Innovative Approaches to first year engineering education.

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ABSTRACT

The moment students have enrolled into an undergraduate engineering study program a number of expectations have already been placed upon them. It is often assumed that these students enter tertiary education with a wide variety of study skills and abilities. The majority of engineering educators also assume that each student has a similar learning style that is compatible to their teaching style. An extensive pilot study conducted at Monash University has indicated that these assumptions contribute to a low retention rate and instil shallow learning. It was found that the success of quality learning and teaching is very much dependent upon the manner in which life learning skills based on Maslow's Hierachy of Needs and Bloom's Taxonomy of Thinking are integrated into the course. This paper discusses these factors in detail and suggests the reasons for their incorporation into first year engineering education.

INTRODUCTION

Ultimately, the quality of student learning is influenced by the lecturers' understanding of what it means to teach (1). Currently, the concept of learning and teaching for Australian tertiary students and their educators has been gradually moving away from a transmission approach to that of constructivism. Therefore it is important to recognise that a learner will individually construct and reconstruct meaning for purposeful understanding. No longer is it satisfactory for educators to assume that learning has occurred 'en masse' simply because the content has been delivered. Unfortunately, this has been a longstanding, strong traditional culture whereby knowledge has been considered sacred and that learning has been controlled, objective and efficient (2). Generally academics are beginning to believe that effective learning must involve appropriate problem solving related activities, however, it appears that the transmission of information continues to be the most favoured teaching approach, because of a reluctance to change. Yet ironically academics expect that students will constructively process the given information.

Consequently this paper discusses the effective teaching practices employed by those engineering academics at Monash University Gippsland campus working with all first year undergraduates in a common civil engineering unit. A series of research projects have enabled the identification of transition issues and an increasing attrition rate, influenced by maligned teaching and learning practices (3).

BACKGROUND

Some academic staff from the Gippsland School of Engineering over the past three years has given priority to understanding and accommodating the individual learning practices of their first year undergraduates. Firstly, an intensive orientation program has assisted with the development of a learning profile of each student which inturn has been integrated into a quasi problem based learning approach throughout common civil engineering units. In this way students have had to further their content knowledge, but most importantly develop transferable life long learning skills such as verbal and written communication and collaborative team work. As a result, both engineering academics and students have had to consider the merits of a process driven approach rather than an emphasis on product. For the Gippsland campus educators, an approach such as this has taken sometime to develop, particularly for those who have limited pedagogical knowledge and also equate in depth content knowledge with effective teaching practices. For first year undergraduates, there was a need to reconsider how students personalise and internalise information presented in lectures, tutorials and laboratories. Previously too many assumptions had been made by both academics and students concerning the efficient processing of knowledge (4).

MAJOR ASSUMPTIONS OF LEARNING AND TEACHING

1. Held by Freshmen

- the purpose of a lecture was to simply record the content information provided
- that academics would indicate the degree of importance of content provided
- that tutorials and laboratories were scheduled to specifically revisit lecture notes
- that assignments and examinations were separate components of the course and were completed for each unit with little or no consideration of the overall aims or objectives presented in the unit outlines
- that detailed reading was the only strategy to be employed to prepare for tutorials

2. Held by Some Engineering Academics

- that freshmen were able to differentiate between main and secondary points presented in lectures and record them efficiently
- that tutorials and laboratories should be presented a non threatening interactive learning environment
- that assignments and examinations would provide a clear indication of transference of knowledge
- that all background reading would be completed before lectures and tutorials
- that first year units would provide a strong learning platform for continued studies
- that freshmen could efficiently produce clearly structured written and verbal presentations
- that freshmen were able to work collaboratively in groups of 3-5
- all students had a similar learning style
- that learning was ultimately the sole responsibility of the student

PILOT PROJECTS UNDERTAKEN TO ADDRESS THESE ASSUMPTIONS

To determine such a comprehensive list of assumptions specific to the Gippsland School of Engineering was a lengthy and intricate process involving academic staff from other faculties and adjacent secondary schools. Observations, team-teaching, formal and informal discussions and questionnaires involving both academic staff and students assisted with the process. Nevertheless it has provided invaluable information contributing towards future quality engineering learning and teaching. Fundamentally, it appears that these assumptions have identified a vacuum existing between traditional transmission tertiary teaching and learning styles and the practices expected of effective constructive independent learners. As previously mentioned there is an ongoing expectation that the performance of undergraduates will shift towards a greater student centred learning approach whilst a strong teacher centred approach still remains. Therefore, the aim of engineering education for the Gippsland School is to implement innovative approaches that will place an emphasis on independent, constructivist learning styles.

Initially, to further strengthen the teaching practices of interested engineering academics a formal on campus professional development program, 4 MAT®(4) was implemented to initiate discussions on individual learning styles. This two day workshop provided thought-provoking information and began to address the notion that one teaching practice would not suit all students. Previously, some engineering academics had sought assistance from educators outside of the faculty and insisted that they be provided with 'the formula" for effective teaching. A reasonable suggestion considering these academics had limited pedagogical knowledge. It is now understood that individuals favour a left or right hemisphere approach to learning (4) and may utilise a field dependent or field independent practice(5).

EFFECTIVE LEARNING AND TEACHING STRATEGIES

The quality of project work submitted by first year undergraduates has also been of major concern for engineering academics. It became obvious that for some students, their assignments and examinations demonstrated insufficient understanding. As well, there was an unawareness of how to transfer content knowledge across related first year units and the use of foundation knowledge during the later years of study. It appeared that first year undergraduates were typically limited to lower order thinking skills as outlined in Bloom's Taxonomy , whilst academics had expectations of high order thinking to occur(6). In order for effective learning and teaching to occur, the features of low and high order thinking, as listed below in Figure 1, need to be made more overt. Previous formal and informal discussions with students, to assess the quality of learning and teaching, have revealed an unawareness of and inability to address the higher order thinking processes. This can be attributed to students' and lecturers' preoccupation with a product driven approach. It is suggested that quality independent and group project work can only be achieved for example by modelling and discussing unit objectives as well as open ended questioning. Clearly academics need to build a holistic image of individual student's learning profiles and adjust their teaching accordingly. Undoubtedly for those engineering academics without a formal teaching qualification, appropriate professional support would beneficial to enable this to occur.

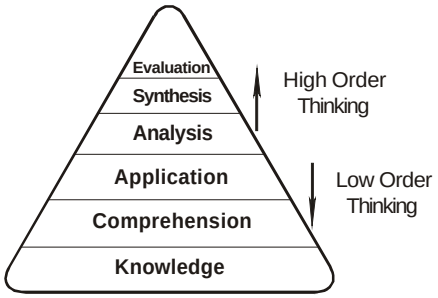

Figure 1. Components of Bloom's Taxonomy of Metacognition

It is also understood that for students to achieve personal goals, basic and more complex physiological factors need to be taken into account. The informal and formal discussions with first year undergraduates have indicated that low and high order needs such as those outlined in Maslow's Hierachy, in Figure 2 were not often met, resulting in poor quality learning and contributing to a disappointing attrition rate. Therefore at Monash University, Gippsland Campus the appointment of an empathetic first year coordinator as well as particular lecturers making a concerted effort to develop a sense of collegiality, independence and self worth have assisted to develop a cohort of undergraduates who are highly motivated with a positive self esteem. This has been achieved through regular communications with students, both independently and within classes to identify and assist with academic and personal issues. A time-consuming but worthwhile activity, that may only be possible on small campus due to strong networks involving Community Services, Language and Learning Services Unit and other student supports.

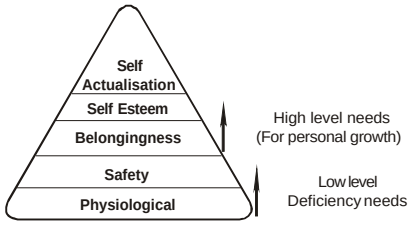

Figure 2. Maslow's Hierachy of Needs

PROBLEM BASED LEARNING APPROACH

Finally there was a need to address the quality of the first year engineering course by modifying the recently introduced Problem Based Learning (PBL) approach. Being a constructivist and student centred approach to learning, PBL in theory would address the individual needs of all learners. The main aim was to ensure that the students developed an understanding not only of the content domain but also acquired problem solving skills, self directed enquiry and critical thinking, adaptive form of reasoning that are all essential in real life engineering problems. These skills encompassed the issues raised by Bloom and Maslow. In the engineering profession, the skills of identifying problems, managing solutions or improving problem situations are considered to be important competencies.

Problem based learning environments are likely to increase students' motivation, to develop critical thinking skills, adaptability and deeper understanding of significant content. On that idea, the first level subject-civil engineering was implemented as a problem based subject where students worked in a group of 4-5 on a typical civil engineering task. The main objectives were

for students to learn, to use high level thinking about the problem and identify various types of problems encountered whilst completing the task. This would involve full engagement in civil engineering, developing communication skills and teamwork. Success being dependent upon each student's sense of responsibility, maturity and commitment.

The PBL approach was a partial success. However, after a year of implementation in practice it left many academics and students feeling confused, cheated and with a sense of loss of control over the unit's content (7). A reasonable reaction, especially for those who previously had experienced and expected a traditional transmission approach to teaching and learning. It seems that engineering students are visual oriented, prefer demonstrations, design tasks, site visits and other hands on applications to help them learn and understand better. It was also observed that the first year students learn more effectively when given a specific project. However it became increasingly obvious that a more structured approach was required to ease students and academics into a PBL approach.

MODIFIED PBL APPROACH AND INTEGRATING LANGUAGE AND LEARNING

The ill feelings were slowly over come through flexible negotiations and discussions with faculty staff and various educators from the teaching community outside of the university. Consequently, collaborative groups of five students were reduced to three as most secondary schools projects were completed in pairs. Further, engineering academics readily accepted support and advice on how to work simultaneously with a number of small groups of students. Academics also became aware that students needed to be regularly reminded of approaches to working collaboratively as well as the importance of group accountability. Specific allocations of activities contributing to the problem at hand had to occur to prevent students from focussing on sections of the project, which would be detrimental to their examinations. Integrating the support of the Language and Learning Services Unit also contributed significantly to the written and oral communication skills of these undergraduates. As a result this modified version could be seen as specific project orientated learning which utilised a combination of student centred and teacher centred learning, essential for meeting the learning needs of first year undergraduates.

CONCLUSIONS AND FUTURE DIRECTIONS

These innovative approaches have been implemented over thee past two years at Monash University Gippsland campus and have contributed significantly to the quality of student learning. Students have demonstrated significant improvements in confidence, and ability to reflect critically on information, understanding, and to work independently. The retention rate has improved considerably(nearly 90%) and academics working with subsequent year students have noted a change towards independent and collaborative learning. It is understood that each intake of students will present new teaching challenges. However with a clear understanding of learning and teaching differences and a developing support network within and outside of the university, the task of educating first year undergraduates has become a positive experience for all involved.

REFERENCES

1. Ramsden, P.(1998) Learning to lead in higher education . Routledge London p.64
2. Cranton, P.(1996) Professional Development as transformative leaning; new perspectives forteachers of adults. Jossey_Bass, SanFransisco.
3. Osborn, M. (2001) Helping academic to help themselves: Investigating appropriate professional support strategies for academics with no formal teaching qualifications. D.Ed Thesis Melbourne University,Australia.
4. McCarthy, B. (1987) The 4 Mat System: Teaching to learning styles with right/left mode techniques, EXCEL Inc.USA.
5. Entwhistle, N.J. (1991) Cognitive style and learning in K. Marjoribanks(ed) The foundations of students' Learning Pergamon, Oxford.
6. Bloom, B.S. (1956) Taxnomy of Educational Objectives Handbook 1 : Cognitive Domain, Longman, London.
7. Osborn, M., Setunge,S., Nag,D., McGowan, R. & Reid, M.(1999) " Developing Teaching Practices to incorporate Problem Based Learning" 11th Australasian Conference on Engineering Education, Adelaide, Australia 26-29 September 1999

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