

Developing Transferable Groupwork Skills for Engineering Students*

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Student assessment and the development of transferable personal skills are receiving increasing attention in higher education establishments. This study examined the potential for enhancing student learning through the development of groupwork, presentation and self- and peer-assessment skills on an industrial engineering undergraduate course. A methodology is described which indicates the approach adopted and a questionnaire evaluates students' impressions of the process. The overall conclusion to be drawn from the investigation is that skill development does take place and that students find groupwork an enjoyable learning experience. With regard to self- and peer-assessment, students were not as enthusiastic. 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 proactive 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 [1]. Just at the time when academics are coping 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 ingenuity and flexibility, while still monitoring and assuring the quality of the process [2].

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 [3–5].

At the same time many of the new teaching and learning strategies developed have been designed to ensure that students become more aware of the demands of future employers for graduates who are able to display a range of personal transferable skills. These include:

- communication and presentation skills;
- problem-solving and organisational skills;

- team-work;
- leadership skills.

In addition, in many fields of professional training there has been a concern for developing students' ability to assess and evaluate their own work in ways which are applicable to their future profession [6]. According to Boud and Lublin [7], 'one of the most important processes that can occur in education is the growth in students of the ability to be realistic judges of their own performance and the ability to monitor their own learning'.

From an historical viewpoint the prevalent model for assessment throughout the education system has been one in which, 'students have little or no input, are often unaware of the assessment criteria and have little recourse regarding the judgements made of them' [8]. Within the context of the changing climate of higher education, development of groupwork and self- and peer-assessment skills are becoming increasingly important issues in many institutions, reflecting the changing face of the work and social environment as outlined below.

In relation to the requirements of the workplace, various studies have indicated employer dissatisfaction with the development of transferable skills in undergraduates [9] and a recognition by undergraduates of their weakness in these skills [10]. This is particularly important for engineers, who spend a considerable proportion of their day working and dealing in a group environment. For example, engineers may be part of a project team involved in R&D or new product development. As a member of a work group that 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

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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 [11]:

- security and protection;
- affiliation;
- esteem and identity;
- task achievement;
- member roles and status;
- group cohesiveness;
- norms;
- conflict resolution;
- negotiation;
- teamwork;
- communication.

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 which require further work. At the same time, an increasing number of professional bodies [12, 13] 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 [14], 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 article to examine the approach adopted, on an Integrative Studies (IS) module, at the University of Hong Kong, within the Department of Industrial and Manufacturing Systems Engineering (IMSE), to developing a methodology for enhancing transferable skills and to encouraging students to take a more proactive role in assessing their performance. Briefly, the aims of the study are to:

1. Determine the benefits and learning outcomes of group-based assignments.
2. Determine whether there is a development of transferable personal skills through the use of this specific assessment process.
3. Assess whether group presentations are an effective way of developing interpersonal and presentational skills.
4. Judge whether the practice of using self-

and peer-assessment enhances students' competencies with regard to self reflective learning.

PROGRAMME BACKGROUND

The IS module in the 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 years, to the manufacture of a typical commercial product.

The integrating principle of the programme is achieved through the use of a 'vehicle' that is an actual product that the students must 'design and manufacture'. In addition to the integration of technical knowledge, the programme also aims at providing 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 that has been selected by the academic staff. 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

established and manufactures a range of similar products).

The programme is planned using the active learning approach. The students' own activities are expected to be the focus of the program, while lecturers act as facilitators, giving guidance and advice throughout the entire project. The emphasis is on 'action learning'—learn best by doing—rather than the traditional 'passive' teaching approach. Lectures are given only on those topics with which the students have had little exposure at the time of the project. A supervisor is assigned to each group to provide administrative guidance throughout the project. For technical advice and information, students are encouraged to seek the opinion of other lecturers. 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.

METHODOLOGY

The research approach adopted can be broken down into five phases (see Fig. 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 undergraduate (54) industrial engineering students, within the context of writing

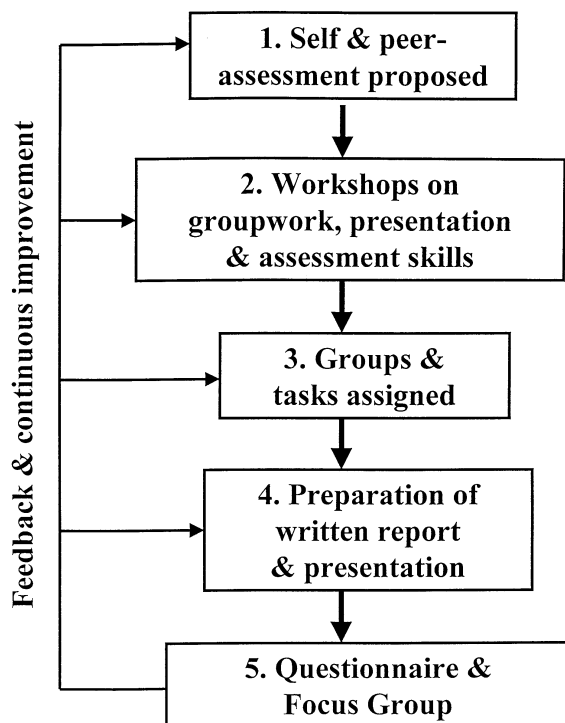


Fig. 1. Research methodology.

and presenting a group report relating to the application of theoretical business and engineering concepts.

Phase 2 (weeks 1–6)

Before commencement of the assignment students were introduced to the concepts of groupwork, presentation and assessment skills through a series of participative workshops and formal lectures. Within the groupwork session, students carried out a number of exercises in order to understand the dynamics of the process and to identify the various skills which groupwork can develop. In terms of presentation skills students had to view a customised (amateur) video tape which had been recorded by one of the tutors involved in the study and reflected the subject matter that the groups had to cover. This video provided a variety of delivery styles and students, through discussion, had to identify those attributes which were important in delivering an effective presentation. In order to provide them with experience of assessment, students were asked to mark a short essay and then compare the mark that they awarded against that of the course tutor. Ample opportunity for discussion of the relevant issues identified from the essay was provided.

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 tutors 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. In terms of mark allocation, the presentation was worth 30% (split in equal proportions between the tutor and students) and the group report 70%. These mark allocations were discussed and agreed with the students. The presentations were assessed by the other student groups in the class and by the tutors, according to the criteria developed in Phase 2.

Individuals in each group were then required to weight the contribution of all members throughout the project duration. A 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 are 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 collecting the total information for each group, a peer weighting could be established for each individual and this was applied to the final group mark (combining the presentation and report). Thus, students had the opportunity to be assessed by their peers as well as allowing provision for self-assessment. 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 via 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 groupwork. 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.

RESULTS

In order to evaluate the success of the project, all the students ($n = 54$) who attended the integrative studies module completed a detailed questionnaire. In order to check the validity of the questionnaire design, content validity was applied. Content validity is a subjective measure of how appropriate the questions in the research instrument appear to

Table 1. Summary of questionnaire results ($n = 54$)

	Mean rating	Standard deviation
<i>Development of skills</i> (1 = strongly disagree, 5 = strongly agree)		
How do you feel the exercise has improved the following skills:		
Problem solving	3.9	0.83
Leadership	3.4	0.82
Research	3.6	0.77
Study	3.4	0.84
Communication	3.9	0.74
Time management	3.8	0.80
Presentation	3.9	0.62
Peer-assessment	3.3	0.78
Self-assessment	3.5	0.86
Subject knowledge	3.7	0.88
Teamwork	4.1	0.81
<i>Attitudes to groupwork</i> (1 = strongly disagree, 5 = strongly agree)		
It was easy to work collaboratively in the group	3.6	0.83
I learned more through interaction with others	4.0	0.92
The groupwork sessions:		
(a) were enjoyable	3.7	0.8
(b) helped me to learn	3.8	0.82
(c) enhanced my motivation/interest levels	3.4	0.84
(d) helped me to integrate more with other students	3.9	0.68
I felt reluctant about becoming a group member	2.4	1.11
I feel that groupwork only suits the non-contributor	2.2	0.84
I would have learned more working alone on this project	2.4	1.01
The groupwork sessions:		
(a) limited my potential	2.6	0.9
(b) decreased by level of ability	2.4	0.96
(c) were a complete waste of time	2.2	0.95
<i>Attitudes to assessment</i> 1 = strongly disagree, 5 = strongly agree)		
I felt the peer assessment was fair and correct	3.1	0.83
Group sessions increased my ability to assess myself and peers in a more analytical way	3.5	0.75
I felt uncomfortable about assessing other groups	2.8	0.86
I would prefer not to assess members of my own group	3.4	1.02
I resented being assessed by other students	3.1	0.85

a set of reviewers who have knowledge of the subject matter. For the purpose of this study, a two-stage process was applied. Firstly, the questionnaire was designed based on the work of previous researchers who empirically investigated various aspects of skill development, groupwork and self- and peer-assessment [1, 15, 16]. Secondly, the research instrument was evaluated by a number of educational experts who have experience with the groupwork process and only minor modifications were proposed and applied to the questionnaire design. Table 1 indicates those questions relating to the issues of skill development and groupwork/assessment attitudes and the mean ratings and standard deviations obtained.

In terms of *skill development*, it can be seen that the overall marks ranged from 3.3 (peer assessment) to 4.1 (teamwork), with an average score of 3.6 over the eleven categories identified. Since a score greater than 3.0 can be viewed as a positive response to skill development, the results would suggest that the process adopted to develop transferable personal skills appears to have been successful.

With regard to attitudes to *groupwork*, a favourable response was obtained in terms of enhancing the learning of students (3.6), 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 (2.4) and that groupwork did not limit student ability (2.2). Students also felt more comfortable with the evaluation system, which attempted to minimise the effect of group members not contributing (2.2).

Attitudes to *assessment* indicated that students viewed the preliminary workshops positively and that it increased their ability to critically evaluate personal and peer contributions (3.5). However, with regard to implementing peer-assessment, they were indifferent to assessing other groups (2.8) and to being assessed by other students (3.1). This would seem to indicate that students view assessment as being the responsibility of the lecturer

and they remain unconvinced that they have the requisite skills for assessment. Comments made on the questionnaires regarding the assessment process and at the focus groups support this argument. For example, one student stated, 'very subjective, lecturer has a more in-depth knowledge of the topic and should better appreciate the work completed'. Another student when referring to the marking of the other groups indicated, '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.

Boud [17] argued that self- and peer-assessment was, 'fundamental to all aspects of learning', and encourages the development of the reflective student, one who has a degree of self-directing independence and who is well placed to become a lifelong learner. This reflects the growing need to give students a more active role in successfully managing their own learning, as well as meeting the needs of industry for flexible, creative thinkers who can transfer their learning and cope with new situations in the workplace.

The results of the project to date would appear to indicate that overall there has been a favourable response to developing transferable personal skills and groupwork, even though some students did feel uncomfortable about evaluating both their own work and that of their peers. In addition, detailed discussions with the focus group would appear to suggest that further developments of the assessment implementation are required.

FURTHER DEVELOPMENTS

In terms of the methodology developed, three important areas for future work have been identified based on an analysis of the questionnaires and

Date of meeting	Members present	Work completed	Problem areas	Agreed action for next meeting	Group member(s) responsible

Fig. 2. Project log template.

focus group discussions and these are outlined below.

Groupwork

With regard to the groupwork 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.

Figure 2 provides an illustration of a template for the contents of such a project log. This log would serve a number of purposes, namely:

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

Assessment

The results above have indicated 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 could act as a barrier to the successful introduction of new forms of assessment [18], when students enter higher education. The present approach is a fairly rigid, highly competitive, examination-dominated system involving heavy workloads with a strong if not exclusive academic focus. The introduction of groupwork, 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 also enhance their capability to judge their own 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 one peer evaluation during the year, regular assessment would be established with students obtaining feedback on four occasions (middle and 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 obtain practice in evaluating themselves and their colleagues, that their prejudice will begin

to diminish and that 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 difficulties in evaluating them. 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 to compare them against. 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, certain developments are planned:

1. 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.
2. Each presentation will be recorded on videotape, and a copy will be 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 taking place 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.

CONCLUSIONS

The groupwork project described in this paper supports the views outlined by Parnaby and Donovan [3], Finniston *et al.* [4] and Steiner [5], who recommended possible improvements to engineering education. They indicated that:

- programmes should focus on participants' needs and be more interactive in design;
- they should offer participants the opportunity to apply theoretical concepts in practical situations;
- curriculum development must focus on utilising appropriate pedagogic techniques which enhance learning and develop leadership and interpersonal skills.

In addition, Katz [19] suggested that major obstacles to student learning included a lack of collaboration in learning and lack of opportunity for student responsibility. Too often, as indicated by Race [20], a 'passivity' still dominates learning and 'higher education students may still be over-taught', therefore limiting the development of the highly valued transferable skills. Such an over emphasis on attaining knowledge assumes that understanding comes later, but perhaps a more realistic or flexible approach would help in advocating personal involvement, by the student, in the learning experience: 'I hear and I forget; I see and I remember; I do and I understand' [21].

Undoubtedly, some tutors may be concerned that the group assessment process described may lack some of the precision of marking the traditional written assignment, but this is more than compensated for by the development of transferable skills and an enhancement of the overall learning experience for the students as highlighted by the favourable response to the questionnaire. Certainly, over-reliance on any single form of assessment is questionable and a

variety of different forms of assessment, including oral presentations, group projects, self- and peer-assessment as well as the more formal and traditional written submissions, is a better alternative. The controversial aspect of self-assessment is its contribution to grading student work, but when moderated and used as an element of collaborative assessment its potential is significant, providing a shared culture between the various stakeholders in the learning process and helping to strike the right balance between assessment and development.

With such an approach, there will always be a problem of subjectivity and variation in individual preferences and the right balance must be achieved between assessment and the management of the development process. If used correctly as additional techniques, groupwork and assessment can be effective and adaptive in improving many aspects of performance. The aim is to continue this work, to monitor trends in student development throughout the course, whilst continuing to develop the necessary cognitive and affective skills. However, a parallel need is to monitor the syllabus content and assessment methods, to ensure that students are not merely overloaded with unnecessary innovative methods, which may be just as monotonous and ineffective as the more traditional versions. It is important to recognise that there is potential for competence and incompetence in all teaching methods and programmes.

Traditionally, we have conceived of two separate learning arenas: the academic institute and the organisation. The university has provided cognitive, intellectual frameworks; the organisation or enterprise has taught skills in applying these to the work environment. It is argued that new assessment practices should attempt to integrate these two areas, so that the students' overall learning experience is enhanced. The assessment process described in this article together with the planned improvements should go part of the way towards achieving the aspirations of both engineering educators and teaching and learning professionals.

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REFERENCES

1. I. Kemp and L. Seagraves, Transferable skills—can higher education deliver? *Studies in Higher Education*, **20**, 3 (1995) pp. 315–328.
2. S. Brown and P. Knight, *Assessing Learners in Higher Education*, Kogan Page, London (1994).
3. J. Parnaby and J. Donovan, Education and training in manufacturing systems engineering, *IEE Proc.*, **134**, 10, Pt. A (1987) pp. 816–824.
4. M. Finniston, T. Duggan and J. Bement, Integrated engineering and its influence on the future of engineering education in the UK, *Int. J. App. Eng. Educ.*, **5**, 2 (1989) pp. 135–145.
5. C. Steiner, Educating for innovation and management: the engineering educators' dilemma, *IEEE Trans. Educ.*, **41**, 1 (1998) pp. 1–7.
6. D. Magin, and A. Churches, *What do Students Learn from Self- and Peer-Assessment? Designing for Learning in Industry and Higher Education*, Australian Society for Educational Technology, Canberra (1989) pp. 224–233.

7. D. Boud, and J. Lublin, *Self-assessment in Professional Education: A Report to the Commonwealth Research and Development Committee*, Tertiary Education Research Centre, University of New South Wales (1983).
8. N. Falchikov, Product comparisons and process benefits of collaborative peer and self-assessment, *Assessment and Evaluation in Higher Education*, **11**, 4 (1986) pp. 146–166.
9. S. Otter, *Learning Outcomes in Higher Education*, Leicester University, Unit for the Development of Adult Continuing Education (1992).
10. J. Brennan and P. McGeevor, *CNAA Graduates: their employment and their experiences after college; Summary Report*, CNAA Development Services Publication 13, London (1987).
11. R. Vecchio, *Organisational Behaviour*, Third edition, Dryden, Fort Worth (1995).
12. F. Barthorpe, Marking time over CPD, *Professional Engineering*, **9**, 12, June 19th (1996) p. 32.
13. The Institute of Management, New approach to training, *Professional Manager*, **5**, 2, March (1996) p. 20.
14. N. Falchikov, Peer feedback marking: developing peer assessment, *Innovations in Education and Training International*, **32**, 2 (1996) pp. 175–187.
15. J. Garvin, C. Butcher, A. Stefani, V. Tariq, M. Lewis, N. Blumson, R. Govier and J. Hill, Group projects for first-year university students: an evaluation, *Assessment and Evaluation in Higher Education*, **20**, 3 (1995) pp. 273–288.
16. A. Wollard, Core skills and the idea of the graduate, *Higher Education Quarterly*, **49**, 4 (1995) pp. 316–325.
17. D. Boud, Assessment and the promotion of academic values, *Studies in Higher Education*, **17**, 2 (1990) pp. 101–111.
18. J. Biggs and D. Watkins, *Learning and Teaching in Hong Kong*, University of Hong Kong (1993).
19. J. Katz, *Teaching as Though Students Mattered*, Jossey-Bass, London (1993).
20. P. Race, Quality for some—what about the rest? *J. Further and Higher Educ.*, **19**, 1 (1995) pp. 54–61.
21. M. Jackson and M. Prosser, Less lecturing, more learning, *Studies in Higher Education*, **14**, 1 (1989) pp. 55–68.

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