluency, flexibility and originality. Each group then presents their solutions to the class for further comments and discussions.

Students also form themselves into teams of four each to work on a final project which is to create a brand identity for a product, for a company or for an event. These final projects provide the opportunities for students to conceptualise explore and experiment with original and novel ideas, to brainstorm in a group to challenge old structure and preconceived patterns and further manipulate new ideas. The aim is to facilitate a new identity formation by providing a creative solution for a design problem. The goal of this process is to nurture creative thinking by

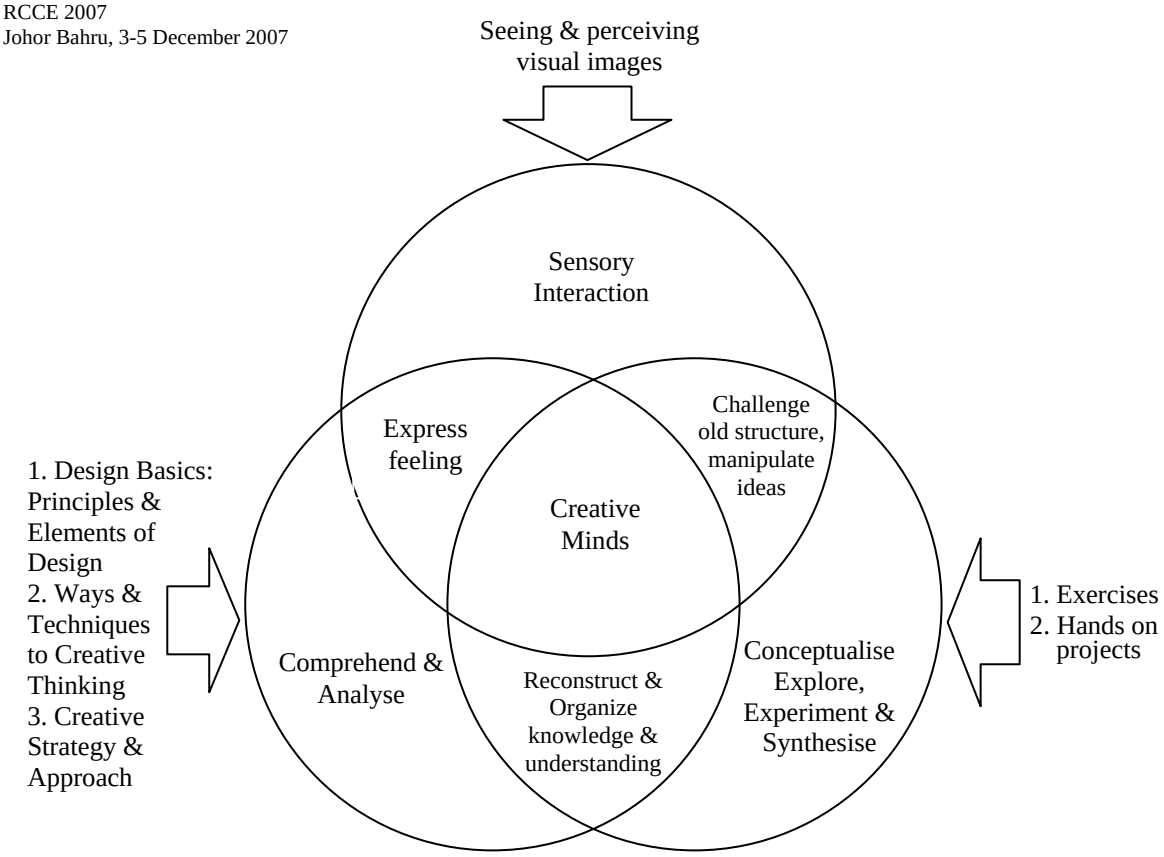

Fig.1. Learning Model to nurture Creative Minds.

providing opportunities for cognitive growth, for exploration, experimentation and synthesis, to challenge the mind and to learn through sensory interactions.

Putting students in a team environment is to enhance learning from peers. This allows ideas to be conceptualised individually, discussed further in a team environment and, subsequently, projected into physical forms for further manipulation. Each group then has to submit a report on how they conceptualise the idea and the creative strategy and approach involved and present this to the whole class.

5. Learning Outcomes

5.1 Final Group Project

Based on the experience of the past few years, the performance of the students in the final group projects can be grouped broadly into three categories. The first category consists of works in which distinctive brand identities with designs that are original and novels were successfully created. It is evident that these groups had gone through thorough brainstorming to come up with very creative ideas. Their strategies and approaches were excellent and improvements were made during the process. They also submitted more design applications than required. Before their presentations, they used other media, such as video, to set the mood so that the audience can have a better idea about the nature of their project. 40% of the final group projects fall under this category.

The second category, comprising 35%, consists of works in which very good brand identities were created. There were some originality in the designs which indicate that these groups had gone through their brainstorming sessions and came up with some reasonable strategies and approaches. They submitted sufficient applications and made good presentations.

The third category consists of works in which the brand identities were not clear. Although there were some good ideas for the designs, these were not well executed. There seems to be a lack of thorough brainstorming for creative ideas and the strategies and approaches proposed needed further improvements. These groups, comprising 25% of the all the projects, only submitted applications which meet the minimum requirements.

5.2 Exercises

It is observed that students enjoyed themselves and had fun when they were in small groups doing their exercises. Most were relaxed, had good team spirit and spent a great deal of effort in brainstorming and discussion. They were instructed to delay judgment on their peers' ideas and, consequently, came up with quite divergent and novel solutions on the same problem given. For example, instead of just the 'visual with words' idea, some groups worked out a storyboard for a TV commercial.

6. Challenges faced and Observation

The engineering curriculum at NTU is very heavy and leaves little time and space for students to strive for creative, original ideas. In the group projects, while most strived for good results, not all members put in the same effort. Still, the group project brought out the different talents the group had – one may be good in computer graphics, another in writing the report, and others in presentation and in organizing the group effort. Students also learn the importance of working harmoniously in a team, making good use of each other's talent and, equally important, to have fun. It is observed that those who had fun went through a very thorough brainstorming process and were motivated to put in extra efforts to produce more creative results. Works that are not original and unique reflect a lack of thorough brainstorming and a tendency to take short cuts. As students can opt for pass-fail grade in all electives, the tendency of not putting in sufficient effort in creative solutions will persist unless this option is taken away.

7. Conclusion and Implications

Based on the survey of students conducted at the end of each semester, most students rated this elective favourably. They enjoyed doing the exercises and final group projects although they admitted that this was hard work and much effort must be spent to achieve creative results. They fed back that the skills learnt in creative thinking will help them seek divergent solutions and not just settle for the first idea that comes to mind. With the knowledge learnt in perceiving and creating visual images, they were also more confident of being effective in visual communication. Most felt that the knowledge gained in this elective will be beneficial to them in their future careers. Some, in fact, had signed up to do part-time design works while still on campus.

Some indicated that they would like to take more electives in visual literacy and courses including *InDesign* and *Photoshop* to sharpen their technical skills.

Based on the experience gained over six semesters in teaching this course on *Creative Design in Communication and Marketing* to primarily engineering students at NTU, it can be concluded that a broad application of visual literacy has been successfully attempted in a predominantly technology undergraduate curriculum. The ultimate test will be whether the students will continue to use and build upon what they have learnt. As creativity requires a continuous, life-long creative thinking effort to pursue and sustain, the potential for learners to apply the skills learnt not only in visual communication but also in the engineering and science disciplines is limitless. It is also up to the learner to combine the multi-disciplinary knowledge acquired to seek new frontiers and to change society for the better.

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