GROUP PROJECT WORK AT SUB-DEGREE LEVEL

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Introduction

At a recent conference on "The Teaching of Mathematics at Third Level in Ireland" the notion of student projects was briefly discussed. The Department of Mathematics at the University of Ulster has been involved with both individual and group-based projects for a number of years and this paper attempts to summarize our experiences with students on the Higher National Diploma in Mathematics, Statistics and Computing where the regulating body, the Business and Technician Education Council (BTEC), insists on the completion of a group-based project as an integral part of the course.

Philosophy

Diplomates i.e. technicians will, at least during the initial years of employment, work as a member of a team often undertaking well defined individual tasks under a fairly rigid time-scale. The success of the team clearly depends on the motivation and effort of each individual and hence HND students must be well prepared in all aspects of group work. Since the project is the main vehicle for refinement of the various skills they have hopefully acquired during the course, it is necessary to put it into context within the overall course structure.

Structure of the Higher National Diploma

A course at Higher National level under the auspices of BTEC entails a minimum of two years full-time study. A sandwich element is encouraged and indeed the HND in Computer Studies at the Jordanstown campus incorporates a year long placement making the course of three years duration. The HND in Mathematics, Statistics and Computing with which this paper is dealing has no placement aspect and hence this course must attempt to simulate the workplace experience as closely as possible.

All BTEC courses place great emphasis on the acquisition and development of "Common Skills" [1,2] and at present the seven defined Common Skills break down into eighteen competences as given in Appendix I.

Clearly, therefore, any discussion of the project in isolation would be inappropriate and the following sections attempt to show how it becomes the natural culmination of both the academic and inter-personal skills developed during the course.

Year I

During the first year of the HND all students take a unit entitled 'Workshop'. This unit serves several purposes:

(i) It introduces the cohort to the hardware and associated operating systems they will use throughout the course. Included are terminal clusters linked to the Vax mainframe, networked 386 based DEC workstations, networked 286 based PS/2's, a NIMBUS network and various stand-alone PC's. Many students have done little or no computing prior to joining the course and it is essential that their initial anxieties at being faced with such a daunting array of new technologies are quickly allayed. During this acclimatization phase students are encouraged to learn from each other and the initial atmosphere of individual uncertainty is soon replaced by group confidence and cohesion.

(ii) It challenges the students' concepts of learning by making them responsible for the pace and depth at which they acquire knowledge. From the outset is is explained that the theme of student-centred learning is central to the whole course and that,

for approximately 25% of the entire programme, they themselves will determine their rate of progress. This is a new concept for students recently arrived from the formalized teacher/pupil relationship which exists in secondary education but, almost without exception, they relish the freedom and responsibility it brings. Computer-based tutorials with associated self-assessment tests on such topics as MS-DOS, word processing, spreadsheets and databases are worked through systematically and, while these topics are not examined explicitly, it is made clear that their usage will be assumed throughout the course.

(iii) It provides students with instruction and practice in the areas of oral communication, presentation skills and group work. The last of these is clearly crucial to the whole structure of the course and is introduced in the following manner;

(a) Each individual completes a problem-solving/decision-making exercise. This involves deciding the order of priority to be given to various actions in a difficult situation. This year the EARTHQUAKE simulation exercise [3] was used and participants must decide on their immediate and long-term actions when trapped in a building damaged in an earthquake. Groups of 4 to 6 persons are then formed and often after heated debate, a group ranking is achieved. The solutions, as provided by the experts who produced EARTHQUAKE, are then given out and individual scores are compared against the group decisions. Almost inevitably the group produces better results than the individuals who comprise it indeed this year only one student out of 26 produced a score lower than that of their group. (Note that a final score is formed as the sum of the absolute differences of the true results and the stated results. Thus the lower the score the better the correlation between the views of the experts and those of the person simulating the earthquake scenario.) This illustrates graphically the advantages of group effort, and also provides a valuable insight into the difficulties which can arise when attempting to reach a consensus decision.

(b) The students are then split into those groups with which they will work for the remainder of the term. As a preamble to

the main investigation each group was asked to produce a solution to a real-life problem. This year the problem was how to organize the Christmas party for a medium-sized shirt manufacturing company, given some personal and financial constraints. As no single solution to such a problem exists, the debate to convince other groups of the validity of a particular solution is often lively and stimulating. The point of this exercise is however not so much the solution itself but the means by which it was obtained. After the orals each group is asked to write down all situations which can prevent a group from functioning properly, with up to 10 points often being noted. Larger groups are then formed which comprise one member of each of the smaller groups. These large groups pool their comments on how groups can be disrupted thus ensuring that all possibilities are discussed. The original groups now reassemble and have, in addition to their previously agreed points, those points which they may have overlooked and have been identified by their counterparts. All groups now have a similar list of potential pitfalls.

(c) Finally each group is asked to draw up a set of rules which they themselves would adopt to ensure that any problem undertaken is tackled in a fair and structured manner. They then write down these agreed rules and sign their names to the document. This form of "learning contract" provides the framework for both the operation and ultimate assessment of the group.

At periodic intervals the group is asked to refer to its agreed rules and check whether in fact they are being followed.

(iv) The Programme of Integrative Assignments (P. I. A.) This takes up most of the time allocated to the Workshop in the second term. As the name implies the P. I. A. offers the students the opportunity to undertake one or more group-based investigations, each of which requires them to use their recently acquired knowledge from at least two of the fields of Mathematics, Statistics and Computing. Each report is word processed, bound and accompanied by an oral presentation at which all Year I students and staff of the Department are present.

In previous years two Integrative Assignments have been un-

dertaken with the groups being rearranged for the second investigation. Experience has shown however that approximately five weeks is insufficient time for the task briefing, the analysis and solution of the problem and the production of a structured report and visual aids for the oral. This year, for the first time, only one Integrative Assignment was given. The groups were given approximately eight weeks to submit their report, one week to prepare for the orals and one week for their actual delivery. This less frenzied approach has proven to be much more successful with each team now having the time to produce a more substantial solution.

The topics undertaken this year were

(a) A user guide for Statistical applications of Lotus 1-2-3.
(b) Numerical Methods via Lotus 1-2-3 and DERIVE.
(c) Production of a software package to assist with central heating installation.
(d) An investigation of random numbers.
(e) A user guide to SECMATHS and CALMAT for non-mainstream mathematics students.
(f) Student attitudes to 'The Learning Process'.

Year II

The notion of investigation is again central to the practical aspects of many of the Year II units. The unit "Mathematical Modelling via Mechanics" relies almost entirely on this form of assessment while the Numerical Methods and Statistics units also include at least one group-based piece of course work.

The Project

At the beginning of the academic year the students are informed of their groupings together with their project title and its associated supervisor. The Department has tried to effect this linkage in two quite different ways:

(i) By giving each student a list of proposed projects and asking them to be ranked in descending order of preference. As far as possible students are then assigned to their first choice project.
(ii) By forming groups on the basis of their Year I results. Each group thus contains a range of abilities and is assigned a project by the Senior Course Tutor.

The pros and cons of these approaches are self-evident namely:-

Method (i)

pro – student motivation is maximized due to their involvement in the selection of the project to be undertaken.
con – a group can consist entirely of academically quite weak students and will thus require close supervision throughout the year. The standard of such a project may well be significantly lower than that anticipated at the outset.

Method (ii)

pro – the mixture of abilities within the group means that the weaker students can learn from their more gifted peers.
con – students may be forced to undertake a project in an area in which they have little interest and hence total commitment may be somewhat lacking.

An amalgam of these two approaches seems best namely:

(a) an element of choice being given to individual students
(b) groups being organized in such a way that a balance between preferred project and academic ability is achieved.

Group size

Experience has shown that the optimum group size is four. Projects have run with as many as five students and as few as three in a group (often due to one of the original members leaving the course) but neither of these formulations is particularly suitable. Many projects have sub-tasks inherent within them and subgroups of two students tackling such tasks and reporting back to the group as a whole seems the most efficient way of addressing a given problem.

Our initially intuitive and then experiential thoughts on optimum group size have since been confirmed at conferences at which group teaching methods are discussed.

Project organization

Before commencing the project the group agree on the rules under which they will operate and sign this "learning contract". The experience gained from the Programme of Integrative Assignments in Year I is clearly invaluable in drawing up these rules and the students themselves now realize the importance of adhering to them throughout the year.

In an attempt to simulate how a similar task would be undertaken in the workplace and indeed to emphasize the importance of the project within the course some supervisors have organized their group meetings on a formal basis with each of the students in turn assuming the role of secretary or chairperson. They produce an agenda, take and then produce minutes etc. and hence monitor the progress or otherwise of the project as a whole. Meetings are normally arranged on a fortnightly basis for the first term then on a three weekly cycle as the project gets fully underway. The minutes of the meetings form an appendix of the final document.

Project titles

These have fallen mainly into four categories:

(i) Statistics — Simulation
(ii) Statistics — Data Analysis
(iii) Numerical Analysis
(iv) Package Investigation

Sample titles for each of the above are;

(i) Factors affecting the accuracy of a golf putt. Sampling frequencies to minimize economic loss. Simulation of acceptance sampling for BS6001.
(ii) Causes of muscular dystrophy using multiple linear regression analysis. The Black-Scholes method applied to traded option

forecasting. The application of AR techniques in the analysis of the relationship between stock market performance and company turnover. An analysis of customer complaints received by a software house.
(iii) Multivariate optimization with constraints using the NAG library. Development of a software package for the solution of linear simultaneous equations. Methods for unconstrained optimization. Euclid's Algorithm.
(iv) The FAMULUS package. Applications of LOGO. Computer-Assisted learning via SYMBOLATOR. LATEX user guide and applications.

Project assessment

In the early years of the project most supervisors had no experience in the assessment of group work and it was this aspect which caused most of the initial misgivings. It soon became obvious, however, that the assigning of individual marks was not a particularly difficult task due to the fact that, at the end of a twenty five week period, the supervisor was well acquainted with both the group members and their commitment to the overall project.

The formal assessment breakdown for the project is given in Appendix II.

As well as the final seminar mentioned in Appendix II, an interim presentation is given at the end of the first term. This not only informs the members of the supervisory panel of the progress made to date but also gives the students the opportunity to practice for the seminar in a real-life situation.

Self and peer assessment have not been introduced and indeed are unlikely to be included in the foreseeable future. This form of assessment is less relevant to a situation in which a member of staff has worked closely with a group and can confidently determine the respective weightings for each member of the group.

The completed project is read by both the supervisor and a second marker from within the Department. The Moderator for the HND will also examine each document to ensure comparability in standards.

Recent innovations

Many of the projects, especially those in the field of Package Investigation, are essentially practical in nature and their assessment must reflect this fact. If the objective has been to produce a user-friendly guide to a particular package then the best way to verify the success of the project is to test the guide on non-specialists and obtain their reaction. The fact that their end-product will be used in this way acts as a tremendous motivating influence on the group members who normally act as facilitators during the test session.

Examples

(i) The group working with LOGO used a subset of their final document to provide Key Stage 2 pupils from a local secondary school with a basic introduction to turtle geometry. The pupils spent a day at the University under the supervision of the group members and the event proved stimulating and rewarding for both parties. The replacement of the formal seminar presentation by such a practical session allowed the students to demonstrate both their academic and interpersonal skills in a realistic environment and give real meaning to the project as a whole.

(ii) As noted above the ultimate test of a user-guide is whether or not it enables its reader to access a particular package quickly and painlessly. These were the criteria against which the user-guide to the computer algebra package SYMBOLATOR was to be assessed and hence the formal oral presentation was replaced by a laboratory session in which engineering students were required to check their solutions to a given tutorial via SYMBOLATOR. The mathematics students acted as demonstrators and the engineering students submitted their written comments the following day. Once again the need for concise, accurate and understandable instructions, both in written and oral form, was brought home to the group all of whom found the experience very useful.

(iii) The ideas outlined above were also applied to the LATEX user-guide produced by one of this year's groups. The standard computer services documentation was somewhat less than helpful and the group was set the task of providing not

only a detailed investigation into LATEX and its applications but also a short checklist which would enable non-specialists to edit, compile, preview and print a simple LATEX program. Once again a number of "guinea-pigs" were asked to use the checklist and see whether it achieved these objectives. The students soon realized that no detail could be excluded from such a listing and it illustrated vividly the pitfalls which exist should an author be so familiar with the subject matter that the same degree of familiarity is assumed in the reader.

Summary

Group based projects have now been running at sub-degree level within the Department of Mathematics for seven years. Initial misgivings have been dispelled and they now form an integral, timetabled part of the work of the Department.

Student motivation has been, in general, excellent with most groups taking a genuine interest in their work.

The assessment process has become well established and innovative methods of assessment are being introduced whenever possible.

Appendix I

Common Skill	*Competence*
Managing and Developing Self	1. Manage own rôles and responsibilities
	2. Manage own time in achieving objectives
	3. Undertake personal and career development
	4. Transfer skills gained to new and changing situations and contexts
Working with and Relating to Others	5. Treat others' values, beliefs and opinions with respect
	6. Relate to and interact effectively with individuals and groups
	7. Work effectively as a member of a team
Communicating	8. Receive and respond to a variety of information

	9. Present information in a variety of visual forms
	10. Communicate in writing
	11. Participate in oral and non-verbal communication
Managing Tasks and Solving Problems	12. Use information sources
	13. Deal with a combination of routine and non-routine tasks
	14. Identify and solve routine and non-routine problems
Applying Numeracy	15. Apply numerical skills and techniques
Applying Technology	16. Use a range of technological equipment and systems
Applying Design and Creativity	17. Apply a range of skills and techniques to develop a variety of ideas in the creation of new/modified products, services or situations
	18. Use a range of thought processes

Appendix II: Project assessment

(a) The project must normally be submitted by the first week of the third term.

(b) The project will be assessed by
  (i) the supervisor
  (ii) another suitably qualified member of staff.
  In addition each project group will be expected to give a short seminar upon the conclusion of their project and the performance of each member will be assessed by the project supervisory panel.

(c) The project will normally be assessed in accordance with the following marks allocation;

A. Presentation and organization		30%
(i) written presentation, including layout, aim, and purpose outlined, bibliography, and index.	10%	
(ii) clarity of written project including use of English, style, spelling and punctuation etc.	10%	
(iii) oral presentation, i.e. the ability to inform non-specialists in the project area on its content.	10%	
B. Contents and Results		25%
(i) evidence that the subject has been investigated in some depth.	10%	
(ii) results, including how far the aims have been realized.	10%	
(iii) conclusions, including suggestions as to possible extensions to the project.	5%	
C. Student Understanding and Motivation		45%
(i) student initiative in obtaining and analysing relevant material.	15%	
(ii) contribution to the project as a whole.	20%	
(iii) understanding of the techniques and concepts encountered in the project.	10%	
TOTAL		100%

(d) The seminar will normally provide the mark for (iii) in part A above.

References

[1] Common Skills, Consultative Pack 1, Business and Technician Education Council, 1991.

[2] Common Skills, Consultative Pack 2, Business and Technician Education Council, 1991.

[3] EARTHQUAKE, A Team Building Simulation, Orion International Limited, 1990.

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