Cooperative Learning in a Manufacturing Management Course

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Abstract

Cooperative Learning methods were used in a university-level manufacturing management program for students with a technical college preparation. Not only were the exam results improved, diagnostic tests indicated that the students had developed more effective learning and problem solving strategies when compared with similar students who had not learned in an interactive classroom.

Introduction

Two innovative programs, Manufacturing Engineering (MSSF) and Manufacturing Management (MBSF), designed to attract students who would normally not enter an honors curriculum in an English university, have been developed in the Department of Aeronautical, Mechanical and Manufacturing Engineering, at the University of Salford. This paper describes the use of cooperative learning as a new instructional technique in the MBSF program, as well as a longitudinal study to evaluate the effectiveness of teaching methods used in these programs. Data for the longitudinal study has been obtained through three paper instruments: one for measuring student personality type - the Myers-Briggs Type Inventory (MBTI), one for measuring divergent thinking - Hypotheses Test of Divergent Thinking (HTDT) and the third for measuring student developmental level - the Technical Students Learning Environment Preferences questionnaire (TSLEP). Over the past four years, data have been accumulated for students in the MSSF and MBSF courses, as well as conventional Salford degree programs in mechanical and electrical engineering, and postgraduate engineering students.

The University of Salford

Prior to 1968, the University of Salford was known as the Royal College of Advanced Technology, Salford, and offered the Diploma in Technology, equivalent to the BEng, awarded at universities. As with the other former CAT's, Salford has continued to admit a relatively large percentage of students who received prior education at a technical college, leading to a BTEC diploma, as compared with direct entry upon completion of the national GCE Advanced Level examinations given to most university-bound students upon completion of their secondary education. Salford now offers three-year instructional programs leading to the B.Eng. Honors degree in a wide variety of technical subjects, including mechanical, electrical, and civil engineering, physics, and chemistry. Postgraduate studies leading to the Ph.D. are available in support of an active research program.

With British universities now facing a national mandate to increase the number of students in higher education and a decline in applications for technical programs, Salford has taken the initiative to address these challenges by implementing two new innovative programs, MSSF and MBSF, to provide alternative paths to a technically oriented baccalaureate degree.

Manufacturing Engineering (MSSF) and Manufacturing Management (MBSF)

In the MBSF and MSSF programs, students first complete a two year technical program, receiving a BTEC Higher National Diploma (HND), in manufacturing engineering or manufacturing management at one of four nearby technical colleges. This is a vocational course of modular nature, in which the students obtain 18 units over the two years. Units are assessed by a combination of coursework, phase tests (tests during the term) and end of unit tests. The examinations count for approximately 40% of the assessment with the other 60% being from coursework. This is significantly different from traditional university assessment which is based primarily on end of year examinations, with coursework having a significant impact only in the final year when the students undertake a major design project.

Students can enter an HND program with one 'A' level pass (having studied two) or other suitable vocational qualifications. Thus, MBSF and MSSF courses attract students from a much wider background than is usual for a traditional three year degree. Many
are older than the conventional university student, having worked in industry in a technical capacity. Thus, they are highly motivated to complete this program which is their best chance for professional advancement.

While it is generally accepted that the HND is approximately equivalent to the first year of a traditional university three year degree, Salford academic staff found that HND students joining the second year of a three year degree tend to have marginal backgrounds in mathematics. Indeed, the main reason for introducing the MBSF program was to cater for the demand of students wanting to study manufacturing subjects with a reduced level of mathematics, as well as a request from employers for individuals with these qualifications. In order to smooth the transition for MSSF students, the collaborating colleges increased the emphasis on mathematics and mechanics over the usual HND program. To transfer into the B.Eng. program at the University of Salford, the students are required to have an average of 65% in their second year units in the HND program. The mathematics requirement for the MBSF program is much lower.

The equivalence of A Level and BTEC preparation has been the source of continuing debate for years. A 1964 study of students’ success in CATs which indicated that, while the top A Level students had the highest level of accomplishment, the students admitted with ONC preparation had a higher success level than those with marginal A level results.[1] Heywood [2] reported that students with A Level preparation were found to need additional practical preparation, while those from HNC/HND programs needed additional tutelage in the mathematical and science subjects. In 1967, Salford started providing adjustment courses for this purpose. [3]

Since all MBSF and MSSF students come to the University via the BTEC route, there are certain common strengths and weaknesses in their academic preparation, as well as their predilection toward certain educational structures. To accommodate these students and meet the educational goals set for these programs, the MBSF and MSSF curricula have a high level of practical content through laboratories and projects, and incorporate a relatively high percentage of continuous assessment marks in determining the final degree designation. In addition, Dr. John Sharp, who was the original course tutor for the MSSF program, instituted a series of seminars dealing with study methods and personal learning styles to assist students in the transition to the more independent learning methods required of the university student. These seminars, sponsored by a grant from the University’s Teaching Quality Committee (UTQC), were first provided in 1990 for the entering MSSF transfer students by Professor Heywood and Ms. Fitzgibbon, Trinity College, Dublin.

Clearly, a program designed exclusively for HND graduates raises questions concerning academic standards in comparison with a traditional engineering program in which most of the students are admitted after A Level preparation. This study is one of the efforts undertaken, under a UTQC grant, to determine whether, with proper academic support and program, students with HND preparation can achieve an academic level equivalent to traditional engineering students.

Problems with Traditional Instruction

As the MBSF and MSSF students come from a practical environment at the feeder colleges, they have difficulty coping with traditional instruction via lectures and end-of-year examinations. In particular, the MBSF program contains considerable descriptive material in the management subjects. The traditional instructional approach in this material allows superficial learning of definitions without understanding the concepts or the ability to apply them. So long as the examination questions require only definitions, the students can survive. But the students were not prepared to perform at the higher levels of intellectual functioning requiring analysis and synthesis. To move beyond surface learning to deep learning, in which the material is truly mastered, another approach to instruction was required.

Innovations through Interactive Learning

The innovative instructional method selected is known in the USA as cooperative learning and as interactive teaching in the UK. In cooperative learning, [4] the lecture is broken down into a series of segments or mini-lectures in which lots of questions are asked. The students have to develop answers, both inside and outside the class. During a typical class period, students initially develop their own solutions to problems or questions set by the instructor, with the class in silence. Next, they work with a partner and try to produce an improved joint solution. This continues throughout the class period. Students are required to sit next to a different student for each separate class period. By contrast, in the tutorial sessions, the students are allocated to base learning groups where they work together on larger problems which may span the entire semester. Because of the class interaction, it is more
difficult to get through a full syllabus, therefore the students are often set tasks such as reading additional material or working on solutions outside of class. These activities, described in detail in [4], have been found to promote improved critical thinking and therefore improved problem solving [5].

Two MBSF final year subjects, taught by Dr. Sharp, ‘Human Resource Management’ (HRM) and ‘Logistics and Strategic Planning’ (LSP) were chosen for cooperative learning. These topics accounted for four hours of class contact per week over 24 teaching weeks (over 32 weeks including the Christmas and Easter vacations). In addition, each student participated in four practical classes of three hours duration. Thus, two out of five final year subjects (not including group and individual projects) were delivered using cooperative learning methods.

This was the third year that Dr. Sharp taught the Human Resource Management (HRM) course completely on his own. In the previous two years, the HRM exam had the lowest average of all subjects on the MBSF final year exams. This year, using cooperative learning, the subject average moved from around 50% to just over 54%, equivalent to an increase of a half a letter grade, from C to B-. There was also a slight gain in the Logistics and Strategic Planning (LSP) exam result. However, since this was the first year that Dr. Sharp taught the subject, it is not possible to attribute this solely to the change in instructional method.

In contrast to examinations set by previous instructors, the questions on the HRM and LSP exams demanded that students function at the analysis level of intellectual ability. Therefore, the improved results on the HRM exam were very encouraging and can be partially, if not fully, attributable to the cooperative learning environment.

It was found that cooperative learning methods make greater demands on the instructors in that they are no longer lecturers but rather facilitators. This type of instructional method requires different skills than traditional lecturing; it is necessary to facilitate, coach, motivate and coax students into meaningful interaction in order to promote learning. This requires handing over control of the class to the students and trusting them to work outside the class as there isn’t time to get through the full syllabus in class when using such interaction. Slightly less material was covered, but at a deeper understanding level, as the exam results confirmed.

Initially, the students preferred structured lectures and resisted interactive instruction. However, after several weeks of participation they appeared to enjoy it. Indeed, towards the end of the year, the students’ experience with cooperative learning caused problems for several colleagues; they were being asked searching questions by students who were finding it hard to sit passively in a lecture and listen to the instructor for 50 minutes. In telephone interviews with some of the MBSF students, Culver found that most preferred the cooperative learning approach, felt that they learned the material in more depth, and had developed confidence in their ability to explain and defend their own ideas on a technical subject.

Running such classes can be very demanding on the instructor in terms of preparation and in maintaining the class momentum in order to promote student inquiry. However, it was all worthwhile when a weaker student was seen explaining a concept, members of a base learning group helped each other to promote learning, or a particularly stimulating and challenging inquiry came from a student.

Diagnostic Tests

At the start of the MBSF final year, the students completed a battery of psychometric measures including MBTI, HTDT and TSLEP. These tests were repeated at the end of their final year (approximately 32 weeks later). The three tests are as follows:

Myers-Briggs Type Indicator (MBTI)

The Myers-Briggs Type Indicator, MBTI, [6] measures personal style. Based on Jungian psychology, the MBTI characterizes an individual on four dimensions: Introvert-Extrovert (I/E), Sensing-Intuitive (S/N), Thinking-Feeling (T/F), and Judging-Perceptive (J/P). This corresponds to 16 possible personality types. Engineers tend to be thinking and judging, although all 16 types will be present in any large population of engineers. Studies of the MBTI show that a person’s style typically does not change as the person matures, although coping skills can be developed to permit competent performance in ways that are not natural for the individual. The MBTI was used as the basis for seminars with the MBSF students to assist them in understanding their natural learning style and in developing more effective learning strategies.

Hypothesis Test of Divergent Thinking (HTDT)
This test is based on a conception of intellectual ability found in the work of Guilford [7] and Hudson [8]. Effective thinking is regarded as having two main dimensions, the capacity to range flexibly or ‘diverge’ in the search for relevant factors in a given problem, and the capacity to focus or ‘converge’ on those factors identified as being relevant. The HTDT focuses on the ‘divergent’ aspect of problem solving. This test allows an assessment on the convergent/divergent variables.

Technical Student Learning Environment Preferences Questionnaire (TSLEP)

The TSLEP, based on Perry’s nine point scale of intellectual development, asks students to select statements reflecting their ideal learning environment. [9] Two measures are possible. In the first, the CCI (Cognitive Complexity Index) a number between 200 and 500, reflects the student groups’ average intellectual level. By comparing CCI values of a group over a period of time, it is possible to show the level of intellectual growth occurring in the group. In the second measure, the change in preferred statements for the group shows a change in learning sophistication.

Results of Diagnostic Tests

The diagnostic test results of MSSF and MBSF students obtained prior to the cooperative learning instruction proved to be very illuminating as they showed that these students have different personality profiles and learning styles from traditional “A” level entry Engineering students. They also have less confidence in their academic ability than the other students. From the MBTI tests, it was observed that the MBSF/MSSF students have higher levels of Extroversion and Feeling. The MBSF students exhibit high levels of Intuition and Perception. The TSLEP shows that the entering MBSF/MSSF students have a slightly lower position on the Perry scale than other engineering students, reflecting a preference for the instructor to control the learning environment. The HTDT shows that they tend to converge on a solution rather than explore other possibilities. It was also observed that MBSF/MSSF students used labels to describe concepts and precepts which in a University environment demand analysis.[9]

Comparing the TSLEP for students on the MSSF and MBSF courses, it was found that the MBSF students who were in the HRM and LSP courses which used cooperative learning exhibited a 30 point increase in the CCI, from 345 to 375, in the final year, while the MSSF students experienced a 12 point increase, 355 to 367. Furthermore, the MBSF students exhibited a significant increase in preference for student control of the learning process, both as individuals and in conjunction with peers. Preferred assessment methods moved towards using it for improving performance and allowing students to demonstrate their own solutions, and away from measuring how hard the students are working. Changes in the preferred learning environment were much more modest for the MSSF students.

The MBSF students also had an increase in HTDT of over 30% which supports the TSLEP results that they were prepared to evaluate a problem more thoroughly rather than just use the first viable solution.[10] This indicates that the students are operating a higher level of critical thinking and, therefore, at a higher intellectual level.

Discussion/Recommmendations

While the results from one year’s experience with cooperative learning cannot be considered conclusive, they are encouraging. They also suggest that it is possible to use the HTDT and TSLEP as diagnostic instruments to measure growth that occurs as a result of innovative instruction. The study is being continued and expanded during the current academic year.

References