Chapter 6

Conclusions

6.1 Introduction

The initial aim of the research reported in this thesis was to establish whether there was any significant educational difference between students taught in the traditional manner or by using newer methodologies, in this case the Integrated Studio Teaching approach. The basic research methodology was to, first, establish that two groups of students following the same course were equivalent, then teach each of the groups using different methodologies, whilst using the same assessment procedures. Finally, these assessments were analysed to establish whether any differences existed. If there were educationally significant differences then this was explained with reference to results from similar studies elsewhere, as well as some consideration of the possible learning style differences between the groups. The results were to be interpreted in conjunction with feedback from the students on their attitudes and responses to the studio teaching approach.

6.2 Overview of the thesis

In Chapter 1 the historical context in which studio teaching evolved was discussed. It was seen as an extension on the work carried out into co-operative and collaborative learning in the 70s and 80s, itself based upon the pioneering work of Dewey in the 1920s, Abercrombie in the 1960s and others. At the same time the influence of Piaget was also discussed. This led to the work of Papert, who with his attempts at integrating the enabling technology of computers with Piaget's theory of learning were to have a strong influence on the work reported in this thesis.

The continuing development of research into collaborative and co-operative learning in the 1970s and 1980s led to fairly well established methodologies for measuring the effectiveness of the pedagogies. Although two schools of thought emerged as to whether collaborative or co-operative learning was the better strategy, in practice most teachers probably used a mixture of both, and it is one of the assumptions of this thesis that both take place in the teaching studio, so much so that in the later parts of the thesis the two terms become fairly interchangeable.

The initial chapter then looks at the introduction of studio teaching in the USA and Hong Kong, especially at Rennselaer Polytechnic Institute, and City University of Hong Kong. Although initially a concept based upon empirical observation by a number of long-serving educators in science and engineering, this chapter is an attempt to place those concepts into the historical context, and continuing evolution of the educational theory of small group learning. Examples of the implementation of studio teaching at CityU is given, with further details of the concept.

Next, the introduction of computers into schools is discussed, more as a cautionary tale of how the introduction of technology in the classroom can lead to unintended consequences. The examples of large scale projects, like PLATO, and smaller localised ones like the LOGO experiment for teaching mathematics, show that there was, and still is, a misconception amongst many teachers as to the correct and most effective way of using computers in the classroom. The rapid acceptance and distribution of the Internet allowed a different take on the use of computers, and it is no coincidence that the concept of studio teaching really became practical at the same time, that is, in the early 1990s.

The second chapter analysed the intake measures for the students entering the two courses under study. The non-A/AS level entrants, e.g. those direct entries from vocational college, were eliminated in this analysis. It was shown that the two groups - the control group and the experimental group - were equivalent in their entrance grades, with a correlation factor of more than 0.75 for the t-test also gave a p-value of 0.78 for all subject scores, thus allowing the null hypothesis, that the groups were equivalent, to be maintained.

A questionnaire was given to both groups of students at the beginning of the semester. This contained general questions on computer ownership, usage and familiarity. It also contained 50 technical questions to assess the pre-knowledge that the students had. This was given to all students.

The results showed that ownership of computers, with CDROM and modem is now universal amongst the students in the two groups. However, some students - around 20% of the class - were not comfortable using computers, although over 90% were familiar with the Internet. A number of the qualitative questions were grouped to give a measure of IT skills - basically familiarity with the most common applications software - which showed that such skills had remained constant at around 50-60% over the period of the study. Only just over 20% regularly used a computer to do their homework, whilst around 80% felt that computers helped them learn. This percentage rose during the period of the study - but only by around 10%. Strangely, the number of students who enjoyed using computers fell during the period of the study. However, the percentage using a computer for over 10 hours/week rose from 30% to 60%.

In general, there were few of these items where there were major differences between the groups. Although no analysis was carried out on these responses, a brief study of the results, presented in graphical form, shows a similarity between their attitudes.

The third chapter described the analysis of the output measures of both the pre-test questions and all the assessments during the courses for the two groups. It was noted that the syllabus had changed considerably during the period of the study. Initially, it was based on a traditional engineering course concentrating on factual learning - formulae as well as methods of solving standard problems. This was gradually change to a more ‘systems’ based approach, where broad concepts were addressed, allowing the students time to apply this is practical situations. These changes were applied to both the ITS and non-ITS classes simultaneously, which is why an intra-cohort analysis was carried out for each year, in preference to an inter-cohort analysis. It could be concluded that this change of emphasis, which was made to all first-year courses in the MEEM department, not just the ones studied in this thesis, emphasised, and ‘rewarded’, those students who were able to practice deep-learning compared to those who took a more strategic or surface-learning approach. Whilst aware of these implications, they were not considered when analysing the assessments in this chapter. However, the data are available for the assessments in the appendices to this thesis, and it may be interesting to analyse them at a later date to see if there is any relationships to be found between the syllabus changes and the results of the various assessments looking at the different learning styles.

Effect size has been used in preference to the more common methods of statistical significance to analyse the results of the intra-cohort assessments, as the results were easier to interpret in an educational context. The effect size of the pre-test for all six cohorts was 0.16, with a p-value greater than 0.05 (0.88) for the t-test, thus validating the results from the analysis of the entrance qualifications that the two groups were equivalent. The assessments over the two semesters studied for each cohort were analysed in a number of ways. The key data was the effect size of the different assessments and the overall effect size of all the assessments over the six years, concentrating on the results for Semester A. This was shown to be 0.51. Assessments for Semester B were also considered, although more for comparison than evaluation, as the assessments in that semester were not designed to test any hypotheses. The combined effect size for the two semesters was 0.40. Consequently it was concluded that there was significant difference between the two groups in educational terms, with an effect size of 0.58 for the descriptive section of the final Semester A examination, which would indicate that there was learning at a deeper level, as defined, for example, by Entwistle (1981), for the experimental ITS-based group than for the control non-ITS group.

The chapter finished with the results of a meta-analysis performed on data from 37 studies on small-group teaching for science and engineering students in N America (not studio-based classes) which produced effect sizes of similar to that from the study reported in this thesis.

The fourth chapter presented the qualitative data from two groups of students; the first, from second year students at CityU who had taken the studio-based courses in their first year; the second from students taking a class in electronics and instrumentation at Rensselaer Polytechnic Institute. These were supplemented by data from feedback questionnaires at CityU and RPI. The chapter also included a section from a doctoral thesis in second language learning amongst engineering students at CityU, where students in the non-ITS (control) group were questioned over a whole semester concerning the teaching techniques of the author of this thesis. This gave insight into how the students reacted to some of the multimedia presentation material used in both groups. Also included were data from the Teaching Feedback Questionnaire (student rating of teachers) performed on both groups at CityU over the period of the study. This showed that, in general, students rated the teaching lower for the studio-based group than the traditional mode group, even though the overall performance of the students in the studio-based group was better and the methodology contributed to deeper learning.

Data from less comprehensive surveys carried out on the studio courses at RPI was also included for comparison with the data collected for this thesis. The results were generally similar. The seeming contradiction between the student experience and their assessment results was considered in Chapter 5.

The fifth chapter first looked at studies carried out on studio-based groups other than those at CityU and RPI. Again, although not as comprehensive as the study in this thesis they did report similar results; in every case the groups taking the studio-based courses reported deeper learning among the students, and the majority of respondents to the questionnaires felt that they had more opportunity to learn in the studio environment. However, few of the other surveys went on to discuss the problem with the small group of students who found it hard to come to terms with the studio methodology.

In trying to answer this question, the theory of learning styles was discussed. Although somewhat controversial when used for analysis of personality type, some of these ideas may help to explain why the reaction of students is so different. A lot more work needs to be carried out in this area before any definitive answer can be given, but it is one of the central observations from this work that different learning styles affect the student response to the studio - possibly with the use of concept inventories giving better understanding and analysis of the metacognitive benefits. However, it is possible to state that even though studio-based teaching is still considered experimental in some universities, at least using the methodology does no harm - one of the tenets of any experimental work into learning - and in fact allows even those who do find the learning environment not to their personal taste, they still learn at least the same as from alternative methods they might prefer. But many students excel, with the pedagogy of small group interactive teaching based around a multimedia computer-based problem/project-based curriculum giving them a chance to use a mixture of learning styles in one environment.

6.3 Answers and questions

The major question that the research was designed to answer was whether there was any significant educational difference between students taught in the traditional manner or by using newer methodologies, in this case the Integrated Studio Teaching approach. This thesis has shown that the results of the assessments do indicate that something educationally significant has taken place, with those students taught in the teaching studio performing significantly better than those taught using more traditional methods. These finding are supported by work carried out by other researchers working independently and around the same time.

However, in analysing the results a number of different questions have arisen, which cannot be easily answered from the data recorded. In some ways, it is inevitable that after analysis of results such as these it becomes clear that more comprehensive conclusions would have been reached if things had been done differently! But it is not possible to go back and carry out the whole exercise again, especially when there were unique circumstances that allowed the work to be carried out in the first place, and that cannot now be easily repeated. However, it is possible to fill in some of the gaps with newer tools, as well as setting up some new research to answer some of the questions that have been raised.

There are two major unanswered questions raised by the reported work. The first is why do students seem to perform better in studio teaching environment while not liking the methodology as much as more traditional methods? Secondly, does studio teaching really address all learning styles and reinforce deep-learning over surface-learning? The first question is the more difficult to answer, but some attempt has been made in the discussion in the previous chapter. An alternative approach to answering this question may be possible with some recent work at CityU, and this will be looked at briefly later. However, the other question, concerning the type of learning that takes place, could be answered by some newer tools that have recently become available, aimed at conceptual learning.

At the beginning of the study, in 1996, there were few tools available for measuring the conceptual understanding of engineering students when they first entered university. The 50 question multiple choice test that was developed for this research was based upon my experience as a teacher over 30 years, and the questions were chosen to cover as broad a range of concepts as would be covered in the first year electronic engineering course. The results from the pre-test presented in this thesis do seem to have given enough data to be able to establish some broad trends over time, as well as to establish the equivalence of the two groups. However, in no way could the pre-test results be used to gauge conceptual understanding in either an absolute fashion, or in relationship to students elsewhere. Maybe trying to measure the ‘increase’ in conceptual understanding over the duration of the course would prove a meaningful indicator of whether deep-learning really takes place in the studio.

Since the late 1990s there has been much work on Concept Inventories (CIs). Concept Inventories are instruments used to assess students’ conceptual understanding of a topic. They are usually constructed in a multi-choice format, with the distracters identifying common areas of student misunderstanding. The most widely used of these assessments is the Force Concept Inventory (FCI), designed to assess students’ conceptual framework of Newtonian and non-Newtonian mechanics.

The FCI was developed by David Hestenes (1992) and his collaborators at Arizona State University. This is a 30-item multiple-choice survey meant to probe student conceptual learning in Newtonian dynamics. It focuses on issues of force (though there are a few kinematics questions), and it is easily deliverable. Students typically take 15 to 30 minutes to complete it. When the class’s gain on the FCI (post-test average–pre-test average) is plotted against the class’s pre-test score, classes of similar structure lie approximately along a straight line. The maximum ‘gain’ is 100, the minimum 0, the latter indicating that nothing has been learned! (Hestenes, ibid)

The FCI has demonstrated that simple instruments can be developed to help faculty identify how well instruction has changed how students think about the concepts of the courses. Using the appropriate CI for the course subject, and in a “continuous improvement mode,” instructors can then refine their pedagogy and classroom management techniques and gauge their effectiveness by comparing gains on the CI from semester to semester. They can also gauge the effectiveness of their teaching by comparing the scores to a normed central register of scores from other universities around the world. From a CityU perspective, where most of our science and engineering courses have students of lower entry qualifications than many other universities in Hong Kong, this would be useful method of determining which courses added ‘value’. As most universities using CIs send their results to a central registry in the US, it is also possible to determine whether the courses at CityU, for example, measure up to that elsewhere. It would have been very interesting to have been able to have had a post-test for the classes reported in this thesis, so that a measure of the comparable ‘value-added’ between the two groups could have been determined. This would have complemented to effect size measurements, and, hopefully, reinforce the conclusions. Unfortunately, CIs for electronic engineering were not initiated until after the study in this thesis had started! Using the original pre-test in a post-test mode was considered initially, but rejected owing to ‘assessment overload’ on the students at the end of the semester. The online CIs are less demanding, and it is anticipated that there will be few problems in this area.

Another interpretation of the slope of the line obtained from the CI graph is that different styles of teaching and learning produce different results. The greatest ‘gain’ has been shown to come from small-group problem-based learning, the smallest from traditional lecture based courses. There would therefore seem to be some connection with the results from the analysis of the effect size data.

To investigate this further, and to see if it is possible to connect the two, a series of CIs for first year electronic engineering students at CityU is being developed by a team which I am leading. The aim of this project is to adapt or modify existing CIs, or develop new ones, so that all students taking first year courses on EE department programmes can be assessed on their improvement in conceptual understanding of the topic. This will be used as an additional measure for assessing the outcome of different learning methodologies, as well as to reinforce best practice in teaching.

The other question raised is why students do not like studio courses. The questionnaires used for the student feedback in this thesis were not designed to ascertain the students’ attitudes to the subject of the courses, just their attitude to the studio teaching methodology. This was so that this could be compared with other courses taught the same way, which is why the validity is rather suspect if the results are used for other purposes. Informal feedback from the MEEM students and staff over the past decade indicates that electronics is considered a ‘difficult’ subject for non-electronic engineering students. Maybe some of the adverse comments about studio teaching arise from a lack of confidence in studying the subject or even anxiety at the final assessment result, and that these emotions can be amplified by the strangeness of the teaching environment? There would seem to be some basis for this conclusion, even though it has been shown that studio teaching caters for all learning styles.

Recently, the introduction of a questionnaire for all first year students at CityU, as mentioned in Chapter 3, is producing detailed analysis of the learning and study strategies employed. (Weinstein et al, 1996). It provides a basis for improving student's learning and study strategies, including, a diagnostic measure to help identify areas in which students could benefit most from.

Data from the first questionnaire given to first year students in MEEM studying the current Mechatronics Degree showed a high degree of anxiety about taking the Electronic Engineering courses. The LASSI data are shown below:

Summary of Average LASSI Test Scores											
	ANX	ATT	CON	INP	MOT	SFT	SMI	STA	TMT	TST	No. of Participants
EE2917	44	16	38	50	34	48	42	50	35	31	22

Number of Students in each of the scores categories										
	ANX	ATT	CON	INP	MOT	SFT	SMI	STA	TMT	TST
0% - 25%	4	20	7	7	10	5	8	5	9	11
26% - 50%	12	4	11	6	9	8	8	6	10	8
51% - 75%	6	0	5	5	2	9	6	9	4	5
> 75%	2	0	1	6	3	2	2	4	1	0

Figure 6.1 LASSI data for 2005-6 cohort

A score of >75% indicates that there are few problems that need be addressed; a score 51 -75% indicates that some improvement may be needed; a score 26 - 50% indicates that there is a problem to be addressed; a score below 25% is serious.

This would seem to indicate that a majority of respondents - about 50% of the class - are anxious (ANX) about taking the course, with some (4 students) very anxious. Also, the attitude (ATT) to the course shows serious lack of interest. Motivation (MOT) is also very low, as are time management skills (TMT) and their use of test preparation and test taking skills. At the moment overall data is not available for the whole Mechatronics Degree Programme, so it is not possible to compare the data for the Electronic Engineering course with others that are being taken.

However, this does indicate an area for further study, and it will be interesting to attempt to relate the information from LASSI to the results of the research detailed in this thesis, especially the feedback from students. It may provide a means of interpreting the data, including the seeming contradiction between attitudes to studio teaching and the results of the assessments.

6.4 Consequences of the study

The consequences of the study reported in this thesis have been considerable, as far as developing the two studio-based courses are concerned. Many of the points made in the student feedback, as well as comments from peer review and papers published during the past few years on student learning, have been incorporated in to the latest version of the courses. One consequence of this is that both exam rates and Teaching Feedback Questionnaire (TFQ) scores have been rising, although student entrance grades and course difficulty have not changed significantly, although there is evidence, presented earlier, that understanding had fallen over the period of study.

There were two opportunities to change the structure and content of the courses under study. The first occurred in 2000, when there was a revision to the BEMTE and BEME programme. This has been commented on in some detail in previous chapters and in several published papers (Bradbeer, 2002a, 2002b).

The next opportunity for change occurred in 2002, when the need to teach electronics to the first year BEME programme, in parallel with the BEMTE courses was removed, when it was decided not to teach electronic engineering to the BEME students. This provided the opportunity to completely revise the electronics syllabus for the whole programme, as well as to introduce major modifications to the studio courses, changes which were not possible while the BEME programme had to be supported.

The feedback from the students and staff in the previous six years was analysed, and grouped into various areas of concern. These have been addressed as follows:

6.4.1 Documentation

There were a number criticisms of the course documentation, text-books and web site. These were resolved in some ways by converting the course from purely .html-based web pages to WebCT. The underlying structure of WebCT allowed a more orderly presentation of the web material. It also allowed a mixture of formats to be used for the course materials. This included simplifying and updating the powerpoint presentations where lectures were given (and also where they were not, so that they could be used as course notes). At the same time, the detailed course notes were relegated to background reading, and the synopses of the previous courses extended to give students more information. The textbooks were also updated with a wider range of recommended books. This allowed for the different learning styles of the students - some wanted detailed notes, others just brief ones; some wanted one book to refer to, some a number. There were also more references to more book chapters in the notes.

6.4.2 Tutorials

One of the main problems with studio-based courses is the integration of tutorials into the format. If there are specific time slots for tutorials - or examples sessions, as they inevitably turn out - this can interrupt the flow of the course. However, students want examples classes as they feel they are learning how to answer questions in the format that they will encounter in the examination. This proved to be one of the biggest hurdles to overcome. Student expectations, especially in the first year, are still predicated on their experiences of the learning environment at school and college - where the traditional, even rote learning, format is still widely practised, especially in Hong Kong.

One answer was to make more use of the short quizzes in the EDEC courseware, where these were available. Previously, the tutorial sessions had to be similar in content for both the studio-based and non-studio based courses, as they essentially took the same examination. With the freedom to choose, the embedded tutorials/examples in the interactive courseware came into their own. As they tend to be in the appropriate place, as well as more discussion oriented, they worked very well. However, they still needed to be supported by traditional example sessions where the online material was not available. This ‘Hobson’s Choice’ works well, as it does allow the students to relate to a more ‘normal’ classroom environment at some points during the courses. One side effect of using the embedded quizzes was the reduction in the number of formal ‘Tutorial Sheets’, from ten to five.

One of the bonuses of project-based collaborative learning is the level of discussion that goes on between both students and instructors. One consequence of this is that students have become more confident in expressing themselves in English, to the extent that some groups conduct their discussions in English and not Hong Kong Chinese (Cantonese) or mainland Chinese (Putonghua). This is especially true of the groups which have mixed Hong Kong and mainland China students.

6.4.3 Assessment

In order to give the students more feedback on their progress - another criticism of the former courses - the number of assessments was increased. Two 20 minute quick quizzes were introduced in week 5 and week 11 of the semester. Unlike many of the university courses in the US, where studio teaching is used, Hong Kong universities do not have a tradition of regular quizzes and tests. It is always a surprise when looking at the semester workplan for American courses that they sometimes have one quiz a week! The assessment regime now consists of two homeworks, two quizzes and one 35 minute, more formal, mid-semester test. This seems to be the limit acceptable to the students, and at the same time giving them enough feedback to allow their weaknesses in certain areas of understanding the courses to be addressed - both by the teacher and themselves.

One interesting aspect is that the results of the assessments for the whole class are also put on the WebCT site. This may pose some problems in publicising personal data, and may not be possible in some jurisdictions. However, the students say they appreciate it as it allows them to come to the aid of anyone falling behind. This is certainly true when applied to the groups that form during the collaborative learning parts of the course.

Finally, as the amount of practical sessions has been significantly increased (see below), along with the assessment, the weighting of the final examination has been reduced to 60%, with the possibility of that going down to 50% in the near future.

6.4.4 Problem-based projects

One of the major criticisms of the original courses was that the practical work did not seem to be fully integrated with the main part of the course. This, again, was a consequence of the need to have similarities in the courses content between the non-studio and studio-based courses. Once this restraint was gone it proved possible to create a fully integrated course that took full advantage of the studio environment. One other factor that allowed more flexibility was the reduction in the number of students taking the course. The numbers have been restricted to 36, and this includes any repeat students. In practice, the number has not gone above 30 for the past four semesters. This allows for a more intimate atmosphere, although the teaching studio is still designed for up to 60 students. On the other hand, it does mean that there is a tendency for students to monopolise one terminal each, instead of sharing, even if they are working in groups of two or three.

In the initial courses there were a number of practical based experiments, but these really just imported traditional laboratory work into the studio setting. This really did not make full use of the facilities or environment, and was not really conducive to true collaboration between students. This gave rise to a number of the criticisms voiced in the feedback in the previous chapter.

The new courses have emphasised project-based learning at the expense of lectures. And even where there are lecture segments they are now mostly based around the EDEC interactive courseware. There are three projects which take up to 60% of the scheduled class time. Each project is based around a series of objectives. These range from the investigation of the maximum power transfer theorem, through the design of a single transistor audio amplifier, investigation of various op-amp circuits to design of filters, and finally, design of a simple sequential logic circuit.

This mixture of investigation and design seems very popular. The investigations are based around standard circuits, which are provided in the notes. After being asked to carry out simple step-by-step instructions, so that the students get introduced to the problem, they are then given a series of questions to answer. They have to figure out the best way of doing this, usually by experiment and calculation.

The design problems are more straight forward. A design criteria is set out clearly after a similar introductory section where they analyse set circuits. In the design exercise they are usually given the transistor or IC type but have to work out the final circuit and component values. Usually there are frequent interruptions from the instructor to go over pints of theory, design or experimental technique in response to questions from the students. These design-based exercises are very interactive, and quite often, very noisy with everyone talking and contributing in their smaller groups.

One of the problems with first year students, especially those from school, is that they have not been taught how to make notes of their laboratory work as they proceed. Consequently, much time is taken up teaching laboratory techniques, log book and report writing skills. This does eat into the time available for the project work. Although most of the projects are designed to be a mixture of simulation and prototype board work with real components, only a few of the groups are able to complete all parts of the project in the allocated time. This is no problem if simulation is involved as they can do this in their own time, as the software is available over the student LAN. However, the circuit construction can only really be done in the studio, so they miss out on this aspect of the course. This would possibly be a major problem with electronic engineering majors, but most on are BEMTE programme do not seem too worried, although comments have been made about this in the student feedback.

6.4.5 Comments

It is clear that not all of the negative comments from students have been addressed by the new course structure. However, most of the serious ones have been. The number of negative comments on the TFQ have been reducing, and the number of positive ones increasing - although the vast majority say nothing! Comments in the class have also been positive, with a number of students

choosing the following electronics electives based on their experiences in the first year.
There is also evidence to support the improvement in 'deep learning', as discussed above, although further work needs to be carried out in this area to come to a definitive conclusion. The latest version of the course, which emphasises a more problem-based approach, along with a more systems based curriculum, and which is structured to address different learning modes, seems to have resulted in a different attitude to electronics on the programme. If it were possible to give the new LASSI questionnaire at the beginning of Semester B, and not just at the beginning of Semester A, any change in attitude, anxiety and motivation could be measured.

I have been teaching the second year electronics course for the BEMTE students recently. Form informal feedback it appears a number of the students are quite upset that they have to go back to the traditional teaching structure and environment. At the same time, a larger number of final year BEMTE students have been choosing electronics-based final year projects since the courses were restructured. And this from a course that used to 'frighten' the students since they considered it not part of their manufacturing engineering expectations. Empirical evidence from those staff teaching later courses which include an electronics component, such as control systems, also indicate that there is now a better understanding of the basic principles and concepts. Once the CI evaluations are in place, there may be qualitative data to back up these comments.

6.5 Final conclusions

The research results presented in this thesis have shown that studio teaching, broadly defined as small-group problem-based teaching using interactive technologies, has significant educational benefits over traditional methodologies. This is shown by the higher scores in assessments, especially in those directed at assessing 'deep learning' as distinct from strategic learning. However, it is clear that the different nature of studio teaching, as experienced by the students, is not entirely acceptable to those who have been taught in a more traditional mode previously. In fact, there is a considerable number of students who do not like studio teaching even though the results of their assessments are significantly better.

There is also evidence to show that studio teaching can address multiple learning styles within a single class structure, which overcomes the disconnect experienced in traditional engineering and science courses where lecture, laboratory and tutorial are taught independently.

Some of the questions raised by the work reported in this thesis - the exact extent of the conceptual learning achieved, the attitudes and motivations of the students - are being addressed by continuing research involving Concept Inventories and the Learning and Study Strategy Inventory. At the same time, CityU is moving towards having all courses and programmes at the university changing to an outcome based teaching and learning culture (OBTL). Many of the ideas discussed in this thesis are relevant to this process, especially as much of the research reported here is an analysis of the outcomes, and it proving very useful in the discussions aimed at implementing OBTL