PROMOTING DEEP AND PRACTICAL STUDENT CENTRED LEARNING IN ENGINEERING ANALYSIS

Stephen Donohoe[1], Melanie Parker [2], Sue Turpin-Brooks[3] and Paul Murray[4]

Abstract — *This paper describes a student centred approach to engineering analysis as part of the work carried out under The Student-centred Learning In Construction Education (SLICE) project. SLICE is a UK government financed project supported by the Fund for the Development of Teaching and Learning (FDTL) Phase 3. The project seeks to enhance the quality of construction education by promoting effective student -centred learning in the building and civil engineering subject areas. The main objective of SLICE is promoting good practice and assisting staff to develop effective student centred learning activities. This paper sets out how a student centred learning exercise was used to teach mathematical concepts to overcome practical engineering problems for a group of civil engineering undergraduates. The exercise involved students learning mathematical concepts and applying these to practical engineering problems i.e. flat slab design. The students presented their work to an audience of their peers who assessed what had been done in the context of the project brief. All students in the class were given a test carried out under exam conditions to find out whether they had learned the mathematical concepts.*

Key words — Civil Engineering; Deep Learning; Education; Mathematics; Peer Assessment

INTRODUCTION

It has been recognised that in training undergraduates, experiential (not only theoretical) learning is important to employers of civil engineering graduates (Jennings & Ferguson [1]). Professional bodies [2]; Universities (Ryan *et al*.[3] and Government [4], have all commented on the importance of graduates in the modern economy.

One of the fundamental subjects studied by prospective graduates enrolled on Engineering, Science or Computing degrees is Mathematics. The importance of mathematics in undergraduate degrees was observed by Drake [5] who commented:

> …there are opportunities within undergraduate programmes to enhance and develop mathematical competence. Furthermore, these opportunities should be systematically exploited so that emergent graduates complement the warp of their specialist degree with a weft of reliable core skills in mathematics, computers and communications…

Although Drake commented on the significance of mathematics generally, it has long been recognised that the subject plays an important part in engineering degrees Hopkinson & Forrest [6]; Inglis [7]. In a modern context, the standard of mathematics education for Engineers has been perceived as declining and this seen as a serious problem by educators and the engineering professions. An report entitled *Measuring the Mathematics Problem* (Learning and Teaching Support Network *et al*.[8] found that:

> This past decade [1990 - 2000] has seen a serious decline in students' basic mathematical skills and level of preparation of entry into Higher Education.

These views are echoed by the Engineering Council[9] who asserted:

> …we have no confidence that the matter is being properly addressed by Government and its agencies.

PLANNING THE PROJECT

It is against this background that the Student centred Learning In Construction Education (SLICE) team and staff from the School of Civil and Structural Engineering at the University of Plymouth reflected upon the idea of how to embed mathematical concepts into civil engineering students.

One of the key objectives identified whilst planning the project was to instill a sense of deep learning into the students. The importance of deep learning has been identified by Marton and Säljö [10], Entwistle [11], Ramsden [12] and Morgan [13]. Ramsden [14] provided a useful summary of distinctions between deep and surface

[1] Stephen Donohoe, Project Leader - **S**tudent centred **L**earning **I**n **C**onstruction **E**ducation, (SLICE) University of Plymouth, Construction Education Unit, School of Civil and Structural Engineering, 3 Palace Court. Plymouth, PL9 9LA, sdonohoe@plymouth.ac.uk
[2] Melanie Parker, Research Officer, SLICE University of Plymouth , mcparker@plymouth.ac.uk.
[3] Susan Turpin - Brooks, Project Consultant, SLICE University of Plymouth, sturpin-brooks@plymouth.ac.uk
[4] Paul Murray, Project Director, SLICE, University of Plymouth, pmurray@plymouth.ac.uk

approaches which have been adapted and shown in Table 1 below:

TABLE I
SURFACE AND DEEP APPROACHES TO LEARNING
(ADAPTED FROM RAMSDEN, p19)

FEATURES OF SURFACE LEARNING
Breadth of knowledge, Vague
Memorized Rote Learning
Focus on discrete knowledge without integration
Atomistic
Non-reflective
External Emphasis
FEATURES OF DEEP LEARNING
Depth of knowledge (i.e. dense and closely related)
Intention to understand
Relates previous knowledge to new knowledge
Relates evidence to conclusions
Holistic
Reflective
Internal Emphasis

Wilcox [15] identified strategies that promote deep learning as those which have:

- clear statements of goals
- student input into course structure and content
- faculty / student interaction
- student / student interaction
- active / interactive exercises (e.g. partner work; buzz groups; case studies)
- teaching learning skills explicitly
- providing a choice and / or range of assessment tasks
- projects involving research and reflection
- collaborative projects
- integrative (multi-source) assignments
- full and proactive feedback on student work and assignments.

The lecturer involved in teaching this subject (Engineering Analysis) stated succinctly that in his opininion the results obtained in the module tests had been “disappointing” and reflected a lack of understanding of basic concepts by the students. The lecturer reflected on what might be done to improve the situation and concluded that some fresh thinking or a new approach was needed to promote deeper learning. Beder [16] recognised the need for a new educational approach

> …that not only helps students to understand basic engineering principles but also gives them the ability to acquire more specialist knowledge as the need arises.

In the planning of the exercise the following concept model shown in Figure 1 below was used.

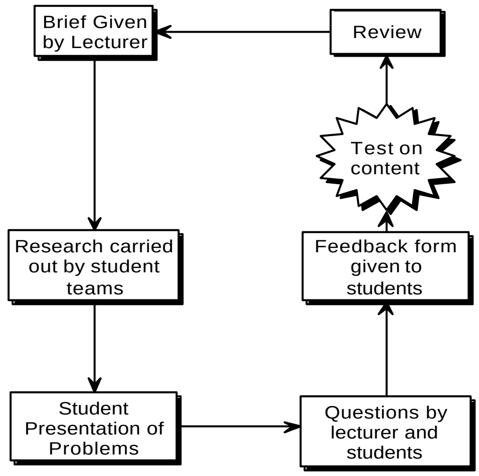

FIGURE 1
PLANNING THE ENGINEERING ANALYSIS STUDENT CENTRED LEARNING EXERCISE

The first stage of the concept model was the brief given to the students by the lecturer. This was purposely and deliberately introduced as a active rather than passive forum. The lecturer wanted to move beyond giving a series of traditional lectures to the students. Instead the students were formed into groups , told the nature of the problem and then asked to leave the lecture theatre to discuss their approaches to solving the problem. In this way a clear statement of goals was given to the students, one of the strategies identified in promoting deep learning mentioned above.

The second stage of the concept model was that the students were expected to identify the important criteria that would be needed to be investigated in order to solve the problem. Although the lecturer was on stand by to advixe the students, the objective of the student centred approach was to minimise the input of the lecturers and maximise the input of the students.This accords with the strategies which maximise student input into structure and content, allow faculty / student interaction as well as student / student interaction, and involve interactive exercises (in this particular exercise the use of mathematical concepts to solve real engineering problems).

The third stage of the concept model was for students to present their findings to their colleagues. The thinking behind this part was that students might be inclined to take more notice of their contemporaries than listen to a series of lectures given by the lecturer. This emphasises student / student interaction and promotes the use of explicit teaching skills. After the presentations the students were given a feedback form and asked to comment on how their learning had been affected by the student centred approach. The questions on the feedback form were open ended in that students were free to make negative comments as well as positive comments on their individual learning experiences. This accords with one of the strategies advocated by Wilcox [17] in which she advised that “full and proactive feedback” ought to be used as often as possible.

The students carrying out the presentations were subjected to a teaching observation appraisal by members of the SLICE team. The teaching observation was carried out e using the same standard teaching observation forms used by staff at the University. Although the teaching observation was not formally assessed, the observations were given to the students and dicussed with the respective student groups. The purpose of giving the students access to the teaching observation forms was to help the students improve presentation skills. This affects only for academic work within the University but also the development of students when they graduate and enter into industry as engineers. Braham[18] and Dunn[19] have separately identified the negative stereotype of engineers and improving personal, social and presentation skills is one approach that might be used in minimising negative perceptions concerning engineers. This has important implications for attracting and recruiting young people into engineering.

Although the teaching observation was considered to be useful and the students involved said that it was useful to them, the key objective of the exercise was to encourage the use of mathematical concepts to overcome practical engineering problems. The teaching observation reports were not included in the assessment process it was felt that this might be a distraction from the main purpose of the exercise. In carrying out the work, the students had to identify relevant codes of practice, consider the suitability of the codes of practice for the task in hand, produce an analysis of a problem involving flat slab construction and demonstrate and their understanding to an audience comprising students and staff. The assessment strategy and evaluation of the work are considered in the next section below.

ASSESSMENT

The lecturer decided to use a combined blend of his own and peer assessment based as a vehicle for exploring whether or not learning had taken place. The lecturer used his own expertise to assess group work based on work developed by himself and the Head of Educational Development at the University of Plymouth [20]. The peer assessment was used as an integral part of the assessment process being "a useful process using students with the same background and expertise" [21]. According to Chin et al. [22]

> Peer assessment not only enhances the student's higher thinking skills and motivation to study but also requires higher level thinking and knowledge…

One interesting perspective was that the students appeared to be far tougher on their peer group than the staff.

The students indicated that as they were required to sit a test based on the content of the presentation they needed to be more demanding than they would have been had the material been delivered by the lecturer. When this issue was explored further the students felt that the lecturer as staff member of the university was more accountable and available than their peers. Consequently the students felt that they needed to form a schema of knowledge quickly and explore and expand the knowledge for themselves. In the feedback forms 75% of the students indicated that they had enjoyed the student centred learning experience and had learned something from the presentation.

However enjoying the experience is only one part of the learning encounter, the crucial outcome was to test the amount of learning that had actually occurred the students were subjected to a test which was subject to exam conditions. Although the examination process has been criticised [23], it still remains a useful tool to acquire a "snapshot" of learning in a particular window of time.

The students results showed a marked improvement over previous years and this is encouraging to the lecturer as well as the students. The students comments and the test results indicated that deep learning had taken place. Several students commented that " I don't just understand the mathematical concept but I understand why I need to know it".

EVALUATION

Although the experiment might be judged a success, the promotion of deep and practical student centred learning is an on-going process which needs to be evaluated. Rowntree [24] suugested the following checklist in carrying out evaluation which is shown in Table II below:

TABLE II
CHECKLIST (ADAPTED FROM ROWNTREE P.160)

Theorectical instruction
• Relevance of content to aims and objectives
• Adaptability of content / objectives to learners interests
• Adequacy of study time
• Suitability of methods and media
• Availabilty of personal guidance
Practical work
• Coverage of all necessary skills
• Relation of theory to practice
• Relationship of exercises to "real life" situations
Assessment
• Appropriateness
• Clarity of information
• Helpfulness of feedback
General evaluation
• Reponsiveness to learners' needs
• Learners perceptions of what he /she has gained
• Most / least satisfactory features
• Suggestions for improvements from learners

The results of the evaluation revealed that the majority of the students concluded that the student centred approach had helped their learning.

CONCLUSION

The use of the student centred learning approach appears to be have been received positively by the staff and students at the University of Plymouth. As a result of the evaluation exercise some minor changes will be made however the approach generally remains unchanged.

ACKNOWLEDGEMENT

The authors would like to sincerely thank Dr. Yaqub Rafiq for his help, co-operation and support in the preparation of this paper.

REFERENCES

[1] Jennings A. & Ferguson J. D., Integrating Communication Skills into Civil Engineering Education, *Civil Engineering*, Vol. 114 May 1996, pp 73 – 80.

[2] Institute of Directors, e-Business, Kogan Page, 2000.

[3] Ryan S., Scott B., Freeman H & Patel D., The Virtual University :The Internet and Resource Based Learning, Kogan Page Ltd. 2000.

[4] Department for Employment and Education, The Learning Age: A Renaissance for a New Britain, *The Dearing Report,* H.M.S.O. 1988.

[5] Drake P., Mathematics and all that: Who Teaches the Number Stuff? *Active Learning in Higher Education,* Vol.2. No.1 July 2001 p46.

[6] Hopkinson J. & Forrest J. The James Forrest Lecture 1894, The Relation of Mathematics to Engineering, *Minutes of the Institution of Civil Engineering Procedings* Vol. 118 Part 4, May 1894, pp 331-348.

[7] Inglis C., Mathematics in relation to Engineering, Journal of the Institution of Civil Engineers, Vol.29 No.4, February 1948, pp276 – 289.

[8] Learning and Teaching Support Network (Maths, Stats & OR), The Institute of Mathematics and its Applications, The London Mathematical Society and The Engineering Council, *Measuring the Mathematics Problem*, 2001, p1.

[9] Engineering Council, EC(UK) No.3 Section 11 (2002), http://www.engc.uk/register_news/HOC.asp .

[10] Marton F and Säljö , On Qualitative Differences in Learning, *British Journal of Educational Psychology*, Vol 46 No.1, 1976, pp 4 –11

[11] Entwistle N., Styles of Learning and Teaching; *An Integrated Outline of Educational Psychology for Students, Teachers and Lecturers* 1981

[12] Ramsden P., Beswick D. & Bowden J., Learning Processes and learning skills, *Student Learning: Research in Education and Cognitive Psychology, 1987* p19.

[13] Morgan A.R., Student Learning and Students' Experiences: Research, Theory and Practice, 1993.

[14] see .note 12.

[15] Wilcox S., Some Learning and Teaching Strategies that Promote Deep Learning, 2001, http://qsilver.queensu.ca/german/instech/lstrag.htm.

[16] Beder S., Beyond Technicalities, Expanding Engineering Thinking, Journal of Professional Issues in Engineering, Vol. 125 No 1, January 1999, pp12-18

[17] See note 15

[18] Braham J., The silence of the nerds, *Machine Design*, Vol.. 64 No.17, 1992, pp75-80.

[19] Dunn J., Like Father Like Son, *Professional Engineering*, Vol.9, No.9, 1996, pp14-15.

[20] Rafiq M.Y. & Fullerton H., Peer Assessment of Group Projects in Civil Engineering, *Assessment & Evaluation in Higher Education*, Vol. 21 No.1, March 1996, pp 69 - 82.

[21] Topping K., Peer Assessment between Students in Colleges and Universities, *Review of Educational Research*, Vol. 68, pp 249 -76.

[22] Chin C.T., Liu E.Z.F., Lin S.S.J. & Yuan S.M., A Networked Peer Assessment System Based on a Vee Heuristic, *Innovations in Education & Teaching International*, Vol.38 No.3 August 2001, pp 220-30.

[23] McMullen-Pastrick, & M. Gleason, Examinations: Accentuating the Positive, *The Teaching Professor*(1986) 1, 9.

[24] Rowntree D.Preparing Materials for Open, Distance and Flexible Learning: An Action Guide for Teachers and Trainers, (1996), p162.