

Developing Work-based Transferable Skills for Engineering Students

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Abstract

The development of transferable personal skills through student assessment is receiving increasing attention in higher education establishments. This study examined the potential for enhancing student learning through the development of group-work, presentation and self- and peer-assessment skills in an industrial engineering undergraduate course. An action learning approach was applied to developing these skills. A questionnaire evaluating students' impressions of the process was administered before and following the introduction of this methodology. The overall conclusion to be drawn from the investigation is that skill development did take place and that students found group-work to be an enjoyable learning experience. However, students were not as enthusiastic about self- and peer-assessment. Ultimately, there is a need to continue to involve students so that they can see evaluation in a positive, developmental light and to encourage students to take a more pro-active role in assessing their performance.

Introduction

Few issues are currently exciting more attention in teaching and learning in higher education than the student assessment process (Kemp, & Seagraves, 1995). Just at the time when academics have to cope with increasing student numbers against a fixed or falling unit of resource, the focus upon competence-based learning is causing a re-examination of assessment practices. Simultaneously, there is a shift towards assessment of students' transferable personal skills as well as the academic content of what they are studying. All of this is leading to the development of new assessment methods giving rise to the need for greater than ever ingenuity and flexibility, while still monitoring and assuring the quality of the process (Brown, & Knight, 1994).

In the last few years there has been a major impetus for change in the way tutors interact with and communicate knowledge to students. There is a growing awareness amongst educators that it is important to increase student participation in the learning process and to provide a skills-based education as well as one based on academic achievements. This appears to be confirmed by recent analyses of engineering education which concluded that the educational system ignored important practical and personal competencies (Parnaby, & Donovan, 1987; Finniston, Duggan, & Bement, 1989; Steiner, 1998).

Individuals within an organisation spend a considerable proportion of their day working and dealing with groups. For example, engineers may be part of a project team involved in Research and Development or new product development. As a member of a work group and as a representative of a firm who interacts with various groups both inside and outside the firm, organisational personnel must understand the dynamics of groups and how they can influence the total level of accomplishment. It is therefore important that students have an opportunity to work in groups, in order to experience the behavioural and managerial processes that are exhibited, such as: security

and protection, affiliation, esteem and identity, task achievement, member roles and status, group cohesiveness, norms, conflict resolution, negotiation, teamwork, and communication (Vecchio, 1995).

With regard to assessment, individuals practise self- and peer-evaluation in many areas of their lives. For example, staff appraisal in an organisation requires individuals to reflect on their level of achievement over a specified period and to identify areas of weakness that require further work. At the same time, an increasing number of professional bodies (Barthorpe, 1996; The Institute of Management, 1996) recognise the need for their members to carry out an audit of their individual development requirements.

In many of the types of assessment that students undertake, they are expected to assess process as well as product, and while the assessment of product is very often best undertaken by a third person (the tutor), assessment of process necessarily involves those involved in that process. Where, for example, students are being assessed in groups, it is essential that if the process of group working is to be assessed (Falchikov, 1996), the participants themselves should be involved in carrying this out. Thus, self- and peer-assessment gives learners a greater ownership of the learning they are undertaking. Assessment is not a process done to them, but is a participative process in which they are involved. This in turn tends to motivate students, who feel they have a greater investment in what they are doing.

It is the intention of this paper to outline the methodology adopted on an Integrative Studies (IS) module at the University of Hong Kong within the Department of Industrial and Manufacturing Systems Engineering (IMSE). The module was aimed at developing work-based transferable skills and to encourage students to take a more pro-active role in assessing their performance. Briefly, the aims of the study are to:

- determine whether there is a development of transferable personal skills through the use of this specific assessment process;
- assess whether group presentations are an effective way of developing interpersonal and presentational skills;
- judge whether the practice of using self- and peer-assessment enhances students' competencies with regard to self-reflective learning.

Programme Background

a) Traditional

The IS module in second year is designed to build upon the first year courses: Industrial Studies, Manufacturing Engineering Processes, Professional and Technical Communication, and Summer Workshop Training. These courses provide the students with a basic appreciation of the fabrication and use of materials, the range of manufacturing processes, implications of design for manufacture, and engineering communication systems. Integrative Studies makes use of this knowledge and enables the student to apply it, together with the knowledge acquired in other courses in first and second year, to the manufacture of a typical commercial product.

The integrating principle of the programme is achieved through the use of a 'vehicle' which is an actual product which the students must 'design and manufacture'. In addition to the integration of technical knowledge, the programme also aims to provide the students with the experience of autonomous group working and developing communication and meeting skills. At the beginning of the programme each group is presented with a sample of the product which has been selected by the staff for that year. The selection criteria for the product selection includes:

- the product should use a variety of materials;
- the product should involve a variety of manufacturing processes;
- the product should be something that the students can understand and appreciate its use;
- the product design should not be too technically complex;
- the product should allow some design initiatives;
- the product should be capable of manufacture using conventional processes;
- if possible, the product should be of a similar nature to products made in local industry (this facilitates factory visits);
- it should be possible to acquire samples of such a product, preferably of a 'poor' design.

The products that have been used in the past include an electric fan-heater, a portable hair-dryer and a travel iron.

The task of the group is to design and manufacture a new model of the product. The final group reports should include detailed design of the product, details of manufacturing processes, details of equipment, and manpower requirements including jigs and fixtures, some standard times for manufacturing and assembly processes, and some basic costing. The groups are given basic information such as the target retail cost, the annual output and the initial factory conditions (it is generally assumed that the factory is already set up manufacturing a range of similar products).

Throughout the project, the students' own activities are expected to be the focus of the programme, while lecturers act as facilitators who give guidance and advice on technical aspects. Groups are also encouraged to discuss their project with experts from industry and arrange visits to local factories. They must also seek out the necessary technical standards and regulations relating to the product.

However, the regular student evaluation of the IS module, along with comments from academic staff, indicated that there were a number of issues related to the development of group-work skills and the assessment process which could be improved. These included the following.

- Several groups had problems in completing the project within the timeframe available. Some of the reasons given were poor leadership, an inability to identify key tasks and ineffective time management.
- In a number of cases, the relationship between group members became adversarial. This was due, for example, to disagreements over the direction of the project and group members not completing the tasks allocated to them.
- Students felt that there was a lack of opportunity to improve their communication skills. Each group had to give only one presentation at the end of the course and, in many cases, not all the students contributed to the group presentations.
- With regard to assessment, it was felt unfair that each member of the group received the same examination mark. Many students commented that within the groups some colleagues worked exceptionally hard, whereas other students took a more passive role. Consequently, it was felt that the examination mark should reflect the individual contribution of each student to the project.

b) Revised Action Learning Programme

The comments from the students were reviewed by the academics responsible for the IS module and a number of improvements were initiated. Before proceeding to the technical aspects of the project,

students are now required to attend a series of participative workshops and formal lectures. These sessions deal with the concepts of group-work, presentation and assessment skills as follows:

- Within the group-work session, students perform a number of exercises in order to understand the dynamics of the process and to identify the various skills which group-work can develop. Typical topics covered include: contributing to groups, establishing goals, planning actions and allocating tasks, dealing with problems, identifying individual group skills, and leadership development.
- In terms of presentation skills, students view a customised videotape which has been recorded by one of the tutors involved in the study and reflects the subject matter that the groups are studying. This video provides a variety of delivery styles and students, through discussion, have to identify those attributes that were important in delivering an effective presentation.
- In order to provide them with experience of assessment, students are required to mark a short essay and then compare the mark that they award against that of the course tutor. Ample opportunity for discussion of the relevant issues identified from the essay is provided.

In addition, instead of just one formal presentation at the end of the project, students are required to present their work on a regular basis during the IS module. As a result, all students have the opportunity to practise communication skills. Finally, with regard to the assessment process, self- and peer-assessment were introduced in order to evaluate the individual contribution of group members.

Methodology

The research approach adopted can be broken down into five phases (see Figure 1) and covers a 24-week period which represents the length of a typical engineering module at the University of Hong Kong:

Phase 1 (week 1): A self- and peer-assessment process was proposed to 54 undergraduate industrial engineering students within the context of writing and presenting a group report relating to the application of theoretical business and engineering concepts.

Phase 2 (weeks 1-6): Before beginning the assignment, students were introduced to the concepts of group-work, presentation and assessment skills through a series of participative workshops and formal lectures. During these initial workshops students were asked to establish the assessment criteria by which the group presentations would be evaluated. It was felt that this would help to engender a sense of ownership of the tasks to be performed, as well as allowing the students an opportunity to develop their negotiation and communication skills through active participation in setting the criteria. Typical assessment criteria included such factors as visual presentation, content, presentation structure, and verbal communication.

Phase 3 (week 2): Students were assigned to groups of 6-8 students. Over the course of the project, groups were encouraged to verbally report progress on the assignment and the supervisors were therefore able to monitor the process on a continuous basis.

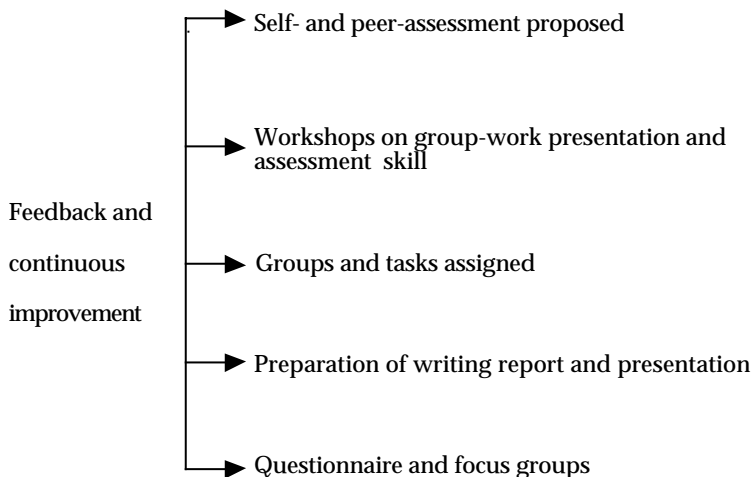
Phase 4 (weeks 7-24): Each group was required to prepare a written report on the assignment topic and also present the findings to their peers. The assignment was concerned with the design and development of an electronic lock. Students had to determine customer requirements, develop a design specification, determine the manufacturing processes, consider the financial and cost implications and provide a working prototype. In terms of mark allocation, the presentation was worth 30% (divided into equal proportions between the tutor and student markers) and the group report 70%. These mark allocations were discussed with, and agreed by the students. The

presentations were assessed by the other student groups in the class and by the tutor, according to the criteria developed in Phase 2.

Once an overall mark was determined for each group, the next stage was to calculate an individual mark for each group member based on their contribution over the duration of the project. A self- and peer-assessment form was given to each member of the group. Completion of this form was confidential and allowed each student to allocate a given number of marks, according to the perception of effort. For example, in a group of three people, 300 marks were available for allocation, and if an individual felt they had been responsible for a significant proportion of the workload, that student might award themselves 120, giving the other two members 90 each. On calculating the total marks for each group member, an individual peer weighting could be established. A weighting greater than 1.0 indicated that a particular student was making a significant contribution to the project. A weighting less than 1.0 would indicate that the group felt a student was not meeting their performance expectations. The final group mark (combining the presentation and report) was then multiplied by this student weighting factor to obtain an individual mark for each member of the group. Hence, the self- and peer-assessment process provided a mechanism for moderating marks in relation to group effectiveness and individual performance.

Phase 5 (week 24): On completion of the presentation and assessment of performance, student feedback on the full process was elicited by using a questionnaire. The questionnaire covered such topics as identifying the skills developed in the course of the assignment and establishing students' attitudes to self- and peer-assessment and group-work. In addition, a series of focus groups were conducted with members from the course to obtain further qualitative data on the study and its outcomes.

Figure 1: Research methodology



Results

It should be noted that the questionnaire was completed by two groups of students. The first group of students (G1) completed the IS module under the traditional approach, that is, they were not provided with any assistance during the project in terms of understanding and implementing the concepts of group-work. The second group of students (G2) were part of the revised programme of study, in which workshops and other changes in the assessment and presentation processes had been incorporated.

Figure 2 provides a summary of the questionnaire results. A 5-point Likert scale was used. In terms of skill development, it can be seen that the overall scores ranged from 3.3 (peer assessment) to 4.1 (teamwork), with an average score of 3.7 over the eleven categories identified. As the average score (3.5) received by G1 is lower than that of G2, it appears that the extent of skill development under the action learning environment is more significant. This conclusion is justified by the statistical results with a confidence level of 95% (i.e. $p < 0.05$). Out of the eleven identified categories, there were three categories (Leadership, Communication, and Study) whose marks allocated to G2 were lower than that of G1. However, as long as statistical results indicate that p values of these categories are higher than 0.05, it cannot be concluded that the action learning approach is weaker for the development of these three skill categories.

With regard to 'attitudes to group-work', a favourable response was obtained, as all the scores for G2 are higher than those of G1. It can be observed that the average score for the group-work sessions for G2 is 3.7, whereas the corresponding figure for G1 is just 3.0. From the action learning group (G2), the marks received for all the identified categories were higher than 3.0, indicating a positive attitude to the group-work process. It can also be seen that students' attitudes were positive in terms of enhancing the learning of students (3.8), providing a motivating effect (3.4) and helping them to integrate more with other students (3.9). The responses also indicated that students did not feel reluctant about becoming a group member (3.6) and that group-work did not limit student potential (3.4). On the contrary, students agreed that they had learned a considerable amount from their group colleagues (3.6) and that they would become more capable students after working in a group setting (3.6). Students also felt more comfortable with the evaluation system which attempted to minimise the effect of group members not contributing (3.8).

The results regarding the assessment of attitudes indicate that students viewed the preliminary workshops positively and that it increased their ability to critically evaluate personal and peer contribution (3.5). However, when it came to implementing peer-assessment, they indicated that they were indifferent about assessing other groups (3.2) and to being assessed by other students (2.9). Moreover, it can be seen that students held negative attitudes towards assessment, especially when they had to assess their own group members (2.6), with whom they may have been collaborating, sharing, and developing a trusting relationship throughout the IS project. As deduced from these results, it seems conceivable that students viewed assessment as being the responsibility of the lecturer and they remained unconvinced that they had the requisite skills for assessment.

Figure 2: Summary of questionnaire

Questions without *: 1 = strongly disagree, 5 = strongly agree. Questions with *: Negative item, therefore reverse score

Development of skills:

How do you feel the exercise has improved the following skills:

	Mean Rating		95% Confidence	
	G2	G1	t	p
Problem solving	3.9	3.2	5.36	0.00
Leadership	3.4	3.7	-1.75	0.08
Research	3.6	3.2	2.54	0.01
Study	3.4	3.7	-1.32	0.19
Communication	3.9	4.0	-0.13	0.90
Time management	3.8	3.1	5.25	0.00

Presentation	3.9	3.3	3.68	0.00
Peer assessment	3.3		NA	
Self assessment	3.5		NA	
Subject knowledge	3.7	3.7	0.25	0.80
Teamwork	4.1	3.6	2.94	0.00
Overall	3.7	3.5	3.63	0.00
Attitude to groupwork:				
*I feel reluctant about being a group member	3.6	2.9	2.83	0.01
It was easy to work collaborate in the group	3.6	3.5	0.91	0.36
*I feel that groupwork only suits the non-contributor	3.8	2.7	7.82	0.00
The groupwork sessions:				
Were enjoyable	3.7	3.3	1.96	0.05
Helped me to learn	3.8	3.1	4.43	0.00
Enhanced my motivation/ interest levels	3.4	3.0	2.17	0.03
Helped me integrate more with others	3.9	3.5	2.58	0.01
*Limited my potential	3.4	2.7	4.46	0.00
I learned a great deal from other members in my group	3.6	3.4	1.29	0.20
I feel I am a more capable student having worked in a group	3.7	3.1	3.46	0.00
Attitude to assessment				
	Mean Rating			
	G2			
I felt the peer assessment was fair and correct	3.1			
*I felt uncomfortable about assessing other groups	3.2			
The groupwork sessions increased my ability to assess myself and my peers in a more analytical and helpful way	3.5			
*I would prefer not to assess individual group members	2.6			
*I resented being assessed by other students	2.9			

The focus groups appeared to support the questionnaire findings with regard to self- and peer-assessment. For example, one student stated, “very subjective, lecturer has a more in-depth knowledge of the topic and should better appreciate the work”. Another student when referring to the marking of the other groups stated, “I would need to be convinced that standards are being maintained and peers had some sort of agreed benchmark”. This may be perceived as a natural response to the move away from traditional assessment practices, and it is anticipated that as students become more experienced at self- and peer-assessment, their attitudes will become much more positive.

Discussion and Conclusion

In terms of the methodology developed, three important areas for future work have been identified based on an analysis of the questionnaires and focus group discussions and these are outlined below.

Group-work

With regard to the group-work process, one measure which is proposed is the introduction of a project log, which would be completed by each student group and provide records of meetings, a description of the tasks allocated along with responsibilities assigned to individuals, and a record of tasks completed. This log would serve a number of purposes, namely to:

- raise the level of student awareness of the dynamics of group-work and the complexities of team-based approach in a work environment;
- enable groups to effectively prioritise the workload and ensure that it is equitably distributed among group members;
- provide a more objective method of evaluating the individual contributions of group members with regard to self- and peer-assessment;
- provide a better mechanism for tutors to monitor the group-work process, so enabling them to assist groups who encounter difficulties.

Assessment

The results above indicate that students are uncomfortable with both self- and peer-assessment. It should be noted that the traditional teaching approaches at secondary school level in Hong Kong might act as a barrier to the successful introduction of new forms of assessment (Biggs, & Watson, 1993) when students enter higher education. The present approach at secondary school is a rigid, highly competitive, examination-dominated system involving heavy workloads with a strong if not exclusive academic focus. The introduction of group-work at tertiary level, therefore, requires a major shift in mindset and culture for the student body. However, it is argued that the practice of encouraging students to become involved in their own and each other's assessment should be developed. This will act as a means of providing feedback to students and will also enhance their ability to judge their own learning performance, thus providing opportunities to develop skills for learning that will be of value long after leaving university.

The focus groups identified the subjectivity of the assessment process as an area of concern, and further consideration suggested that instead of receiving peer evaluation only once during the year, regular assessment would be established with students obtaining feedback on four occasions (i.e. in the middle and at the end of each semester). Such an approach should assist in establishing a culture of ongoing self- and peer-assessment by the students. It is anticipated that over time, as students become practiced in evaluating themselves and their colleagues, their prejudice will begin to diminish and they will come to accept this method of evaluation.

In addition, even though students had been directly involved in determining the criteria for marking the presentations in Phase 2, it was identified during the focus group meeting that they had difficulty in performing evaluations. For most students this was their first opportunity to be involved in evaluating the work of other students. Consequently, for the initial presentations there was no benchmark against which to compare them. Students felt that they tended to be too lenient when awarding marks to these early groups. As the presentations progressed, they felt that their ability to mark effectively improved. In order to assist students in the marking of the presentation, a number of developments are planned.

- After a presentation and before any formal assessment, the class will be given the opportunity to discuss with the tutor the merits of the delivery style and content. This process should allow students to deliberate on the appropriateness of the presentation criteria which they developed and to more fully understand the key attributes of a successful presentation.
- Each presentation will be recorded on videotape, and a copy given to the group involved so that members have the opportunity to view their own performance and critically reflect upon it.

Implications for Staff and Course Development

The project log will provide a mechanism to enable the tutor to take an active role in dealing with group and individual problems. Where conflict arises between group members that cannot be resolved internally, the tutor must be prepared to act as a facilitator. This approach demands appropriately trained staff and has implications for staff development in such areas as team building, conflict resolution and negotiation skills.

The methodology described has only been applied to a limited number of modules within the IMSE Department. The application of this methodology in other years and across courses requires a planned approach. If students are to develop their learning and assessment skills, then they need to perceive a developmental process occurring as they progress through their courses. This demands a dedicated core of tutors who know what has been covered in previous modules and are prepared to enhance the process through continuous improvement.

As students' expectations are raised and as their skills in self- and peer-assessment improve, they are likely to begin to apply those skills to other modules, even those that use the traditional, individual assignment as a method of assessment. Consequently, the long-term implication is that a change in the assessment culture within the University will be required. Tutors must therefore be prepared to accept a changing role, as students take on more responsibility for their own learning. This is likely to be a much more demanding role as students will expect more discussion and clarification in terms of, for example, the assessment criteria and feedback on overall performance.

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