

Teaching Transferable Skills to Undergraduate Engineering Students: Recognising the Value of Embedded and Bolt-on Approaches*

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This paper presents the findings from a study of the development of transferable skills and considers the most effective approach to teaching transferable skills in four university departments of chemical engineering in the UK. Case study methods, incorporating mind maps, follow-up interviews, focus groups and questionnaires, were used to collect data. Although the literature suggests that skills development is best taught in engineering curricula through integrated teaching approaches, findings from this study suggest that embedded and bolt-on teaching approaches are also helpful in augmenting the development of transferable skills. All three approaches help build student awareness of transferable-skills education.

Keywords: transferable skills; mind maps; developing skills; bolt-on method; integrated method; embedded method

INTRODUCTION

PROVIDING ACADEMIC excellence in teaching is an essential part of any degree course. Increasingly, though, employers are looking for more than in-depth knowledge and understanding of relevant subject material from their recruits [1]. It is argued that part of this change has been driven by 'cuts in funding leading to higher education being more directly at the mercy of Government policy' and that they in turn have been influenced by employer demands [2]. Numerous white papers, from the Robbins Report in Higher Education [24] to the more recent Dearing Report [3], have impacted significantly upon higher education by highlighting the need for undergraduates to be better prepared for the world of work. To achieve the 'adaptability' required for working within different contexts and situations, graduates are now expected to have acquired some degree of competence in a range of transferable skills to enhance their personal development and professional abilities. To meet this demand, students will be required, as part of their course, to demonstrate their communication and teamworking abilities on more than one occasion; this is in addition to the more technical skills required of their disciplines.

Transferable skills in higher education

It is important to recognise what has prompted the changes in higher education to accommodate the development of transferable skills. Transfer-

able skills are not addressed seriously enough in higher education [4] and it is argued that course structure and delivery methods need to be radically rethought for the skills agenda to be sufficiently tackled. The Dearing Report [3] cited a number of recommendations which were made to the Government to improve the quality of higher education, including (1) more involvement between student populations and industry and commerce and (2) developing programme specifications, giving outcomes in terms of key skills. Such Government-produced publications imply that the responsibility for the development of skills lies within higher education [4]. It is also suggested in the literature that universities and colleges should provide their students with certain skills and abilities which are applicable outside of the curriculum; i.e. which are not discipline specific [5].

Employers are also keen for graduates to have developed their awareness and aptitude for transferable skills within higher education. Studies conducted into transferable skills in industry demonstrate the increasing pressure placed on graduates to be able to demonstrate such skills by (potential) employers [8, 6]. A briefing paper [7] echoed this view by stating that 'studies of employer needs have repeatedly stressed the priority which they give to personal transferable skills'. There is evidence to suggest that employers and Government organisations are actively assisting higher education in this quest. A press release from HEFCE (Higher Education Funding Council of England) [9] indicates the level of support that institutions of further and higher education are

* Accepted 7 June 2005.

receiving from governmental bodies. Further, supplementary evidence of activity in this area is available from the HEFCE website, denoting the number of bids, successful and otherwise, related to skills development in higher education.

Defining transferable skills

It has been suggested that 'transferable skills' are defined as those which are developed within one situation (education) and are useful when transferred into another (employment) [5]. This term is in common parlance within education. The definition, however, is rather broad, as it also accommodates technical skills; a more specific definition is required to differentiate between transferable and technical skills. Transferable skills have also been described as those that are 'needed in any job and which enable people to participate in a flexible and adaptable workforce' [2].

Even though transferable skills can be defined in a number of ways, they are essentially job-related skills but not job-specific ones (for example problem-solving and project management). One of the most comprehensive definitions is that provided by the Department for Skills and Education (DfES) [7], who identify transferable skills as 'those cognitive and interpersonal skills (application of number, communication, information technology, problem-solving, personal skills, working with others and improving own learning and performance) which are central to occupational competence in all sectors and at all levels'. Henceforth, this definition is used in this paper for conceptualising transferable skills.

Teaching approaches used to develop skills

There are a number of teaching approaches used to achieve the development of transferable skills in undergraduates. For the purpose of this work, three approaches are considered: 'embedding', 'integrating' and 'bolting-on' skills components. These are defined as clearly identified teaching aims and objectives relating to skills development.

- **Embedding:** No direct reference is made to skills development within a module or group of modules, promoting the development of technical 'know-how'.
- **Integrating:** Skills are developed in parallel with the core discipline and the same amount of emphasis is placed on the development of transferable skills as technical abilities.
- **Bolting-on:** Skills are developed independently of the core discipline, enabling the explicit development of students' transferable skills.

Embedding skills into the curriculum is seen as advantageous, as they forge learning links and develop a broad range of skills [10]. It is argued that, although embedded approaches have a number of intrinsic advantages, they have been difficult to operationalise effectively [12]. It is further suggested that, unless there is an explicit

awareness related to developing transferable skills, the associated teaching is less effective [11].

Bolt-on skills development (or stand-alone, as it has been redefined) is viewed as advantageous in making skills development explicit, although students fail to grasp the academic value of such an approach. Cottrell [13] supports this view, maintaining that 'learning development and skills enhancement do not thrive if they are divorced from the students' overall teaching and learning experience'. It is also argued that skills cannot be effectively taught in a vacuum and that skills development needs to be discipline-orientated [12].

There is greater support for integration of skills into the curriculum [4, 14], especially if skills are integrated into regular coursework and taught by the subject teacher. It is argued that, if the provision of skills development is to incorporate knowledge and understanding, analysis, creativity and evaluation, then integration of skills is the only viable option [4]. Research also suggests that integration of skills components into curricula is seen as a more effective teaching approach in higher education, as it is more representative of 'real-life' application of skills in the workplace [15].

This paper presents some of the findings from a study conducted into the development of transferable skills at a number of engineering departments in institutions of higher education in the UK. Particular reference is made to establishing the value which students themselves place on embedded and bolt-on teaching approaches for developing their transferable skills.

RESEARCH

Nine courses were investigated at four engineering departments: three from Institution 1 (embedded, integrated and bolt-on), two from Institution 2 (integrated and bolt-on), two from Institution 3 (integrated and bolt-on) and two from Institution 4 (embedded and bolt-on). All four departments had previously collaborated on an HEFCE project which considered the identification and dissemination of good practice for the enhancement of undergraduate transferable skills. Part of the outcomes of the project was the production of a handbook which could be used to support engineering academics in developing transferable skills in their undergraduate students [16].

The four programmes of study

The departmental approach taken to enhance the quality of skills teaching is different for each of the four university departments involved in this study:

- **Institution 1:** This department has been teaching transferable skills, incorporated into its curriculum, for the past 10–15 years. About 80% of the student population undertakes a professional placement year. All three teaching approaches

mentioned are used in this programme. Examples of teaching techniques which accommodate the aforementioned approach include: student-led debates, students undergoing training for a peer tutoring role, and students undertaking practical problems not directly related to their discipline.

- **Institution 2:** This department has a structured training programme for the development of transferable skills which has been running for about 8–10 years and incorporates much in the way of integrated skills development. Examples of teaching techniques currently used include: students assessing their peers' performance with respect to some specific activity within some predetermined assessment scheme and student teams from the same discipline undertaking a design activity.
- **Institution 3:** Many changes have been made to the curriculum in this department to include further skills development which are currently embedded. The programme now includes a couple of bolt-on skills development courses. Examples of teaching techniques used to accommodate the teaching approach include: external representatives working with small teams of students tutoring paper-based or practical problem-solving sessions.
- **Institution 4:** Transferable skills are mostly embedded and occasionally integrated into the curriculum in this department. Changes are currently being made to the curriculum so that more skills-related activities can be included for the development of these skills. Examples of teaching techniques which accommodate the aforementioned approach include: student teams undertaking a discipline-related, peer-assessed practical activity, and placing students in different teams for different tasks throughout a module.

Using case study methodology

A case study methodology was used for this work, as it provided scope for an in-depth investigation to be conducted into the development of transferable skills in chemical engineering undergraduates [17, 18]. As such, it was possible to explore the particulars of the modules, especially in terms of gauging students' perceptions of the provisions in place to support the development of their skills, as opposed to the generalities of a situation [19]. It was possible to identify the relations of a number of variables and how they impacted upon student learning; identifying these links is considered to be an advantage of adopting a case study method [17]. The subtleties of the four institutions could be investigated in addition to identifying key outcomes. A number of tools were used to collect data, including concept maps, focus groups and questionnaires; the variety of tools helped corroborate findings through triangulation. Volunteer groups (consisting of 5–7 students) from each course were involved with this study and were

asked questions about it to gauge their perceptions of their transferable skills education. The students selected to form the research groups were representative of the peer group as a whole in terms of ability, gender and ethnicity. As such, the majority of students were Caucasian males who had gone straight into tertiary education.

The limitations of using a case study methodology were mainly that it was not possible to work with large number of students when the objective is gaining an in-depth picture from a variety of rich data sources. The research was oriented towards understanding student perceptions, therefore the quality of data would have been compromised if greater numbers of students had been used in the investigation.

RESULTS

The results highlight questionnaire responses which were readily quantifiable. Student responses were sought to the following two questions: 1) How do you feel you are learning/developing transferable skills on this course? 2) How do you judge the success of your development with respect to transferable skills? In addition to which, a sample of comments from students attending courses in which both embedded and bolt-on approaches were used to teach have been shown. Although the numbers of students involved in the study may seem rather low, it should be appreciated that selection of a case study methodology was useful for providing an in-depth study into skills development, from what was assumed to be a representative group of students. Other data were also collected and analysed as part of a wider investigation. Figs. 1 and 2 illustrate samples of questionnaire data obtained from students attending courses taught using an embedded teaching approach to develop students' transferable skills.

Sample comments of students' perceptions of their skills development were obtained from those attending courses in which embedded techniques were used to teach skills:

[We'll learn] by being put into situations where we have to, so we're put into groups and told to carry out a task. To carry out a task you have to work together, work as a team as well.

I think that the lecturer is going to try and give us the responsibility of explaining things to other people.

Focus group response, level 1, Inst. 1

The course is a success, then it should be easier to do the research project than if you hadn't done the course, but that's difficult to judge.

You just know, it's when the design project finishes and you know whether it'll go well if you feel you could do it again.

Focus group response, level 4, Inst. 4

Figs. 3 and 4 illustrate samples of questionnaire data obtained from students attending courses

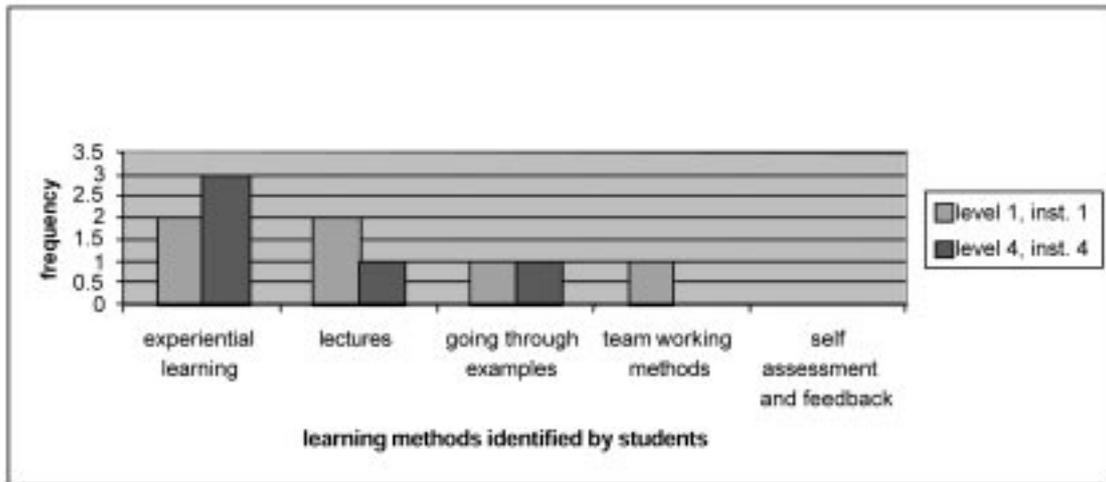


Fig. 1. Graph of students' perceived learning approaches for students attending courses in which embedded teaching approaches are used to develop skills.

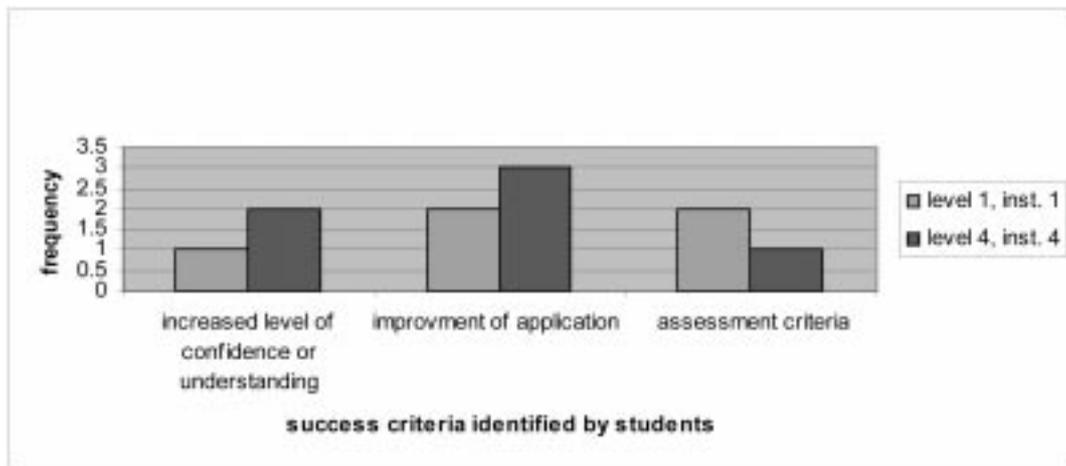


Fig. 2. Graph of students' perceptions of the success of transferable skills development for a course using an embedded teaching approach.

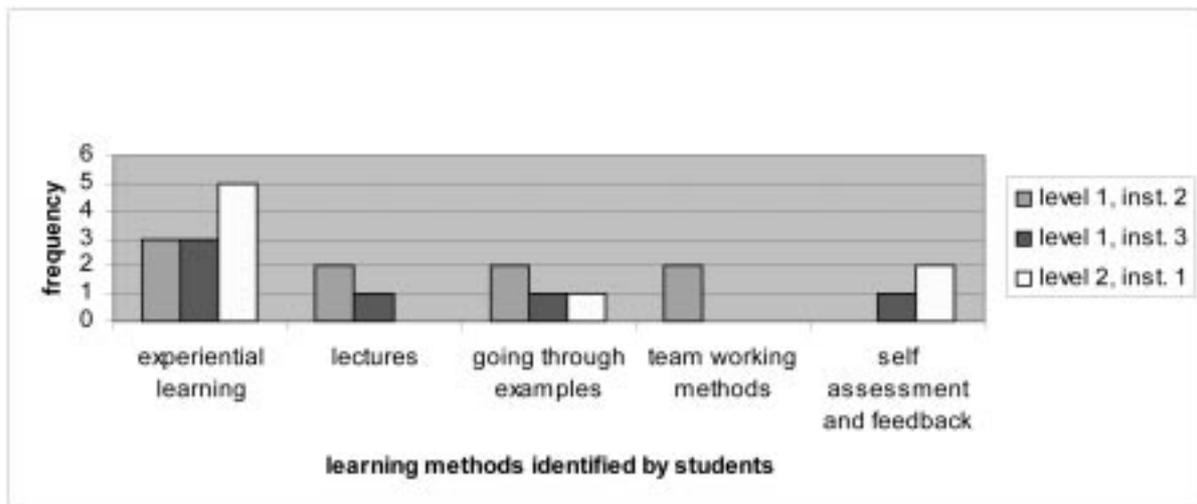


Fig. 3. Graph of students' perceived learning approaches for students attending courses in which bolt-on teaching approaches are used to develop skills.

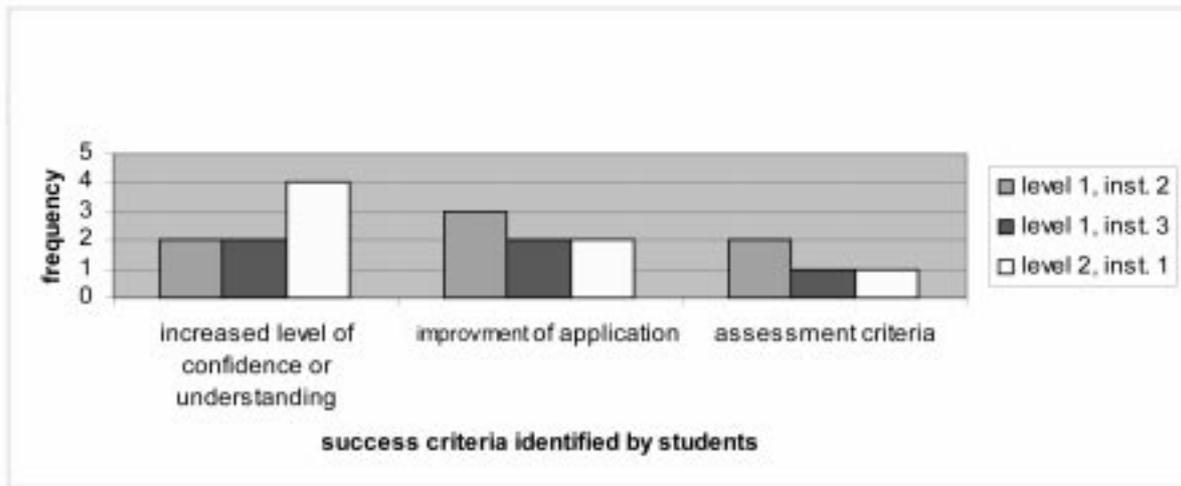


Fig. 4. Graph of students' perceptions of the success of transferable skills development for a course using a bolt-on teaching approach.

taught using a bolt-on teaching approach to develop students' transferable skills.

Sample comments, of students' perceptions of their skills development were obtained from those attending courses in which bolt-on techniques were used to teach skills:

They'll probably also, it's all about practice and being confident and saying what you think in front of people. That's probably one of the key skills they'll try and teach us and the only way to do that is just practise, practise, practise.

Focus group response, level 1, Inst. 2

But if you feel that there has been a change in your behaviour and skills in a positive way after completing the module, then that can be counted as success.

Focus group response, level 1, Inst. 3

It will make you more conscious about using skills, trying to communicate with people around you, especially people you don't get on with well and you don't know.

Generally, building confidence all around and getting us to do things.

Focus group response, level 2, Inst. 1

DISCUSSION OF RESULTS

The findings from the study suggest that the majority of students exposed to an embedded teaching approach for developing their transferable skills are aware of this 'implicit' development of skills. The majority of students feel that they are developing skills through experiential learning techniques. Students also seem to appreciate the value of developing skills in this manner, as the majority recognise an improvement in their application of the skills as the deciding factor on which they would judge their success, even though they were not formally made aware of developing them.

The findings are in contrast to what is suggested in the literature, that more time could be spent

explaining to the learner what skills are being taught [20], and imply that students recognise a benefit to being taught skills which are embedded into the course or programme. It is suggested that if, for example, group work is used by lecturers, opportunities are provided for students to explore their own ideas, to problem solve and to discuss ideas with others [13]. In this way, the learning is implicitly reinforced, therefore such a teaching approach should be routinely considered.

The findings also suggest that there is merit in bolt-on teaching techniques. There is probably little surprise in the perception of the majority of students, that they develop their skills through experiential learning methods, but there is also some indication of 'learning through self-assessment or feedback'. The significance of this finding is that at least some students are aware of their development and are able to recognise this personal reflection as part of the learning process. The literature suggests that a capacity for self-assessment and the related notion of self-awareness are fundamental for maturing and progressing as a learner [21, 22]. Being able to judge one's own performance is a valued attribute in both personal and professional contexts [22]. It is also suggested that self and peer assessment give learners a greater ownership of the learning they are undertaking [10]. As such, it could be argued that bolt-on teaching techniques provide opportunities for students to explicitly develop their abilities as self-assessors.

Another significant finding from investigating bolt-on teaching approaches is the importance students place on 'developing confidence' as a measure of their success. A recent survey conducted by the World Chemical Engineering Council [23] suggested that recent graduates in employment place a high relevance upon their abilities to apply knowledge, analyse information, solve problems, etc., all of which are related to having the confidence to do so.

The findings from this study suggest that students recognise the relevance to learning skills through both embedded and bolt-on teaching approaches. Both approaches should be actively considered in addition to the more traditional integrated teaching approach to developing transferable skills within an engineering curriculum.

FURTHER RESEARCH

To develop this work further, it would be interesting to consider whether transferable skills teaching is affected by the sequence in which teaching approaches are introduced to the curri-

culum. There is an implication, from having analysed all the data, that the sequence in which various teaching approaches are introduced to the curriculum matters (students may reflect upon and relate their learning better at particular levels of study), but there is no evidence to justify this suggestion, and this is worthy of further research.

Research suggests that nearly all transferable skills (and professional attributes) are required to a greater extent at work than they are developed during education [23]. Further recommended research would be to investigate the transition from education to employment and whether the gap between the two is significant and how it could be narrowed.

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