FRISSION CHIPS: PERCEIVED RELEVANCE AND MICROPROCESSOR SYSTEMS

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Abstract

This paper comprises part of the work of the Enhancing Teaching-Learning Environments in Undergraduate Courses project (Project web site http://www.ed.ac.uk/etl). The emphasis is on the content of a course unit, and in particular on the effect that the choice of learning aids deployed affected students' attitudes to the course unit.

Introduction

The present paper reports on a collaborative research initiative forming part of the ETL project, which is funded by the Teaching and Learning Research Programme of the Economic and Social Research Council (http://www.tlrp.org). The work has involved a researcher working closely with a lecturer over a two-year period. The project involves collecting base-line data during the first year, discussing the results of an analysis of those data, and then negotiating a collaborative initiative. The latter is based partly on the feedback from students, and partly on conceptual frameworks that are being developed in the project to describe relationships between students' approaches to studying and their attitudes to the course unit, and their experiences of the teaching and assessment on the course unit. The second year introduces the agreed changes and monitors and evaluates the effects on students' perceptions and the learning outcomes.

The course unit that has been the focus of this part of our project is a module entitled 'Microprocessor Systems'. It forms part of the first-year of a HNC in electronic engineering that follows the Edexcell syllabus. It is offered at a college of further education, and as such is unique in the ETL project. The module tutor characterises its main focus as on using microprocessors in problem-solving systems. This is also the main focus of the Edexcell syllabus, recently altered to an 'outcomes based' approach and so seems to represent the 'ways of thinking and practising' being stressed in the course (McCune and Reimann 1). During the first 'baseline' year, a cohort of ten students aged between 17-19 undertook the course unit, the majority progressing from a two-year National Diploma and studying by day release from their work, for the majority in electrical maintenance in industrial settings. In the second and current year of the project, the eleven students taking the course share those characteristics, with seven having progressed from the National Diploma.
As indicated, one concern of the ETL project is the extent to which the students' experiences of teaching and learning can influence their approaches to studying. The researcher sought to explore issues regarding teaching and learning and propose some tentative ways to address them, and the findings informed a subsequent discussion of appropriate interventions with the module tutor.

Data collection

The module tutor was interviewed in collecting the baseline data, shortly before the module commenced in autumn 2002. The focus of the interview was on the nature of the subject, what the students were intended to learn, and the learning activities undertaken to these ends. Baseline data from the students, as in the other parts of the ETL project, involved two group interviews and two questionnaires, one on general approaches and attitudes to studying (LSQ) and the other on students' experiences of the module (ETLQ). The full questionnaires are available on the ETL project website. The small size of the class had advantages and disadvantages. It meant that no meaningful inferential statistics could be performed upon the raw data obtained from the questionnaires, but it was possible to interview the whole class together, and to do so on two occasions. The responses to the baseline questionnaires could still be used, as descriptive statistics summarising the raw data gave an indication of the extent to which issues raised collectively in the interviews were accepted by students individually. In subsequent sections the patterns of response to individual items are used to complement impressions from the baseline interviews to describe students' experiences of the module.

The student cohort of the academic session 2003-04 has provided follow-up data. Eleven of them completed the LSQ shortly after the module commenced in autumn 2003, and nine participated in a group interview in late January 2004. Shortly before the end of the module in July 2004, nine students participated in a further group interview and completed the ETLQ. While data from the ETLQ is still being processed, impressions from the follow-up group interview have been included in the subsequent sections.

The baseline findings and agreed intervention

Several issues relating to the module as it stood in the baseline year of the study were identified. These should not be taken to imply that the module had serious problems; rather they formed the basis of suggestions for evidence-based enhancement of the students' learning experience to be discussed with the tutor of the course unit. The agreed collaborative initiative has been implemented in the follow-up academic session in 2003-04. The extent and nature of the initiative was constrained by what was realistic and could be implemented relatively rapidly.

The students' attitudes towards the course unit

The question of student engagement loomed large over the course unit. On the LSQ, the 'baseline' group tended to 'agree fairly strongly' that they expected to find the module interesting and to help them understand the subject better. Their responses also suggest an instrumental view; they 'agree fairly strongly' that it will look good on their curriculum vitae. However, they tend only to 'agree weakly' that it is an area that they will need to know about for their careers, and 'agree fairly strongly' that they wouldn't freely choose the module. The current cohort made similar comments during their group interview.

Regarding the intellectual structure of the subject, five concepts were identified that appear to operate at different levels of a hierarchy. The first concerns the 'ways of thinking and practising', of microprocessor systems engineers, and can be considered to be the highest level, in that it subsumes all of the other levels. The second, the role of databases in microprocessor systems, and third, the concept of programme "interrupts", operate at an intermediate level concerning how microprocessors are 'embedded' with other components in a system. They seem simultaneously to represent 'threshold concepts' (Meyer and Land 2), core learning outcomes that represent significant transformations in the learners' ways of perceiving something that are necessary for their understanding to progress, and perhaps 'troublesome knowledge' (Perkins 3), topics or concepts that students find conceptually difficult, alien or counter-intuitive. The fourth, understanding that microprocessors operate by following internally stored instructions in the form of numerical codes, operates at perhaps the narrowest level, how a microprocessor functions. Each level interacts with the others, and the tutor had recognised that managing these layers in a way that facilitates the students' learning is problematic. Responses to the baseline ETLQ corroborate this; the students tended to be 'unsure' if the module had given them a sense of what goes on 'behind the scenes' in the subject area, or that the teaching had encouraged them to rethink their understanding of some aspects of the subject.

In relation to these attitudes, a single issue was identified, the 'perceived relevance' of the module. This issue cuts across several other, interrelated, aspects. They are 'teaching and learning activities', 'ways of thinking and practising in the discipline', 'core and threshold concepts', 'set work and assessment strategies', 'learning resources and support materials', 'the influence of the academic community and validating bodies' and 'students' perceptions of the learning environment'. Two further issues, 'learner independence' and 'social relations and support' invoked the relationships between 'student engagement', student independence' and 'tutor feedback'.

Beginning with the issue of 'perceived relevance', its roots are complex. The researcher's attempts to unravel them led back to two things. Firstly the equipment deployed in the module in the baseline year and how it conditioned the students' learning activities, and the alignment between these technologies and those visible in the students' places of work. In relation to this, the question of what the baseline cohort meant by 'relevant to the real world' is worthy of closer examination; the students commented:

P2: it would be nice to have some link between this and something like. PLC [Programmable Logic Controller] *programming..*
P4: yeah, you know, like because we use that a lot, but then again, you know we don't use Z80's [microprocessor] *at all. It would be nice to use some Alan Bradley programmes perhaps, because Alan Bradley is like standard.*

P1: yeah, because its more useful to engineers…I mean yeah, you can understand the point of having it. I can see the reasoning behind choosing this as a subject, because like I say, you do need to do suchlike, but…like I say, you know, stuff like PLC programming would be a bit more useful.

These comments suggest that their judgements are to a large extent based upon the 'visible' manifestations of microprocessor systems in their professional lives, i.e. particular microprocessor technologies and programming languages that they encounter. The follow-up cohort made similar comments during their group interview.

The microprocessor system

During the baseline year of the project, the students' learning activities were based mainly around the Z80 microchip which, while obsolete, has essentially the same architecture as recent chips, and the BECCA-plus single-board computer, a simple computer with a small Liquid Crystal Display (LCD) that is in appearance rather like a pocket calculator with no outer casing. However, the user friendliness of the BECCA-plus is poor, the small size of the LCD means that it can only show one line of code at a time, and the error messages generated by the device are difficult to interpret. The students consequently expended large amounts of time and energy learning to master the equipment, arguably a 'core concept' aspect of the module. This tended both to sap their enthusiasm and confuse them as to the aims of the module. The module tutor could see things from the students' point of view by virtue of having written programmes on the BECCA-plus for use in class, himself finding the process tedious and lengthy.

The second is arguably a cultural issue. Perhaps a precipitating factor for the baseline student group was social pressure within their occupational milieu. It was clear from their responses during the group interviews that their managers and colleagues did not necessarily understand the material that the students had covered or why they had covered it, and made comments that might predispose the students to believe that basic practical skills were more relevant to their working lives.

All the blokes in my work are convinced that we do practical work, and [say] "Ooh, haven't you learnt how to weld at College" and stuff like that, because they're a bunch of idiots… They go "Do you know what this is", and we go "No", and they say "Didn't you do that at college?", and its like, "Well no, because our college course is completely theoretical, and on stuff .. that we haven't got here…

The influence of this 'community of practice' (Wenger 4) appears to have precipitated some kind of 'crisis of confidence' or 'intellectual isolation' in the baseline group. This may revolve around how the role of an engineer that was arguably built into the module - what Robinson and Bramhall (5) called the 'holistic professional engineer' - related to their occupational milieu, emphasising the practicalities of what might be termed 'engineering technologists'.

The students' perceptions had directly influenced the tutor's plans for the development of the module. In his baseline interview, the tutor acknowledged the students' calls for relevant activities, and was seeking to introduce the Programmable Interface Controller (PIC), essentially an update on the Z80 microprocessor, to address their calls for course programming activities that are relevant to engineers.

At the heart of the collaborative initiative introduced in the follow-up session has been the introduction of a PIC - based single board computer which, being programmed entirely in software and featuring better error messages, is far more user-friendly than the BECCA-plus, and features enhanced functionality. The PIC programming code is highly complex, so the students this session were not required to 'hand assemble' it, first writing abbreviations for each operation of the programme, then looking up the numeric codes for each abbreviation and re – writing the programme using those codes, as did the baseline cohort when working with the Z80 microprocessor. They could thus learn to master the equipment more quickly, without having to grapple with the somewhat tedious complexities of programming. It was anticipated that this would facilitate teaching at a more conceptual level, as we shall see. In a similar vein, teaching the programming concept of 'interrupts', which the students had previously found difficult, was facilitated by the provision of pre-written 'macro' computer code sub-routine modules that the students could incorporate into their own programmes. One of the follow-up cohort comments on the effectiveness of this approach:

I couldn't do it without the existing programmes…no way….I couldn't do it without the ones (names module tutor)'s give us….I don't think anybody could…because there's that much you need to know to set up the banks…and the…PLC and the programme

On the other hand, the follow-up cohort call for more discussion of these received macros, in terms of how they operate. They call for concrete demonstrations of what each one does, the 'why and how' of it, either through diagrammes on a whiteboard or even by physically moving objects on a table.

The module's emphasis in the follow-up session was also shifted from 'core concepts' towards the broader 'ways of thinking and practising' by using microprocessors in problem solving systems, through the introduction of a project-based approach to students' learning activities. This was anticipated to reduce the confusion that the baseline cohort appear to have felt in terms of the balance between the 'programming' and the 'systems' aspects of the module. Indeed, in the interviews with the baseline cohort, the students' comments suggested that involvement in problem solving might arouse their interest.

To these ends, more 'realistic' and 'hands on' learning activities were developed for the follow-up session. One was a 'pelican crossing' exercise, where the students develop a system that controls traffic lights in response to user input. The follow-up students commented that they appreciated this exercise in terms of how it enabled them to see the outcome of their programming and how the programme operated.

Future developments include an exercise involving inputs to electric stepper motors and a set of outputs, while there is hardware available to be driven by the PIC, including a conveyer belt system which assembles an aluminium ring over a plastic peg and checks whether the product is sound before consigning it to an 'accept' or a 'reject' hopper, and a robot arm. The Follow-up cohort also tried 'multiplexing', using the PIC to drive digital Liquid Crystal Displays, and the capacity for 'serial data communication' enabled them to try remote communication between PICs, for example, to control hardware.

Student engagement and tutor feedback

In the baseline session, it seemed that the module was largely tutor-led, albeit with some hands-on programming. The students showed uncertainty about how much choice they were allowed over which aspects of the subject they concentrate on, or how they go about learning. On the other hand, they tended to 'agree somewhat' that their views were valued. To some extent the module has to be tutor-led, to prime the students for their project work. To this end, in the follow-up session the module has provided 'concrete examples' of the use of microprocessors in everyday life, and objects such as toasters and computer hard discs were used to both illustrate the 'theoretical' and hold the students' interest.

To foster independent learning, the follow-up cohort completed a problem-solving project. Biggs (6) believes problem-based learning to be a good example of constructively aligned teaching, the aim being to develop students' ability to solve professional problems through experience of such problems. The students developed a PIC programme to drive a system that incorporated a timer or temperature control, which required them to convert analogue inputs to digital. They worked in pairs to decide, based upon the information contained in several pages of the PIC manual that cover this topic, how to set the processor up to run the system. However, the module tutor referred them to the relevant section of the manual, as it is rather long and daunting.

Assessment procedures

In the baseline year the module assessment took place entirely during the second half of the course, when the students wrote two reports on peripheral equipment, different printers and different data storage devices and took a final three-hour written exam. The earlier-discussed project-based problem-solving approach is an appropriate direction in which to shift the assessment for the current session, and the module tutor is developing projects involving 'authentic tasks' that are encountered in microprocessor systems engineering.

In the baseline session, students 'agreed somewhat' that feedback given on their work had helped them to improve their ways of learning and studying. However, they appeared to contradict this in their responses to an earlier question, tending to be 'unsure' if they were prompted to think about how well they are learning and how they might improve. And the tutor also felt at that time that the assessment process should move towards being formative as well as summative, commenting:

> *You've got no real clues as to whether, when they get to their final written exam they're going to be ok, and I would like to feel they've done enough programming that's been marked.*

In the follow-up session, there were timetabled opportunities for formative feedback, such as in-class student discussions about the learning activities, and related tutor feedback. The follow-up cohort commented that one weakness of this was a tendency for one student's problem to dominate the tutor's time, and suggest that some kind of 'whole class' approach would be more useful.

Similarly, homework was set that relates to the number systems that are fundamental to programming a microprocessor, which the students find troublesome, for example, binary and hexadecimal. This was anticipated to enable the module tutor to assess the level of skills that the students bring to the module so as to identify suitable remedial exercises. To avoid plagiarism, around 14 different worksheets were produced, each student working on a unique sheet.

Turning finally to students' attitudes and their experience in the workplace, in the follow-up session there was far greater alignment between the visible technologies deployed in the module and those in the students' workplaces. While this undoubtedly led follow-up current cohort to feel more comfortable with the module than were their predecessors, it seems that they primarily judge relevance in terms of the actual equipment that they have hands-on contact with at work. One student comments:

> *next year it will be useful, won't it, PLC's and that, but at the moment ..its pretty much nothing to do with our jobs….*

Indeed, the baseline cohort, who had brief experience with the PIC processor at the end of the module last year, are now in their second year of the HNC and presently undertaking a module dedicated to the Programmable Logic Controller (PLC) programme control computer. The PLC is strongly application-oriented, and they are exposed to realistic programming tasks. Typical feedback from them is along the lines of *"This is real"* or *"This is starting to mean something".*

It was seen earlier that the baseline cohort saw the microprocessor systems module as 'too theoretical'. Several students from the follow-up cohort express similar reservations about the relationship between what they have learned from the module and their day-to-day working lives. It is arguable that is the role of abstract theory in the working practices of the 'holistic professional' may be the main 'threshold concept' (Meyer and Land, 2) that the students have to grapple with, rather than any specific content material on the module.

Further possibilities exist for attempts to show the role of theory in practice. The college has links with a major car manufacturer, and field trips might be arranged, to enable the students to see a complex computer operated assembly process first-hand. The students in both cohorts tend to have an interest in cars, so it is anticipated that this would motivate them and so increase their engagement by demonstrating the relevance of microprocessor systems in a manufacturing context.

Discussion and conclusions

While the paper has concentrated on the ways in which the 'baseline' students experienced teaching and learning and on the nature of the collaborative initiative, it is worth reflecting on the underlying assumption in the ETL project. It was believed that it would be productive to bring together two different forms of expertise – that of an independent educational researcher and the experience and subject knowledge of the college tutor. The researcher interviewed the students in confidence, and could then reflect back to the tutor the students' comments about their experience and the tutor's perceptions of their attitudes towards the module. The module tutor had a sound grasp of the teaching and learning issues in relation to the existing module. The process of analysing the data tended to confirm, but also elaborate on, these issues rather than uncover previously unrecognised ones. However, the module tutor valued the findings as a check on his own perceptions.

Regarding the impact of the changes introduced in the follow-up session, there was a marked contrast to the baseline year. Those students had been complaining about BECCA-plus from the start. The follow-up cohort made no similar negative comments about the user-friendliness of the PIC processor-based single board computer.

The introduction of the PIC processor into the module has also had advantages for the tutor, through being able to 'network' with the wider academic community, in particular with the author of 'PIC in practice' (Smith 7), who has developed a PIC-based learning board system and associated learning activities. There are also wider possibilities from another example of the use of a PIC-based single board computer, this time in the context of distance learning, which has been discussed by Hett and Schubert (8).

Finally, it is notable that the majority of the changes made to the module in the current session were to a large extend made possible by the changeover from the Z80 and BECCA-plus to the PIC processor. This highlights how the facilities available tend to condition and constrain the possibilities open to tutors and students, in terms of teaching and learning activities.

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