An evaluation of the effectiveness of studio-based teaching for a first year electronic engineering degree course

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An Evaluation of the Effectiveness of Studio-based Teaching for a First Year Electronic Engineering degree course

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Summary of Thesis

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An Evaluation of the Effectiveness of Studio-based Teaching for a First Year Electronic Engineering degree course

This thesis presents the results of a six-year study conducted on two equivalent groups, one group taught in traditional mode, i.e. lecture/tutorial and laboratory; and another group taught using a studio-based methodology that integrated these three into a unitary whole.

The courses studied were two, linked, first year introductory courses in electronic engineering, taught over two semesters. They were part of the Manufacturing Engineering, and Mechatronic Engineering degree programmes at City University of Hong Kong (CityU).

The first part of the thesis attempts to place the evolution of studio-based teaching into two major streams of educational development over the past century - the move towards collaborative and co-operative learning in small groups, and the integration of computing and the internet as enabling technologies in learning.

Next, the equivalence of the control group (non-studio-based) and experimental group (studio-based) is established. Then, an analysis of the assessments is carried out, which demonstrates that the experimental group not only achieved higher grades, but also achieved deeper learning.

A qualitative analysis of responses from the groups at City University is then discussed, complemented by a similar analysis of students studying on a studio-based electronics course at Rensselaer Polytechnic Institute (RPI), Troy, New York, USA. Responses from other studies of students on studio-based courses at RPI and CityU are also included for comparison.

The next section considers similar, but not so comprehensive, studies of studio-based teaching at institutions other than CityU and RPI. Then, learning style theory is considered as one way of attempting to explain why some students dislike the studio-based classes while continuing to get better results. It is concluded that although learning-styles may be helpful in explaining some of the contradictions in the results, further work is needed before any firm conclusions in this area can be reached.

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Chapter 1

The theory and practice behind studio teaching

"Tell me and I'll listen. Show me and I'll understand. Involve me and I'll learn"
Teton Lakota Native American saying

1.1 Introduction

Cognitive researchers, from Piaget onwards, have shown that real learning and understanding are better accomplished through cooperative and interactive techniques. Recent developments in these theories of learning emphasise the importance of communications and collaboration, both between teacher and students and students themselves. Coincident with some of the latest developments in the theory and practice of cooperative and interactive learning has been the development of computer technology, especially the rapid acceptance and use of the World Wide Web/Internet, coupled with the widespread adoption of computers in education at all levels.

The synthesis of these two developments has given rise over the past decade or so to completely new paradigms of teaching, usually starting with science and technology, and then gradually migrating into other academic disciplines. This introductory section seeks to consider some of the more significant of these efforts, and then show how it has been applied to engineering and applied science courses at university level. As this is an attempt to put the development of the studio teaching paradigm into the historical context of educational developments up to the mid 1990s, a discussion of more recent developments is left until a later chapter. The chapter is then concluded with a series of questions raised by these developments, and also an outline of the research methodology used to try and answer them.

As is inevitable in such cases, there will be many interesting ideas discussed at a very superficial level. This is just to try and set the background of the work being reported; it is just not possible in the space allowed to explore all the fascinating byways of educational theory and practice!

1.2 Historical background

The development of small group interactive learning pedagogies over the past 30 to 40 years differs on each side of the Atlantic. Around 100 years ago, John Dewey in the USA, began arguing for the kind of change that would move schools away from authoritarian classrooms with abstract notions to environments in which learning is achieved through experimentation, practice and exposure to the real world. In the 1920s he was promoting cooperative learning as part of his project method of instruction (Dewey, 1924). Also, at this time, Piaget started producing his seminal works on how knowledge develops in children. Although "Dewey in the USA, Montessori in Italy and Freire in Brazil fought harder for immediate change in schools, Piaget's influence on modern education is deeper and more persuasive" (Papert, 1999). The work of Piaget is central to understanding how small group interactive learning takes place, and will be considered in detail below.

The ideas put forward by Jane Abercrombie (1960) in the 1960s in the UK had an almost immediate impact on the primary and tertiary education sectors there. However, in the US it was the rapid changes and expansion of tertiary education that caused a rethinking of traditional methods of teaching.

The term collaborative learning was coined, and the basic idea first developed, in the 1950's and 1960's by a group of British secondary school teachers and by a biologist studying British postgraduate education-specifically, medical education. Two of the early researchers were Mason (1970), and James (1968). Mason and James were colleagues at Goldsmith's College, University of London, and were committed during the Vietnam era to democratising education and to eliminating from education what were perceived by them as socially destructive authoritarian social forms. Collaborative learning, as they thought of it emerged, from this largely political, topical effort.

Many of these themes had already been explored and their educational value affirmed by the earlier findings of Abercrombie. Her *Anatomy of Judgement: an investigation into the process of perception and reasoning* (1960) culminated ten years of research on the selection and training of medical students at University College, University of London. This research suggested that the art of medical judgement, diagnosis and other key elements of medical practice, were better learned in small groups of students arriving at a diagnosis collaboratively than by students working individually.

She began her study by observing groups of medical students with a teaching doctor gathered round a ward bed to diagnose a patient. She then made some small, but significant changes, by asking the students to make a group diagnosis instead of each one making an individual diagnosis in turn. She asked the students to discuss the case as a group and them come to a consensus, a single diagnosis they could all agree on. What she found was that students learning this way acquired good medical judgement faster than individuals working alone. (ibid., p19)

In 1964 the Hale Committee on University Teaching Methods (University Grants Committee (UGC), 1964) reported that discussion in small groups was to be preferred to large, impersonal lectures. They advocated a more student-centred approach to teaching, and this stimulated much discussion about university teaching. A few years later, The National Union of Students, *Report of the Commission on Teaching in Higher Education* (1969) indicated a distinct preference for small-group teaching.[1] The report showed that, at the top of a list of functions, over 50% of student respondents agreed that the function of group teaching was "to encourage learning and to facilitate the exchange of ideas', as compared to the (lowest placed) 17% who agreed that it was "to train students to work independently" (ibid., Table XV). Abercrombie delves deeper into the

[1] I was involved with this commission, as both an undergraduate and postgraduate student at the University of Surrey. The Students' Union set up an Education Committee, of which I was a member, to provide feedback on discussion papers sent by the NUS to each university. This resulted in a comprehensive report which was presented both to the NUS and the University Senate. This resulted in the establishment of a University Education Committee, with me as a student member. Some innovative ideas were implemented by many departments as a result of this committee, and one outcome was the foundation of the Institute for Educational Technology headed by Prof. Lewis Elton. This pioneered many applications of technology in aiding learning (and provided the initial stimulus for the work I have done in this area over the past 30 years) and has since evolved into the Department of Educational Studies.

implications of these, and other, reports in *Aims and Techniques of Group Teaching*, (SRHE, 1970).

On the other hand, in the United States, a different motivation for investigating new pedagogies arose. According to Brufee (1992, p24):

> "For American college teachers, the roots of collaborative learning lie neither in radical politics nor in research. They lie in the nearly desperate response of harried colleges during the early 1970's to a pressing educational need. A decade ago, faculty and administrators in institutions throughout the country became aware that, increasingly, students entering college had difficulty doing as well in academic studies as their native ability suggested they should be able to do. Of course, some of these students were poorly prepared academically. Many more of them, however, had on paper excellent secondary preparation. The common denominator among both the poorly prepared and the seemingly well prepared was that, for cultural reasons we may not yet fully understand, all these students seemed to have difficulty adapting to the traditional or "normal" conventions of the college classroom."

Symptomatic of the difficulties these students had adapting to college life and work was that many refused help when it was offered. The help offered was mostly tutoring and counselling programmes staffed by graduate students and other professionals. These failed because undergraduates refused to use them. Solutions to this problem included mandated programmes that forced students to accept help they evidently did not want through to sink-or-swim programmes that assumed that students who needed help didn't belong in college if they didn't seek it.

Some college faculty members argued that students were refusing help because the kind of help provided seemed merely an extension of the work, the expectations, and above all the social structure of traditional classroom learning. The social organisation of learning was fashionable in the late 1960s, and the writing at that time, about changes in primary and secondary education, seemed to suggest that it was traditional classroom learning that possibly left these students unprepared in the first place (See Brufee, ibid., p24). They needed help that was not an extension of but an alternative to traditional classroom teaching. Some colleges tried peer tutoring, where teachers could reach students by organising them to teach each other.

Peer tutoring was just one way of doing that. Collectively, peer tutoring and similar modes such as peer criticism and classroom group work were classified as collaborative learning, as defined by the British researchers led by Abercrombie. In practice, the term meant a form of indirect teaching in which the teacher sets the problem and organises students to work it out collaboratively. The term encompassed a range of methodologies, for example, students learn to describe the organisational structure of a peer's paper, paraphrase it, and comment both on what seems well done and what the author might do to improve the work. The teacher then evaluates both the essay and the critical response. In another type of collaborative learning students in small groups work toward a consensus in response to a task set by the teacher.

Whereas as the work of Brufee, and even Abercrombie, uses small group methods, it does not usually involve a teacher being present. The students work everything out themselves with little guidance as they go along. Cooperative learning, on the other hand, involves not only interaction within the group, but also within a more formal learning environment, usually with the teacher being present. This has led to something of a split in the ranks of the small group interactive learning proponents.

According to Mills and Cottell (1998, 6)

> "Bruffee (1995), sees cooperative learning, because it was developed at the pre-collegiate level, as a more "repressive" form of pedagogy with teacher-developed goals and assessments, constant supervision, and the discouragement of dissent. Collaborative learning, he feels, is more adult-centred because it assumes student responsibility for governance and evaluation and encourages disagreement. Bruffee's position fails to recognise the major concerns of virtually all faculty committed to group work: time and content coverage. In an ideal learning environment, students would be free to explore topics as a "shared conversation," reach their own conclusions, and clarify, and sometimes resolve, any academic or interpersonal disagreements".

Unfortunately, the typical classroom is still bounded by the traditional constraints of the timetable and the pressure of working within disciplines especially at the tertiary level. The curriculum also has to introduce students to important concepts and core knowledge. Furthermore, "in classrooms filled with diverse learners at all levels of academic preparation and social enculturation, there are compelling reasons why faculty and students should deliberately create an environment where learning can be both efficient and effective" (ibid., p6). Advocates of pure collaborative learning also neglect to consider that in practice other aspects must be taken into account. These include instructional activity; the instructor's role; the students' roles; the introduction of group dynamics and group formation; rules for instruction; and assessment/evaluation. Faculty may also vary their approaches within an activity.

In practice, most teachers using small group interactive teaching use a mixture of both approaches. For example "during a peer-editing session, the students' roles within deliberately teacher-formed teams might be carefully and fully designated by the instructor (a cooperative approach) who then leaves the room (a collaborative approach)", (ibid. p7)

Most faculty find that students, even adults, welcome the structure provided by a cooperative approach. In fact, most find that the structured nature of cooperative learning results in both efficiency and accountability in the classroom. According to Mills and Cottell (ibid. p7), "Cooper (1990) regards the key to successful cooperative learning as "Structure! Structure! Structure!" (p.1). The end goal should be a smoothly operating classroom, but not one that runs with clockwork-like precision".

The argument that cooperative learning only applies to school-based classes - as much of the research in the last decades has been conducted at these levels - understates its benefits, according to Natasi and Clements (1991); they seem to be universal: "Cognitive-academic and social-emotional benefits have been reported for students from early elementary through college level, from diverse ethnic and cultural backgrounds, and having a wide range of ability levels. Furthermore, cooperative learning has been used effectively across a wide range of content areas, including mathematics, reading, language arts, social studies, and science" (p. 111)

Integrated studio teaching, the pedagogy described and evaluated in this thesis, is a perfect example of cooperative learning at tertiary education level.

1.3 Piaget

It is probably true to say that the ideas formulated by Piaget in the first half of the 20th century have had a most profound impact on current educational concepts. Virtually all students of education in the past 50 years have had to study his work, and have come to know, if not understand, his four major concepts. Most educational reforms over this period of time have also paid lip-service to his ideas. However, it is only over the past twenty years or so that Piagetian concepts have moved from the schoolroom into college and universities.

This is especially true of his concept of formal operations. Piaget studied early adolescents. At this age, many can deal with hypothetical situations and their thought processes are not tied down exclusively to what is immediate and real. According to Beard (1969), "At the beginning of adolescence social life enters a new phase of increasing collaboration which involves exchange of view-points and discussion of their merits before joint control of the group is possible". (p97)

As Beard continues, "This obviously has the effect of leading children to a greater mutual understanding and gives them the habit of constantly placing themselves at points of view which they did not previously hold. Consequently, they progress to making use of assumptions". Beard then goes on to pose the question "Could this development of formal operations occur without co-operation and discussion? Evidently Piaget believes that it would not".

Although college and university students are generally in their late teens or early twenties, even at university level the quality of students' thinking in their own subjects may still only partly attain the level of formal operations, despite Piaget's finding that thinking at this level is normally more fully achieved at sixteen years.[2] According to Beard (1969);

> "Observations and experiments by Abercrombie (1960), with first-year university students in London showed that although they were well-grounded in the facts of biology, physics and chemistry they were often unable to use their information to solve slightly unfamiliar problems or to defend a view in argument, and they tended to observe what the textbook said should be there rather than what was actually on a slide or X-ray" (p117).

Piaget (1926) held that "social-arbitrary knowledge – language, values, rules, morality, and symbol systems (such as reading and maths) – can be learned only in interactions with others" (Slavin, 1996, p29). According to Slavin, "many Piagetians .... have called for an increased use of cooperative activities in schools. They argue that interaction among students on learning tasks

[2] There is some evidence to show that this does in fact occur, with reference to more fully achieved, at 16 and older. For example, Shayer and Adey (1981).

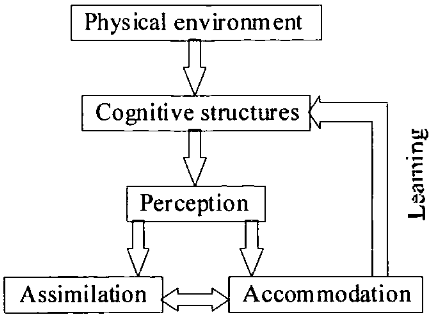

Figure 1.1 Diagramatical representation of the Piaget's theory of equilibration (from Hergenhahn and Olson, 1993, p 280)

will lead in itself to improved student achievement. Students will learn from one another because in their discussions of the content, cognitive conflicts will arise, inadequate reasoning will be exposed, and higher-quality understandings will emerge" (ibid., p29).

Piaget introduced the concepts of assimilation and accommodation, two functional invariants that occur at all levels of intellectual development. Assimilation refers to a kind of matching between the cognitive structures and the environment. As the cognitive structure changes it becomes possible for the child to assimilate different aspects of the physical environment. Accommodation, on the other hand, is the process by which the cognitive structure is modified. According to Hergenhahn and Olson (1993, p279), "It should be clear, however, that early experiences tend to involve more accommodation than later experiences because more and more of what is experienced will correspond to existing cognitive structures, making substantial accommodation less necessary as the individual matures".

Piaget assumed that all organisms have an innate tendency to create a harmonious relationship between themselves and their environment. He defined the concept of equilibration as the continuous drive toward equilibrium or balance. The dual mechanisms of assimilation and accommodation, along with the driving force of equilibrium, provide for slow but steady intellectual growth. Hergenhan and Olson (ibid., p280) construct a diagram, Fig. 1.1, to explain the interaction between these mechanisms. This bears a close relationship to the concepts behind the integrated teaching studio.

Many researchers following Piaget believe that, in many ways, learners construct their own knowledge. If one accepts this, then Meyers, (1986, p. 13) for example, finds that Piaget's concept of mental structures is particularly helpful in thinking about education. Piaget maintains that "children do not receive knowledge passively but rather discover and construct knowledge through activities. As children interact with their psychological and physical environments, they begin to form ...... structures of thought. These structures help to organise the child's experience and direct future interactions" (Piaget, 1976, p. 119)

Meyers and Jones (1993, p 20), commenting about Piaget's concepts in their book, *Promoting active learning : strategies for the college classroom*, state that while "we are not committed to the specific forms of intellectual development Piaget defined, we do agree with him about a basic principle of education: students, no matter what their age, need opportunities to engage in activities – with teachers, fellow students, and materials – that help them create their own mental structures and test them, thus making better sense of the world around them".

In this regard, they identify four key elements associated with active learning that are used to create new mental structures: talking and listening, reading, writing, and reflecting. These elements involve cognitive activities that allow students to clarify, question, consolidate, and appropriate new knowledge. "Each teaching strategy discussed (in this book) incorporates one or more of the key elements, or activities, as building blocks for constructing new knowledge. Nevertheless, we would be the first to admit that nothing is gained by simply having students talk, listen, write, read, or reflect-unless those activities are well structured and guided by teachers. There are sound pedagogical reasons for adopting active-learning strategies, and we are more likely to encourage students in those activities if we better understand how they work and how we can use them effectively" (ibid., p21).

In many ways, it can be seen that the work of Piaget is central to any discussion of small group interactive learning. Coupled with developments of his work in the use of computing as an interactive learning tool, as developed by Papert, for example, Piaget's concepts form one of the theoretical basis of integrated studio teaching.

1.4 Papert

Seymour Papert was an American mathematician who spent the early sixties at Piaget's Centre for Genetic Epistemology. He then went to MIT, where he was one of the founders of the Artificial Intelligence Laboratory. In 1980 he published the seminal book "*Mindstorms; children, computers and powerful ideas*" (Papert, 1980). In this book he details the development of the LOGO computer language as well as the concepts of turtles, dynaturtles and microworlds. Papert's work became the basis for much of the following two decades' development of educational computing. This was based upon two premises. First, that it is possible to design computers so that learning to communicate with them can be a natural process, and that children can learn to use computers in a masterful way, and secondly, learning to communicate with a computer may change the way other learning takes place. In this book, Papert also propounded a computer on the desk of every child. His book "sent shockwaves throughout the education and psychological communities, both of which accused him of pushing an educational pill that would induce psychosis in our children" (Schwartz, 1999).

He also took the cultural interpretations of Piaget, where learning amongst urban children in Europe or the USA and those in African tribal cultures are considered to be different, although both valid, and changed them to look at the difference between pre-computer cultures (whether urban Western or African tribal) and the "computer cultures" that may (and have) develop over

[3] In 1984 I set up a company in UK to design and manufacture educational robots. The first model we designed was a LOGO turtle based upon Papert's ideas. Over 200 of these were sold worldwide. The company developed many extensions and sub-routines based around the LOGO language, in consultation with teachers using LOGO in their classroom, which enabled students to enhance many of Papert's original ideas. Many discussions were held over a number of years with Papert himself, as well as with my fellow members of the British LOGO Users' Group, which has evolved into the EuroLOGO series of meetings and conferences. Papert's ideas were also instrumental in me setting up a programme for teachers as part of a community access computer project at the then Polytechnic of North London. This led to the publication of the journal "Educational Computing", which I edited for a number of years.

the decades following publication in 1980. As *Mindstorms* was published before the world wide web was invented, many of Papert's observations have proved prescient especially in the area of person-to-person communications.

The LOGO environment, "instead of the computer programming the child, the relationship is reversed: the child, even at pre-school ages, is in control: the child programs the computer" (ibid., p 19). The turtle is a computer-controlled cybernetic animal existing in the "cognitive minicultures of the LOGO environment". It serves no purpose other than to be good to program and good to think with. Some turtles exist solely on the computer screen; others have a physical manifestation that can move about the floor or desk, and may have a pen and lights or sound [3]. The idea of programming is introduced by the metaphor of teaching the turtle a new word. Very powerful learning takes place. Children working within a LOGO environment are "learning a language for talking about shapes and fluxes of shapes, about velocities and rates of change, about processes and procedures" (ibid., p 13).

What Papert, and those who applied his ideas, developed was a completely new way of using the computer in the classroom, one that eventually found its way into the integrated teaching studio. As they discovered, "the computer is not a culture unto itself but it can serve to advance very different cultural and philosophical outlooks. ....Of course, the turtle can help in the teaching of traditional curriculum, but I have thought of it as a vehicle for Piagetian learning, which to me is learning without curriculum" (Papert, 1980, p31).

In relating this to his experience with Piaget, Papert goes on to say:

> "There are those who think about creating a "Piagetian curriculum" or "Piagetian teaching methods". But to my mind these phrases and the activities they represent are contradictions in terms. I see Piaget as the theorist of learning without curriculum and the theorist of the kind of learning that happens without deliberate teaching. To turn him into the theorist of a new curriculum is to stand him on his head.
>
> But "teaching without curriculum" does not mean spontaneous free-form classrooms or simply :leaving the child alone". It means supporting children as they build their own intellectual structures with materials drawn from the surrounding culture. In this model, educational intervention means changing the culture, planting new constructive elements in it, and eliminating noxious ones. This is a more ambitious undertaking than introducing a curriculum change, but one which is feasible under conditions now emerging" (ibid., p32)

Papert goes on to enunciate three concepts of what he calls "approbriable mathematics". (Although his work was primarily concerned with learning mathematics, it applies to many other subjects, especially science and engineering, two disciplines traditionally with a mathematical basis). First there is the principle of continuity; the mathematics must be continuous with well-established personal knowledge from which it can inherit a sense of warmth and value as well as "cognitive" competence. Secondly, is the power principle; it must empower the learner to perform personally meaningful projects that could not be done without it. Finally, there is the principle of cultural resonance; the topic must make sense in terms of a larger social context. Although these three principles were originally applied to turtle geometry within a LOGO environment they equally apply to all learning which is computer-based.

Another concept which Papert introduced related to Bruner's influential classification of way of knowing (Bruner, 1966a, 1966b). In this classification some knowledge is represented as action, some as image, and only the third category as symbols. According to Papert "Bruner has asserted that "words and diagrams" are "impotent" to represent certain kinds of knowledge which are only representable as action. ...My perspective is more flexible because it rejects the idea of the dichotomy (between) verbalisable and nonverbalisable. No knowledge is entirely reducible to words, and no knowledge is entirely ineffable" (Papert, 1980, p96)[4].

In developing an integration between computers and Piagetian concepts of learning, Papert essentially developed a new paradigm of learning, one which became more and more influential as the computer became more ubiquitous in classrooms, educational institutions and homes. As he says "Out of the crucible of computational concepts and metaphors, of predicted widespread computer power and of actual experiments with children, the idea of Piagetian learning has emerged as an important organising principle. Translated into practical terms this idea sets a research agenda concerned with creating conditions for children to explore "naturally" domains of knowledge that have previously required didactic teaching; that is, arranging for the children to be in contact with the "material" – physical or abstract – they can use Piagetian learning" (ibid., p187).

Unfortunately, although Papert suggests that this type of discourse is welcome in schools of education and in science departments, "funding agencies as well as universities do not offer a place for any research too deeply involved with the ideas of science for it to fall under the heading of education, and too deeply engaged in an educational perspective for it to fall under the heading of science. It seems to be nobody's business to think in a fundamental way about science in relation to the way people think and learn it"(ibid., p 188)[5].

To summarise Papert's thinking; he saw the popular idea (at the time) of designing a "Piagetian curriculum" as "standing Piaget on his head. Piaget is par excellence the theorist of learning without a curriculum" (ibid., p 216). As a consequence he formulated two ideas; a) significant change in patterns of intellectual development will come about through cultural change, and b) the most likely bearer of potentially relevant cultural change in the near future is the increasingly pervasive computer presence" (ibid., p 216).

In the twenty years or so that *Mindstorms* was published Papert, and his colleagues, have continued to work on the development of LOGO. However, his original ideas have inspired a whole range of projects which do not in themselves involve simply writing LOGO programs to produce geometric

[4] It is interesting to note that much engineering education is based on this dichotomy, which Papert's work tries to undermine!

[5] Many of us involved in science and engineering education would not necessarily agree with this point of view. But then Papert always aims to be nothing if not controversial in these type of statements!

figures. One of these was the development of a new use of programming by interfacing LEGO constructs to the computer. (Resnick et al, 1988). LEGO constructs are interactive, physical objects built with LEGO plastic blocks, gears, pulleys, etc., which are then controlled by a LOGO program on the computer.

> "Giving children the opportunity to program behaviours into vehicles, robots, dinosaurs and other constructs of their own design opened a new horizon onto the possibility of engagement: many children who were mildly interested in the graphics programming showed high degrees of enthusiasm in this new sphere. At the same time many kinds of program structure that were not spontaneously picked up in the old context now seemed obvious to the children. The conclusion to be drawn was not that LEGO constructs were better objects for programming than graphics. But that variety offered more chances for more children to relate to more concepts" (Papert, 1997).

Harel (1991) and Kafai (1995) developed the concept of developing real products with LOGO, with children working for an hour a day over most of the school year instead of for a few hours at a time on isolated projects. The first round had students producing a piece of educational software, the second a complete video game with all the supporting materials. In the past twenty years the LOGO environment has become an important, but not determining, part of computer learning culture. The LOGO environment was one of the first stages of a continuing evolution.

In 1996 Papert published *The Connected Family* (Papert, 1996) where he developed the idea that the computers that will be the pivotal force for change will be those outside the control of schools and outside schools' tendency to force new ideas into old ways. One of the basic assumptions behind integrated studio teaching, for example, is that students are computer and internet aware and competent. Whether this assumption is correct will be considered in later chapters of this thesis.

Finally, Papert writes:

> "It is 100 years since John Dewey began arguing for the kind of change that would move schools away from authoritarian classrooms with abstract notions to environments in which learning is achieved through experimentation, practice and exposure to the real world. I, for one, believe the computer makes Dewey's vision far more accessible epistemologically. It also makes it politically more likely to happen, for where Dewey had nothing but philosophical arguments, the present day movement for change has an army of agents. The ultimate pressure for the change will be child power" (Papert, 1996).

1.5 Small group interactive learning

Although most of Papert and Piaget's writings are concerned with school-based children, many of their ideas have application to adults, and especially those in the early years of tertiary education. As cited above, Abercrombie recognised in the 1960s that many young adults are still at the stage of formal operations, at least in some areas of their learning process. Abercrombie also recognised that the group system of teaching focuses attention on the interaction between all participants, students and teachers, not on the polarised interaction of a student with a teacher.

Since the early 1960s many researchers have followed in Abercrombie's footsteps, and there is a burgeoning literature on the subject. As Abercrombie noted, "man is essentially a social animal and that he has to undergo an exceptionally long period of development" (1970, p6). Slavin (1996) notes that, based on Piaget's theory of *conservation,* i.e. the ability to recognise that certain characteristics of objects remain the same when others change, there is a great deal of support for the idea that peer interaction can help nonconservers become conservers. Although this was directed at children aged between the ages of five and seven the principal can be extended to older students.

As Mills and Cottell (1998, p170) point out, the power of groups is well documented, but groups "functioning well only under structured conditions where there is a clear, compelling task and where...... the team performance requires both individual accountability and mutual accountability". In this scenario "the members hold themselves accountable for their individual contributions to the team, their collective contributions to the team, and the team's overall result" (Katzenbach and Smith, 1993, p277). Within a computerised environment, the challenge, as Salomon (1995) points out, is to create electronically genuine interdependence:

> "For genuine collaboration to take place, you need genuine interdependence. In its absence, teams do not function the way they ought to, regardless of how wonderful the computer tools they are given to work with are. In other words, computers can support collaboration provided it entails interdependence, but the computer is not likely to produce this interdependence all on its own" (ibid., p3).

Meyers and Jones (1993, p 20) believe that, in many ways, learners construct their own knowledge. In this context, they find Piaget's concept of mental structures particularly helpful in their thinking about education (Piaget, 1976, p119). Here,

> "Piaget maintains that "children do not receive knowledge passively but rather discover and construct knowledge through activities. As children interact with their psychological and physical environments, they begin to form ...structures of thought. These structures help to organise the child's experience and direct future interactions"" (Meyers, 1986, p13).

Although Meyer and Jones (ibid.) are not committed to the specific forms of intellectual development Piaget defined, they do agree with him about a basic principle of education: students, no matter what their age, need opportunities to engage in activities – with teachers, fellow students, and materials – that help them create their own mental structures and test them, this making better sense of the world around them.

In this regard, they identify four key elements associated with active learning that we all use to create new mental structures: talking and listening, reading, writing, and reflecting. These elements involve cognitive activities that allow students to clarify, question, consolidate, and appropriate new knowledge.

The concept of 'structured and guided cooperative learning' is fundamental to the understanding of studio teaching, along with the use of some sort of 'incentive', usually based upon group assessment rewards for innovative work. Slavin has attempted to define effective instruction in a more general context, based on the work of John Carroll (1963, 1989), which focuses on the alterable elements of Carroll's model, those which teachers and schools can directly change (see Slavin 1984; 1987; 1994). The components of this model are as follows:

> "1. Quality of Instruction. The degree to which information or skills are presented so that students can easily learn them. Quality of instruction is largely a product of the quality of the curriculum and of the lesson presentation itself.
>
> 2. Appropriate Levels of Instruction: The degree to which the teacher makes sure that students are ready to learn a new lesson (that is, they have the necessary skills and knowledge to learn it) but have not already learned the lesson. In other words, the level of instruction is appropriate when a lesson is nether too difficult nor too easy for students.
>
> 3. Incentive: The degree to which the teacher makes sure that students are motivated to work on instructional tasks and to learn the material being presented.
>
> 4. Time: The degree to which students are given enough time to learn the material being taught". (Slavin, 1996, p5)

Slavin (ibid., p9) also shows that forms of cooperative learning that have consistently increased student achievement have provided rewards to heterogeneous groups based on the learning of their members (Slavin, 1995). "This incentive system motivates students to encourage and help one another to achieve. Rewarding students based on improvement over their own past performance has also been found to be an effective incentive system (Natriello, 1987; Slavin, 1980)".

Again, according to Slavin (1996, p9), in addition to being a product of specific strategies designed to increase student motivation, incentive is also influenced by quality of instruction and appropriate levels of instruction.

> "Students will be more motivated to learn about a topic that is presented in an interesting way, that makes sense to them, that they feel capable of learning. Further, a student's motivation to exert maximum effort will be influenced by their perception of the difference between their probability of success if they do exert themselves and their probability of success if they do not (Atkinson and Birch, 1978; Slavin, 1977; 1994). That is, if a student feels sure of success or, alternatively, of failure, regardless of his or her efforts, then incentive will be very low. This is likely to be the case if a lesson is presented at a level much too easy or too difficult for the student. Incentive is high when the level of instruction is appropriate for a student, so that the student perceives that with effort the material can be mastered, so that the payoff for effort is perceived to be great".

Research on cooperative learning methods has indicated that team rewards and individual accountability are essential for basic skills achievement (Slavin, 1983a, b, 1989). It is not enough to simply tell students to work together; they must have a reason to take one another's achievement seriously.

Further, research indicates that if students are rewarded for doing better than they have in the past, they will be more motivated to achieve than if they are rewarded for doing better than others, because rewards for improvement make success neither too difficult nor too easy for students to achieve (Slavin, 1980).

1.6 The learning environment for small group teaching

Whilst developing the concepts of the studio teaching environment, a number of parallel initiatives were taking place in other teaching concepts. One, The Foundation Coalition, a programme sponsored by the National Science Foundation, (Foundation Coalition, 2001) developed and implemented an Active and Collaborative learning technique that prescribes the following five principles:

1. Positive Interdependence: Tasks are structured to encourage team members to rely on each other in order to accomplish team goals. Each team member should perceive that his/her individual success depends on the success as a team;

2. Individual Accountability: Tasks are structured to encourage team members to be held accountable for doing their share of the work, as well as mastering all material. Each team members should perceive that he or she must be able to demonstrate mastery of the material on an individual basis;

3. Group Processing: Encourages each team to reflect on its performance as a team. Teams should periodically reflect on what they do well as a team, what they could improve, and what they might need to do differently.

4. Interpersonal and Social Skills: Team members practice and receive instruction in leadership, decision-making, communication, and conflict management.

5. Face-to-Face Interaction: Structure team tasks so that members spend all or some of their time working together. Encourage physical arrangements so that team members can see each other as they are working. For example, with teams of four persons, encourage teams to arrange themselves so that they are all facing each other instead of sitting in a row.

Others, such as Kolb (1984) connect the concept to its intellectual roots, Dewey, Lewin and Piaget; and call attention to the important role that experience plays in the learning process, and use the term "experiential learning".

Kolb (ibid.) suggests that the most effective learning process requires the four different learning steps outlined in Lewin's experiential learning model, i.e. concrete experience, observations and reflections, formation of abstract concepts and generalisations, and, testing the implications of concepts in new situations.

Kolb explains this cycle as follows: The immediate concrete experience is the basis for observation and reflections. After that, the observations are assimilated into a theory from which new implications for actions can be deducted. These implications then serve as guides in acting to transform new experiences in knowledge in a learning spiral process. The sequence - experiencing, reflecting, generalising, and applying - is called the experiential learning cycle or Kolb's learning cycle. Experiencing involves sensory and emotional engagement in activity. Reflecting involves watching, listening, recording, discussing, and explaining the experience. Generalising involves integrating theories and concepts into the overall learning process. Applying involves engaging in a trial-and-error process in which the accumulation of sensory experience, reflection and conceptualisation is tested in a particular context (from Malave and Figuerdo, 2002).

Millis and Cottell (1998, p.172) discussing the literature on deep learning, state that

> "Woods (1994) recommends that instructors "create an environment that encourages and rewards, and allows sufficient time for "deep processing." Another way of viewing "deep processing" is: "Don't try to learn everything from the first activity. Build up your subject knowledge successively" (ibid., p7.)". This progression by "deep versatile" learners cannot occur, according to Entwistle (1981), when surface learning is encouraged by: (1) work overload; (2) stress; (3) examinations that emphasise memorisation and "regurgitation"; (4) an environment that rewards surface learning".

When addressing the role of technology in the learning environment, Millis and Cottell (ibid., p.172) say that using technology in ways that promote sequenced learning within groups can lead to more in-depth processing of course content and, hence, more retention of information, whether students are interacting within a classroom setting or interacting through out-of-class electronic networks.

Millis and Cottell (ibid., p. 179) also quote Alexander (1995, p6), who puts learning with the World Wide Web in the broader context of deep, not surface learning, citing work by Biggs and Telfer (1987) and Laurillard (1993). With this framework, she (Alexander) states:

> "The challenge for educational developers is to use this knowledge of learning, together with an understanding of the features of the WWW, to design learning experiences which promote a deep approach to learning so that 'what' students learn is a deep understanding of the subject content , the ability to analyse and synthesise data and information, and the development of creative thinking and good communication skills".

The connection between cooperative learning and technology is long-standing. Light and Mevarech (1992) point out that

> "Since the early 1980s there has been a growing interest in the potentialities of both cooperative learning and of computers as facilitators of student learning. In

some respects, the claims made for each are rather similar. They are both based on theories in the area of social cognition and they both emphasize the role of student interactions in enhancing a wide range of school outcomes, including academic achievement, cognitive processes, metacognitive skills, motivation toward learning, self-esteem, and social development (p. 155)". (from Millis and Cottell, ibid., p171)

Millis and Cottell (ibid., p172) conclude that if technology is to be seen as a tool rather than as a driver or an "add-on," then it must simplify the learning process for students, not complicate it. Too often, early innovators worked out convoluted ways to incorporate technology into the classroom which built in resentment if students were required to use it or apathy if they considered it a complex option.

Unfortunately many applications of technology in the classroom have not made allowances for the incorporation of Piaget's insights about the need for reflection to be supported. As quoted in Meyers and Jones (1993), Piagetian scholars Lawson and Renner (1975) stress disequilibrium and equilibrium as important processes in forming new mental structures. So long as new knowledge fits into our present mental structures, we are pretty much in a state of equilibrium. But when experiences and new knowledge do not fit within these structures, we encounter disequilibrium - a challenging and sometimes painful situation. Then, through a process of integration and appropriation, we either incorporate the new knowledge in our existing mental structures or construct new ones, thus returning to equilibrium. In a sense .... the process of education is an ongoing dialectic between equilibrium and disequilibrium. For it to work, that dialectic must include some quiet time for reflection so that students can integrate and appropriate new knowledge. Successful application of technology must allow time for students to discuss and reflect, both inside and outside the formal class situation.

As Meyers and Jones (1993, p.29) continue:

> "If this Piagetian scenario is valid (and it makes sense to us), then we need to make room for reflection in our classes, especially following the presentation of new, challenging information that creates disequilibrium. By structuring opportunities for pondering and reflection, we can help students sort things out as they restructure old ways of thinking and move on to new understandings. In any significant learning experience, we cannot help profiting from time specifically set aside for reflection. At least that is what our personal experience as students and teachers suggests".[6]

<u>1.7 The studio teaching paradigm</u>

Although the practical implementation of studio teaching, that is, small group teaching based around a problem-based learning strategy, aided by technology, such as internet and World Wide

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[6] For further discussion on this point, see the work of Shayer and Adey (1994), for example, in their CASE project (Cognitive Advancement in Science Education) where they deliberately induce cognitive conflict in the children starting secondary school and propose that this has an impact later on. Unfortunately, there is little room here to consider these ideas further.

Web access, with course materials therefore easily accessible, was originally implemented in an empirical manner, it is possible to summarise some of the ideas in the preceding section as follows (after Wilson and Mosher, 1994)

- Learning is a highly interactive process. Teacher and students become involved in a learning "conversation" in which both parties clarify messages, test for understandings and are both transformed by the experience (Pea, 1992).

- Teachers are not simply the delivery mechanisms of the content of a curriculum. Although good lecturers may be inspirational, the lecture is not efficient in stimulating student learning (Laws, 1991; Hestenes et al, 1992; Redish et al, 1992). The model used by a number of educators when working in collaborative learning situations is one where the teacher is a "coach" of their students' learning process (Pea, 1992; Laws, 1991)

- Education, especially for scientists and engineers, must not be too far removed from the context of its meaning. If learning is to be viewed as a process that has meaning beyond the classroom, the students must be able to reach beyond the classroom. Either practitioners from the field of study must be brought to the classroom – which is not always possible - or the students must be able to access this information in other ways, for example, via the World-Wide-Web.

- Learning can be enhanced by providing students with access to powerful computing tools that can allow them to interact with real data and solve open-ended problems. Learning-by-doing has been shown to be a successful pedagogical model to enable students to solve real-world problems. (Laws, 1991; Redish et al, 1992). This approach also has the advantage of supporting individual differences in learning styles. Students bring to the classroom a diversity of interests, levels of preparation, cultural backgrounds and learning styles.

- Cooperative learning is a highly structured, systematic instructional strategy in which students work in small groups toward a common goal. This strategy has been shown to promote active learning, positive student attitudes towards learning, and increase student interdependence. Increased interdependence is a positive goal for students because of its effects on students interpersonal skills, teamwork capability, and self esteem. While working in teams on a project, it is difficult for students to be passive onlookers; the contribution of each team member is important (Millis, 1991). Teamwork is also becoming a widely implemented organisational strategy in many work settings, including manufacturing, services and government. Instructional practices should prepare students for working in this type of environment.

Drawing on some of these ideas, starting in the early 90s, a number of educators started rethinking the whole process of teaching and learning with respect to science and engineering education, especially at university level. There was clearly a need for new teaching materials and methodology that encouraged different modes of learning. Also, as networking, multimedia, mobile technology, and better software converged, educational institutions tried to discover new ways to improve learning, increase information access - and save money! Rubinstein (1994), in the introduction to a seminal edition of *Science* (Nov. 1994) on the subject, writes:

> "In small and large schools alike, individual teachers are developing innovative curricula – and novel pedagogical techniques as well – to address the problems created by disaffected (and fearfully unprepared) undergraduates". (p843)

At the same time, course feedback has shown that traditional courses were not preparing graduates for the 'real' world, especially in science and engineering:

> "Traditional courses, some will tell you, don't prepare (students) for the real world, and traditional teaching methods don't engage their interest. The world has changed, many say, and their universities haven't" (Rubinstein 1994, p843).

This sense of seeming irrelevancy of traditionally taught courses to a graduate's eventual employment needs affects all aspects of the learning process. Jack Wilson, one of the pioneers of this new paradigm, and who implemented the studio teaching approach at Rensselaer Polytechnic Institute (RPI), is quoted as saying, "We pretended to teach them, and they pretended to learn" (Culotta, 1994, p875).

Massy and Zemsky (1995) tried to summarise many of the arguments for the introduction of these new techniques based on information technology, especially its impact on productivity, as follows:

> "Economists define productivity as the ratio of outputs to inputs, or more generally as the ratio of benefits to costs. Productivity can be improved by:
>
> 1. Producing significantly greater benefits, encompassing quality and well as quantity, at modestly greater unit cost ("doing more with more")
>
> 2. Spending significantly less money while limiting benefits reductions to modest levels ("doing less with less")
>
> 3. Producing greater benefits while spending less money ("doing more with less")"

Productivity also can be increased by improving quality at the same unit cost - a result we consider a limiting case of "doing more with less." (ibid., p5)

However they then try to relate these general criteria to academia, mostly without considering the history of using technology to aid teaching and learning.

So far, most IT-based academic productivity improvements have involved doing more with more. With labour - especially faculty labour - considered to be fixed, IT becomes a quality-enhancing add-on. This fits the faculty culture but suffers from at least two serious deficiencies.

> "First, scarcity of add-on funding limits IT's rate of adoption. While colleges and universities might like to pour money into more-with-more productivity

enhancement, most are not in a position to do so. Funding scarcity constrains the courseware market, thus inhibiting would-be developers from making the large front-end investments needed to exploit fully IT's potential advantages.

Second, and more fundamentally, the more-with-more approach does not address the institution's need for cost containment. One can imagine a scenario where widespread IT add-ons produce a situation like that found in medicine, where technological breakthroughs produce a spending race that eventually threatens the system's affordability. Tight financial circumstances currently inhibit such scenarios, but even if today's constraints could be relaxed, more-with-more productivity growth would eventually encounter new financial limits." (Massy and Zemsky, 1995, p6)

1.8 Studio teaching in practice

Studio teaching was initially implemented by scientists and engineers as a pragmatic and practical answer to questions raised concerning undergraduate teaching of scientists and engineers. Those conceiving the idea did so from many years of experience in teaching, and not from any pre-defined educational theories. For the purposes of this study, studio teaching is defined as that teaching methodology that combines the traditional, and usually disconnected, elements of engineering education into an integrated whole. In other words, lectures, tutorials and laboratory work, are not differentiated, or allocated different time slots or different physical space in the time table. As mentioned above, a studio class, usually lasting two hours, may contain elements of lecture, laboratory and tutorial, but they are presented holistically. This is designed to reinforce learning in the students, hopefully to enable a deeper form of learning to occur. As assessment is also continuous, with emphasis on project-based, interactive, small group learning, there is less opportunity for strategic learning, aimed at 'playing the system' to take place. However, there has to be a commitment from both the institution and the staff members concerned to make it all happen!

Studio teaching was first introduced at Rensselaer Polytechnic Institute (RPI), in the USA, in the early 90s. RPI is a research-oriented university with a strong reputation for quality undergraduate education and innovative teaching. Most of RPI's first year courses have now been converted to studio teaching format, not only in science and engineering, but also across the whole university curriculum (Wilson and Jennings, 2000). The changeover started initially in the Physics Department as described by Wilson (1994), and then in other science and engineering disciplines as detailed by Iannozzi et al (1997), Maby et al (1997), Jennings (1998) and Carlson and Makedon (1996). Other universities quickly picked up on the approach and introduced studio teaching into the curriculum, City University of Hong Kong (CityU) being especially vigorous in its adoption, where it was labelled ITS - Integrated Teaching Studio.

The reasons and methodology behind CityU's decision to take this approach, and its subsequent implementation, are given by Yu and Stokes (1998a), Leung et al (1996) and Bradbeer (1998).

One of the main changes in tertiary education in Hong Kong in the 1990s, as earlier in most of the western world, was the rapid growth in the number of students undergoing university education. Inevitably this has resulted in a more diverse and larger student intake, and the traditionally accepted entrance skills base changes. For engineering and science this poses major problems. At the same time language skills, especially where a subject is taught in a language other than mother-tongue, as in Hong Kong, have been shown by Flowerdew and Miller (1995) to be generally low by world standards.

> "To gain entrance into the university (CityU), they must have at least a grade E in their Use of English paper. The students' entry levels ranged from E to C. An E correlates to around 450 on the TOEFL test, whereas a C correlates to around 530 (Hogan & Chan, 1993). As a point of comparison, most US universities have an entry level of about 550." (p349)

Pennington et al (1992) already noted that in 1992 CityU students' language abilities were restricted.

> "... the present research with City Polytechnic students uncovered ... the occurrence of English was found to he highly restricted, used primarily with Westerns and with Chinese in the academic context. A mixture of Cantonese with English lexis was found to be relatively common at City Polytechnic, used both with other students and with Cantonese-speaking teachers. With both of these groups, (pure) Cantonese was also used, particularly when speaking about non-academic topics." (p69)

Studio teaching has been welcomed by many faculty as one answer to these problems. The philosophy behind the studio teaching format and its ingredients may be summarised as follows. Learning is more effective (a) by doing (mini-labs, exercises), (b) by interactive and cooperative techniques (discussion and group activities), (c) if more of the senses are engaged (interactive multimedia courseware), and (d) by immediate application and follow-up (in-class assignments).

Essentially the methodology replaces the traditional large-group lecture, small-group tutorial and separate laboratory format with an integrated studio approach, that is claimed to be both economically competitive and educationally superior. The focus is on student problem-solving rather than presentation of materials.

A typical ITS session would be two hours long and consist of up to 30 minutes of presentation, possibly a short mini-lecture or interactive demonstration, followed by a question and answer session. Again, this may be either pencil-and-paper type or interactive using the workstation available to each individual or pair of students. This may also develop into a small-group discussion, especially when workstations are grouped around each other, as at CityU in Hong Kong.

Yu and Stokes (1998b) describe the situation where this small group interaction leads students to teach students, drawing on the work of Mazur, at Harvard University (Mazur, 1996, p13). The "students teaching students" approach, was proposed by Mazur and modified and adopted for the Multimedia Integrated Teaching Studio (Yu and Stokes 1999b, p282). Under this approach, students are expected to learn through discussions within a group of students. This is different from the "teacher teaching students" approach in traditional classes, in which students are expected to learn through listening to the teacher. "Problem-based learning" and "interactive learning" are also incorporated in the studio teaching classes.

Many studio sessions allow the students to work with some physical equipment or parts and this will allow them to carry out short experiments that are based on the previously presented material. At CityU, the introductory electronics and physics classes are able to carry out experiments where the instrumentation is represented on the workstation screen, although real parts and components are used on the bench as noted by Bradbeer (1999a) and Bradbeer (1999b). At RPI most of the studios have fixed bays of standard laboratory equipment that can be accessed by the students by turning their chairs through 180° as described by Millard et al (1997).

Owing to the flexibility inherent in the studio environment it is possible for the teacher to modify the structure of the session to take into account feedback from the students. For example, they may request more time for discussion or investigation of one particular aspect of the material being presented. This, of course, means that those teachers more accustomed to a more structured approach may have problems, and this will be addressed below.

Most ITSs have projection screens that can show presentation graphics, animations and web pages, as the instructors' desk, as well as all the student workstations, are not only connected to a local area network (LAN) but also the Internet. There will also be a visualiser that can be projected onto the large screen(s). This inherent interactiveness, associated with access to the Web, and even video on demand (VOD), allows the ITS to be very flexible. At CityU, for example, a management or biology class may follow an electronics class.

Of course, normal lecture material, especially that based on overhead projector slides and/or 'chalk and talk', does not fit into an ITS environment. Consequently much thought, effort and money must be put into the preparation of material. Owing to the ubiquitous nature of multimedia there is much material available commercially that can be easily modified for ITS use, although some investment will still be necessary. At CityU a special authoring unit was established to aid preparation of such courseware - Klassen and Morton (1999).

There is also an initial investment in constructing the studio itself. Many universities have either private or public funds available for improving their teaching infrastructure and these have usually been used. However, some studies, especially those by Massy and Zemsky (1995), Wilson (1994) and Ianozzi (1997) have shown that the efficiencies in staff use and student performance more than compensate for this initial financial investment.

The studio teaching paradigm has shown itself to be robust. It is now ten years since the methodology was first introduced, and not only is it established in those institutions where it was initially introduced, but is gradually "working its way through the system". A number of examples from these other institutions now using studio teaching will be referred to in later chapters.

However, a number of problems have been identified; many teaching staff do not like to take studio classes and a small minority of students do not like working in a studio environment. Others have criticised the reliance on technology as detracting from the teaching and learning process.

1.9 A cautionary tale

However, a potential problem associates with studio teaching is the possibility that the technology may 'hijack' the whole idea. At this point it may be instructive to look at the example of the introduction of some of Papert's ideas as put into practice in British primary and secondary schools., and the way that the learning pedagogy was eventually lost in the obsession with the technology used. Noss and Hoyles (1996) have written an insightful account of this, especially as it comes from two educationalists who have been involved with assessing the impact of Papert's ideas, especially the use of LOGO and turtles, for over 20 years[7].

They introduce the subject by looking at one of the first attempts at computer-assisted teaching, PLATO. As they note:

> ".....a few decades ago, it was generally accepted that a combination of good ideas, money and energy from external agencies could quickly and easily transform schools and curriculum. One example was the introduction of the computer-assisted teaching system, PLATO, into some community colleges in the U.S.A.[8] In a fascinating case study, House (1974) traces the gradual disintegration of this innovation under the combined influences of a multitude of factors: lack of clarity of the change process, naivety in thinking about the translation of objectives into practice, internal politics and conflict between groups, technical problems, lack of resources and limited teacher preparation. This was one of many spectacular failures at that time - all well-resourced and arising from sound educational ideas. (p 156)

They go on to say that "conventional wisdom asserts that the computer has not achieved the radical effects that its proponents believed it would some ten or twenty years ago". As Becker (1982) has put it:

> There were 'dreams' about computer using students. ..dreams of voice-communicating, intelligent human tutors, dreams of realistic scientific simulations, dreams of young adolescent problem solvers adept at general-purpose programming languages - but alongside these dreams was the truth that computers played a mini-

[7] Celia Hoyles and I worked at Polytechnic of North London in the late 70s before she moved to the Institute of Education, London. We were both active in the British Logo Society at that time, and she continues to be so, as well as EuroLOGO.

This section, focusing on the experience of introducing LOGO into British schools is given as an extended case study into how an enabling technology - ubiquitous low cost computing - was considered an educational objective in its own right, and the software that actually had the potential to give rise to a new teaching paradigm - LOGO - was basically ignored, then distributed widely in schools in a form that meant that change was not necessary. Unfortunately, that attitude is still current today, where the introduction of an enabling technology, such as Blackboard, is seen to be a useful tool for administering the tasks of teaching, but is generally ignored when it comes to implementing changes in teaching methodology. The studio teaching concept basically takes the enabling technology of ubiquitous web access, and does attempt to change the teaching methodology - hence the cautionary tale expanded on here.

[8] I had a chance to look at PLATO in action on a visit to Control Data Corps. HQ in Minneapolis in 1982. It seemed a dinosaur of a system even then!

> mal role in real schools. ..." (ibid. p159)

Noss and Hoyles (ibid.) note that in the late seventies, the programming language BASIC was popular .

> "There were claims for the importance for learning mathematics through writing algorithms to make procedures and structures clear and explicit. By the mid-eighties, the rhetoric had changed with the introduction of the notion of 'mathematical programming' -a compromise formula to allow discussion of Logo, a new and apparently more radical alternative to BASIC, without actually having to name the language! Eventually Logo came into its own, quickly followed by spreadsheets, then databases. Now, in the nineties, dynamic geometry software and computer algebra systems are fashionable. Yet Logo survives in two forms: as an elementary drawing program in primary schools, and as a medium for mathematical exploration in some secondary schools." (ibid., p161)

To understand how this has come about, they begin with a little history. When Logo arrived on the educational scene at the beginning of the nineteen-eighties, there was a surge of interest which, although more measured than that in the U.S.A., gave rise to substantial conferences organised to provide a forum for researchers and teachers to meet and discuss the implications of this new software for curriculum and policy. There was enthusiastic curriculum development together with a burgeoning of research projects.

> "Excitement spread throughout the community, although it must be said this was matched by cynicism and opposition from two sources; from those who still advocated BASIC, and those who wanted schools to remain immune from computer use altogether. Provision of computers in schools was entrusted to the Microelectronics Education Programme (MEP), a government agency; in common with many countries at the time, the U.K. government saw their role as equipping schools with machines first, and only, secondarily to aid in the process of deciding what to do with them. On the hardware front schools were exhorted to 'buy British' , and substantial subsidies were handed out to, in particular, the 'BBC' computer.[9] As a result, there was little incentive for the company who manufactured it to develop a viable Logo - after all, it had invested heavily in its own 'improved' variety of BASIC." (ibid., p161)

As Noss and Hoyles continue:

---

[9] I was a member of the committee established by the BBC and the Department of Industry to come up with the design specifications of the BBC computer. We had many discussions on the appropriate roles of both Logo and BASIC in the classroom. The Sinclair machine was rejected partly because it already had a very well established Logo package for the Spectrum. One reason given was that this would 'confuse' teachers! When I co-authored the book of the tv series, BASIC was the only language we could refer to, and Logo was not even mentioned!

> This mildly interesting accident of marketing and economics had some surprising outcomes. It created a serious gap between the sudden flash of interest in Logo's potential, and the ability of children in schools to actually use it. Into this gap stepped a number of 'turtle drivers': simple programs (usually written in BASIC) designed to draw graphics using a screen turtle: the most successful of these was DART. All of these programs allowed the child to drive a turtle using FORWARD and RIGHT, but none had recursion, list processing, proper control structures, arithmetic operations or serious screen editors. Yet some (not, thankfully, DART), happily packaged themselves with the title 'Logo'". (ibid., p162)

In one form or another, 'Logo' was rapidly taken up in the U.K. As early as 1984 the MEP commissioned a report on classroom experiences by an experienced primary specialist and computer 'non-expert' (Anderson, 1986). Anderson's report showed that 'programmable toys, such as Milton Bradley's 'Big Trak', were not distinguished from Logo-turtles; turtle graphics programs such as DART were not distinguished from Logo; and Logo itself was viewed as difficult, expensive, and (possibly) not necessary for doing 'Logo' (Doyle, 1993, p24).

> "It would be simplistic to argue that it was merely an accident of software availability that led to the Logo programming language being reduced to turtle graphics - with little emphasis on any aspect of mathematics or even geometry , let alone on programming as a means of mathematical expression. It is more a question of teasing out the factors by which an innovation like Logo changes so that it becomes deemed as acceptable to teachers and to the system. Which aspects take hold and which wither away?
>
> In this case two contradictory processes were at work. On the one hand, the child-centred approach which had come to characterise English primary schools resonated with cut down 'Logo': teachers, parents and head teachers could view 'Turtling' as happily fitting into the wide variety of 'child centred' activities which could be found in many primary classrooms. On the other hand, the very success of Logo's assimilation led to its being viewed as 'an activity' in its own right - not a way of expressing mathematical ideas, but a way of operationalising existing priorities by an 'added on' school topic rather than one integrated into the educational setting. (Noss and Hoyles, 1996, p162)

There is thus a possibility that studio teaching, as an implementation of interactive learning, may also fall into the same trap. However, the way that it has been implemented in practice, seems to point otherwise.

1.10 Does studio teaching really work?

The main thrust of this thesis is to determine whether studio teaching delivers what it promises to. Does it make the learning experience not only more enjoyable for the students, but also stimulates them to better achievements than traditional methodologies? What do students think of the studio based approach? Do they in fact learn more? Can they apply what they've learned to other courses that follow? What type of learning takes place? These, and other questions will be addressed in later chapters.

The first task, therefore, is to split a class of students into two groups, and then determine whether they are similar - in entrance qualifications, previous knowledge of the subject taught, and interest in the course. Next, can a set of instruments be devised to measure any differences between the groups at the end of a course, without prejudicing the assessment procedures set down by the university? Finally, what conclusions can be drawn from the results? And, once these conclusions have been drawn, what changes need to be made to the course so that it can be made more effective?

The next chapter addresses the splitting of the groups, and assesses whether they are similar. This is then followed by a chapter that looks at the assessments used in two, consecutive and related, courses. The first is analysed in great detail; the second only superficially. Then, a more qualitative approach is taken, where student responses are considered, both on the two courses under study at CityU, and also one at RPI. The results from the quantitative and qualitative analyses are then compared to results from other studies at other universities where studio based teaching has been introduced. A number of recent developments on learning styles and strategies are then considered to see if they may point to better course design, and if they give some insight into why studio teaching works. Finally, some conclusions are drawn.

Chapter 2

Analysis of entrance qualifications and experience of the students

2.1 Introduction

The main objective of the research presented in this thesis is to compare two groups of students who have been taught the same material, and who go through the same assessment procedures, but who are taught using two different paradigms. The first, control, group is taught using traditional methods, including 2 hour lecture, 3 hour lab and 1 hour tutorial. The second, experimental, group is taught using the studio teaching method. The courses studied by both groups of students were the two semester-long courses in introductory electronic engineering for first year students in the Department of Manufacturing and Engineering and Engineering Management (MEEM) at CityU, Hong Kong. These courses were taken by all students taking the Bachelor of Engineering degree programmes in Manufacturing Engineering and Mechatronic Engineering, between 1996 and 2001. The students in each programme were accepted into the two programmes with similar entrance requirements. Those accepted included students who came straight from school or college with a mixture of Hong Kong Examination Authority (HKEA) A level or AS level awards, as well as students from the Vocational Training College/Institutes (VTC) with various technical awards, such as Higher Diploma. The mix of students from these different backgrounds varied with each cohort, ranging from around only 60% of students entering with A or AS levels in the first cohort, to 100% in the last two cohorts.

The two groups will be referred to as the Non-ITS, or non-Teaching Studio, group - the control group, and ITS, or Teaching Studio, group - the experimental group, respectively.

2.2 Entrance qualifications

Before any comparison of grades and added knowledge/understanding can be calculated for the two groups, we must be able to quantify any differences, if any, between the entrance qualifications. The first comparison is the entry qualifications of the students. As noted above, in the first two cohorts there were significant numbers of non-A level entrants - mainly from Vocational Training Colleges/ Institutes. To be consistent these were eliminated from this analysis, as were any repeat students. As will be seen later, this elimination made no significant difference to the performance of the cohorts when it came to any assessments made. Detailed analysis of the entrance requirements - A level or AS level, for example - is shown in Appendix 2. This is restricted to t-tests only. These results are discussed in Section 2.5 below. However, detailed statistical analysis will be carried out on the output measures - i.e. the results of the assessments, in the next chapter.

For Cohort 1 the grades were reported by the students in answer to a questionnaire administered by the instructor, and this did not ask for the specific subject, and all grades could therefore not be confirmed against objective data. For Cohort 2 onwards the grades were supplied by the university registry, and were letter (coarse) grades only. As with A level grades in the UK, the Hong Kong

Examination Authority (HKEA) gives grades from A to E for the Hong Kong A Level Examination (HKALE). From Cohort 3 onwards the university registry supplied both "coarse" grades as well as "fine" grades, which range from 1 to 10, 1 being the highest. Thus coarse grade A can be either fine grade 1 or 2. The fine grade system allowed finer discrimination between students for this exercise as the vast majority - >95% - scored either D or E on the coarse grade scale.

Coarse grades were converted into fine grades using the average equivalent i.e. grade A was given a fine grade of 1.5, and so on. This assumption was valid as an analysis of the fine grade distribution for each coarse grade showed that they were roughly equal for all cohorts.

As the fine grade system is an inverted scale, the grades were subtracted from 11, so that fine grade 10 had a value of 1, and fine grade 5 had a value of 6, for example. This made the scale roughly equivalent to the normal score for A level letter grading, i.e. A = 10, B = 8 etc. but with higher discrimination. AS levels were scored at half the value of A level, again in accordance with normal practice.[1]

The number of students entering the courses with HKEA awards and VTC awards varied by cohort. Table 2.1 shows the percentage of students in each category for each cohort. Note again, that the data for the first cohort was self-reported, and its accuracy cannot be determined.

Cohort	96-97		97-98		98-99		99-00		00-01		01-02	
	Non ITS	ITS	Non ITS	ITS	Non ITS	ITS	Non ITS	ITS	Non ITS	ITS	Non ITS	ITS
A level	54	26	47	32	29	33	32	35	42	29	31	31
VTC	51	10	11	6	18	6	10	0	0	0	0	0
no	105	36	58	38	47	39	42	35	42	29	31	31
% a level	51.42857	72.22	81.03	84.21	61.70	84.62	76.19	100.00	100.00	100.00	100.00	100.00

Table 2.1 Percentage of HKEA and VTC award students in each cohort.

This is represented graphically in Figure 2.1 below.

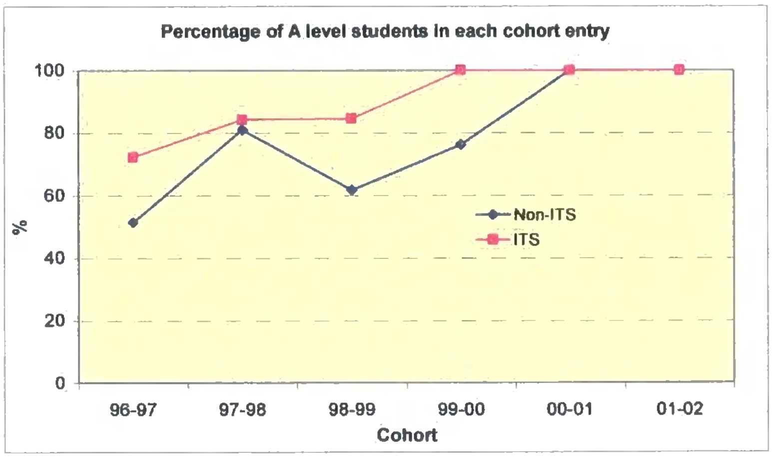

Figure 2.1 Percentage of A level students in each cohort

The first analysis of the A level scores was to compare the average score for each cohort for each

[1] To simplify things, where a score containing both A level and A/S level results is used, it is just referred to as the A level score. If there is reason to differentiate, then the separate scores will be given.

group. This was done in two ways. First, the total score for all examinations was calculated, then the score for only the technical subjects.

Figure 2.2 below shows the total score average for each cohort for the two groups. The top two curves are for all subjects, including Use of English (UoE) and Chinese Language and Culture (CLC) AS level.; the lower two for technical subjects only.

The trendline for each curve was calculated, and also the correlation between the two. An analysis of the results indicated that there was no significant difference between the two groups for both the total and technical subjects only -see Table 2.2. Detailed analysis of the results are given in Appendix 2. Here we will consider correlation coefficient only. The high correlation between the two groups may also be an indication that the pattern of the variation in scores is similar, as can be seen from Figure 2.3. The solid line indicates exact matching of qualifications.

	Correlation coefficient
Total score	0.95
Technical subjects score	0.98

Table 2.2 Correlation coefficients for all cohorts

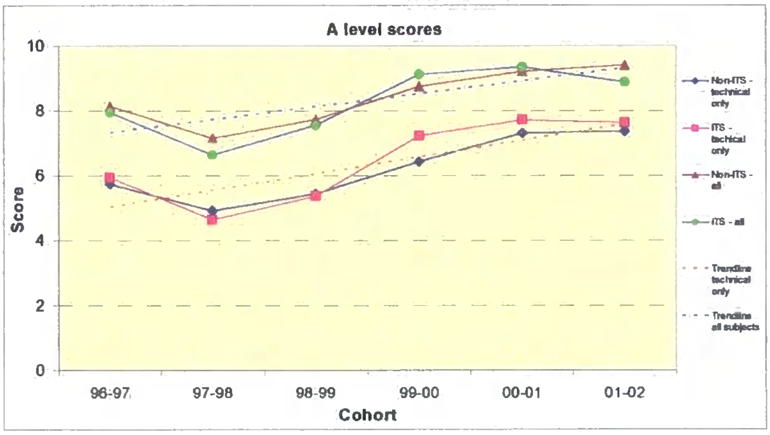

Figure 2.2 Average number of exam pass numbers for those passing both CLC and UoE - excluding CLC and UoE

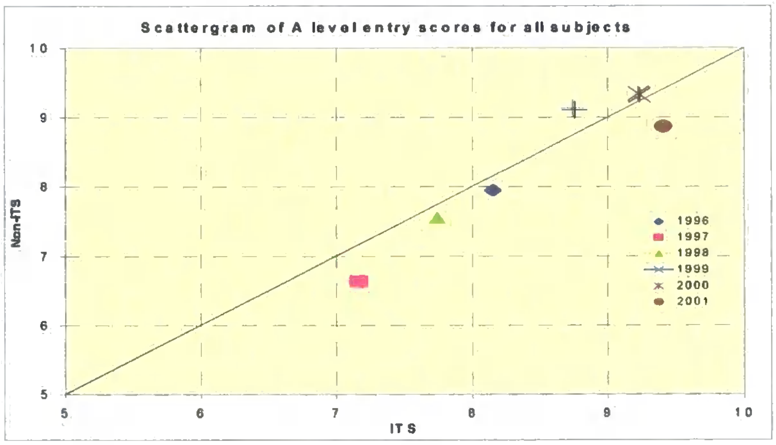

Figure 2.3 shows a scattergram of the scores for both groups for all subjects.

A comparison was then made between the A level scores of the two groups compared to those of A level examination entrants in general [HKEA, 1997, 1998, 1999, 2000, 2001, 2002]. This was to determine the relative quality of students entering the two courses, and their rough position in the overall performance of Hong Kong A level results. Table 2.3 shows the average number of A and AS level examinations taken by all entrants for each of the years considered. These are based on exam pass numbers for those passing both Chinese Language and Culture (CLC) and Use of English (UoE) AS level but do not include those passes. Detailed data, taken from the HKEA annual reports are given in Appendix 3.

These are total numbers of exam entrants, not just school entrants, as some of the students on the two courses also come from a non-school background but with A levels not vocational qualifications. The number of subjects taken is indicated for the two courses being considered is shown as a comparison for each year. These results can be plotted as a scattergram, as shown in Figure 2.4.

Year	HKALE average		Studied courses average		
	A level	AS level		A level	AS level
1996	1.97	0.39	Non-ITS	2.27	0.96
			ITS	2.12	1.69
1997	1.97	0.39	Non-ITS	2.32	0.19
			ITS	2.22	0.16
1998	1.97	0.39	Non-ITS	2.62	0.24
			ITS	2.47	0.19
1999	1.95	0.65	Non-ITS	2.46	0.31
			ITS	2.34	0.26
2000	1.95	0.40	Non-ITS	2.23	0.47
			ITS	2.28	0.52
2001	1.97	0.41	Non-ITS	2.19	0.42
			ITS	2.35	0.35

Table 2.3 Average number of exam pass numbers for those passing both Chinese Language and Civilisation (CLC) and Use of English (UoE) AS level

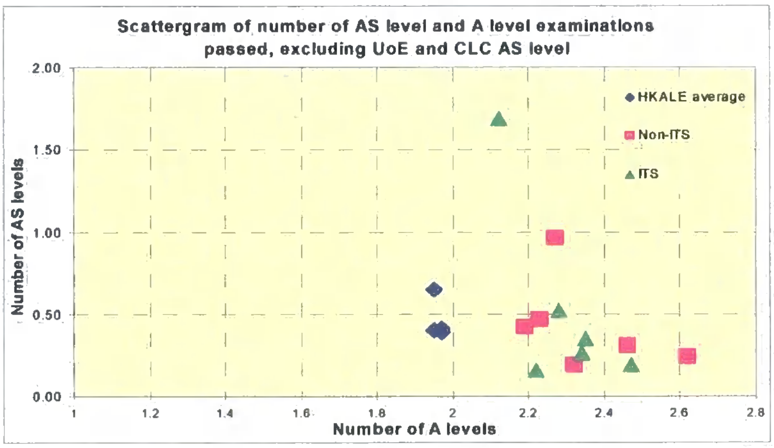

Figure 2.4 Scattergram of number of AS level and A level examinations passed, excluding CLC and UoE

These results can be plotted as a scattergram, as shown in Figure 2.4. It is clear from Table 2.3, Figure 2.4 and Figure 2.5, that entrants to both courses under consideration passed more examinations than the average, although the average grade was much lower than average. At the same time there was no significant difference in the number of examinations passed by both groups.

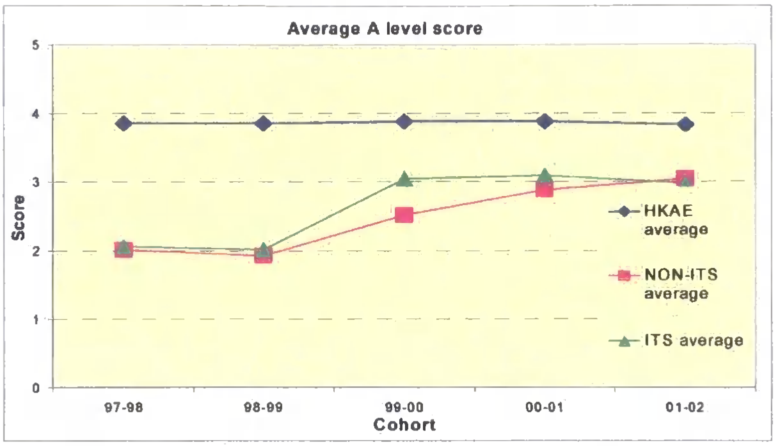

Figure 2.5 Average score of students compared to HKALE average

Again, the average score for each group was calculated across all cohorts. The correlation is shown in Table 2.4 below.

	No A levels passed	No AS levels passed	Average A level score
Correlation coefficient	0.63	0.98	0.91

Table 2.4 Correlation coefficient between two groups for various factors

2.2.1 Technical subjects

A further analysis of the entrance grades for each technical subject is given in Figure 2.6a and 2.6b. This is for Pure Maths, Chemistry and Physics A level only, as these were the subjects taken by the majority of students. Also shown are the average grades for each subject for all students taking HKALE examinations in these subjects. Appendix 4 shows the grade distribution for each year, against the HKALE average for each subject analysed.

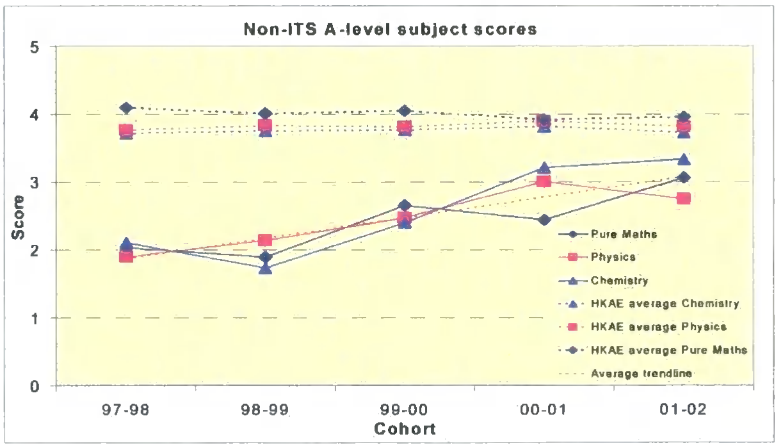

Figure 2.6a Technical A level subject scores for Non-ITS group

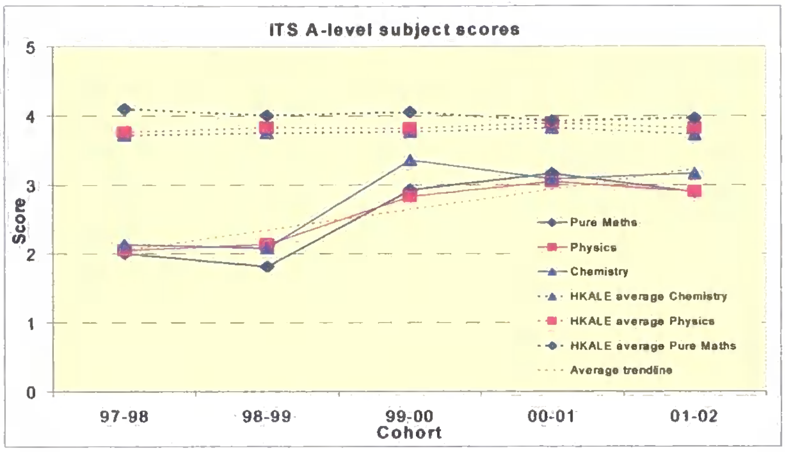

Figure 2.6b Technical A level subject scores for ITS group

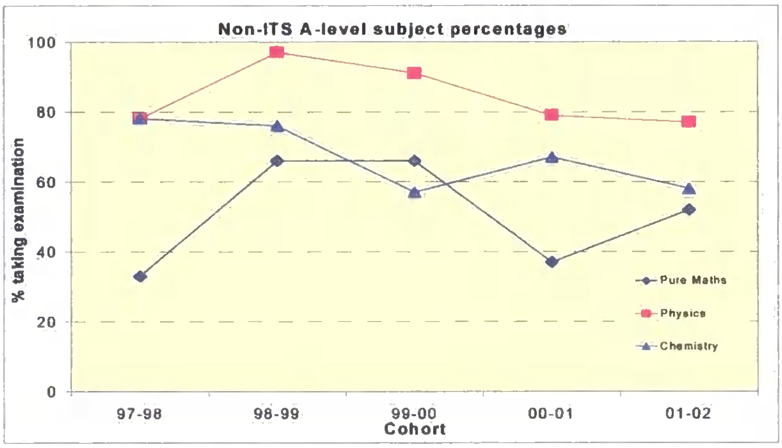

Figure 2.7a Percentage of students taking main technical subjects for Non-ITS group

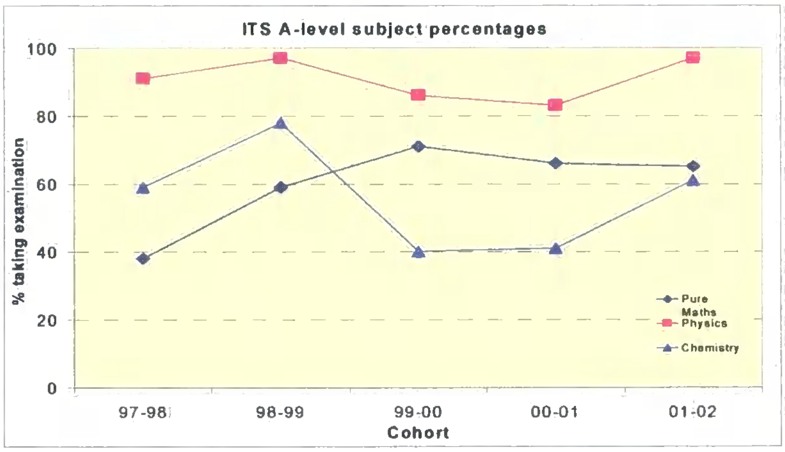

Figure 2.7b Percentage of students taking main technical subjects for ITS group

Figures 2.7a and 2.7b show the percentage of students in each group taking the three main technical subjects. From these it can be seen that there maybe a tendency for the ITS group to have a greater proportion of students that took Maths at A level, compared to the non-ITS group, although the varying data over the whole period makes any detailed comparisons difficult.

2.2.2 Language subjects

An analysis of the language capabilities of the two groups studied is shown in Figs 2.8 a and 2.8b. These show that average AS level score for the two main compulsory language subjects, Use of English and Chinese Communication and Culture. The average score for all HKALE entrants who passed these subjects is also shown, as is a composite score made by summing the two individual scores. The full details of the actual distribution is given in Appendix 4.

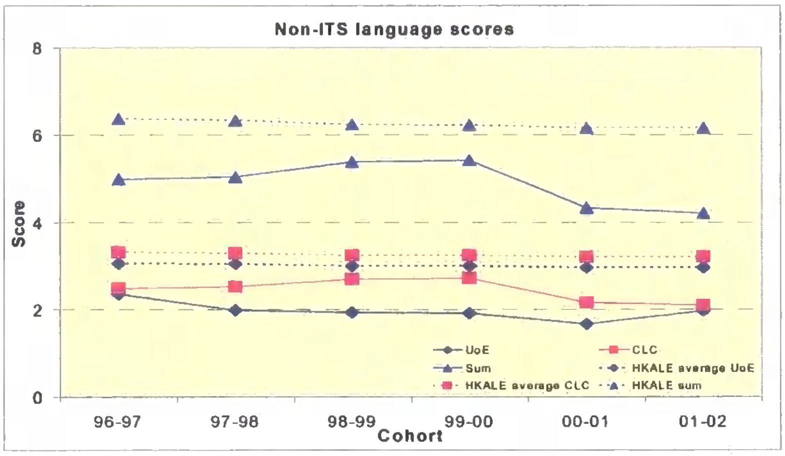

Figure 2.8a. Average scores in UoE, CLC and the sum of both for non-ITS group

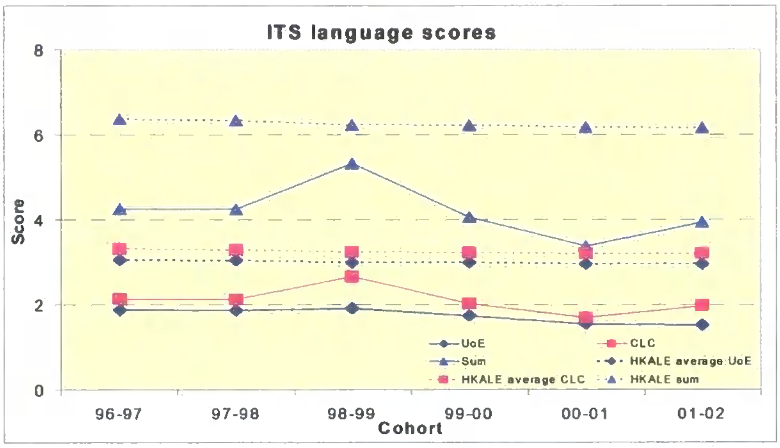

Figure 2.8b Average scores in UoE, CLC and the sum of both for ITS group

2.3 Survey questionnaire

At the beginning of Semester A, for each cohort, a questionnaire was given to both groups by the instructor. This included questions about the ownership and awareness of IT and computers, as well as a 50 question section asking technical questions. This questionnaire is shown in Appendix 1, and the results in Appendix 5. These will be looked at in greater details later in the chapter. However, some results will be referred to below, to relate attitudes towards learning in English and these will be related to the UoE results.

2.4 Language preferences

As part of the questionnaire/test given to each students on the first week of the courses, Appendix 1, a number of questions related to language preferences. The results from these questions are given in Appendix 5. One of the questions, Question 20, asked in which language the students preferred lectures to be given. The percentage of students preferring English only, Chinese only, or a mixture of the two, are shown in Figures 2.9a and 2.9b.

Further questions, questions 21 and 22, also asked the same for tutorial and laboratory work. To get an approximate indication of the overall preference for the language of instruction, these three questions were combined and the students' responses are shown in Figures 2.10a and 2.10b.

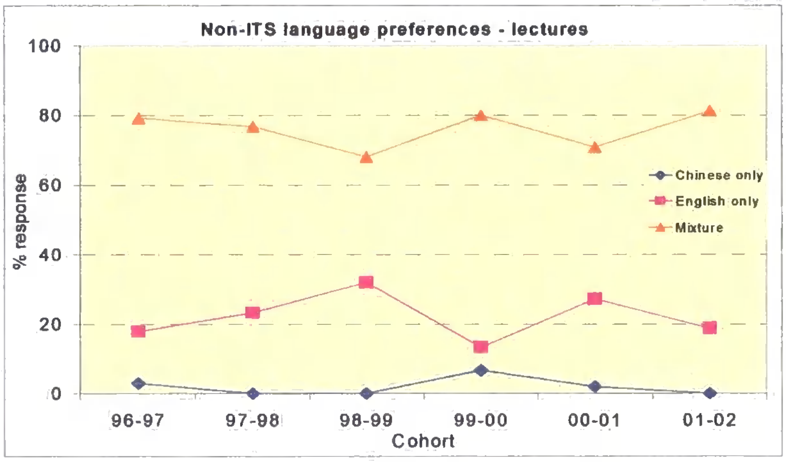

Figure 2.9a Percentage of students preferring various language options for lectures in the Non-ITS group

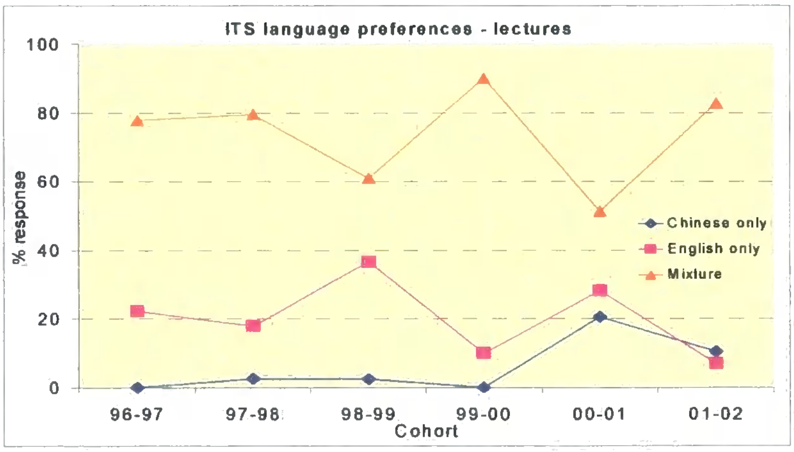

Figure 2.9b Percentage of students preferring various language options for lectures in the ITS group

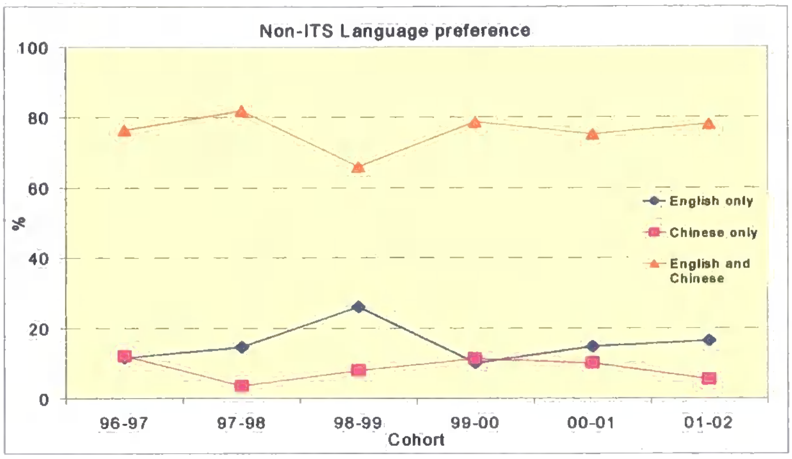

Figure 2.10a Overall language preferences, percentage of students in Non-ITS group

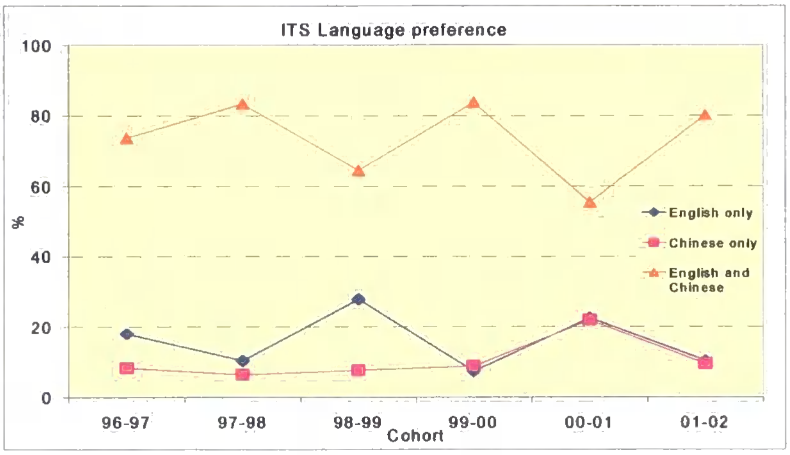

Figure 2.10b Overall language preferences, percentage of students in ITS group

2.5 IT skills and competence

Questions 3 - 6 on the pre-test questionnaire related to the knowledge of various commonly used programs, including word processor, spreadsheet, database and web browser. Students were asked

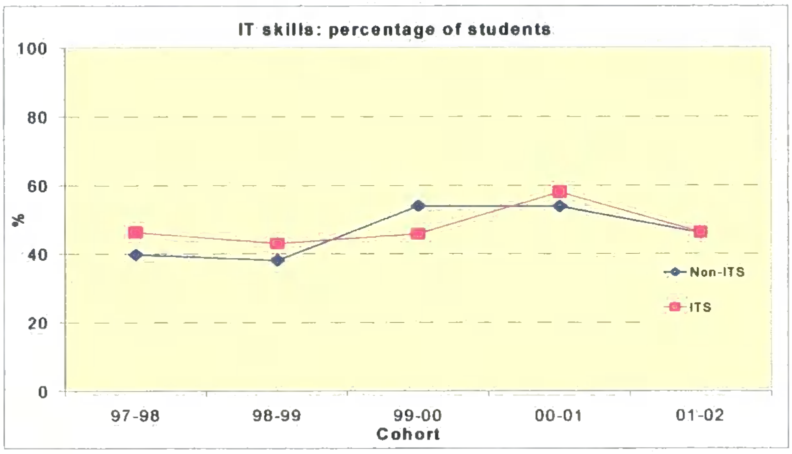

Figure 2.11 Aggregate answers from Questions 3-6, indicating IT skills, percentage of students

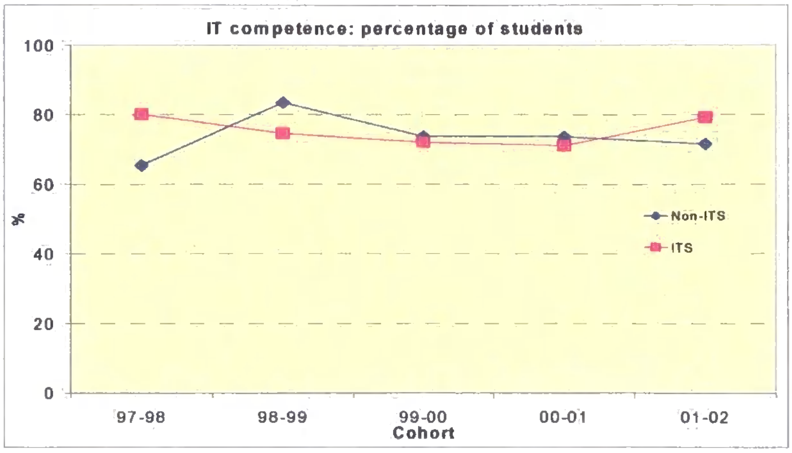

Figure 2.12 Aggregate answers for Questions 1-2 and 7-9, indicating IT competences, percentage of students.

if they were familiar with these programs. Their responses to these 4 questions have been aggregated as shown in Figure 2.11. This shows the percentage of students who say they are familiar with the four programs, and was used as an indicator of IT skills.

Questions 1-2, and 7-9, assess the students' attitudes to using computers in their learning. Question 10 asks how many hours a week they use the computer. A usage of greater than 10 hours a week was counted as indicating that the student was familiar with the computer. The answers from these five questions were aggregated to indicate a measure of IT competence. This is shown in Figure 2.12.

2.6 Equivalence

The objective of the analysis above is to assess the equivalence of the two groups at entrance to the courses under study. From Figure 2.2, it can be seen that the A level scores have been rising each year (Except for the first cohort, where the objectives of the data is in doubt, anyway). This would seem to indicate that the courses studied have been attracting better students. However, the scores from the technical section of the pre-test, shown in Figure 2.13 show that the average ability of each class has been declining over the same period. This would seem to indicate some form of grade inflation in the entrance qualifications. This will be discussed in greater detail in the next chapter.

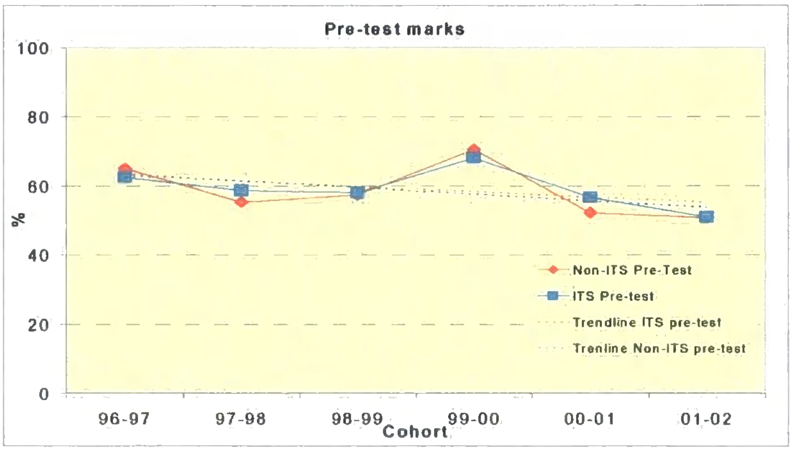

Figure 2.13 Pre-test scores - technical section

At the same time it can be seen from Table 2.2 that there was close correlation between the A level scores of both groups. This is shown diagrammatically in Figure 2.3. This close correlation is also indicated when the number of subjects passed at AS and A level are considered. Figure 2.4 shows a significant clustering of points on the scattergram of number of AS levels against A levels passed. (Reference to Appendix 2 at this point, will show that the actual relationships between this data is quite complex, and further work will need to be carried out to determine exact relationships).

However, as can be seen from Figures 2.6a and 2.6b and the detailed figures in Appendix 3, it is clear that students in the earlier cohorts were in the bottom quartile of students passing the three main technical subjects at A level, but that recent cohorts are now in the third quartile. It is also clear from these figures that there is again close correlation between the scores of both groups, as shown in Table 2.5 below. This gives correlation coefficients of 0.95 for Physics, 0.8 for Chemistry and 0.75 for Maths.

One area where there is difference between the two groups studied is in the percentage of the class taking various A level technical subjects. This varies over the period studied, as can be seen from Figures 2.6a and 2.6b. As mentioned above, it would be complicated to analyse the correlation between the two groups because of this variation, but by inspection it can be seen that the ITS group has a higher percentage of students with Physics, with a slight advantage in Chemistry and Maths.

The data for the non-technical subjects can also be used to determine the correlation between the groups. This is also shown in Table 2.5 below; the correlation coefficient is 0.55 for UoE and 0.69 for CLC.

The graphs for language preference are also difficult to analyse. For the language preference in lectures, there are correlation coefficients of 0.43 for English and 0.47 for mix of English and Chinese. The responses to Chinese only are too few to correlate. Similar figures for the overall language preference are 0.63 for English only, and 0.3 for a mixture.

A level	**r**
Physics	0.95
Maths	0.75
Chemistry	0.8
UoE	0.55
CLC	0.69
IT skills	0.93
IT competences	0.9
Language Preferences	
Lecture	
English	0.43
Mixed English and Chinese	0.47
Overall	
English	0.63
Mixed English and Chinese	0.3
Pre-test	0.88

Table 2.5. Correlation between groups for various analyses

The data from the two graphs showing IT skills, Figure 2.11, and competence, Figure 2.12, have correlation coefficients of 0.93 and 0.90 respectively.

One point of interest to note is that there is a 'peak' in the 'sum' score for the 1998-99 ITS cohort shown in Figure 2.8b. This corresponds to the higher preference for English shown in Figure 2.10b. However, the slight increase in the corresponding score for the 2001-2 ITS cohort does not translate into a higher preference for English - in fact exactly the opposite!

The correlation coefficient for the pre-test scores shown in Figure 2.13 is 0.88. Finally, a t-test was carried out on the three sets of A level scores combined, as shown in Appendix 2. This showed that the p-value of the analysis of all the scores was 0.78; that for the technical subjects only was 0.77, and that for language subjects only was 0.04.

From the above we can conclude that both groups studied are equivalent at intake, except for the language abilities, as shown by the AS level results. Therefore the splitting of the students into a control group and experimental group based on self-chosen criteria i.e. the degree course to be taken, is valid for comparative purposes.

2.7 Further analysis of the pre-test data

Assuming that it is possible to consider the two groups homogeneous, a more detailed analysis of the students' responses to the questions in the pretest leads to a better understanding of students' experience with, and attitudes to, computers and IT in general. This will be especially useful when considering whether such experience and attitudes affects student learning in an environment which is based around that technology.

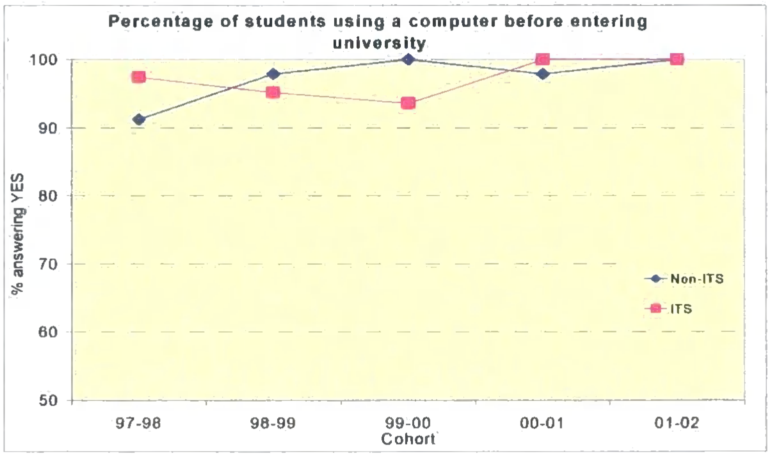

Figure 2.14 Percentage of students having used computers before entering university

The first question asked whether the student had used a computer before. The results are show in Figure 2.14.

As can be seen, and expected, the number of students having used a computer has now reached

100%. What is surprising is that just 5 years ago 6% of students had not used a computer before entering an engineering programme.

Question 2 asked whether the student felt comfortable using a computer. Although the response to this question was predicated on the interpretation of 'comfortable', it was never the less one of a number of questions, which when combined together, gave a good indication of the student's attitude. The results are shown in Figure 2.15.

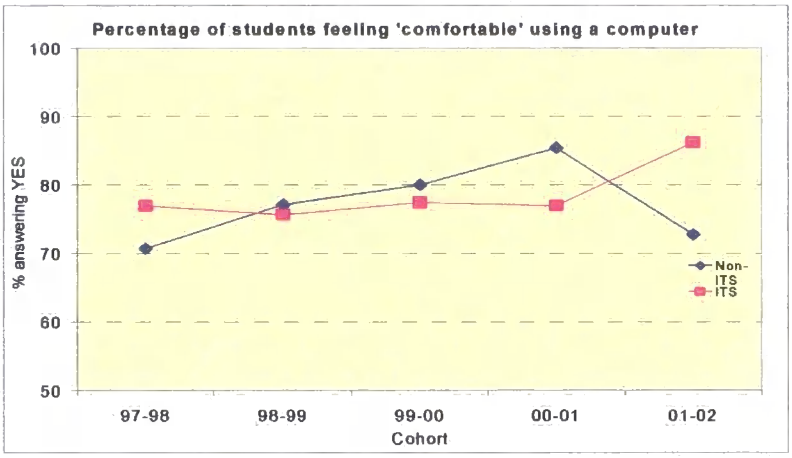

Figure 2.15 Percentage of students feeling 'comfortable' using a computer

It can be seen that the response has peaked, at 85% for the non-ITS group, but dropped for the last cohort, whereas the ITS group has continued to rise. Again, this is surprising considering that these are engineering students who will be spending considerable time using computers, not only in their courses, but also in their eventual jobs.

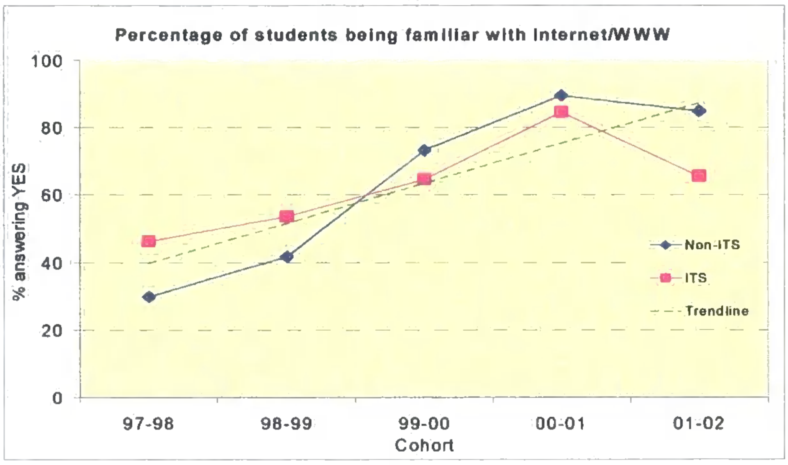

Figure 2.16 Percentage of students being familiar with the internet/WWW

The next questions considered the students' technical skills at using, or at least being familiar with, the most common computer applications. Question 3 concerned the use of the Internet/WWW. The responses are shown in Figure 2.16. The combined trendline shows that over the past 5 years familiarity with the web has risen substantially, although the 01-02 cohort shows a drop-off that is not expected.

Although their ownership, use of computers, and computer skills had risen steadily, their willingness to use computers as part of their course looks as though it is decreasing. However, the two courses studied were consistent in their responses, which indicated that this feeling was prevalent independent of the programme. One explanation could be that at the beginning of the survey period ownership of computers was low, although not significantly so, whereas web access, for example, has increased significantly. The decrease in willingness to use the computer/web/internet for studying seems to have dropped by about the same amount as the increase in ownership, indicating that at the beginning of the survey those using computers were more willing to use them. As ownership has increased as well as access to the web, the change in use has also affected the students attitudes. It now seems that the computer has become more of a social tool than one for study.

Figure 2.17 shows the aggregated results of all the questions concerning what might be called 'IT skills'. These questions asked about knowledge or experience of using word processors, spreadsheets and databases, and also includes the results of the question above concerning the Internet/WWW. A slight bias has been introduced to weight the results towards the more familiar applications, such as word processing, and against more uncommon ones, like databases. The results are shown in Figure 2.17. 100% would approximate to a good familiarity with all the common applications.

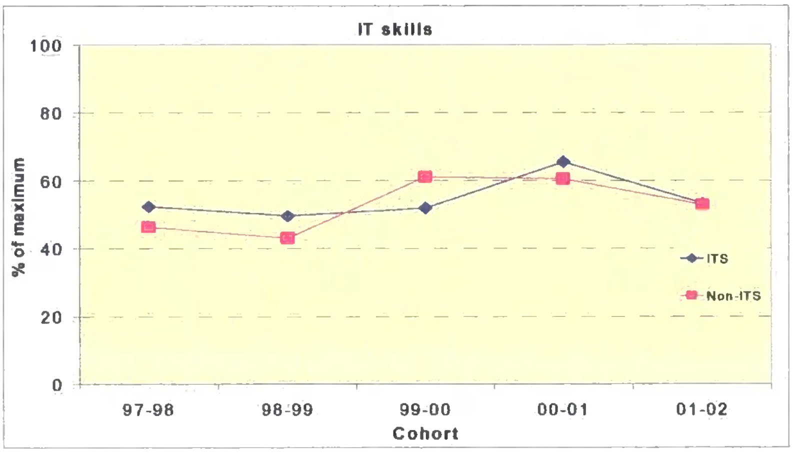

Figure 2.17 IT skills

Again, a saturation point seems to have been reached, with students averaging around 60% skill level on entry compared to those who would be considered adequately skilled.

Figure 2.18 shows those responding positively to a question that asked if they use a computer to do their homework. Surprisingly, the trend has been falling, with around 20% using computers for homework in 01-02. However, as will be seen below, over 95% of students owned a computer by that time.

The next set of questions focused on the students' reactions to computer use. Figure 2.19 shows the percentage of those who felt that using computers help them learn, and Figure 2.20, the percentage of those who enjoyed using computers.

The answers to these two questions seem to indicate that whilst most students considered computers a useful learning tool fewer students didn't really like using them for doing so, and this seems confirmed by the responses to the question on homework, Figure 2.18, where a small minority, around 20%, actually used them for such a purpose.

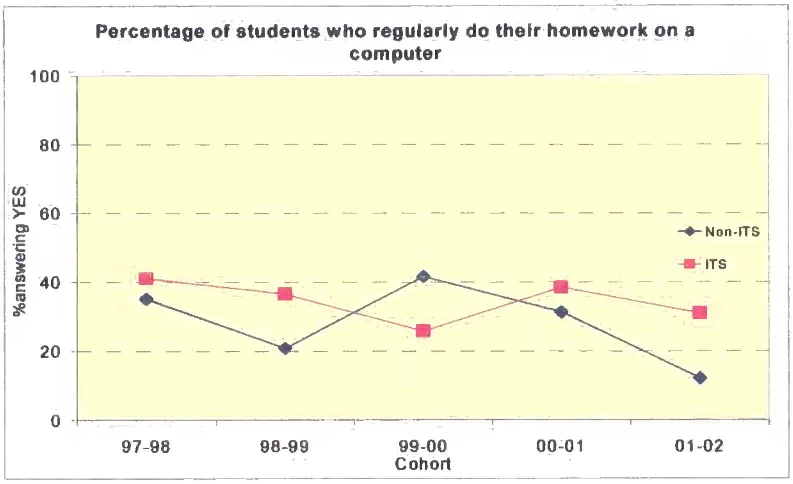

Figure 2.18 Percentage of students who use a computer to do their homework

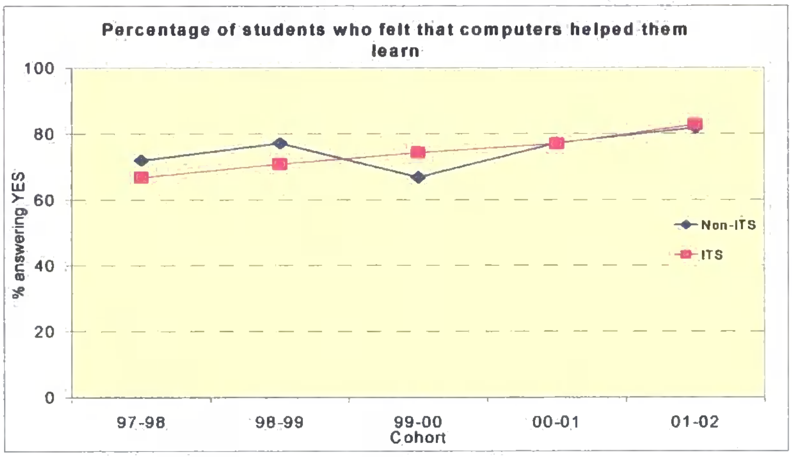

Figure 2.19 Percentage of students who felt that computers helped them learn

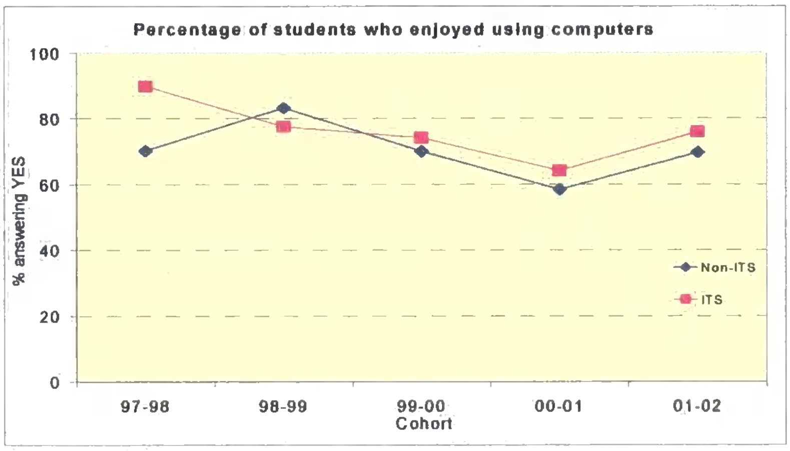

Figure 2.20 Percentage of students who enjoyed using computers

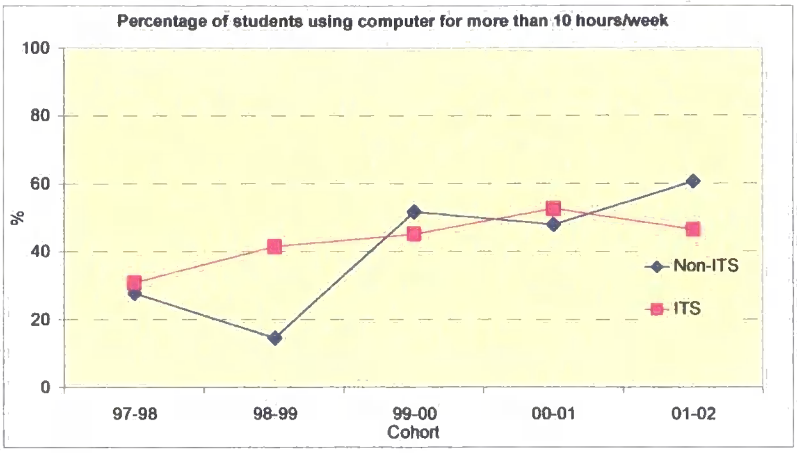

Figure 2.21 Percentage of students using a computer for more than 10 hours/week

However, it is interesting to see the responses to a question concerning the number of hours that they use computers each week. As can be seen from figure 2.21, that has been increasing over the years of the study. Although the original study requested detailed information about the number of hours, Figure 2.21 shows those who use the computer for more than 10 hours a week, a median point derived from the original survey.

A related survey, discussed in Chapter 4, showed that most of the time spent on the computer was used for game playing, surfing the web and chat rooms. Educationally related usage was a distant 4th in the list.

The responses to the questions relating to computer usage and the students' feelings were aggregated into a single response. This is shown in Figure 2.22. 100% would be a rough measure of someone feeling happy, competent and at ease when using a computer. The percentage is the class average of this very rough and ready measure. It can be seen that the feelings towards using computers have been fairly constant over the period of the survey.

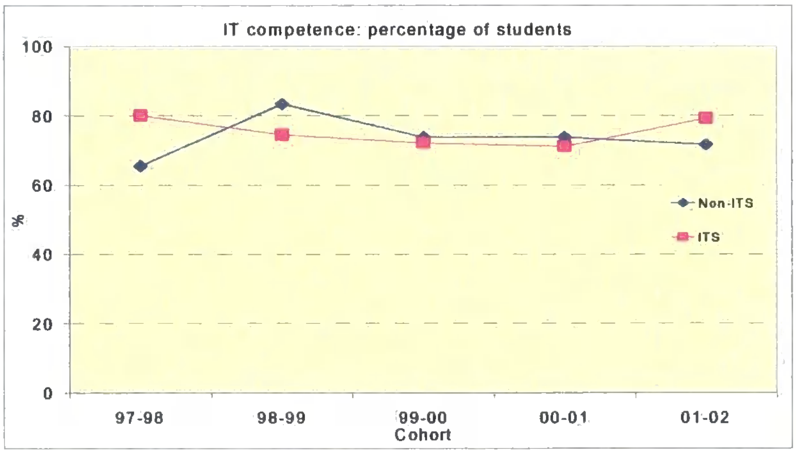

Figure 2.22 Feelings towards using computers. 100% would indicate a feeling of competence and comfort. Class average

The next three questions were related to the ownership of computers and the technical details. Figure 2.23 shows the percentage of students owing a computer, Figure 2.24 the percentage of these having a CDROM capability, and Figure 2.25 the percentage having a modem. These questions were considered important as much of the course material was placed on the web over the period of the survey and it was possible to access the university network from home via the web. At the same time, some of the coursework was also made available in CDROM format.

As was to be expected the responses followed very closely the development of technological progress. It can now be safely assumed that only a small minority of students do not own a computer, and this is probably because of financial problems. During the past two years the university has allowed students to borrow laptop computers which have wireless LAN capability for use on campus, and circumstantial evidence shows that those not owning a computer themselves now have access to one for most of their study time.

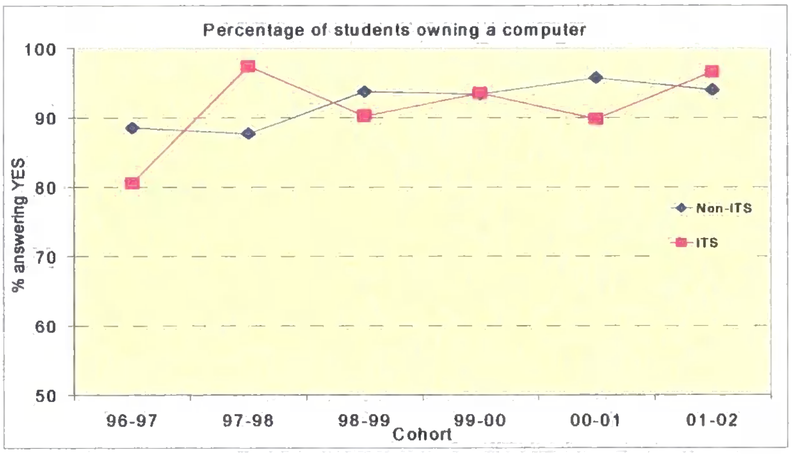

Figure 2.23 Percentage of students owning a computer

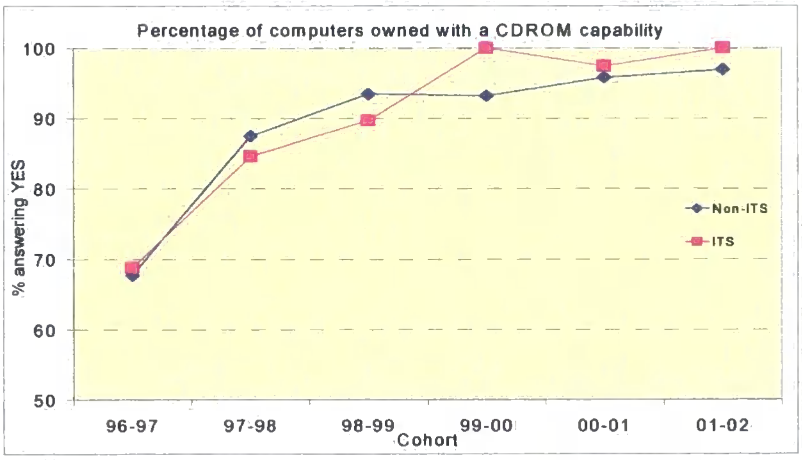

Figure 2.24 Percentage of computers owned with a CDROM capability

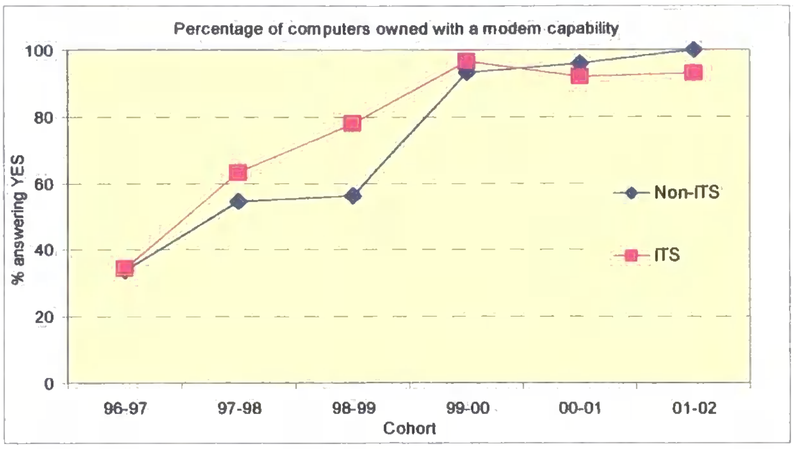

Figure 2.25 Percentage of computers owned with a modem capability

Two final questions related to the students' thoughts about how the courses should be presented. As the courses became more web based and interactive, it became possible to allow them to study in a self-learning mode, and not attend classes. In fact, the responses to a question asking if they would consider using this mode of learning, shown in Figure 2.26, indicate a trend away from doing so.

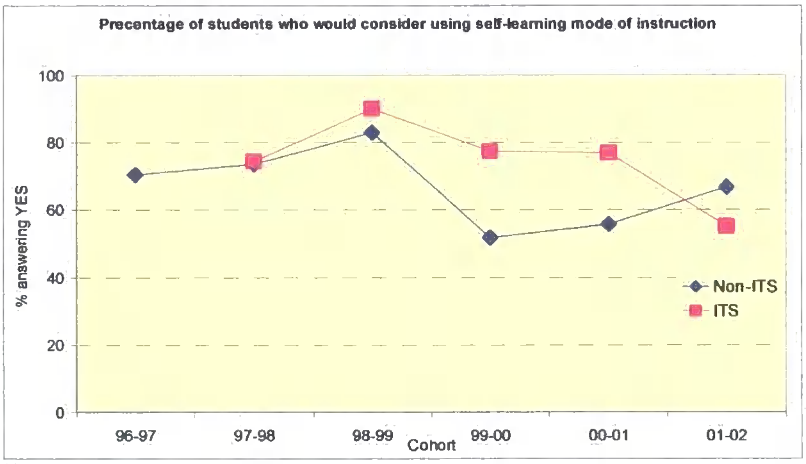

Figure 2.26 Percentage of students who would consider using self-learning mode of instruction

A related question asked if, owning a modem, they would consider doing some study work at home

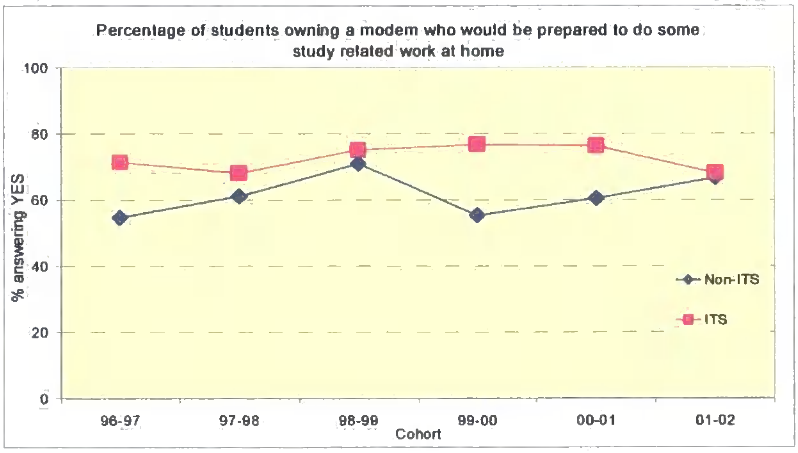

Figure 2.27 Percentage of students owning a modem prepared to do some online study related work at home

online. The responses are given in Figure 2.27. This percentage has remained remarkably steady over the period of the study even though modem ownership has increased from 25% to near 100% over that time.

2.8 Discussion of questionnaire answers

Many courses established over the past five years or so have made basic assumptions concerning the level of computer literacy of the students, and this is especially true of engineering courses. There has also been a very substantial move away from the more traditional pedagogies of engineering education to those which are more student-centred and interactive.

Admittedly, the two bachelor's degree programmes studied at City University of Hong Kong do not reflect the situation on a wider basis - they just reflect the unique conditions of the Hong Kong educational system that is currently in transition from a pedagogy formally based on rote learning to one more oriented towards more investigative pedagogies. The students studied in the survey reported here were products of a system in transition and their attitudes towards learning showed this, in their classroom behaviour as well as their general knowledge of the subjects they elected to study. The next chapter shows that the aptitudes of the students had dropped over the period of the study even though their entrance grades had improved. This dichotomy also seems to have been seen in the results of the study reported here.

For example, although their ownership, use of computers, and computer skills had risen steadily, their willingness to use computers as part of their course has decreased. However, the two courses studied were consistent in their responses which indicated that this feeling was prevalent independent of the programme.

One explanation could be that at the beginning of the survey period ownership of computers was low, although not significantly so, whereas web access, for example, has increased significantly. The decrease in willingness to use the computer/ web/internet for studying seems to have dropped by about the same amount as the increase in ownership, indicating that at the beginning of the survey those using computers were more willing to use them. As ownership has increased as well as access to the web, the change in use has also affected the students attitudes. It now seems that the computer has become more of a social tool than one for study. It is therefore not possible to correlate the increase in computer ownership with an increase in the desire to use computers for learning. This belief, which may be erroneous if the results from the survey reported here are corroborated, has been a foundation of the move towards more web based interactive learning pedagogies. Vast investments have been made in designing and evaluating these new pedagogies, many of which have not taken into account the changing nature of student attitudes towards computers.

From the survey reported here a number of clear trends can be discerned as far as Hong Kong is concerned. They may or may not have relevance to other countries. First, ownership of computers by first year engineering students is nearly 100%, and these computers are equipped with CDROM and modem capabilities. 100% of students are able to make use of computer applications, although these are heavily weighted towards web/ internet access and word processing but not spreadsheets and/or databases. There are a substantial minority - about 20% - of students who do not feel comfortable using computers, although over half those reporting used the computer for more than 10 hours a week.

Around 60% of students should be considered computer literate with respect to their knowledge of basic applications. The majority of students - around 80% - think that using computers helps them learn, but around 70% would be prepared to use computer-based self-learning pedagogies. In fact, the percentage of students that use a computer to do their (school) homework is only around 30% and dropping.

Clearly, these attitudes towards computer-based or computer assisted learning are of concern to those academics who are involved with developing such courses, and this surely has implications for such areas as distance learning which are becoming more and more dependent on internet-based-learning pedagogies.

Having established the academic equivalence of the two groups in this chapter, we will now consider, in the next chapter, how they performed in the assessments, and whether there was any significant difference in performance and learning.

Chapter 3

Analysis of the results

3.1 Core competencies

Before it is possible to compare performance in assessments over the period of the study on an inter-cohort basis, the possible variation in core competencies in the academic subjects studied at A level needs to be considered. These can be measured by an analysis of the second part of the pre-test questionnaire, dealing with technical questions. It may then be possible to determine if there is any relationship between the falling score for the overall test mark, and if one aspect of the test is responsible. The second part of the test itself - see Appendix 1 - covers four basic areas. The main one is electronics, which is itself made up of several areas, such as basic electrical theory, devices and applications. For this analysis all these have been grouped into a single variable. The other three areas are physics, computing and mathematics. The physics questions were mainly concerned with basic physical phenomena such as electromagnetism, electrostatics and dimensions/ units. The computing section was basic binary concepts, whilst the maths was concerned with trigonometric concepts used in electronics. Figures 3.1 to 3.2 show the changes in percentage of the class giving correct responses to each grouping.

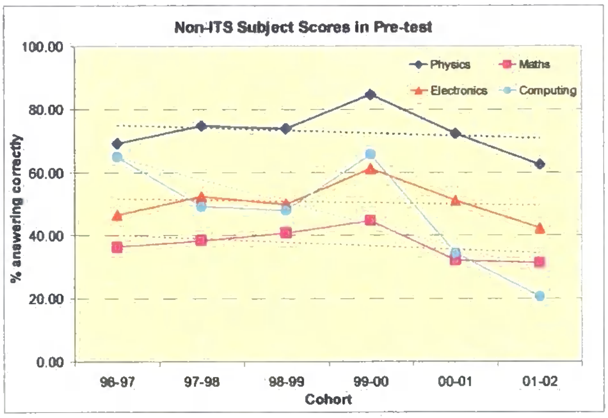

Figure 3.1 Percentage correct responses to the pre-test by subject area of the question for Non-ITS group

As can be seen from Figures 3.1 and 3.2, other than for electronics which remained fairly constant, all the other subject areas showed a decline in correct responses over the period of the study. The surprising decline is in the understanding of basic computing theory, which shows a significant decrease in correct responses. The implications of this are discussed below, as well as in Bradbeer (2002a and 2002b).

In Figure 3.3, both courses are considered together, and the results for the 1999-2000 cohort have been taken out of the trendline, owing to the different nature of the testing conditions, and the resulting anomaly (In 1999-2000 the pre-test questionnaire was administered in a different way to the other years. The instructor allowed discussion amongst the students, so that the result reflects a group response more than an individual response, as in other years).

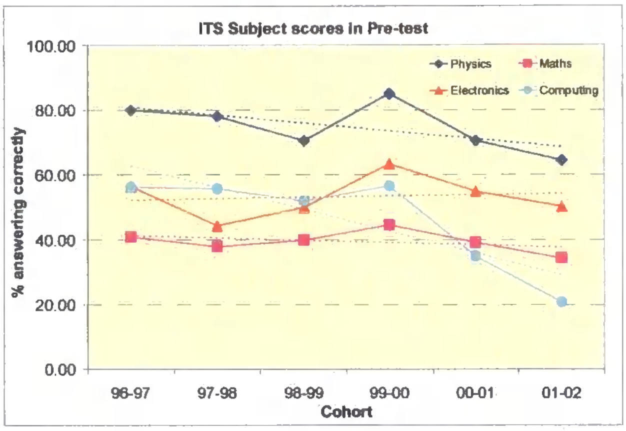

Figure 3.2 Percentage correct responses to the pre-test by subject area of the question for ITS group

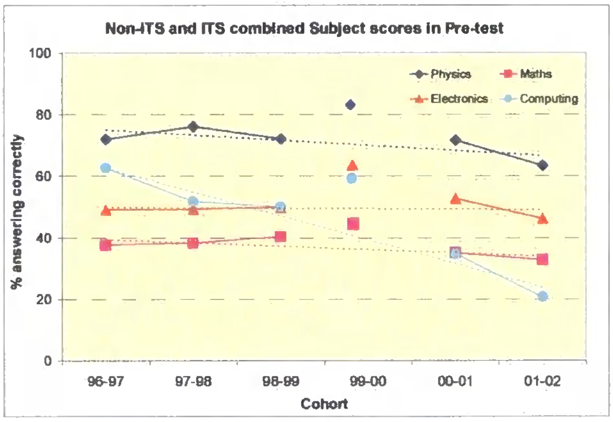

Figure 3.3 Pre-test subject scores for combined results of Non-ITS and ITS groups with anomalous data from 1999-2000 cohort removed.

3.2 Implications for course content

The changing extent of the basic knowledge of new entrants has meant that assumptions made in 1996 cannot be applied in 2002. This has had implications in the syllabus content of the courses themselves. The amount of time needed to cover basic theory that should have been covered in the A level syllabus and was not - or may have been but was not understood by the students - increased substantially over the period of the study. So much so, that the courses themselves have been drastically rewritten to cope with this. From 2002, two completely new courses replaced those taught for the previous 6 years. These now emphasise the design aspects of electronics and not concentrate so fully on analysis.

Also, a more problem-based, student-centred learning approach is being taken, based upon the experiences of using integrated studio teaching for the BEMTE course.

A brief look at the first semester syllabuses for 1996, 2001 and the new 2002 courses will show clearly the changes that have had to be made to accommodate the changing environment.

> 1996: Revision of basic electric and magnetic fields. Inductance, self-inductance, mutual inductance. Transformers; principles of operation and applications. Revision of circuit theorems and laws; Simple dc transient analysis. Revision of ac fundamentals; Phasors and complex numbers. Three phase systems. Revision of basic semiconductor devices; modes of operation. Amplifier circuits. Feedback. Introduction to the operational amplifier. Power amplifiers. The transistor as a switch.

> 2001 Basic Magnetic Fields: Revision of basic magnetic laws. Inductance, self-inductance, mutual inductance, Magnetic circuits. Transformers; principles of operation and applications. Basic Electric Fields: Capacitance and capacitors, energy storage in capacitors. DC Circuit Analysis: Revision of circuit theorems and laws. Simple dc transient analysis. AC Circuit Analysis: Revision of ac fundamentals. Phasors and complex numbers; reactance, impedance, power and power factor. Semiconductor Devices: Revision of basic semiconductor devices; pn junction, characteristics of junction diode, diode circuits, bipolar transistors, field effect transistors, modes of operation.

> 2002 Circuit analysis techniques, basic discrete semiconductor devices, integrated circuit fundamentals, the transistor as an amplifier, the transistor as a switch.

It can be seen that by 2001 most of the first semester course had been taken up with basic revision of fundamentals, which were assumed to be generally known by the students in 1996, an assumption which could not be made in 2001. A subjective analysis of tests, quizzes and coursework over the period of the study support these assumptions.

The 'knock-on' effects of having to cover fundamentals in the first semester meant that less coverage could be given to the more design aspects of electronics in the second semester and this itself meant that courses taken in the second and third year were also affected, in most cases adversely. This was especially true of the virtual elimination of power electronics from the syllabus. There was also some criticisms that basic electronics courses, which were designed to support the manufacturing and mechatronics engineering programmes should not become applied physics courses!

Another reason for changing the course structure was the change in the BEME programme to a BEng in Manufacturing and Information Systems Engineering (BEMISE). The basic electronics courses for this new programme would become second year electives, not first year core courses. The BEMTE programme was also revised to become more design mechatronics based, although still keeping the basic electronics courses in the first year core.

This led to a complete rethink of what such a basic course in electronics should provide, both as a student learning experience and as a basis for further study in later years. It was decided that most theoretical 'applied-physics' fundamentals should be ignored completely, and that a more systems approach should be taken in teaching the basic electronic circuits. In other words, any design processes should be based around the use of 'black-box' modules, which would correspond roughly to the most popular integrated circuit packages, such as logic gates, operational amplifiers etc.

At the same time, there would be a more 'hands-on' experience with simulation and experiment replacing basic theory. This would seem to be shifting the course more towards the technician engineer pedagogy compared to the more traditional university approach. Also, group based projects would replace more individual learning experiences.

Bradbeer (2003) discusses the implications for the changing course content, and it is clear from the data presented in that paper and also presented above, that there has been a gradual decline in the basic knowledge of physical fundamentals, maths and computing over a six year period from 1996, even though the grades achieved at A level have been rising. This may be a consequence of the Hong Kong government's policy of rapidly increasing the number of university places available for 18 year olds, from around 6% of school leavers to today's 18%, starting in the early 1990s.

It would also seem to indicate that the Hong Kong Examination Authority has condoned a gradual and sustained inflation in grades over that period of time. Also, even though universities and departments are quite happy to publicise the fact that quality of their student entrants is getting relatively better, in fact this hides the fact that, in absolute, terms they are not.

The implications for syllabus and course design are even more profound, and means that a constant and continuing shift in course content and level is needed to give the students a meaningful learning experience that is suited to their level of knowledge. Unfortunately, programme leaders and course lecturers who just take the raw entrant examination grades as an indication of how to 'pitch' their courses are in danger of getting it wrong, with disastrous consequences, which can be seen in the lack of commitment and energy that students have for their studies. This problem will be addressed in greater detail in Chapter 5.

The implications for the intra-cohort comparison is that it would not be possible to compare cohort with cohort over the period of the study as the course content changed during this period. However, there would be few problems with an inter-cohort comparison as the changes were identical for each of the two courses under study.

3.3 The assessments used in the comparison.

Although the students studied two consecutive courses, only a detailed analysis was made of the first one. The main objective of the assessments used was to determine whether there was an educationally significant difference between the performance of the two groups. Many students in Hong Kong have been taught to study in a strategic manner, mainly for the purpose of passing examinations. This is one of the main failings of the government school education system in Hong Kong. At the same time, students are not prepared for a university environment, where a less exam oriented assessment is used, with far more emphasis on project and lab based work than usually found in local secondary schools. The assessment tools designed to determine the learning outcomes also had to be acceptable to the university assessment scheme, which limited the amount of innovation that could be used. Consequently, a series of tests, projects and reports were designed which closely mirrored accepted practice for the programmes, whilst trying to probe more deeply into the learning taking place.

One of the objectives was to establish whether deep or surface learning was taking place. Deep and surface are two approaches to study, derived from original empirical research by Marton and Säljö (1976) and since elaborated by Ramsden (1992), Biggs (1987, 1993) and Entwistle (1981), among others. According to Atherton (2005), it is important to clarify what they are not:

> Although learners may be classified as "deep" or "surface", they are not attributes of individuals: one person may use both approaches at different times, although she or he may have a preference for one or the other.
>
> They correlate fairly closely with motivation: "deep" with intrinsic motivation and "surface" with extrinsic, but they are not necessarily the same thing. Either approach can be adopted by a person with either motivation.

There is a third form, known as the "Achieving" or strategic approach, which can be summarised, as Atherton does (ibid), as "a very well-organised form of surface approach, and in which the motivation is to get good marks. The exercise of learning is construed as a game, so that acquisition of technique improves performance. It works as well as the analogy: insofar as learning is not a game, it breaks down".

Ramsden (1998) summarised the two approaches as follows: Deep learning focuses on "what is signified", relates previous knowledge to new knowledge, relates knowledge from different courses, relates theoretical ideas to everyday experience, relates and distinguishes evidence and argument, organises and structures content into coherent whole and emphasises is internal, from within the student. Surface learning, on the other hand, focuses on the "signs" (or on the learning as a signifier of something else), focuses on unrelated parts of the task, information for assessment is simply memorised, facts and concepts are associated unreflectively, principles are not distinguished from examples, task is treated as an external imposition, and the emphasis is external, from demands of assessment.

Although both Entwistle (1981) and Biggs (1987) had developed methodologies for analysing whether deep or surface learning was taking place, it was not possible to introduce these into the courses as they were structured at the time of the study. From 2005, all first year students at CityU have to take part in a Learning and Study Strategies Inventory (LASSI) survey, based upon the work of Weinstein, Schulte, and Palmer, Ph.D. at University of Texas (Weinstein et al, 2000).

This is beginning to give some of the detailed information needed to make such a comparison, but as they were not able to be used at the time of the study, another approach was needed. Consequently, a simplified approach had to be taken, and this was based around a mixture of multiple choice tests, group based projects (for the ITS group), lab work for the non-ITS group, and descriptive examination questions that probed more deeply. The analysis of the results could then determine whether one group scored higher on the multiple choice questions - possibly indicating more surface learning, as compared to the descriptive questions in the final examination, which hopefully indicated the level of deep learning.

A multiple choice test was given midway through the first semester. This multiple choice test was based upon material taught in the first half of the semester, and consisted of 30 questions, mainly to do with the basics of electricity, magnetism and simple electric circuit theory. The test was the same for each cohort. The answers were not given to the students, just their marks.

At the end of the first semester the students sat an examination which consisted of two parts. The first was a multiple choice section of 25 questions, based on work for the whole semester. This accounted for 25-30% of the final mark. The rest of the exam was a more traditional one, with students have to answer three questions from four in a more descriptive manner. Again, the questions covered the whole of the syllabus.

Three sets of multiple choice questions were used, and rotated on a 3 year pattern, so that no test was used twice during a three year period. To ensure that the standard of the multiple choice test was approximately consistent each year, a number of colleagues compared the papers, and adjustments were made accordingly. As mentioned at the beginning of the chapter, intra-cohort comparison was not an easy task to undertake, owing to the changes in the syllabus during the period of the research. However, as the same test was given to both courses, inter-cohort comparisons could be reliably made. No analysis of the answers was made to determine whether any of the four subject areas tested in the pre-test, and reported above, varied form cohort to cohort.

The final grading for the semester was based upon a combination of coursework, which included two assignments (not part of this study), mid semester test, and laboratory/group work, and examination performance. For the first two years of the study this split was 60:40 examination:coursework changing to 70:30 in the third year. To determine whether there was any relationships between the results, the two examination components, and the final marks including coursework, were kept separately.

Although the second semester course was not studied in such detail, the students sat a mid term test, all questions being descriptive with some calculation, followed by a final exam that was of a more traditional style. They also carried out a number of assignments and laboratory based project work. Again, final grading was based upon a combination of coursework and examination performance, in the same ratio as Semester A. The results of the mid-semester test in Semester B for 1996-97 and 1997-98 were not available for analysis, and have been left out of the data. The results from the assessments in the second semester course are not analysed in great detail, but will be given for completeness only.

Owing to the nature of the course structure, there are always a number of repeat students in each class. These have been eliminated from the analysis. Similarly some students are given exemption from taking the Semester A course. These students have been eliminated from the analysis of the Semester B results.

The results are given as percentages of maximum marks. Grades have not been shown, as the change in course structure affected the grading system but not the marking system. In Semester A, the final mark is shown in three sections - first, the total mark for both coursework and examination, then as the mark for the multiple choice examination, and then for the descriptive examination. In Semester B, the final mark is shown, first as a total for coursework and examination, and then as examination only.

3.4 Implementation of the Integrated Teaching Studio.

One other factor that has to be taken into account when analysing the results is the fact that the construction and inauguration of the ITS was fraught with problems, which resulted in some variation of teaching pattern compared with that originally planned. In the first year, 1996-97, the interface cards to provide the laboratory component of the course were not working properly. It was therefore decided to use a normal laboratory for all experimental based work. In 1997-98, the interface cards provided proved impossible to use for the experimental work in Semester B, so this was also held in a normal laboratory. There have been few problems with this aspect of the implementation since then, and all experimental work for the ITS-based classes have been run as planned.

From 1998-99, the multimedia courseware used in the ITS was also used as part of the presentation graphics in the lecture theatre for the non-ITS class. In 1999-2000 the classes were taught by colleagues as I was on sabbatical leave at Rennsalaer Polytechnic Institute in New York for Semester A. These colleagues did not use studio teaching and taught both classes in traditional mode. Also, each colleague only taught one of the courses, so there were different styles for each course. The results from these classes in semester A have been included in this study as they provide an interesting comparison for the effectiveness of the ITS based teaching, although only the pre-test and final examination have any data that can be useful. In Semester B of that year I only taught the ITS class, and not the non-ITS class. The results for both groups in Semester B 1998-99 have, therefore, been ignored in this analysis.

From the start of the 2000-2001 academic year, the studio has been functioning well, and there have been few problems since then that might affect the overall results.

3.5 Cohort analysis

The results for each assessment in each cohort are shown in Appendix 6. Each year shows the results in three ways, always comparing the inter-cohort analysis. Where available the results compare each of the two groups in each cohort for the following:

Pretest
Mid-semester test Semester A
Final total mark for Semester A end-of-semester assessment (coursework and exam)
Total examination mark for Semester A end-of-semester exam
Multiple choice section mark for Semester A end-of-semester exam
Descriptive section for Semester A end-of-semester exam
Mid-semester test for Semester B
Final total mark for Semester B end-of-semester assessment (coursework and exam)
Examination mark for Semester B end-of-semester exam

The first is a box and whisker plot, with confidence intervals. The second is a table showing the data used to draw the box-plots and parametric statistics for each year. The third is a table showing the calculation of effect size for each type of assessment, or outcome measure. Each cohort will be examined in turn, with a meta-analysis carried out on that cohort's data to determine the overall effect size.

Effect size has been used in preference to the more common methods of statistical significance for three main reasons. First, it is the size of the impact that is of substantive importance, and yet statistical significant testing is dependent on sample size – the same effect acquires statistical significance with larger samples. Secondly, effect sizes can be compared from one study to another and under suitable circumstances can be combined using meta-analysis. Thirdly statistical significance testing employs arbitrary cut-offs. Such issues became apparent during the study. Initially, all the data analysis was based on statistical significance assuming a null hypothesis.This gave some results that were hard to interpret. For example, some of the intra-group comparisons showed a statistical significance with $p<.05$ but only just ($p=.048$) whilst others were not significant ($p>.05$) but only just ($p=.052$).. Is there really any difference, educationally between the two? The use of Effect Size overcomes this problem.

Effect Size is usually defined as the (mean of the experimental group - mean of the control group)/ standard deviation of the control group. However, a number of assumptions are made in this formula. First, the control group is assumed to be large. If it is not, and this is true in this study, a pooled estimate value of standard deviation is used. Secondly, if the population of each group is small, then there will be a bias in the calculation. Thus Hedges correction is used (Hedges and Olkin, 1985). Similarly, it is useful to know the CI of the Effect Size calculated. For the analysis used in this study, an Effect Size calculator devised by Robert Coe (2000) was used. A more detailed explanation is given in Appendix 6.

In the following sections only the standardised Effect Size (with Hedges transformation) will be shown. The treatment group is the ITS group, and the control group is the non-ITS group. Reference should be made to the full data in Appendix 6. In the following analyses, the overall effect size for Semester A and Semester B assessments does not include the pre-test results. As there were no significant differences between the pre-test scores for all but the final year of the study, this appears a rational decision. Appendix 6 also contains data analysis of the confidence interval and p value for each cohort.

3.5.1 1996-97

pretest	mid a	fin a mark	fin a exam	fin a mc	fin a desc	fin b mark	fin b exam
0.18	0.94	1.10	0.95	0.67	0.88	-0.11	0.35

Table 3.1 Standardised Effect Sizes for 1996-97 cohort for each assessment.

It is clear from the data for the pre-test that there is no significant difference between the groups. However there is a significant difference between the two groups for the Semester A mid-test, as well as for all measures of the final Semester A assessment. However, there is little significant differences between the Semester B results.

For Semester B, although the non-ITS group gained higher marks in the overall assessment, the ITS group did better in the examination. The laboratory marks for the ITS group were lower than that for the non-ITS group, which may have been a reflection of the rather chaotic nature of the practical work that year.

3.5.2 1997-98

pretest	mid a	fin a mark	fin a exam	fin a mc	fin a desc	fin b mark	fin b exam
-0.02	0.30	0.36	0.26	-0.09	0.38	0.04	0.06

Table 3.2 Standardised Effect Sizes for 1997-98 cohort for each assessment.

For this cohort the message is rather mixed. It is clear that there is no significant difference between the two groups for the pre-test. However, the effect size for the Semester A assessments is low, although indicating some effect in favour of the non-ITS group. This is especially true of the differences between the multiple choice and descriptive components of the final semester exam, where the ITS group scored relatively higher, with a negative ES for the multiple choice part, indicating a higher average mark for the control group. Again, there is no significant difference between the two groups in Semester B.

3.5.3 1998-99

pretest	mid a	fin a mark	fin a exam	fin a mc	fin a desc	mid b	fin b mark	fin b exam
0.16	0.70	0.88	0.89	0.16	0.94	-0.10	0.48	0.57

Table 3.3 Standardised Effect Sizes for 1998-89 cohort for each assessment.

The result for this cohort is very similar to that for that for 1996-97.

3.5.4 1999-2000

pretest	fin a mark	fin a exam
0.04	-0.61	-0.39

Table 3.4 Standardised Effect Sizes for 1999-2000 cohort for each assessment.

This cohort was an anomaly, but, as has been explained above, is kept for comparison. As can be seen from Table 3.4, there was no significant difference between the two groups in the pre-test, but in the final assessment in Semester A, the course which has been previously classified as non-ITS, i.e. the BEME students, scored higher marks than the other, BEMTE, group. As they were both taught using traditional methods in the same class, it is a noted that the consolidated effect size for the semester was - 0.5, indicating a significant difference in favour of what would otherwise have been the control group.

3.5.5 2000-01

pretest	mid a	fin a mark	fin a exam	fin a mc	fin a desc	mid b	fin b mark	fin b exam
0.08	-0.10	0.24	0.37	0.29	0.35	0.29	0.32	0.17

Table 3.5 Standardised Effect Sizes for 2000-01 cohort for each assessment.

Again, it can be seen that there was no significant difference between the two groups for the pretest, but in this cohort, the non-ITS group scored higher for the Semester A mid-test. This was probably an anomaly, as the expected pattern for the final Semester A assessment asserted itself, although with a smaller effect size. The difference between the two groups reduced in Semester B.

3.5.6 2001-02

pretest	mid a	fin a mark	fin a exam	fin a mc	fin a desc	mid b	fin b mark	fin b exam
0.50	0.63	0.48	0.40	0.45	0.35	0.18	0.21	0.01

Table 3.6 Standardised Effect Sizes for 2001-02 cohort for each assessment.

This cohort was slightly different to the others, in that there was a significant difference between the two groups for the pre-test. It is interesting to note this result - as the data provided in Appendix 2 indicates that there should be homogeneity between the groups except in language abilities, where the non-ITS were significantly better than the ITS group! The ITS group continued to score higher than the non-ITS group for all assessments, but again, the narrowing of the difference in Semester B is noticeable.

3.5.7 Overall assessment effect size

If all the cohorts except 1999-2000 are considered together, it is possible, using meta-analysis, to determine what the overall effect size for each assessment will be. This is shown in Table 3.7.

pretest	mid a	fina mark	fin a exam	fina m/c	fin a desc	mid b	fin b mark	fin b exam
0.16	0.49	0.61	0.58	0.25	0.58	0.12	0.19	0.23

1999-2000 cohort results not included

Table 3.7 Standardised Effect Size for each assessment for all cohorts except 1999-2000

Again, it can be seen quite clearly that there was no significant difference between the two groups as far as the pre-test was concerned. However, for Semester A, there was a significant difference between the two groups for all but the multiple choice element of the final examination. The implications will be discussed later.

Similarly, although there was a difference between the two groups in Semester B, it was not so pronounced.

3.5.8 Semester effect size

An alternative way of looking at the results is to perform a meta-analysis on all the assessments, except the pre-test, for each semester for each cohort, except for 1999-2000, which was for the final examination in Semester A only. This is shown in Table 3.8.

	1996-7	1997-8	1998-99	1999-2000	2000-01	2001-02
sem a	0.91	0.24	0.72	-0.50	0.23	0.46
sem b	0.12	0.05	0.32	-	0.26	0.13

Pre-test results not included

Table 3.8 Standardised Effect Sizes for each cohort for each semester

These results are from a meta-analysis of all the results for all the assessments in each semester for each cohort. The overall Effect Size for all the assessments in each semester is shown in Table 3.9

all sem a	0.51
all sem b	0.19

1999-2000 cohort results not included
Pre-test results not included

Table 3.9 Overall effect size for all cohorts for each semester

3.5.9 Overall effect size

Finally, a meta-analysis is performed on all the assessments over all cohorts, excluding the pre-test. This is shown in Table 3.10. Little can be read into this, as the metric for Semester B was significantly different to that for Semester A, as mentioned above. However, notwithstanding this, there is some noticeable effect present.

	1996-7	1997-8	1998-99	1999-2000	2000-01	2001-02	All
all	0.68	0.19	0.57		0.24	0.34	0.40

1999-2000 cohort results not included
Pre-test results not included

Table 3.10 Overall Standardised Effect Size for both semesters for each cohort, and for the whole period of the study.

3.6 Discussion

It was shown in Chapter 2 that there was close equivalence in the entrance qualifications of both groups - the control non-ITS group, and the experimental ITS group - see Appendix 2 for the statistical analysis. The data for the pre-test has also been analysed and the average effect size across all cohorts was found to be 0.156, indicating approximately a 10% non-overlap (See Introduction to Appendix 6). Alternatively, a t-test analysis of the pre-test data shows a p of 0.88, see Table 3.11 below. All this strongly suggests that the two groups are equivalent on entry.

Source of Variation	*F*	*P-value*	*F crit*
Between Groups	0.022161	0.88462	4.964603

Table 3.11 t-test analysis for pre-test marks, all cohorts

It is therefore instructive to consider the effect of the difference in teaching methodologies on the final assessments of the two groups. From Table 3.9 it can be seen that there is a significant effect in Semester A, with a lower effect in Semester B. Table 3.10 shows that the effect size for both semesters is 0.40, indicating a lower effect overall, but still important. This effect size means that the mean of the experimental group is at the 66th percentile of the control group. There is little doubt that the teaching methodology had an effect on the assessment results.

Further analysis of the data shown above does raise some interesting questions, however. Why does the effect seem to 'wear off' in the second semester? There also seems to be no simple relationship between the difference in pre-test results and the final result. For example, in 2001-02, the ITS group had significantly higher marks for the pre-test, and the assessment at the end of Semester A showed a similar effect, but at the end of Semester B the difference between the two groups was small! These questions will be addressed in the conclusions.

It is interesting to note the similarity between the results given here and those reported in two meta-analyses carried out on small group collaborative learning. The first, by Johnson, Johnson and Stanne (2000) considered 164 studies investigating eight cooperative learning methods. This covered schools as well as colleges. Consequently, we will not look at this study in detail, other than to comment that the authors state that the consistency of the results and the diversity of the cooperative learning methods provide strong validation for its effectiveness.

The other meta-analysis study was in 1998 by Springer, Stanne and Donovan (1998). This analysed 383 reports in literature related to small group learning in post-secondary science, maths, engineering and technology (SMET) courses from 1980 or later, 39 which met the inclusion criteria for the meta-analysis. These were, first that the undergraduates were on science, mathematics, engineering, or technology courses or degree programmes at accredited post-secondary institutions in North America. Secondly, studies must have incorporated small-group work inside or outside of the classroom. Thirdly, the study was conducted in an actual classroom or programmatic setting rather than under more controlled laboratory conditions. Fourthly, the research was published or reported in 1980 or later on the grounds that recent studies may be more relevant to the current global context in which students learn, and fifthly, the research reports enough statistical information to estimate effect sizes.

Of the 39 studies analysed, 37 (94.9%) presented data on achievement, 9 (23.1%) on persistence or retention, and 11 (28.2%) on attitudes. Most of the reports retrieved did not qualify for inclusion because they were not based on research.

According to Springer et al (ibid):

> "The main effect of small-group learning on achievement, persistence, and attitudes among undergraduates in SMET was significant and positive. Based on 49 independent samples, from 37 studies encompassing 116 separate findings, students who learned in small groups demonstrated greater achievement (*Effect Size, d* = 0.51) than students who were exposed to instruction without cooperative or collaborative grouping. Similarly, based on 12 independent samples, from 11 studies encompassing 40 findings, students in small groups expressed more favourable attitudes (d = 0.55) than their counterparts in other courses or programmes. Finally, based on 10 independent samples and findings from 9 studies, students who worked in small groups persisted through SMET courses or programmes to a greater extent (d = 0.46) than students who did not work cooperatively or collaboratively".

Ignoring the effects for gender, race and group size, which were not included in the study in this thesis, two significant effects were reported.

First, for the procedures used in small-group learning, Springer et al state:

> There was a higher average weighted effect for supplemental instruction (d = 0.65) - typically study sessions outside of class - than for in-class instruction (d = 0.44). The pattern of differences was reversed for attitudinal outcomes: more favourable effects on attitudes were evident for in-class instruction (d =0.59) than for supplemental instruction (d = 0.24). The data suggested that greater time spent working in groups had significantly more favourable effects on students' attitudes, with effect sizes of 0.77 for high group time, 0.26 for medium, and 0.37 for low. No significant association between time spent in groups and achievement was evident".

The other effect was that on the outcome measure:

> "The effects of small-group learning on achievement were significantly greater when measured with exams or grades (d = 0.59) than with the standardised instruments (d = 0.33). Although small-group work among students had significant and positive effects on students' attitudes toward learning the material (d = 0.56) and their self-esteem (d = 0.61), the effect on their motivation to achieve (d = 0.18) was one of only two nonsignificant results of small-group work that we report in this study".

It would be instructive to complete another meta-analysis of the published literature in this field with data published since 2000. Many papers have recently been published on studio teaching - see next chapter - and further data is now available that was not included in these two analyses. However, the data presented above does seem to support the findings of the study in this thesis which gave the overall effect size of 0.4 for both semesters or 0.51 for the first semester. These two effect sizes are within the range of those reported by Springer et al above. They found an effect size of 0.51 for greater achievement for those learning in small groups in a collaborative or cooperative manner. They also found that those who worked in small groups persisted in their courses or programmes to a greater extent - an effect size of 0.46, as reported above. This would seem to be confirmed from attendance data taken during the duration of the study reported in this thesis. For the non-ITS group attendance at lectures and tutorials started off high (around 95%) at the beginning of the semester, but dropped to around 50% by the end. For the ITS group attendance has remained at around 95% throughout the course, a figure which continues to this day.

Also, from the data presented in this study in Section 3.5 above, it is clear that the highest consistent effect sizes were for the final examination in Semester A. This would seem to corroborate the findings of Springer et al reported above, that The effects of small-group learning on achievement were significantly greater when measured with exams or grades (d = 0.59). This compares with an effect size of 0.58 in the current study.

Having established that, at least in the first semester, there is a difference in educational performance between the two groups based on their assessment results, it is now useful to consider the students' reactions when presented with the studio environment. As the two groups had no choice in this matter, as the groups were delineated by the degree programmes the students enrolled in, the reactions of the studio-based group is important for our understanding of the methodology.

At the same time, students at Rensselaer Polytechnic Institute chose to take the studio course, and also had previous experience of studio based teaching. It is instructive to compare their reactions to those from CityU.

Chapter 4

The student experience

4.1 Introduction

During the course of collecting data for this research, two main opportunities arose for obtaining and analysing student responses to studio teaching. The first was at CityU, where a selection of students in the 2nd year of the BEMTE programme were interviewed and asked their opinions of their experiences. The second was at Rennselaer Polytechnic Institute (RPI), where a questionnaire was given to all students taking the Electronics and Instrumentation course as part of the Mechanical Engineering and Aeronautical Engineering programmes.

There were other avenues available for obtaining student feedback. At CityU students are allowed to comment at the end of the Teaching Feedback Questionnaire, which is given as part of student rating of teachers and counts towards annual appraisal. Similarly, one of the fraternities at RPI also asked students to comment on their learning experience, and this data was also available. CityU also uses a Teaching Evaluation and Improvement Package (TEIP), which is a questionnaire given to students in the middle of a semester so that teaching staff can obtain feedback early in the course. This is voluntary and not linked to annual appraisal. There is space for comments at the end of the form.

It was also fortunate that a colleague at CityU, from the Department of English and Communications, was researching for his PhD on how students learn in a second language. He was able to attend a number of classes of the BEME course - the non-ITS control group in this thesis - and his comments are included here also. Finally, colleagues from the Physics Department at CityU, who were partners in establishing the Integrated Teaching Studio, as well as staff in the Electrical, Computing and systems Engineering Department at RPI, have also conducted surveys of students taking studio-based courses. These are quoted for comparison at the end of the chapter.

4.2 City University

4.2.1 Interviews with students

All the BEMTE students who had taken the studio course in 2000-2001 were asked to volunteer for a series of interviews in late 2000, when they had started their second year. The nine students interviewed were self-chosen and therefore do not represent a statistical cross-section of the class, probably only those who had strong opinions to communicate! The interviewees were questioned in Cantonese by student helpers from the Department of Applied Social Sciences, as part of their internship programme. The answers were translated by the student interns, and then transcribed. They were asked a series of questions based upon the 18 question questionnaire given to the students taking the course in Electronics and Instrumentation at Rennselaer Polytechnic Institute in 1999-2000, as detailed in the latter part of this chapter. The aim of this series of interviews was to ascertain attitudes to studio teaching, in addition to those comments made on the TEIP and TFQ questionnaires mentioned above. The students who were interviewed, as well as those giving comments on the TFQ and TEIP forms were not identified, so it was not possible to carry out any further follow-up at a later date.

The first question asked whether they owned a computer. This allowed some comparison to the first question asked in the Pre-test given in Semester A of the first year course. All students interviewed owned their own computer. The next question asked what proportion of the time they used their computer for schoolwork? The majority used their computers for about 50% of the time for schoolwork. The next question concerned what other uses they made of their time on the computer. Web surfing, chatrooms, email and games were the main responses.

The fourth question asked, on average, how many hours a week they spent outside the scheduled studio classes on work related to this course? The average was 3 hours/week, with a low of 1.5 hours and a high of 10 hours.

The last nine questions were more qualitative, and were aimed at getting the students responses to particular aspects of studio teaching. The quotations are directly as transcribed by the interviewers. As most of the students have some difficulty with grammatical English, the original grammar is retained for authenticity. Some students did not answer all the questions - or gave simplistic answers that provided no content. These have been omitted.

First, they were asked if they thought they learned more efficiently from the studio teaching approach.

> *Student CA: "No, I cannot learn more efficiently from the studio teaching approach and explains that it is a general phenomenon in the class. Since the students attend classes in computer room, students are easily distracted by computer and do not listen to the lecture. It is because the students can play computer game, check emails and see other websites conveniently. More, they do not worry the lecturer discover because it is very easy to cut the screen".*
>
> *Student CB: "No. The interactive style of teaching mode is good but the facilities are poor to match the needs of teaching."*
>
> *Student CC: "No. I prefer reading information from paper to reading information from computer because it is better to him to achieve more knowledge. Information printed on paper is more clear and easy to read as well as memory, and is convenient to bring along everywhere".*
>
> *Student CD: "No. As many other students, he distracts to play computer game, surf other websites and read emails with classmates. He thinks it is not necessary to use computer in the classes because there is no animations shown in the classes, and the students can print the lecture notes and bring back classes".*

Student CE: ""No. I cannot find the difference because the style of studio teaching is similar to the lecture and tutorial held in lecture theatre and classroom".

Student CF: "The answer is yes only when software is used during the studio. Only going through the notes but not using a PC to help us learning, it is not efficient too much".

Student CG: "No, I have to browse the Web Page during the studio classes, it make me confusing since I am required to click here and then click there. I have to jump from one page to another page. It makes me confusing and wastes a lot of time. On the other hand, there is too much information on the Web site. Sometimes, I do not know which part is important. So I cannot learn more efficiently form the studio teaching approach. I would rather choose the traditional teaching method and sit in the lecture room with lecture notes".

Student CH: "Sometimes, I can learn more efficiently from the studio teaching approach as there is enough information in the studio classes so that I can study at home throughout. On the other hand, the material delivered is good, especially when the EDEC software is used. You can deliver a good class with the use of EDEC software. But sometimes, I cannot learn more efficiently from the studio".

Student CI: "No, I cannot learn efficiently from the studio teaching classes as there is too much information in the Web sites. So I don't know which part is important. On the other hand, it is not a good way to follow up the classes by browsing the Web sites. It is not convenient to study by using PC. I prefer to use notes that enable me to study wherever I am".

Next, the students were asked if they agreed with the statement "In the studio, I have a chance to know how other students handle the same problems, and can sometimes learn different ways of thinking, which cannot be achieved through traditional system of assignment submitting and marking".

Student CA: "I disagree with this statement for two reasons.

> *a) Every student is provided a computer and they do not need to share opinions and discuss with others in doing tutorial exercises. Every student does his or her own exercises without concerning others.*
>
> *b) In doing experiment, I find it is difficult to change partner to observe other students' ways of solving problem and thinking. It is because I need to share work with the same partner such as writing data, in order to do the experiment. Also, generally, an experiment cannot finish in one lesson and the partners need to continue their experiment next lesso*n".

Student CB: "No. It is because students are divided into small group and the groups sat separately so he cannot know how other classmates do and think. Yet, the studio mode allows him to go to see other classmates' work, share opinions with other classmates and ask the lecturer questions in break".

Student CC: "No. I think it is quite equally to achieve in both studio and traditional system. I find many classmates only look at his or her screen and did not observe others working. In the lessons, many students surf websites, send email and play computer game without listening to the teaching. Actually, I used to concentrate on his own work without discussing and seeing others because he does not want to be absent-minded."

Student CD: "No. It is because there is not compulsory discussion and the students are not active to share opinions and observe others' working. More, the setting of the experiment cannot produce chances to allow interactive activities among the students".

Student CE: "Yes. I can achieve through sharing with the partner and discussing with other classmates in break. Most of the classmates could do the same, too".

Student CF: "Yes, as the student can learn the different ways of thinking through discussing the materials. ".

Student CG: "No, I cannot learn different ways of thinking as I don't have time to discuss during the studio class. If I have problem, I would like to rise up my hand at once".

Student CH: "No, I cannot learn different ways of thinking in the studio. After I finish the tutorial assignment in the studio, you only check the answer with me but don't give me enough time to discuss with other students".

Student CI: "No, I don't have chance to learn different ways of thinking from other students. I don't have chance to discuss with other students during the studio classes".

Question 7 asked if the students agreed with the following statement "If a lot of students have questions when solving a problem or they get things wrong in the same problem, studio teaching gives opportunities to the lecturer to repeat the corresponding facts, concepts or techniques right away".

Student CA: "I agree with this statement, but I think that lecturer can also have the same chances to repeat the corresponding facts, concepts or techniques right away in the setting of lecture theatre and traditional teaching approach if the students ask their problems in class at once".

Student CB: "Yes. Since the lecturer and the students can search for relevant *information from computer directly and conveniently, the lecturer can answer the questions with the corresponding facts, concepts or techniques immediately. I think it can make learning smoothly".*

Student CC: "Yes. It is because the studio setting that has computer can help to provide relevant information quickly when the lecturer and the students need it. Also, the students can ask the lecturer questions at once when they meet problem. Usually, the students can get feedback about their problems from the lecture before the lesson end".

Student CD: "The lecturer has the same opportunities to repeat the corresponding facts, concepts or techniques right away in the lecture theatre and studio if the problem is about theory and concepts because the lecturer uses only write broad and pen to explain. However, it is necessary to ask in the studio if the questions are relevant to the software".

Student CE: "Yes. It is because the class size of the studio teaching is only 40 students which allows the students to ask questions directly and conveniently compared with the class held in lecture theatre which is over hundred students. At the same time, the students are handling the same problem so they can share the questions or similar questions with one another and ask the lecturer. Also, the lecturer can explain immediately".

Student CF: "Yes, but the best use of the studio teaching is not done because you only go through the notes and spend little time to use software or PC. So most of the studio class is quite boring. It is better to let the student to involve the class by giving them work to do in the class".

Student CG: "No, actually the studio teaching cannot give you opportunities to repeat the corresponding facts, concepts or techniques".

Student CH: "No, the studio teaching does not give the chance to repeat the concept as the teacher actually don't know whether we understand the concept or not. Most of the time, we don't understand the concept in the studio classes so that I have to spend a lot of time to study at home".

Next they were asked to comment on the statement: "It is easier for me to follow the materials delivered in a studio teaching approach".

Student CA: "It is easier for me to follow the materials delivered in a studio teaching approach. There are several reasons.

a) I can download and print the notes and needed materials to read and study before the class.

b) I can find and get the notes and materials easily, quickly and immediately *even if I forget to take the materials to class.*

c) I can follow the teaching efficiently in class because A can find and follow the talking materials from web immediately.

d) I can search for other useful information and materials from Internet at once in class".

Student CB: "No. Since all other courses' notes are put on the web and I also print them out to read, there is no difference to follow the materials delivered between the studio teaching approach and traditional teaching approach. However, I like the interactive software such as the one provided by CSC because it helps him easier to understand the materials and have deeper impression on the materials through entering and calculating the data".

Student CC: "No. It is difficult for me to follow because I can read information printed on paper more quickly and efficiently compared with reading information on monitor".

Student CD: "Yes. It is because I can find the materials from the web in the lesson easily. Yet, it is inconvenient to read the notes if one cannot bring along a computer everywhere".

Student CE: "Not completely agree. I can read the notes on the web easily and conveniently. However, I am short-sighted (over 700 degree) so it is easy to have headache when I see the monitor. Hence, I cannot be last longer to see the monitor and I dislike using the computer frequently. Though I can print out the notes, it wastes much of time".

Student CF: "Yes, as student involve in the class more during studio teaching method".

Student CG: "No, as it is not convenient for me to click here and then there. It makes me confusing. As I am required me to click too much, a simple concept will become more complicated due to too much linkage".

Student CH: "No, there is no difference between the traditional teaching method and the studio approach. Now I have to spend a lot of time to study at home as I don't understand the concept in the studio classes".

To provide some linkage with questions asked by colleagues using the studio for a Physics course (detailed later in the chapter), the students were asked if the present studio teaching classes have successfully focused on 'student-centred learning' rather than on 'teacher-centred teaching'.

Student CA: "I disagree with this statement. I think that the present studio teaching classes focus on "teacher-centred teaching" rather than on "student-centred *learning" because there are too many lectures. The lecturer usually teaches all of the materials instead of letting students read the materials themselves and ask questions when they find problems in understanding the notes".*

Student CB: "No. It is because the most of the time are lectures and there is less chance the students' thinking are stimulated. I think that more time should be given to do experience and manual had to be clear in instruction".

Student CC: "No. There is no emphasis on student-centred learning. In my opinion, student-centred learning should be that the teacher teaches the students according to the students' quality and desires in learning in order to control and speed the students' improvement. In addition, more group discussions are needed to share opinions. Yet, I think there is no need to discuss because the course is not difficult and all solutions and conclusions could be found in books. More, I think group discussion is good for the studies of social sciences, but is not suitable to the teaching of engineering".

Student CD: "No. The classes are focused on teacher-centred teaching because the classes emphasise on lectures and the lecturer does not concern whether the students understand the materials taught when the course cannot catch up the schedule".

Student CE: "No. Some topics have focused on student-centred learning but some have not. Yet, I think the abstract concepts such as transistor should be explained by the lecturer and the basic concepts learnt in Form 7 can use student-centred learning".

Student CF: "The answer depends on the whether software and PC is used. The student will learn more when you go through the notes and let students to use PC at the same time".

Student CG: "The present studio-teaching mode cannot focus on 'student-centred learning' as too little care is paid to student learning progress. The teacher still goes through the materials when I don't understand the concept. The teacher should observe the student's learning progress so that they can repeat the material once the students are not clear about the concept".

Student CH: "No, the present studio teaching approach is on teacher-centred learning as the teacher doesn't pay attention to the student's learning progress".

Student CI: "Some of the information given by the teacher is unrelated to the Exam. And they give too much information, I am very confusing. Most of the students are actually interested in the calculation rather than the concept. On the other hand, the teacher cannot explain the concept clearly and the concept is different to understand".

The tenth question asked that if the same materials are taught by the same lecturer, does the student think they will learn more during studio teaching classes than in traditional teaching classes.

Student CA: "Though studio teaching classes allow me to get the materials conveniently and easily due to the causes of more teaching media such as Internet and video to get the information, I think that there is no difference in the amount of gaining the knowledge between the two types of teaching classes. It is because both teach in the form of lecture.

More, I likes to do experiment by hand in laboratory because it is more interesting. In addition, I am more alert and think clearly in carrying out the steps of experiment in laboratory owing to the consideration of the realistic danger. On the contrary, the attitude is more light-hearted in doing the stimulate experiment of computer in studio teaching classes because there is no realistic danger. Also, I find I could not do anything when I do not understand how to use the relevant computer programme of the experiment".

Student CB: "Yes. It is because I can be immediately find out the relevant materials and linking to get more information through Internet in the studio".

Student CC: "No. I think traditional teaching classes lets me learn more because I dislike doing experiment with software. The ideal conditions set by software have no error and I only follow the guided procedure so I has no chance to practice with realistic tools and carry out analysis when error occurs as doing experiment in laboratory".

Student CD: "No. It is because other students whom do not listen to the lecture, but do other computer activities distract me. In the lecture theatre, the students have no computer so they can be more concentrated on listening to the teaching".

Student CE: "Yes. It is because I can have more chances to share different opinions and discuss with other classmates. Also, I can ask the lecturer questions and get solutions conveniently".

Student CF: "Yes, but the lecturer does not use the appropriate teaching method – only going through the notes but rarely apply the theory into the practical case. For example, they could use Discman, MD, TV, such electronic device to apply the theory so that it makes classes more interesting and practical".

Student CG: "No, as I can learn more in the traditional teaching classes. The traditional one allows me to follow the notes easily, compared with the studio teaching classes".

Student CH: "Yes, I can learn more efficient in the studio teaching as the use of PC can help me to learn. The Web sites contain enough information and is well organised so I can easily get what information I want".

Student CI: "I would learn more from the traditional teaching method that consists of the lecture and tutorial classes. The tutorial classes allow me to ask questions and discuss with the lecturer".

Next, they were asked that if the same materials are taught by the same lecturer both in studio teaching mode and traditional teaching mode, would they prefer attending classes in the studio teaching mode.

Student CA: "No. There is no difference between the two modes because the studio teaching mode also emphasis on lecture and it is boring to listen in lecture. Moreover, I like doing experiment with realistic tools in laboratory rather than doing stimulate experiment with computer programme in studio".

Student CB: "Yes. I like the learning climate of the studio teaching mode which is free for students to share opinions and discuss with one another in break. More, it is more benefit to learning because I can find much useful information on web in the lesson at once".

Student CC: "No. As stated before, I like doing experiment in laboratory that can allow me learn more".

Student CD: "No. As stated before, discipline is an important factor to him because I cannot concentrate to listen to the lecture in the studio. I thinks that there are fewer disturbances to me in lecture theatre because the students whom do not want to listen to the class would not attend. However, they are willing to attend studio classes because they can play computer.

Moreover, I likes doing experiment with realistic tools and practice by hand in traditional teaching classes. I think some skills such as soldering, should start to practice early".

In my opinion, lectures should carry out in lecture theatre and the topic such as transistor and relevant to software operation can carry out in studio".

Student CE: "Yes. I can ask the lecturer questions in lesson so I will not waste the time of the lecturer and himself after school".

Student CF: "I prefer studio teaching mode as I can use the PC".

Student CG: "No, as there is too much information in the studio and waste a lot of time to browse the Web page".

Question twelve asked if their attendance in the studio teaching classes is higher than in other classes.

Student CA: "My attendance in studio teaching classes is higher. Yet, the studio *teaching classes were not special attractive and were boring as other classes. I continue to attend the classes because the studio had computer which allowed me to surf other websites when other classes had not the facilities".*

Student CB: "No. I attends all classes. However, the learning climate of the studio teaching mode which is free for students to share opinions and discuss with one another, can attract me to attend the classes".

Student CC: "No. In fact, my attendances is 100% in all classes because I fear missing any information and find it is important to listen to the explanation of the lecturer and then I can understand the knowledge easily to read the relevant books after the lesson".

Student CD: "Yes. It is because attendance is compulsory to be 75% and other courses have no this rule. However, I like electronics so I must attend the studio teaching classes if the problem of discipline is solved".

Student CE: "No. I attended all classes because listening to lesson helps me to understand and remember main points of the course that make me able to answer half of the questions in test even I do not review the notes.

However, I has more interest in attending the studio teaching classes because I can ask the lecturer questions directly, individually and immediately in the lesson. Since the problems could be solved in the lesson immediately, I can gain the knowledge and catch up the course schedule that make me find the course more interesting, too".

Finally, they were asked whether they felt that they had been enthusiastic in the activities in the studio teaching classes.

Student CA: "No, I wasn't. I dislike doing stimulate experiment because it is not realistic".

Student CB: "I was not fully enthusiastic in the activities because I suspect whether the studio teaching mode is effective in teaching and helping students to get the knowledge the lecturer gives to students. For example, I cannot catch up and find out the webs the lecturer had clicked to show useful information. In addition, I find there are not enough interactive activities, but too many lectures".

Student CC: "No. The activities are all computer related, but I do not like always face computer screen and I like reading information printed on books".

Student CD: "No. I dislike that there are less chances to analysis in the process of experience because I can only follow the guide of manual in doing tests. Also, *there is not much sharing between the partner. Most of the classmates are passive and seldom ask questions and discuss together. Some classmates would find the answers in books while some only copy the data from other classmates. It should be better if there are compulsory interactive activities in the studio classes. In addition, more animations can be used in teaching software which are more interesting and attractive to students and the outcome would be more effective".*

Student CE: "No. Firstly, I do not like using computer frequently due to my problem of short-sighted. Secondly, I am annoyed that I cannot take up the procedure and the principle at once because the students do the stimulate experiments without teaching before. I finds it is very difficult and too abstract to comprehend the procedure and the principle without touching the realistic tools. More, the graphics seem to be two-dimensional and unclear, so I easily miss some steps of experiment and fails to read data finally.

On the other hand, I think that doing computer stimulate experiment is more efficient in time used and resource utilization. Also, computer stimulate experiment is the tendency of practice in the process of designing electronic product so I think I should adapt this type of experiment".

Student CF: "No, because a) little interaction between the lecturer and student and b) too much theory in the class".

From the preceding comments it can be seen that those students who offered to talk about their impressions of the studio classes had mixed feelings. Some, like the visually impaired student had particular problems with the screen based material; others had problems accommodating the relative free-form approach to the classes compared to more traditional methods. One thing that was fairly universal was the fact that studio classes involved doing more work, and that the responsibility was placed on the student to make the most of the environment. It is also clear that, although not really liking the studio classes, their performance in the assessments was better than the control group - see Chapter 3, something of which they seemed unaware. Also, many of the comments were contradictory, possibly showing the ambivalent nature of the response to studio teaching.

4.2.2 Other feedback

As explained at the beginning of the chapter, two other methods of assessing student feelings about the studio teaching approach were possible by analysing the written responses in two questionnaires used each year by the faculty. One is the Teaching and Evaluation and Improvement Package (TEIP). This is given, voluntarily, in the middle of each semester so that staff can get an idea of how their teaching is evaluated by the students. The second is the Teaching Feedback Questionnaire (TFQ) given at the end of each semester. It is graded and the results are entered in the staff record. At least one such TFQ must be carried out each academic year.

Many of the comments written were not relevant to this survey - being specifically focussed on specific lectures or tutorials. However, below are some of the comments on the TEIP relating to the studio classes which were relevant to the study presented in this thesis.

> *Semester A, 1996. The tutorial questions are too hard for us to solve......the lecturer should teach us how to memorise the equations and the materials in an interesting way.*

> *Semester A, 1996. The lecture time is mixed up with the tutorial time and I think it is hard to understand the lecture at the same time immediately. So, I think it should separate into two parts in different times. The method is much more suitable for us to understand and ask lecturer question in the class.*

> *Semester A, 1997. The teaching is quite interesting, because she uses the power point and also the lesson in the studio........It is better for the lecturer to explain the difficulty theory deeply, because she always teach us about the same effort in both the easy and difficult topics. Overall she is quite good in teaching.*

> *Semester A, 1997. About lecture, we can catch lecturer's meaning and we have fairly good absorption of the material. About tutorial, I think it used too much time for doing the tutorial sheet. It's because it assumes the student had attempted the sheet before. The pace in the tutorial is so slow and it has certain degree to waste the time.*

Owing to the anonymity of all the comments made by students it is not possible to relate these comments to the preceding ones. They may have been the same students. It is interesting to note that in these examples most comment was made about the tutorials being an integral part of the programme and not separate. Most students seem to like the tutorial/examples classes to be some time after the lecture so that they can absorb the theory, although in practice it is often the case that they are as equally unprepared even in that case!

The TFQ gives scores for a number of different aspects of teaching performance. There is also one overall figure which is the one used in personnel decisions. Recent work by Bradbeer, Shah, Lo and Wong (2004) has shown that there is a close relationship between the overall score given by students at the end of the questionnaire and the individual scores given for different aspects of the teaching, so that the overall score is an accurate reflection of these. However, Bradbeer et al (ibid) also show that there is considerable bias in the overall score, with the most bias being shown for classes which were given to other departments, and in subjects which were not considered part of the main programme but still compulsory core subjects, and for first year classes compared to later years - all the factors present in the courses under consideration in this thesis! The overall score as recorded did not reflect these biases, and as the raw score is the only one available, it has to be assumed that any bias was the same in each of the years studied if any comparison is to be made. Table 4.1 below shows the overall scores for the classes being considered, where a lower number represents a better score. The standard deviations are also given, where the data is available.

Year	1996-7	1996-7	1997-8	1998-9	2000-01	2001-02
Semester	A	B	A	A	A	B
ITS	3.93 (1.27)	3.59 (0.87)	3.33	2.92	3.77 (1.43)	-
Non-ITS	3.33 (1.21)	-	2.97	2.85	3.95 (1.02)	2.89 (0.94)

Table 4.1 TFQ scores: raw score with SD in brackets where available (7 point scale)

As can be seen, the ITS classes consistently gave higher scores, i.e. worse marks, than the non-ITS classes. The contradiction between the students' seeming dislike of studio teaching and their better performance will be considered in the next chapter.

4.2.3 Miller's study

At this point it is instructive to consider an alternative point of view. In 1999 Lindsay Miller from the Department of English and Communications at CityU asked students to keep a diary of how they reacted to a number of different teaching situations. This was part of his PhD thesis (Miller, 2003). One of the classes that he studied was the first year BEME Electronic Engineering class i.e. non-ITS class which was part of this study.

Although the class was not held in the studio, as pointed out previously, the same material was used for the lectures in both ITS and non-ITS courses. Relevant abstracts from Miller's comments follow. To preserve anonymity, I am referred to as Dr. R, male. Like the previous section, Miller also keeps the original grammar.

Miller first comments on my attitude to teaching the students from MEEM. He comments that the amount of effort expended by me on writing my lectures does not seem to match my claim that I lack enthusiasm for lecturing (this class).

> "One might think that a lecturer with such negative perceptions of his students, seemingly borne out by poor attendance of his lectures, might not prepare or present well. Instead, the opposite was true for Dr R since he provided handouts and numerous examples, and prepared special computer graphic presentations of his material, all of which must have taken hours to prepare. It may be the case that Dr R is used to presenting his material in such a manner to any audience of students, but his claiming a lack of enthusiasm for lecturing at CityU was not matched by his performance.
>
> As in the case of Dr P, Dr R's general lecture conduct may be considered exemplary, and if his students were aware of the effort expended on his lectures, they might take greater interest in them. Achieving this, though, may require the help of the MEEM Department, i.e. the students' parent department, highlighting the importance of Dr R's course and his value as a lecturer".

Miller states that lecture handouts were extremely important in my lectures. During his observations of my lectures he noticed that I made constant reference to them. He postulates that, perhaps as a result of providing such extensive support via handouts, I felt that I was able to proceed with the lectures at a reasonable pace, i.e. I did not need to wait for students to copy any of the equations or diagrams as they were reproduced on the hand-outs. However, as one student, Wilson told him, this was not always the case - (D) indicates a diary entry:

> *Wilson (D): The lecture was about digital system. I understand the lecture's speaking but I couldn't follow the topic. As he didn't has any notes for us and all text shown on the screen was too small. I totally couldn't understand all the things. And I can't write quick enough to make the notes.*
>
> "Dr R complained about his students' lack of proficiency in English. He believed that this caused them many problems in his course even though he provided supporting hand-outs and extensive references for each lecture. He felt that the students did not have enough language ability to comprehend much of the lectures. However, in another part of the interview Dr R complained about the students' lack of background knowledge, especially in mathematics, which he said made it difficult to teach them. There may be some confusion here between the students' general English proficiency and any specific background knowledge expected of them. For example, in one of the lectures I observed mathematics work played a significant role and anyone not familiar with the level of mathematics assumed there would have had difficulties following the lecture, regardless of whether they were first or second language users.
>
> Similar to Dr P, Dr R also did not see incorporating language strategies into his lectures as something he was prepared or qualified to do. Still, Dr R's views of the students' proficiency levels assisted him in the first weeks of his course. He was highly aware of the type of students he was teaching and so at the beginning of the semester he gave them an outline of the course and a study plan, suggesting what they should aim to do during the semester. He also informed the students what he expected from them, namely two to three hours of reading in addition to class work. In addition to this assistance at the beginning of the course, Dr R also helped students during his lectures by using micro and macro-signals for forward and backward referencing, relating the content of the current lecture to lectures he had already given and those that he was planning to give in the future, using phrases such as "We have covered some of this before..." and "I'll talk about this more later on, don't worry about it right now."

Miller writes that students' responses to my lectures indicate that they were more aware of content problems rather than specific language problems. Many students wrote in their diaries about not understanding the concepts or principles that were presented even though they understood the words the lecturer used.

> *Ken (D) I can hear the lecture, but a large part did not understand. Just hear the words. The lecturer teached clear, but I didn't know why I didn't understand.*

Although, I can guess the vocabulary and the meaning and know the method to calculate the equation, I didn't know what he said.

"A much more detailed analysis of this Dr R's language and the problems the students have in comprehending the content through it is required, more than can be attempted here. However, there does appear to be a great deal of confusion between the concepts of language proficiency and content knowledge, concepts that in engineering courses are difficult to separate for both lecturer and students. For instance, Dr R's perception that the students' language proficiency hinders their ability to follow his lectures does not match what a former TI student had to say:

Ernie (D): In this lecture, a new topic was started. It was about logic system. This subject I had learnt before. As a result, I understood it very well. It recalled some memory which is about this subject."

Another issue related to the language proficiency of students was that I was one of the lecturers who was considered by some of them to speak fast, causing some difficulties, especially as my speech was also delivered in a non-local accent.

Johnson (D): I am not follow the speaking of the lecturer. I think English is a big problem. Is the lecturer change to local lecturer it may be better. [Is it the lecturer or his English you do not like?]. Second entry: *His English.*

"The hidden issue here is to what degree is the students' inability to comprehend a lecture a function of their low general language proficiency (including their relative inability to understand a foreign accent), and to what extent is it a result of not having the specific subject matter knowledge required of them?

Nevertheless, SPs did not offer any criticism of Dr R's inability to use Cantonese with them. Since Dr R was a foreign teacher they expected all his lectures and interactions with them to be conducted in English. However, as first-year students this was probably the first time many had a non-Chinese teacher, possibly accounting for the apparent lack of communication between students and lecturer, which in itself may have been perceived as lack of English language skills by the lecturer".

Terry (D): The style of the lecture, I think the local lecturers are more suitable because foreign lecturers' speaking speed is too fast. It is difficult to catch to the point. Besides, for some difficult idea, it is not easy to understand, so if the lecturer is local, he can use Cantonese to explain the difficult idea.

On the subject of the heavy use of technology in the teaching of the course, Miller writes that it was clear I had gone to great lengths to prepare computer-generated examples of models and diagrams to illustrate my lecture. He observes that this high-tech approach to lecturing appears to be in keeping with the mood of academic management these days at CityU, which is to make use of sophisticated technology in teaching. My use of a computer program was a way of introducing the models and diagrams but had the benefit of familiarising them with computer programs in preparation for their own use of them in the teaching studio after the lecture.

However, he states that the students reacted badly to my computer presentations for two reasons: Firstly, as I moved the mouse to point to different parts of a diagram or example, the students became frustrated by not being in control of the program themselves. All the students were computer literate and used to working with computers every day, and therefore having to watch someone else use a computer seemed to annoy them. Secondly, to make it easier to see the images projected onto a large screen, I dimmed the lights. This was often done at the beginning of a class and the students would sit in semi-darkness for extended periods of time. In such an environment the students succumbed to their tiredness and easily lost their concentration. In addition to this, while extemporising about the diagrams I used stress to highlight features, for example by contrasting two words: "If I put a current *here*, I'll get a field like *this*." This meant that the students had to focus on the diagram instead of getting textual support from the speaker. During my presentation of computer graphics I often looked at the screen myself – unsurprisingly as I was pointing out features as they talked – but this meant that I was unable to monitor the students' comprehension, or lack thereof.

> *Jack (D): Dr R use a computer program called EDEC to present his lecture. To keep the image clear, he turned most of the lights off. This cause the hall dark and made me feel sleepy. In addition, it's hard to read the words on the screen as the projector's image aren't so clear. There's lot of "here, that, this" Although there is visual aids it is hard to follow. There are animations in the software which should help us to understand the lecture. However, it don't help much actually.*

Miller writes that the use of computer technology as a teaching device was criticised in respect of other lecturers as well , and so it was not specifically my use of the technology that was being criticised. It is possible that students were not sufficiently well prepared to shift into learning via this new mode, that is, they had not yet learned how to apply their undoubted computer literacy in a lecture context. As a result the demands placed on the students by trying to integrate this new literacy with conventional literacies was too great for most.

The two case studies presented in Miller's thesis serve to illustrate that although lecturers and students may take part in the same lectures, they may still hold differing views about what is actually happening in those lecturing events.

> "These mismatches in perceptions of the behaviours of lecturers and students respectively can cause problems for students attempting to comprehend lectures in their second language. In order for lectures in an L2 to be successful, both lecturers and students must share similar views and perceptions of the lecture event, and of those features which aid in the students' comprehension of the information pre-

sented."

4.2.4 The Studio Physics study

Another study, carried out in 1998 by one of the other CityU staff using the ITS also gives some interesting insights. This was based on a questionnaire similar to the one used for the study in this thesis. Yu and Stokes (1999) report the following:

"Student-teaching-student approach

(1) 77% of the students agree that it is easier for them to ask questions or express their ideas during discussions with their group members in the "students teaching students" approach compared to the traditional "teacher teaching students" approach. Only 7% disagree.

(2) 63% of the students agree that they have more opportunity to reinforce or correct their concepts quickly after discussions with their group members, while only 8% disagree.

(3) 54% of the students agree that they have more confidence to approach the instructor, or to express their ideas to the instructor, after discussing first with their group members. Only 8% disagree.

(4) As a whole, 50% of the students agree that they learn more efficiently from the "students teaching students" approach, while about 12% disagree.

Problem-based learning and interactive learning approaches:

(1) 69% of the students agree that they have chances to refresh, apply and test their knowledge as they go through the lecture, and not after the lecture, and this helps them learn more during the lecture. Only 9 % disagree.

(2) 62% of the students agree that the system provides opportunity to see how other students handle the same problems, and sometimes different ways of thinking, which cannot be achieved in through the traditional system of assignment submission and subsequent assessment. 12% disagree.

(3) 63% of the students agree that they have chances to know how the lecturer marks the answers, so that they can know immediately the concepts they are unclear about, the facts they have overlooked and the techniques they are unfamiliar with. Only 8% disagree.

(4) 75% of the students agree that, if a lot of students have problems when solving the problem or get wrong in the same problem, the "interactive learning" has given

opportunities to the lecturer to repeat the corresponding facts, concepts or techniques right away. 10% disagree.

(5) As a whole, 55% of the students agree that they learn more efficiently from the "problem-based learning" and "interactive learning" approaches, while only 7% disagree.

Overall:

(1) 57% of the students agree that they learn more efficiently from classes in the MMIT studio using the above teaching approaches. Only 8% disagree.

(2) 56% of the students agree that the present studio teaching classes have successfully focused on "student-centred learning" rather than on "teacher-centred teaching". 13% disagree.

3) 60% of the students express that if the same materials are taught by the same lecturer, they will learn more during these classes in the MMIT studio than in traditional teaching classes

4.2.5 Discussion

From the studies considered above it is clear that there was considerable dissatisfaction with some aspects of studio teaching, but also some satisfaction, quite often both feelings being expressed by the same student. First, many students did not like long lectures, but did like the informal atmosphere of project-based learning where they could discuss things with their classmates. Secondly, the actual environment was appreciated, especially some aspects of the multimedia material, such as the interactive tutorials. There was also some dissatisfaction with the seeming disconnect between the material being presented and the lack of focus as far as what was expected of them.

The result of all this feedback from students was a major reworking of the studio concept, and the way in which the courses were structured. This took place after the end of the period considered in this thesis. The implications are discussed in the next chapter.

4.3 Rensselaer Polytechnic Institute

4.3.1 Introduction

As reported in Chapter 1, Rensselaer Polytechnic Institute in Troy, New York, was the first university to really apply studio teaching in a major way. By 2000, all first year courses across the curriculum were taught using the methodology, with many other courses up to 4th year undergraduate also taught the same way. As part of the research for this thesis, at the end of 1999 I spent 8 months in the Electrical, Computer and Systems Engineering Department, where I taught one of the courses.

This was a course in Electronics and Instrumentation taken by 3rd and 4th year Mechanical Engineering and Aeronautical Engineering majors.

The total course intake was around 120, with the class split into three sections of 40 students each, each section taken by a different professor as instructor. They were organised in groups of 4, each sharing a computer workstation connected to instrumentation for carrying out experiments. Unlike the courses taught at CityU, there were no lectures given as part of the course, and no formal tutorials. Everything was project based with a short description of the project given to the students by the instructor before each one started. The instructor was assisted by two Teaching Assistants. Each section had 2 two-hour sessions in the teaching studio, with another 2 sessions available as a first-come, first-served open shop period.

The students in the courses had little or no electronics experience during their preceding courses, other than some physics. Most of the class had experienced 3 or more studio courses before this one. There were extensive notes available on the course web site, provided by the professor in charge of the course. The course was based around a series of projects with little lecturing and no tutorials, although quizzes were held regularly. The web pages were updated regularly reflecting some of the questions raised in class, and also to provide more material for the projects if it was not available elsewhere. He also provided hints as to how to complete the project.

The groups had to provide a pre-project report based upon their initial work in the studio, which was then supplemented by a final project report. The pre-report and final report were both assessed. During the course there were two quizzes with a final in-class test. Students were expected to use the textbook (actually a physics text that I felt was not really suitable for this class!), as well as the web to access information. This was expected to be done either in class or as out of class work.

The emphasis on self-learning and larger group size provided an interesting contrast to the CityU approach, which had far more instruction and less project work, as at the time of this study. The students were given two questionnaires; one before their final assessment by me, and another after their assessment by one of the fraternities. The first was given to all students in the course, and had a 35% response rate; the latter, only to the class I taught, and had a similar response rate.

4.3.2 The first questionnaire

The questions and responses to the first questionnaire are given in Appendix 7. Question 1 ascertained that a small percentage of students did not own a computer. This is surprising as RPI has a scheme for students to buy lap-tops at a steep discount, as well as the whole campus being wired for internet access. However, it seems that even in 1999 some students did not feel it necessary to buy a computer.

The second question asked what proportion of time they spent using the computer for schoolwork.

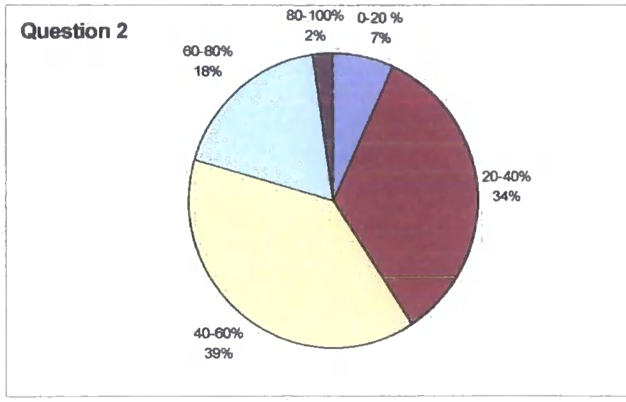

Figure 4.1 What proportion of your time do you use your computer for schoolwork?

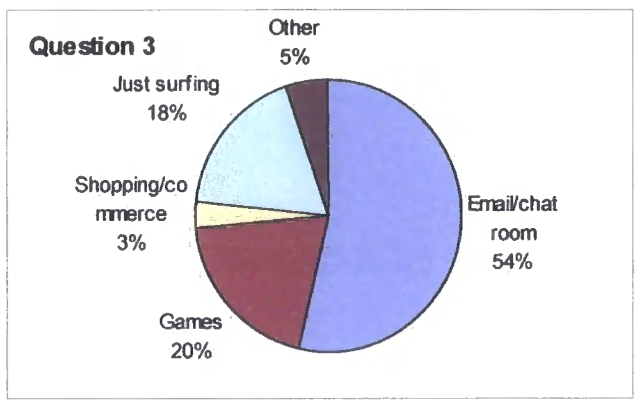

Figure 4.2: Other than schoolwork, what computer application takes up most of your time?

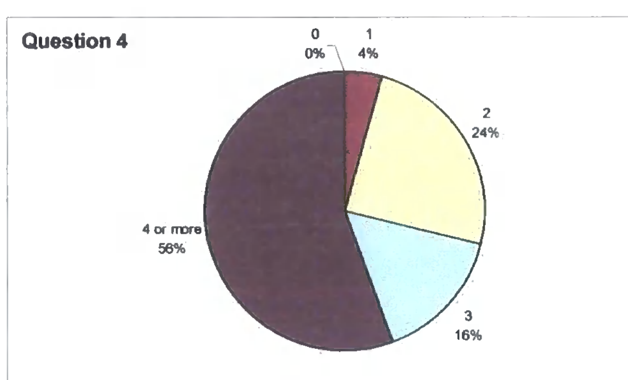

Figure 4.3: How many studio-type courses have you taken before this one?

The large majority spent under 60% of their computer time on school activities - Figure 4.1; however, Question 3 asked what the rest of the time was spent on, and this is shown in Figure 4.2 below. It is clear that email/chat rooms dominated, as may be expected.

The next question asked about the number of courses taken in studio mode before this one - Figure 4.3. Surprisingly the majority had taken 3 or more. Only 2 respondents had only taken one such a course. There were no students who were new to the methodology.
Question 5 shows the main difference between this course and the ones taught at CityU - Figure

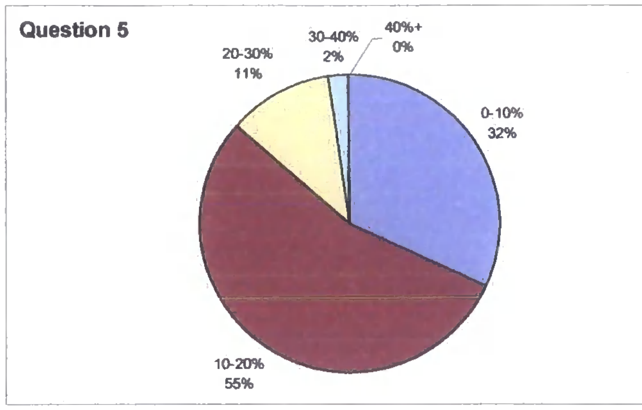

Figure 4.4: On this course, when in the studio, what is the ratio of time is spent on presentations by the instructor to other coursework?

4.4. The large majority of the respondents claimed that less than 20% of the class time was taken with presentations by the instructor. This compares to around 50% at CityU. The next question - Question 6 - asked about the amount of time spent out-of-class on the course work. Over half the class spent between 4 and 6 hours on such work, again different to CityU, where empirical evidence shows that 2 to 4 hours is normal for most students.

The final group of questions were looking for a range of responses from strongly agree to strongly disagree on a 5 point scale. It should be noted that the questionnaire was framed such that these general questions on studio teaching were from their experience of all studio courses, not the one taken here. These final questions were based on a questionnaire used by RPI to determine student feedback. They are also similar to those used by Yu and Stokes (1999). As far as I know there has been no analysis carried out as to the bias or construct validity of these. They are used here for comparison with the results of the feedback from the RPI and CityU Physics students taking similar courses only.

Question 7 concerned the ability to carry out group discussion. As can be seen from Appendix 7, around 67% strongly agreed, or agreed.

Question 8 asked about reinforcing or correcting concepts. In this case 58% strongly agreed or agreed.

Question 9 concerned confidence in asking questions of the instructor. 64% strongly agreed or agreed that they would have more confidence after initially discussing the ideas with their group.

Question 10 showed that only 54% either strongly agreed or agreed that studio classes allowed them to learn more efficiently. A surprisingly high number of 36% of students disagreed, or strongly disagreed, with this statement.

Question 11 continued this line of thinking by asking whether the studio environment changed their ways of thinking about a problem. A small majority - 52% agreed, whilst 12% disagreed or strongly disagreed.

A similar small majority - 55% agreed or strongly agreed that there are more opportunities in studio teaching for interaction with the lecturer, whereas 56% agreed or strongly agreed that it was easier for them to follow the material in the studio - Question 13.

One of the claims made for the studio teaching approach at RPI is that it allows for more student-centred learning. However, only 45% agreed or strongly agreed with this statement, with 19% disagreeing or strongly disagreeing.

The next two questions asked students to give their opinions as to whether their instructors would have performed better in studio teaching or in traditional teaching. In some ways this was not a fair question as few, if any, of the students had come across their instructors previously, so any comparison was rather imaginary. However, it is interesting to note that 53% agreed or strongly agreed that they would learn more from that instructor in the studio and 48% agreed or strongly agreed that they would learn more with the same materials.

The results from the questions are shown in pie-chart form in appendix 7. For ease of comparison, the results are restated in slightly different form in Table 4.2 below. This gives the responses in terms of a scale from 1 to 5 - where 5 corresponds to strongly agree, and 1 to strongly disagree. The mean and standard deviation are given for each question.

	Mean	SD
Question 7: It is easier for me to ask questions or express my ideas during discussions with my group in the studio teaching classes than to do the same in front of the lecturer and the whole class in traditional lectures.	3.8	1.2
Question 8: After discussions with my group members, I have better chances to reinforce or correct my concepts quickly.	3.5	1.2
Question 9: I have more confidence to ask the lecturer questions or to express my ideas to the lecturer after discussing with my group members.	3.7	1.2
Question 10: I can learn more efficiently from the studio teaching approach.	3.1	1.4
Question 11: In the studio, I have a chance ot know how other students handle the same problems, and can sometimnes learn different ways of thinking, which cannot be achieved through the traditional system of assignment submitting and marking.	3.4	1.2
Question 12: if a lot of students have questions when solving a problem or they get things wrong in the same problem, studio teaching gives opportunities to the lecturer to repeat the corresponding facts, concepts or techiques right away.	3.5	1.2
Question 13: It is easier for me to follow the materials delivered in a studio teaching approach.	3.0	1.4
Question 14: The present studio teaching classes have successfully focused on student-centred learniing rather than teacher-centred teaching.	3.3	1.3
Question 15: If the same materials are taught by the same lecturer, I think I will learn more during studio teaching classes than in traditional teaching classes.	3.5	1.2
Question 16: If the same materials are taught by the same lecturer both in studio teaching mode and traditional teaching mode, I prefer attending classes in the studio teaching mode.	3.7	1.2

Resondents: 45

Response Scale: 5 = strongly agree, 4 = agree, 3 = neutral, 2 = disagree, 1= strongly disagree

Table 4.1 Table 4.2 Responses to questions concerning attitudes to studio courses at RPI

Other than for Question 13, the means indicate that the average response is between neutral and agree.

The next question asked about their attendance in studio teaching classes. Virtually all respondents attended for between 80-100% of the timetabled time. This corresponded to attendance rates at the CityU studio courses, which averaged 95% attendance over the six cohorts studied (compared to 95% at the start of the semester dropping to 50% at the end for the non-ITS courses!).

Finally, the respondents attitude to studio teaching was ascertained. This was measured in their enthusiasm for the classes. As can be seen from Figure 4.5, the vast majority had favourable responses.

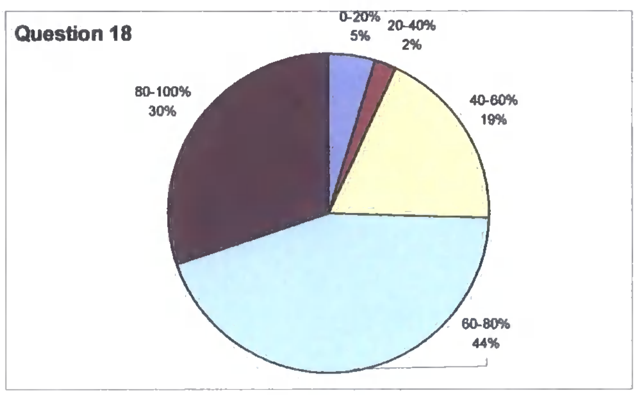

Figure 4.5: I feel that I have been ?% enthusiastic in the activities in the studio teaching classes.

At the end of the questionnaire a space was left for comments from students. Many of these were related to questions from the survey.

> *Student RQ1: "When lecturing teach – don't just go over the topics we should know. Overall the course was fun – I enjoyed it".*

> *Student RQ2: "There is too much paperwork involved in this class. There was always a rush to finish assignments. Spend the first few lectures reviewing basic concepts since most of us have not seen this material since (early) physics courses. Make all announcements in class – the web page is great but it cannot circumvent personal communications. ".*

> *Student RQ3: "Not enough time spent on teaching the material. Maybe 30 if mins per day was spent on lecture the concepts would be better understood".*

> *Student RQ4: "The professors waste too much time talking when we need the time to do labs".*

> *Student RQ5: "Overall I really enjoyed this course. But too much was expected to be previously known. We have never had this coursework before. The design in*

most projects was over our heads".

Student RQ6: "I definitely learned a lot from this course. This can be attributed to the fact that I never was introduced to the field of electronics and circuits. I still learned a lot. I just thought that many times it seemed as if we were expected to know much more than we actually did know".

Student RQ7: "The class as a whole was a good learning experience".

Student RQ8: "Class at times had too much going on and took up most people's time, while it was not their only class".

Student RQ9: "Groups of 4 are too large, especially for this classroom. The work can easily be divided among 3 people, but adding a 4th makes it too crowded for all 4 to work together and it becomes much more difficult to find work for that person to do".

4.3.3 The Fraternity questionnaire

The other questionnaire given to students was aimed at getting feedback from students for return to individual instructors after assessment was completed, and was administered by one of the university fraternities, Tau Beta Pi. It simply asked for comments or suggestions which would be given to the instructor concerned. As may be expected, there was some duplication of responses, but it was impossible to ascertain which students had returned both questionnaires, as they were both confidential. The comments relevant to this thesis are given below:

Student RF1: "Class was a lot of work – too much at times".

Student RF2: "Too much work. This class isn't even my major and I spend the most time on it. The material is gone over so fast that I will never remember what I was quizzed on or any useful information. Emphasis wasn't on learning – it was on finishing the experiment on time because there was so much work to do. I was excited about this class originally, but it's structure and style of lecturing has caused me to not be as active or even care about what I am learning'.

Student RF3: "Studio is much more conducive to the hands on learning style I have. I wish a studio classes were as well instructed as this one is".

Student RF4: "I got very little from this class. The teaching format, or lack thereof, was insufficient. Questions weren't addressed the best way possible. As a result the out of class work load was too severe for this course".

Student RF5: "Studio (classes) should have supplementary instruction".

Student RF6: "Although the studio class approach is very helpful for 'hands on' circuit building, I feel more time needs to be spent lecturing to provide a more *solid theory base before breaking loose and building circuits. Also, the preproject reports seem to be a huge waste of time because you basically have to have the project completed to do well".*

Student RF7: "I think that the idea of studio classes is good, but they rarely seem to work out as well as planned. This class seemed to just throw projects at us without enough background information. Most of us are not electrical engineers, and therefore need a little more explanation of how the components work before we can properly apply them to projects. This class could be improved upon greatly by including more instruction at the beginning of class".

Student RF8: "More time needs to be spent on a lecture in the studio. Perhaps 1 day out of 3 could be a lecture about the materials needed for the week's experiment. I enjoyed working in groups of 4".

Student RF9: "The class format is good in theory – however, resources (lab equipment) and instructors are insufficient. 4 people is too large for a group. A little more focus on learning, then doing. Just throwing us into an activity teaches nothing".

Student RF10: "My major complaint about this class is that I don't feel the lecturer taught us anything. We would be told to perform an experiment and to generate a plot from it. We would then be told to explain it. The problem was that we never had it taught to us, so we had no knowledge to use to evaluate it. Overall I did not enjoy this class. I did like some of the projects, but I feel as though I didn't learn very much. It was hard to get help during the class because of all the groups, and so few TAs".

Student RF11: "Lecture more! It doesn't have to be for 2 hours a day, but we need something to supplement the text. Sometimes more teaching was needed to clarify different concepts in the course. It made labs more difficult to understand since many of us had little or no knowledge about the experiments. Studio courses are definitely more effective that boring students by lecturing for 2 hours".

Student RF12: ". .....the class was great: very well organised, interesting projects etc...well chosen TAs".

Student RF13: "Again, as I saw in all my Physics classes, I like the IDEA behind the studio teaching, the implementation here at RPI needs work. I don't think studio teaching is an excuse not to lecture. We were hardly ever taught anything in this course. All was left to be figured out, or was left to the TAs. Therefore, because our group was more apt to figure stuff out ourselves, our overall grade suffered compared to groups that had the TA stand over them the whole time and answer every question for them. Basically, I want to see more STRUCTURED TEACHING. At least ½ an hour of lecturing at the beginning of each class, perhaps".

Student RF14: "I prefer lectures. Too much time in lab is spent doing, rather than learning and understanding for a studio class to be effective".

Student RF15: "Many mechanical engineers have to take this class. Without a lecture I don't know how it can be expected that we learn much. In addition, you can still do well without having an understanding".

Once again it seems that some students really like studio classes and some do not! However, the amount of time needed to complete the work in studio project-based classes is clearly a problem. Many students complain about the amount of work they have to do. This reflects some of the views of CityU students. At the same time students would like to see more actual teaching, i.e. material presented more formally in the form of lectures. The balance between the formal and the informal must, therefore, be at the heart of effective studio teaching. This will be addressed at the end of the chapter.

4.3.4 Other survey results from RPI reported in the literature

Similar student feedback studies were carried out at RPI during the first few years of studio implementation. The most comprehensive was by Carlson, Jennings and Schoch (1998) in 1997. They also compared two cohorts - one in the studio and one in lectures.

The student demographics given in Table 4.3 indicate that the two groups were well matched academically.

	Studio course	Lecture course
Number of students	27	27
Non-majors	1	2
Females	5	5
Caucasian	13	14
Black	2	2
Asian and others	12	11
Average QPA	3.179 ± 0.530	3.164 ± 0.532

Table 4.3 Student demographics (from Carlson et al, 1998; Table 1)

Nonetheless, as shown in Table 4.4, students in the studio course on average performed better on the three exams than the students in the lecture cohort.

	Studio course	Lecture course
Average	77.01	75.81
Standard deviation	10.59	10.8
Median	79.68	74.29

Table 4.4 Total percentage exam scores (from Carlson et al, 1998; Table 2)

As Carlson et al. write:

"Note, in particular, that the median score of the studio students was more than five percent higher — roughly equivalent to half a letter grade. Since the two groups were apparently comparable, and since the preparation was the same for both, the studio format itself led to the improved performance. At the very least, the studio format appears to be as effective in the cognitive domain as the more conventional format"

They then analyse responses from two surveys. One was given to all School of Engineering students all engineering courses in 1997, and the other from a survey of just those students taking the studio course mentioned above.

Significant differences emerged in the affective domain, judging from surveys of student attitudes and perceptions. Table 4.5 lists selected average responses from the survey administered to all engineering courses. There were 16 questions in the survey, with only the questions that prompted noticeable differences quoted in the study.

Carlson et al, comment:

"The "bottom line" here is the overall course rating (statement 16), which was 3.6 on a 4.0 scale for the studio course, as compared with 3.0 for the lecture course. Increased student satisfaction with the studio format is also reflected in the responses to statements 11, 13, and 14. Furthermore, the studio course received higher positive responses than the lecture course on all aspects of the survey. Of particular interest is the comparison of responses to statements 4 5,6, and 10. Since the assignments, exams, etc., were identical for both courses, the studio format again seemed to be more satisfactory from the student viewpoint. Finally, a special survey was administered to students in the studio course alone for evaluation purposes"

Statement	Studio	Lecture
4. The written assignments aided the learning process	3.7 ± 0.5	3.4 ± 0.7
5. The level of difficulty is reasonable	3.3 ± 0.7	3.1 ± 0.6
6. The amount of work required is reasonable	3.3 ± 0.6	2.9 ± 0.8
10. The tests, quizzes, etc., are learning experiences	3.4 ± 1.0	2.9 ± 0.8
11. The course format is appropriate to the subject	3.6 ± 0.7	3.1 ± 0.8
13. The course encourages students to think for themselves	3.6 ± 0.6	3.2 ± 0.8
14. The course increased knowledge/skills in the subject	3.8 ± 0.4	3.4 ± 0.7
16. Rate the overall quality of the course	3.6 ± 0.7	3.0 ± 0.7

Respondents : 25 in the studio course, 34 in the lecture course
Response scale: 4 = strongly agree, 3 = agree, 2 = disagree, 1= strongly disagree
Course rating scale: 4 = one of the best, 3 = above average, 2 = average, 1= below average, 0 = one of the worst

Table 4.5 School of Engineering Course Survey (from Carlson et al, 1998; Table 3)

According to Carlson et al, the selected results given in Table 4.6 reveal the following points:

- "The studio format promoted class attendance. (Indeed, attendance remained above 90% throughout the term, whereas it dropped appreciably in the lecture course.)

- Students appreciated the individualised attention in class and felt less need for extra help outside of the classroom.
- Students did the outside work necessary for the studio class and felt that they benefited from the experience.
- Students felt that they learned more from the studio format and preferred it to a conventional format.

The higher student rating for the studio course evidently reflects these points".

Statement	Mean ± SD
1. I attended most of the studio class sessions	3.0 ± 0.3
3. I appreciated having a staff member nearby in the studio to help me when I needed it.	3.8 ± 0.4
5. I sought out-of-class help for this course more than I usually do	2.4 ± 0.8
6. I liked having the experiments and computer projects integrated with other studio activities	3.5 ± 0.6
8. I did most of the out-of-class work with another student	3.1 ± 0.6
10. I did most of the preparation work on time	3.1 ± 0.5
18. The studio format helped me learn how to learn	3.4 ± 0.6
19. I thin I learned more from the studio course than I would have from a conventional format	3.6 ± 0.6
21. The studio format felt more "friendly" than a conventional format	3.8 ± 0.6
21. I enjoyed the studio course format more than a conventioal course	3.8 ± 0.5
Respondents :26 *Response scale:* 4 = strongly agree, 3 = agree, 2.5 = neutral, 2 = disagree, 1 = strongly disagree	

Table 4.6 Studio course survey (from Carlson et al, 1998; Table 4)

4.4 Discussion

Considering the diversity of views quoted above, it is difficult to come to any firm conclusions about the students' attitudes to studio teaching. If conclusions can be drawn, then the main one would seem to be that the experience of students with exposure to studio classes before the one surveyed is different to those who have not. For example, the majority of RPI students had been in studio classes before, and could therefore grasp the reasons behind the methodology, even if this resulted in just a hardening of their responses. One response - not quoted as the language was rather crude - hated the studio classes with a passion; however, some of his classmates had exactly the opposite feelings, and, indeed thrived in the environment.

One aspect common to both the CityU and RPI surveys was the compulsory nature of the two courses at CityU and the course at RPI studied in detail. Both were given by the Electronics or Electrical Engineering Departments to non-EE students. And the courses were all 'core' courses which were not elective. As Bradbeer et al (2004) showed, this type of course - usually referred to as a 'service course' - has a lower student rating than core courses in the students' major and certainly lower ratings than for elective courses. The possible implications of this on any qualitative survey are looked at in Chapter 6. Some other comparisons have been made between studio and non-studio classes in the main disciplines of the students, and these are considered in the next chapter.

As for the CityU students - they were in the majority first year students, except for repeats. In fact, during the period of the study, for two cohorts, the studio class was their first ever class at the university. Not only did they have to cope with a completely new learning environment - starting university after school or college is always a stressful time - they were also exposed to a teaching and learning methodology that was totally outside their previous experiences.

Trying to understand the reason for the apparent dichotomy between the feelings towards the studio based classes and the better assessment results is the main focus of the next chapter. One possibility is to consider learning styles, and to determine whether this provides an explanation for some liking and some loathing the studio classes.[1]

[1] During the course of writing this thesis I attended two workshops. The first on learning styles and the other on metacognition. Whilst not including much in the thesis on the latter, I was struck by the concepts behind the former; they seemed to fit into my own experiences, and I considered them empirically correct. This may be a controversial statement in the light of some recent publications e.g. Coffield. F., Moseley, D., Hall, E, Ecclestone, K. (2004).

Chapter 5

Studies and styles

5.1 Introduction

The preceding chapters raise a number of interesting questions and seeming contradictions. The first of the contradictions is the student responses to the studio teaching methodology. It seems that there is a polarisation of opinions, although most like the approach, and achieve greater learning, but consistently rate the experience worse than traditional methods. Yet, student responses from many disciplines show clearly that the studio teaching approach, based around small-group problem or project based learning, consistently out-performs traditional modes, as far as assessment (and it is claimed, deeper learning) is concerned. The first part of this chapter will look at work reported at universities other than RPI and CityU, and see if there are any similarities in their conclusions.

The second question to be addressed is why some students clearly enjoy and thrive in the studio environment, but others hate it, sometimes with a passion. Consideration of learning types, although controversial, as well as the use of Type-Indicators may be one way to address the wide spectrum of student responses, and the second part of the chapter will consider this, taking into account recent criticisms.

Finally, we need to consider changes to the methodology that, hopefully, will address these issues. The third part of this chapter will explain the changes to the courses studied in this thesis and the responses of students to these changes.

5.2 Results from other studies

5.2.1 Studies on other studio-based courses

Recent studies by researchers, other than those at RPI or CityU, seem to reinforce the findings at these two universities. These include Little and Cardenas (2001), Voigt, Ives and Hagee (2003), Carbone and Sheard (2002), and Lynch and Markham (2003).

Little and Cardenas report a study carried out at Harvey Mudd College, where they used studio teaching for a first year Introductory Design Engineering Curriculum. They based the design course around the familiar architectural studio layout, rather than a specialised classroom, as used at RPI and CityU. Another slight difference was the use of more open-ended projects:

> "The traditional pedagogy of the architecture studio addresses the evolving design space by the use of considerable interaction between the instructor and the student, often taking the form of "desk critiques," in which the work in progress is discussed. Students are encouraged to a variety of design elements and to expand their initial

solution to consider factors that may not have been apparent at the beginning of the design exercise. As the work progresses students may simply be encouraged to continue in their present vein. Many engineering instructors have active interactions with students regarding their work, but these "desk critiques" appear to be at odds with some of the hoped-for efficiency gains spoken of by some studio advocates".

They continue by considering the exercises they implemented. They build a case for several exercises that train the students in formal skills and lead up to a larger project. They comment that this is particularly true if the teacher is not able to provide "on-the-spot" reviews and criticisms of work at each class.

"The corresponding metaphor in the visual arts is using a series of exercises as sketching or studies. Successful engineering design studio exercises:

- Have sufficient complexity to permit an evolving design space
- Allow for multiple acceptable solutions
- Lend themselves to learning formal design methods and benefit from the use of design tools
- Require interaction with a large number of participants (e.g., clients, users, technical experts outside the students' or instructors'' fields.)
- Have sufficient "length" to demonstrate the benefits of good project management".

Although Little and Cardenas did not carry out a comprehensive survey of students reaction to the studio course, they make the following comments based upon student feedback:

"While student reaction was generally positive, studio-based learning represents a radical change from the traditional classroom. Not surprisingly, student reactions therefore covered the full spectrum from highly negative to highly positive:

"The organisation of the material was helpful because each subsequent assignment built upon techniques or concepts learned previously. Examples used in class illustrated important points and ideas well". "There was a lot of practical application of the course material, which is an excellent way to teach a subject". "I feel that the studio style of this class was especially helpful. It caused us to have to learn the material by actually being put in situations in which the engineering design techniques would be helpful".

> Negative comments generally were related to the duration and scope of the projects. A very high percentage of the students indicated that more time needs to be allocated for the final project.
>
> *"There was a lot of stress from a shortness of time and from trying to get everything done on time". "Shorter design exercises would improve things". "Give us more time for the final project".*

In their conclusions they state:

> "While there is widespread interest in the use of studio-based engineering education, much of it appears to overlap so extensively with other forms of active learning that it is difficult to specifically indicate the effect of the studio method itself. We structured and taught an introductory engineering design course which was closely modelled on the traditional architectural studio approach. The results strongly suggest that this is a viable style of teaching and learning engineering design. Because a strictly studio-based approach is unfamiliar to students, care should be exercised in the selection of exercises, the workload of the students, and in providing appropriate feedback on student work. We believe that continued experiments in studio-based engineering education are warranted, and plan to continue them".

Carbone and Sheard (2002) conducted a study with first year students on a 2 semester IT course at Monash University taught in a teaching studio. The course was part of the Bachelor of Information Management and Systems (BIMS). This study investigated students' experiences learning in the studio teaching and learning environment. The students were surveyed during the last week of semester 1, and the same students were surveyed in the last week of semester 2. All the students were asked to complete an online questionnaire; participation in the survey was voluntary.

The questionnaire asked students to rate the learning environment, the facilities available to them, the subject content, assessment method, and the level of satisfaction, on 5-point Likert scales. Demographic data in terms of gender, international basis, degree and age were gathered. The questionnaire also contained questions to help establish a profile of the students and enable comparisons to be made between responses on the basis of gender and the background of the students. The students were given the opportunity to provide open-ended comments about aspects of the studio environments. Only the responses on the teaching and learning methodology, and their level of satisfaction with the studio were considered.

The means and standard deviations of the students' ratings of components of the teaching and learning method in semesters 1 and 2 are shown in Table 5.1. Data analysis (independent groups t-tests between the two groups) showed that, according to Carbone and Sheard:

> "The following significant differences were found:

• students were collaborating within the group more frequently in semester 1 compared to semester 2.

• students were seeking considerably more assistance from the teaching staff in semester 2 than semester 1.

• students felt the studio activities in semester 2 were better at developing their skills and knowledge than those provided in semester 1".

Question	Jun 2001		Oct 2001	
	Mean	SD	Mean	SD
I used content and skills from other core subjects	3.65	1.01	3.68	0.94
Group work contributed to my learning	3.95	0.93	4.02	0.93
I collaborated with my group to complete the activities	4.17	0.82	3.9	0.89
Access to the studio spaces was available	4.01	0.95	3.84	0.92
I received sufficient assistance from the teaching staff	3.6	1.05	3.96	0.82
I was required to manage my time when undertaking the studio activities	3.92	0.87	4.12	0.8
I was required to negotiate involvement with team members when working on activities	4.16	0.88	4.02	0.91
The level at which the studio activities developed my own skills and knowledge	3.77	0.96	4.17	0.87
The level which the seminar session prepares you for your studio work	3.52	1.15	3.57	1.04

The means and standard deviations of the students' ratings of components of the teaching and learning method in semesters 1 and 2. A 5-point Likert scale was used, where 1 indicated not at all and 5 indicated frequently.

Table 5.1 Students' ratings of the teaching and learning approach (Table 4 from Carbone et al, 2002)

The means and standard deviations of the students' ratings of the level of satisfaction of the studio at the end of semester 1 and semester 2 are shown in Table 5.2. A significant difference was found with students showing greater preference to learning in the studio environment in semester 2 than compared semester 1. An interesting finding in semester 2 was that the ease of which students felt they were able to represent their level of skills and knowledge in their portfolio was highly correlated with the students' level of satisfaction with the subject's content and the students' level of satisfaction with the overall course. Other strong relationships were shown which were not unexpected. A high correlation was found between the students' level of satisfaction with the course and their level of satisfaction with the subject, and whether students would recommend the course to others was highly correlated with their level of satisfaction with the subject and the course."

Carbone and Sheard also publish student comments as part of the feedback. Those relevant to the study in this thesis were:

> *"I think that the Studio is a very good place in which to further our skills in both team work and various applications". "The facilities and atmosphere in Studio 1 is really terrific and relaxing. I love going there to do my work". "The studio subject was the only subject I could not really understand its*

Question	Jun 2001		Oct 2001	
	Mean	SD	Mean	SD
My level of satisfaction with this subjects content	3.16	1.00	3.30	0.80
My level of satisfaction with my overall course so far	3.50	0.96	3.44	0.92
The chances that I would recommend others to do this course	3.33	1.11	-	-
I preferred learning in the studio environment as compared to the standard lecture/tutorial environment	3.87	1.04	4.18	0.99
I prefer to work as part of a team/group as compared to individual work	3.48	1.09	3.34	1.18
The pace of the subject compared to other non-core subjects was very slow	2.66	0.92	2.80	1.08

The means and standard deviations of the students' ratings of components of the teaching and learning method in semesters 1 and 2. A 5-point Likert scale was used, where 1 indicated not at all and 5 indicated frequently.

Table 5.2: Students' ratings of the level of satisfaction (Table 5 from Carbon et al, 2002)

purpose". "The course material was too broad, but I expect that over the next two years I will be able to gradually focus on my particular area of expertise". "What I have learnt in studio has been through some of the class members". "The studio activities and group works really help me a lot in understanding the course better". "I like to put things into practice, ahead of learning the theory behind it, so the studio openly provided that opportunity". "I preferred the learning environment of the studio as it promotes interactivity amongst students which mimic the workforce environment". " I really like the Studio environment as compared to standard/lecture/tutorial, since it really makes it interesting to attend. Even three hour session fly by just like that".

They also drew the following conclusions:

"In general most first year students enjoyed learning in the studio environment. The studio facilitates learners' construction of knowledge by providing them with an environment in which they are encouraged to think, create and integrate. An unexpected finding of the study was the evidence of students developing metacognitive skills. Although, there were concerns raised in semester 1 regarding the portfolio assessment, by the end of the year students found it easier to decide what to submit for the self-select part of the portfolio, and how to organize their portfolio. By the end of the year students also found it easier to represent their level of skills and knowledge in the portfolio, which had a significant impact on their satisfaction of the subject.

This research has highlighted four aspects of learning environments; the physical space, the teaching approach, the assessment method and the IT facilities provided, that are important to consider when constructing new learning environments. It has shown which aspects of these impacts on the students' level of satisfaction with their learning. It is intended that the results presented in this paper act as a guide for other institutions planning to implement a studio based teaching and learning approach".

A later study from Monash, published by Lynch and Markham (2003), compares the responses of students on the BIMS programme, described above. A survey was designed to examine how the educational environment of the studio compared with the environments of related non-studio units in the course.

"The instrument consisted of 19 questions where students were asked to place on a scale where the studio or non-studio environment suited their learning needs best. The questions where framed with a preamble for the students to place the survey in context, 'Think about this [the survey questions] in terms of your learning needs and how they are being met; you might relate this to the level of personal comfort'. The scale used was a continuum, or a balance, where the students would mark a position on the scale that indicated where they felt the environment was best situated for their learning needs. The addition of a 'not sure' option was used if the student was unsure of where on the scale they placed the issue. The middle point of the balance was 'zero'. A zero point was explained as the point 'that both conventional [traditional] learning environment and the studio environment give the same feeling of personal comfort.' One hundred and thirty four students participated in the survey, representing approximately 43% of the enrolled cohort. Students from each of the three year levels of the degree programme participated in the survey (33%, 46% and 49% respectively). The survey was conducted during studio time, and participation in the research was anonymous and voluntary".

The first table from Lynch and Markham presents the 19 questions used to assess the studio-traditional dimensions. It also includes the means and standard deviations for each of the items. In order to make the data more directly readable, the -5 to +5 ratings were converted to a 1 to 11 scale. This gives a mid-point of 6 and a value below 6 represents a favourable rating for the studio environment.

As the students who were surveyed came from all years levels of the course so an analysis of variance was carried out to compare the relative differences in student perceptions of the Studio programme given their experience of that programme. The means and standard deviations for the 8 questions by year level (Q.1, Q.3, Q.13, Q.15, Q.16, Q.17, Q.18 and Q.19) were also calculated.

Lynch and Markham note that:

"From Table 1 (5.3 below) .... it can be concluded that overall, the students favoured the studio style of teaching over traditional teaching on the majority of the evaluation items - all except questions 2, 7, 8, 14 and 16.

Opinion	N	Mean	SD
1. Efficient use of my time	130	5.4	3.18
2. Developing personal time management skills	131	5.63	2.98
3. Knowing which staff member is responsible for material in a current topic	131	5.3	2.78
4. Developing negotiation skills	131	4.81	2.79
5. Using collaborative work (group work) approaches	132	4.17	2.78
6. Developing problem solving strategies	132	5.24	2.99
7. Being in charge of my own learning	132	5.48	3.18
8. Having a structured timetable	130	5.93	2.94
9. Internalising the ethics of my profession	129	5.29	2.67
10. The level of direct engagement with my lecturers	130	4.83	2.77
11. The impact of having multiple experts deliver on topics	128	4.7	2.66
12. Developing and understanding of professional practice	129	4.91	2.59
13. Enhancing my feeling for what is wanted in jobs in my professional area	130	4.76	2.62
14. Feeling secure with the content of what I am doing	130	5.73	2.74
15. My satisfaction with the learning experience	129	5.28	2.63
16. The depth of my understanding of the 'average' topic we have covered	128	5.55	2.69
17. My feeling that I am involved in a rich learning environment	128	5.33	2.76
18. The sense that I am getting all that I can from staff expertise	130	5.39	2.72
19. My preferred learning environment.	131	5.3	3.12

Fig 5.3 Survey questions and descriptive statistics (Table 1 from Lynch and Markham, 2003)

An examination of the frequency plots for each of the questions indicated that they were skewed towards the studio end of the scale. The plots also showed that the students used the mid point, on the average, thirteen percent of the time. This suggests that most students had a clear point of view on one side or the other.

The differences between the students from the three years of the course are based upon the third year students being less oriented towards the studio than either of the earlier years. The questions could be said to cover the broad concept of the studio, particularly questions 15-19, and its affinity to collaborative teamwork rather than individual work".

They conclude:

"Overall, the study indicates that the studio model is a preferred learning environment for students undertaking the Bachelor of Information Systems. Nevertheless, it is important to note, that there is not one *best* environment for *all* students, but gathering and incorporating a range of ideas, models and pedagogies into the learning environment adds to the students' level of comfort in satisfying their learning needs. This leads to the student's development and readiness for the IT workforce".

In another study carried out at U. S. Naval Academy, Voigt, Ives and Hagee (2003), report on a studio-based course teaching Electrical and Computer Engineering to non-engineering majors. All non-engineering students at the Naval Academy are enrolled in a two course Electrical Engineering sequence as a core requirement. According to Voigt et al.:

"We also have always had class sizes of around twenty and were not willing to

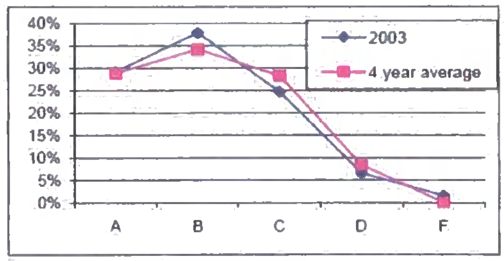

Fig 5.1 Comparison of grade distribution. The 2003 results were for the studio group. (Fig. 3 from Voigt et al, 2003)

> sacrifice our low student-to-teacher ratio. The teaching concept of the studio classroom was what we really wanted for our students. The students in this course were not engineers so we felt that this format for learning was an obvious choice. The students would get more hands-on applications-oriented learning than we could offer in a separate classroom and laboratory experience. It was also clear that we would be able to maximise this effect for a wider variety of topics in a single studio classroom better than with application specific labs and generic classrooms. We had one other goal: we wanted this to be fun and interesting to students who really had no desire to be in the class for its content, but were there simply because it was required. This goal is not as altruistic as it sounds: recruiting technical majors is challenging, but if the students can enjoy the material, it makes attracting freshmen that much easier".

The study was of a two-course sequence covering everything from basic circuits and motors/ generators to digital communications and networks. As Voigt et al report:

> "Collaborative learning did play a part in this course. Students were encouraged to collaborate on homework problems together, although duplication of work was not allowed. In general, since there are several ways to attack complex electrical problems, this fostered an exchange of ideas and methods on the best way to reach a solution.
>
> Since there were enough lab benches for each student, most Practical Exercises (PEs) were done individually. There were, however, some PEs that supported working in teams. In particular, the PE that measured the DC transients in a capacitive circuit which involved recording varying voltage levels, and the Motors and Generators PE due to its complex wiring and level of hazard. In addition, the precalculations for most PEs were performed in groups".

Although Voigt et al did not carry out a comprehensive analysis with comparative data, they did compile an average of grades given for the original (non-studio) course over the previous 4 years, offered in both semesters, and compared them to the single semester of grades for the new studio-based course. Those results are in the Figure 5.1 above. There appears to be no significant differences in performance by the students. Their conclusions include the following points, although, as they point out, "only one semester of the new course had been given at the time of this report:

• The amount of time and effort in the planning stages for these courses was significant.

• Feedback from the students has been mostly positive, however, some rather pointed comments on how all of these many and varied topics fit together has been a consistent theme.

• Much of the feedback with respect to the PEs from the course was very positive. Students commented on how in traditional laboratory courses they had taken, the theory might have been covered up to a week's time away. They really appreciated being able to reinforce the lecture material so soon after hearing it. This is yet another endorsement for the studio classroom/laboratory concept. It works as advertised and, for this audience, much better than the traditional methods.

• Instructor feedback was also very positive. If the instructor was used to bringing hardware demonstrations to their classroom, they were delighted to have the facilities close at hand. For those who did not, when demonstrations were provided, they became more inclined to use them.

• Their initial impression of this style of teaching was very positive. They have begun to implement this type of teaching in the Electrical Engineering major introductory courses. Their primary goal was one of pedagogy, a better way to present and teach the material that would increase understanding and retention. Side benefits that they had not planned for were the efficiency of room scheduling and the time gained by incorporating the laboratories into the class periods. Both instructors and students are more engaged.

• They did not see this as the only way to teach a laboratory course. Single use laboratories that are also used for research were not well suited for this approach. They do, however, see it as a better way for much of the core courses as they continue to improve and refine their programme".

5.2.2 Other studies

A number of other studies have been reported, although not as in much detail as those above. Palmer et al (2002) for example, at Virginia Commonwealth University, report on a studio-course developed for an engineering chemistry course. This referred mainly to the setting up of the studio and the structure of the course, but had little quantitative data relating to student assessment or feedback. There have also been a number of studies carried out at RPI in areas other than engineering. Thompson (2001) reports a study at RPI on aeronautical engineering, makes the comment that "this studio approach is shown as an example of pragmatic relevant education without abandoning the principles of the fluids engineering sciences", but does not include any useful data. McNiell and Keenaghan (2002) at Worcester Polytechnic Institute, report on the transition from traditional methods to studio-based teaching on an Analogue Integrated Circuit Design course. 13 students volunteered to 'test-drive' the new course, but no systematic analysis of the results was carried out. They comment:

> "In an attempt to test the effectiveness of the studio format during the actual course, one question on each of the course exams was geared specifically to information covered in the studio (lab and simulation) sections of the lectures. A total of 29 out of 43 students performed better on these "studio questions" than on the remaining traditional questions. Interestingly, of the six "test-drive" students who enrolled in the course, all performed better on the studio questions.
>
> From the student evaluations administered at the end of the course, all but one student commenting on the new format mentioned a preference to the studio format. In response to a question regarding possible improvements, many students requested longer lecture periods. For the next offering of the course in the spring of 2003, two-hour lecture periods will be held three times a week, with both simulations and lab measurements in each period".

Although not directly related to studio-based teaching, some other studies have been published that mirror the methodology in this thesis. What is important about these studies, especially the ones carried out by Felder and colleagues at North Carolina State University, is their attempt to explain the results using Personality Typing and Learning Styles. Although this methodology has come in for some trenchant criticism recently, most following the publication of Coffield et al (2004) in the *"Learning styles and pedagogy in post-16 learning: A systematic and critical review"* booklet, there is some benefit in using the concept of learning styles in trying to explain why different students show such different reactions to the studio teaching paradigm[1].

Felder, Felder and Dietz (1997) report the conclusions from a 5 semester longitudinal study of chemical engineering students at North Carolina State University. They split the classes into a control group that took the courses in the traditional manner, and an experimental group that were taught using extensive collaborative (team-based) learning. Although not a true studio-based class the experimental method contained the main elements of studio teaching - e.g. problem solving and collaborative learning. Four previous reports presented the detailed analysis of the data obtained in greater detail (Felder et al, 1993; Felder et al, 1994; Felder et al, 1995a; Felder et al, 1995b). These results, although interesting, are not entirely relevant to this thesis and thus only the summary findings will be quoted.

First, Felder et al (1997) address the gender issue. This has been ignored in many publications on

[1] We should also have to take into account that much of the early attempts to assemble a theory of collaborative learning were based on early learning style papers, such as Kolb (1984), as detailed in the first chapter of this thesis. It seems, therefore, logical to continue in this general direction, even though the statistical evidence for some of the approaches may be in some doubt!

the subject, but as Felder's work mainly involves Personality Typing and Learning Styles (see below) they consider it important.

> "Cooperative (team-based) learning was a major component of the experimental course sequence and was viewed positively by both men and women but more so by the women; however, the women were also significantly more likely to feel that their contributions were undervalued by other group members. When asked what they perceived to be the greatest benefit of group work, the men were much more likely to say they benefited from explaining the material to others while the women were more likely to cite having the material explained to them".

They then consider the different responses to studio-type courses taking into account Personality Type based on the Myers Briggs Type Indicator (MBTI). This will be explained in greater detail below.

> "The experimental courses emphasised applications over theory, included both traditional and open-ended questions and problems, and problem-formulation exercises that stressed creative thinking, and involved a great deal of group work, both in and out of class, as opposed to exclusive formal lecturing and individual homework. More sensors than intuitors rated the experimental courses much more instructive than other more traditional chemical engineering courses they had taken (although well over half of the students in both categories expressed this opinion)". (Felder et al, ibid)

They consider that the use of more collaborative, student-centred, instruction was a worthwhile goal:

> "Evidence suggests that relative to traditionally-taught students, the students who proceeded through the experimental sequence emerged with more positive attitudes about the quality of their instruction, higher levels of confidence in their engineering problem solving abilities, a greater sense of community among themselves, and perhaps a higher level of employability resulting in part from their extensive experience with team projects" (Felder, 1995b).

> "The nature of the study made it impossible to draw statistically verifiable conclusions about whether the experimental group actually achieved a greater mastery of the curriculum content or graduated with higher skill levels than the comparison group. It is also not possible to determine the extent to which the positive effects that were observed could be attributed to the experimental instructional methods and the extent to which the Hawthorne effect could be responsible. However, it is fair to conclude that positive results can be expected if an instructor teaches in a way that integrates theory and practice rather than proceeding deductively from theory to practice, and if the students are required to work with, learn from, and teach one another rather than relying on the instructor

as the sole source of information". (Felder et al, 1997)

However, they finally consider the gains in student learning against the extra effort required of those doing the teaching:

> "Moving to a student-centred instructional approach may not be an easy step for professors of technical subjects (or any other subjects, for that matter). They have to deal with the fact that while they are learning to implement the new approach they will make mistakes and may for a time be less effective than they were using
> more familiar teacher-centred methods. They may also have to confront and overcome substantial student opposition and resistance, which can be a most unpleasant experience, especially for teachers who are good lecturers and may have been popular with students for many years. The experience of the longitudinal study suggests that instructors who pay attention to collaborative learning principles when designing their courses, who are prepared for initially negative student reactions, and who have the patience and the confidence to wait out these reactions, will reap their rewards in more positive student attitudes toward their subjects and toward themselves, and probably in more and deeper student learning (although it may be difficult to quantify the latter outcomes). It will take an effort to get there, but it is an effort well worth making" (Felder et al, 1997).

5.2.3 Discussion

It is clear from the studies quoted in this section that there are consistent advantages from studio-type courses. These findings complement those given in Chapter 3. Students who use the teaching studio initially find problems with the methodology, but once comfortable with it, most achieve greater learning as shown by assessment and feedback. Again, there will always be those who are unhappy and cannot thrive in the studio environment.

We now go on to consider whether various aspects of student diversity can explain this.

5.3 Student diversity and personality type

5.3.1 Introduction

There have been many attempts over the past 50 years or so to categorise students into types according to how they are perceived to learn. Much of this work has been carried out over the whole curriculum, with few people focusing on engineering students. At the same time, many teachers of engineering have seen that students do learn in different ways, with some learning more in formal lectures, some in tutorials, some in laboratory classes. This evidence is mostly empirical, and any teacher who has been teaching for a few years (or decades!) will come to their own conclusions. Most of these conclusions have never been published, but are the background to many discussions on curriculum development in many staff rooms across universities and colleges worldwide. They are also the 'folk-wisdom' passed down from experienced teachers to newer teachers during the mentoring process.

In fact, the major basis for the development of studio-based teaching, originally at RPI, was the fact that the more experienced faculty realised that there must be a better way of teaching science and engineering. Little theoretical basis for the methodology was apparent in the early papers by Wilson (1994), for example. The introduction of studio teaching at CityU was also based on a 'gut feeling' by those involved that this was the way to go, as far as improving the student learning experience was concerned. Again, little or no theoretical basis was given in any of the plans or proposals.

However, a decade or so has passed since then, and during that time a number of studies have been published that consider engineering students in particular. Much of this has been carried out by Felder and his colleagues, as mentioned in the previous section, based on the work by Lawrence at Florida State University, Gainesville. The following section looks at this in some detail.

5.3.2 Learning Styles

Although many studies have been carried out over the past few decades on different learning styles and their correlation with personality types, little had been published with specific reference to diversity among engineering students until the seminal work carried out by Felder and his associates (1998) at North Carolina State University. Much of this was based upon work originally published by Lawrence at University of Florida (1982, 1984) into personality typing. The brief synopsis of the subject given below relies heavily on these two sources, especially a review paper published by Felder and Brent (2005). By studying the diversity of learning styles of education, especially in the engineering programme, it may be possible to derive an explanation for the different reactions students have to studio-based teaching.

Felder and Brent (2005) opine that if it is pointless to consider tailoring instruction to each individual student, it is equally misguided to imagine that a single one-size-fits-all approach to teaching and meet the needs of every student.

> "Unfortunately, a single approach has dominated engineering education since its inception: the professor lectures and the students attempt to absorb the lecture content and reproduce it in examinations. That particular size fits almost nobody: it violates virtually every principle of effective instruction established by modern cognitive science and educational psychology (Bransford et al., 2000; Biggs, 2003; McKeachie, 2002; Ramsden, 2003). Any other approach that targets only one type of student would probably be more effective, but it would still fail to address the needs of most students. It follows that if completely individualised instruction is impractical and one-size-fits-all is ineffective for most students, a more balanced approach that attempts to accommodate the diverse needs of the students in a class at least some of the time is the best an instructor can do".

According to Keefe (1979), learning styles are "characteristic cognitive, affective, and psychological behaviours that serve as relatively stable indicators of how learners perceive, interact with, and respond to the learning environment".

> "The concept of learning styles has been applied to a wide variety of student attributes and differences. Some students are comfortable with theories and abstractions; others feel much more at home with facts and observable phenomena; some prefer active learning and others lean toward introspection; some prefer visual presentation of information and others prefer verbal explanations. One learning style is neither preferable nor inferior to another, but is simply different, with different characteristic strengths and weaknesses. A goal of instruction should be to equip students with the skills associated with every learning style category, regardless of the students' personal preferences, since they will need all of those skills to function effectively as professionals." (Felder and Brent, 2005).

Several dozen learning style models have been developed, five of which have been the subject of studies in the engineering education literature. The best known of these models is Jung's Theory of Psychological Type as operationalised by the Myers-Briggs Type Indicator (MBTI). As Felder states, "strictly speaking, the MBTI assesses personality types, but MBTI profiles are known to have strong learning style implications (Felder, 1996; Lawrence, 1993; Pittenger, 1993). This instrument was the basis for a multicampus study of engineering students in the 1970s and 1980s and a number of other engineering-related studies since then (McCaulley, 1976; Yokomoto et al, 1982; Felder et al, 2002). Other models that have been applied extensively to engineering are those of Kolb (Stice, 1987; Felder, 1996), and Felder and Silverman (Felder et al, 1988; Felder; 1993; Rosati et al, 1995; Sharp, 2003). Two other models that have been used in engineering are those of Herrmann (Felder, 1996; Herrmann, 1989) and Dunn and Dunn (Dunn et al, 1989)". As relatively little assessment has been performed on the applicability of the latter two models to instructional design in engineering, only the first three are considered here further. According to Coffield et al (2004), Felder and Silverman's model is closely related to those of Kolb (1984), Herrmann (1989), Honey and Mumford (2000), amongst others. Coffield classifies these models as being in the 'family' of flexible, stable, learning preferences.

Starting with the MBTI - one of the most widely used models, people are classified according to their preferences on four scales derived from Jung's Theory of Psychological Types (Lawrence, 1993):

- *extraverts* (try things out, focus on the outer world of people) or *introverts* (think things through, focus on the inner world of ideas).

- *sensors* (practical, detail-oriented, focus on facts and procedures) or *intuitors* (imaginative, concept-oriented, focus on meanings and possibilities).

- *thinkers* (sceptical, tend to make decisions based on logic and rules) or *feelers* (appreciative, tend to make decisions based on personal and humanistic considerations).

- *judgers* (set and follow agendas, seek closure even with incomplete data) or *perceivers* (adapt to changing circumstances, postpone reaching closure to obtain more data).

Lawrence (1993) characterises the preferences, strengths, and weaknesses of each of the 16 MBTI types in many areas of student functioning and offers numerous suggestions for addressing the learning needs of students of all types[2].

A number of studies have been carried out to determine the applicability of MBTI to engineering students (McCaulley et al, 1983; Godelski, (1984); McCaulley et al, (1985); Rosati, (1993); Rosati (1997)). In one such study, Felder, Felder and Dietz (2002) carried out a longitudinal study by administering the MBTI to a group of 116 students taking the introductory chemical engineering course at North Carolina State University. That course, and four subsequent chemical engineering courses, were taught in a manner that emphasised active and cooperative learning. Type differences in various academic performance measures and attitudes were noted as the students progressed through the curriculum. The results were remarkably consistent with expectations based on type theory:

- *Intuitors* performed significantly better than sensors in courses with a high level of abstract content, and the converse was observed in courses of a more practical nature. *Thinkers* consistently outperformed feelers in the relatively impersonal environment of the engineering curriculum, and feelers were more likely to drop out of the curriculum even if they were doing well academically. Faced with the heavy time demands of the curriculum and the corresponding need to manage their time carefully, *judgers* consistently outperformed perceivers.

- *Extraverts* reacted more positively than introverts when first confronted with the requirement that they work in groups on homework. (By the end of the study, both groups almost unanimously favoured group work.)

- The balanced instruction provided in the experimental course sequence appeared to reduce or eliminate the performance differences previously noted between *sensors* and *intuitors* and between *extraverts* and *introverts.*

---

[2] I attended a workshop led by Lawrence in Florida in 2004. At the beginning of this he asked a number of questions to determine how we learned things, and how we responded to learning. According to MBTI we should have divided ourselves into 16 neat groups. However, at least half of the workshop attendees had great difficulty answering the questions with any certainty - on many occasions we could have answered either way, with some questions eliciting the answer 'both'!! It was clear at the end of the session that the 16 groups referred to with some certainty by those applying the MBTI are in fact rather fuzzy!! This does go someway to empirically proving the points that Coffield et al (2004) make in their book, which is referred to later.

• *Intuitors* were three times more likely than *sensors* to give themselves top ratings for creative problem-solving ability and to place a high value on doing creative work in their careers.

• The majority of *sensors* intended to work as engineers in large corporations, while a much higher percentage of *intuitors* planned to work for small companies or to go to graduate school and work in research. *Feelers* placed a higher value on doing socially important or beneficial work in their careers than *thinkers* did. (Felder and Brent, 2005)

In Kolb's model, students are classified as having a preference for (a) *concrete experience or abstract conceptualisation* (how they take information in) and (b) a*ctive experimentation or reflective observation* (how they process information) (Stice, 1987; Kolb, 1984). The four types of learners in this classification scheme are:

• *Type 1* (concrete, reflective)—*the diverger*. Type 1 learners respond well to explanations of how course material relates to their experience, interests, and future careers. Their characteristic question is "*Why*?" To be effective with Type 1 students, the instructor should function as a *motivator*.

• *Type 2* (abstract, reflective)—the *assimilator*. Type 2 learners respond to information presented in an organised, logical fashion and benefit if they are given time for reflection. Their characteristic question is "*What*?" To be effective, the instructor should function as an *expert*.

• *Type 3* (abstract, active)—the *converger*. Type 3 learners respond to having opportunities to work actively on well defined tasks and to learn by trial-and-error in an environment that allows them to fail safely. Their characteristic question is "*How?*" To be effective, the instructor should function as a *coach*, providing guided practice and feedback in the methods being taught.

• *Type 4* (concrete, active)—the *accommodator*. Type 4 learners like applying course material in new situations to solve real problems. Their characteristic question is "*What if ?*" To be effective, the instructor should pose open-ended questions and then get out of the way, maximising opportunities for the students to discover things for themselves. Problem-based learning is an ideal pedagogical strategy for these students. (Felder and Brent, 2005)

Traditional science and engineering instruction focuses almost exclusively on lecturing, a style comfortable for only Type 2 learners. Effective instruction involves *teaching around the cycle* - motivating each new topic (Type 1), presenting the basic information and methods associated with the topic (Type 2), providing opportunities for practice in the methods (Type 3), and encouraging exploration of applications (Type 4).

According to a model developed by Felder and Silverman (1988) and Felder (1993), a student's learning style may be defined by the answers to four questions:

- What type of information does the student preferentially perceive: *sensory* (sights, sounds, physical sensations) or *intuitive* (memories, thoughts, insights)? Sensing learners tend to be concrete, practical, methodical, and oriented toward facts and hands-on procedures. Intuitive learners are more comfortable with abstractions (theories, mathematical models) and are more likely to be rapid and innovative problem solvers (Felder, 1989). This scale is identical to the sensing-intuitive scale of the Myers-Briggs Type Indicator.

- What type of sensory information is most effectively perceived: *visual* (pictures, diagrams, flow charts, demonstrations) or *verbal* (written and spoken explanations)?

- How does the student prefer to process information: *actively* (through engagement in physical activity or discussion) or *reflectively* (through introspection)? This scale is identical to the active-reflective scale of the Kolb model and is related to the extravert-introvert scale of the MBTI.

- How does the student characteristically progress toward understanding: *sequentially* (in a logical progression of incremental steps) or *globally* (in large "big picture" jumps)? Sequential learners tend to think in a linear manner and are able to function with only partial understanding of material they have been taught. Global learners think in a systems-oriented manner, and may have trouble applying new material until they fully understand it and see how it relates to material they already know about and understand. Once they grasp the big picture, however, their holistic perspective enables them to see innovative solutions to problems that sequential learners might take much longer to reach, if they get there at all (Felder, 1990).

<u>*5.3.3 Approaches to learning and orientation to studying*</u>

Entwhistle (1998) is of the opinion that students may be inclined to approach their courses in one of three ways. Those with a *reproducing orientation* tend to take a *surface approach* to learning, relying on rote memorisation and mechanical formula substitution and making little or no effort to understand the material being taught. Those with a *meaning orientation* tend to adopt a *deep approach*, probing and questioning and exploring the limits of applicability of new material. Those with an *achieving orientation* tend to use a *strategic approach*, doing whatever is necessary to get the highest grade they can, taking a surface approach if that suffices and a deep approach when necessary. A goal of instruction should be to induce students to adopt a deep approach to subjects that are important for their professional or personal development.

Ramsden (2003) and Entwhistle (ibid) conclude that a student may adopt different approaches to learning in different courses and even for different topics within a single course. An *orientation to studying* is a tendency to adopt one of the approaches in a broad range of situations and learning environments. Students who habitually adopt a surface approach have a *reproducing orientation*; those who usually adopt a deep approach have a *meaning orientation*; and those inclined to take a strategic approach have an *achieving orientation*.

Felder and Brent (2005) quote a number of studies that used the Lancaster Approaches to Studying Questionnaire (LASQ) as described by Ramsden (1983). This is a is a sixty-four-item questionnaire that involves twelve subscales relevant to the three orientations and four additional subscales. Three studies are quoted:

> "Woods et al. (2000) report on a study in which one of the short forms of the LASQ was administered to 1,387 engineering students. The strongest inclination of the students was toward a strategic approach, followed in order by a surface approach and a deep approach. Bertrand and Knapper (1991) report LASQ results for students in other disciplines. Chemistry and psychology students went from a preference for strategic learning in their second year to a preference for deep learning in their fourth year, with both groups displaying consistently low inclinations toward a surface approach.
>
> Bertrand and Knapper (1991) also report on three groups of students in two multidisciplinary curricula—students in the second and fourth years of a project-based environmental resource studies programme and students in a problem-based programme on the impact of new materials. All three groups showed relatively strong inclinations toward a deep approach. There was little difference in the profiles of the second- and fourth-year students, suggesting that the results might reflect the orientations of the students selecting into the programmes more than the influence of the programmes".

There are similarities between orientations to studying and learning styles. As Felder and Brent (ibid) state, "Both represent tendencies that are situationally dependent, as opposed to fixed traits like gender or handedness that always characterise an individual. Just as a student who is a strong intuitor may function like a sensor in certain situations and vice versa, a student with a pronounced meaning orientation may under some circumstances adopt a surface approach to learning, and a strongly reproducing student may sometimes be motivated to dig deep. Similarly, just as students may be reasonably balanced in a learning style preference, frequently functioning in ways characteristic of, say, both sensors and intuitors, some students may be almost equally likely to adopt deep and surface approaches in different courses and possibly within a given course".

They also report three studies that assessed student approaches to learning and correlated the results to various learning outcomes. First, Ramsden (2003) cites studies where students who took a deep approach to reading created comprehensive and integrated summaries of material they had read, interpreting the information rather than simply repeating it, while those who took a surface approach were more likely to recite fragments of the reading content almost randomly. The deep approach also led to longer retention of information - presumably because the information was learned in context rather than by rote memorisation - and to consistently higher grades on examinations and in courses.

Felder and Brent (2005) also cite Prosser and Millar (1989) who examined first-year physics students' understanding of force concepts before and after their introductory mechanics course. Eight out of nine students who took a deep approach and only two of twenty-three who used a surface approach showed significant progress in understanding force concepts, moving away from Aristotle and toward Newton. They also cite Meyer et al. (1990), who found that engineering students who adopted a deep approach in a course were very likely to pass the course (in fact, none of their subjects in this category failed), while students who adopted a surface approach were very likely to fail. The students who adopted a deep approach also generally expressed greater satisfaction with their instruction.

How does a teacher motivate a deep approach to learning? Felder and Brent (2005) suggest that the approach a student might adopt in a particular situation depends on a complex array of factors. Some are intrinsic to the student (e.g., possession of prerequisite knowledge and skills and motivation to learn the subject), while others are determined more by the instructional environment (e.g., the content and clarity of the instructor's expectations and the nature and quality of the instruction and assessment).

They cite Biggs (2003) as proposing that achieving desired learning outcomes requires *constructive alignment* of the elements just listed. *Alignment* means that the factors under the instructor's control are all consistent with the goal: the desired outcomes are clearly communicated to the students as expectations, instructional methods known to favour the outcomes are employed and methods that work against them are avoided, and learning assessments (homework, projects, tests, etc.) are explicitly directed toward the outcomes. *Constructive* means that the instructional design adheres to the principle of constructivism, which holds that knowledge is constructed by the learner, as opposed to being simply transmitted by a teacher and absorbed. They continue:

> "Well-established instructional strategies can be used to achieve these conditions. Inductive teaching methods such as *problem-based* and *project-based learning* can motivate students by helping to make the subject matter relevant to their prior experience and interests and they also emphasise conceptual understanding and de-emphasise rote memorisation. An excellent way to make expectations clear is to articulate them in the form of instructional ob*jectives* - statements of observable actions students should be able to do (define, explain, calculate, derive, model, design) once they have completed a section of a course.
>
> Several student-centred teaching approaches accomplish the goal of actively involving students in learning tasks , notably *active learning* (engaging students

in class activities other than listening to lectures) and *cooperative learning* (getting students to work in small teams on projects or homework under conditions that hold all team members accountable for the learning objectives associated with the assignment). Trigwell et al. (1998, 1999) found a positive correlation between an instructor's use of such instructional methods and students' adoption of a deep approach to learning".

Finally, most students undergo a developmental progression "from a belief in the certainty of knowledge and the omniscience of authorities to an acknowledgment of the uncertainty and contextual nature of knowledge, acceptance of personal responsibility for determining truth, inclination and ability to gather supporting evidence for judgments, and openness to change if new evidence is forthcoming. At the highest developmental level normally seen in college students (but not in many of them), individuals display thinking patterns resembling those of expert scientists and engineers. A goal of instruction should be to advance students to that level by the time they graduate" (Felder and Brent, 2005).

Following the general direction of Felder and Brent's review paper, a number of models of intellectual development will be considered. Perry's Model of Intellectual Development (Perry, 1988; Love and Guthrie, 1999), is the only one that has had widespread application in engineering education. The others are the King-Kitchener Model of Reflective Judgement (King and Kitchener, 1994, 2001), which is probably the most widely used and validated of the models outside engineering education, and Baxter Magolda's Model of Epistemological Development (Baxter Magolda, 1992). Belenky et al. (1986) suggest that Perry's model largely characterises men (its formulation was based almost entirely on interviews with male students) and propose an alternative progression of stages intended to characterise women's development

"The developmental pattern described by all four models has the following general form. Students at the lowest levels (Baxter Magolda's *absolute knowing* and Perry's *dualism*) believe that every intellectual and moral question has one correct answer and their professors (at least the competent ones) know what it is. As the students confront challenges to their belief systems in their courses and through interactions with peers, they gradually come to believe in the validity of multiple viewpoints and concurrently decrease their reliance on the word of authorities (Baxter Magolda's *transitional* and *independent knowing* and Perry's *multiplicity*). Baxter Magolda's highest level, *contextual knowing*, which parallels Perry's *contextual relativism* (Level 5) and the early stages of *commitment in the face of uncertainty* (Level 6 and perhaps Level 7), is characterised by final rejection of the notions of the certainty of knowledge and the omniscience of authorities. Contextual knowers take responsibility for constructing knowledge for themselves, relying on both objective analysis and intuition and taking into account (but not accepting without question) the ideas of others whose expertise they acknowledge. They move away from the idea commonly held by independent knowers (Level 4 on the Perry scale) that all opinions are equally valid as long as the right method is used to arrive at them, and they acknowledge the need to base judgments on the best available evidence within the given context, even in the face of uncertainty and ambiguity" (Felder and Brent, 2005).

Two major studies of intellectual development have been reported. Pavelich's study (1996) was carried out to assess the effect on intellectual development of the strong experiential learning environment at the Colorado School of Mines. The other study by Wise et al. (2004) was intended to determine the effect of a first-year project-based design course at Penn State. The studies are remarkably consistent in their assessments of the initial and final average levels of the subjects.

"Most of the entering students were near Perry Level 3, only beginning to recognise that not all knowledge is certain and still relying heavily on authorities as sources of truth. The average change after four years of college was one level, with most of the change occurring in the last year. Neither instructional approach met its goal of elevating a significant number of students to Level 5. As discouraging as these results might seem, one could speculate that a curriculum lacking such features as the experiential learning environment at Mines or the project-based first-year experience at Penn State would lead to even less growth than was observed in the two studies in question"(Felder and Brent, 2005).

Wise et al. (ibid) also report Perry ratings of eight male engineering students and eight female engineering students who completed the first-year project-based design course.

"There was initially no appreciable difference between the two groups in average Perry rating or SAT scores. At the end of the first year, the average Perry rating

A. Variety and choice of learning tasks
1. Varied problem types
2. Varied levels of assignment definition and structure
3. Choice on assignments, tests, and grading policies
B. Explicit communication and explanation of expectations
I. Instructional objectives covering high-level tasks
2. Study guides and tests based on the objectives
C. Modeling, practice, and constructive feedback on high-level tasks
I. Assignment of relevant tasks and modeling of required procedures
2. Practice in assignments followed by inclusion of similar tasks on tests
D. A student-centred instructional environment
1. Inductive learning (problem/project based learning, guided inquiry)
2. Active and cooperative learning
3. Measures to defuse resistance to student-centred instruction
E. Respect for students at all levels of development
I. A sense of caring about students
2. Awareness of and respect for current levels of development while promoting higher levels

Table 5.4 Instructional conditions that facilitate intellectual growth (Table 4, from Felder and Brent, 2004)

> was 3.50 for the men and 3.16 for the women; at the end of the third year the ratings were 3.50 (men) and 3.00 (women); and at the end of the fourth year the ratings were 4.00 (men) and 4.50 (women). None of the differences were statistically significant although the differences for the third year came close ($p = 0.054$). The lack of significance could be an artifact of the small sample size. To the extent that the observed differences are real, they support the contentions of Belenky et al (1986) and Baxter Magolda (1992) that men and women exhibit different patterns of development" (Felder and Brent, ibid).

Felder and Brent (2004) propose five instructional conditions that should provide the balance of challenge and support needed to promote intellectual growth and suggest numerous ways to establish the conditions. The conditions are listed in Table 5.4.

They write that "most of the methods suggested are supported by extensively cited references on teaching and learning (Bransford et al, 2000; Biggs, 2003; Ramsden, 2003; Chickering and Gamson, 1991; Eble, 1988; Lowman, 1995; Wankat 2002), and the student-centred approaches of Condition D have repeatedly been shown to have positive effects on a wide variety of learning outcomes (Hake, 1998; Springer et al, 1998; Johnson et al, 2000; Teremzini et al, 2001; Fagen et al, 2002). However, until a researcher implements the recommendations and assesses the intellectual development of the subjects (ideally comparing their growth with that of a control group that goes through a traditionally taught curriculum), the effectiveness of the conditions in Table 4 at promoting growth will remain speculative".

5.3.4 Discussion

The very brief survey of learning styles and type indicators above is not designed to derive a learning model for the studio based classes. It is to give an idea of the broad spectrum of ideas that might give some indication of what's going on in the studio. It would take considerably more detailed analysis, as well as a dedicated research project to achieve this.

Having said that, it may be helpful to try and relate some of this to the classes that have been observed in some detail in this study at CityU. Although no quantitative data is available to come to any conclusions, there is clearly a lot of qualitative data, as well as a decade of observation of how the classes operate in practice. This may allow some empirical conclusions to be drawn.

One of the strengths of the integrated studio approach is that there is no clear distinction between lecture, tutorial and lab. The assessment therefore combines all aspects of the teaching methodology. Classes that are assessed on lectures only will benefit those who can learn in that environment; and the same goes for tutorials and labs. Reference to the previous section can show clearly that whatever model of learning is used, some students learn better than others in different teaching and learning environments.

In the studio classes it becomes very clear, especially of the class is small, and there is long term contact between the students and the instructor, as in this study (i.e. two semesters), that the class splits into four different groups when it comes to learning. This is even noticeable during the PBL sessions when small groups are formed, usually of two students, but in practice larger as they tend to conglomerate into groups of four.

It is true that some students pay most attention to the formal presentation sessions, which are close in nature to lectures. Some students pay close attention and make notes; others listen; and a small group will be doing something not connected with the class - just like behaviour in normal lecture classes.

In the pencil and paper tutorials, again, some start work immediately, some take a long time to get started, and others just stare at a blank sheet of paper and wait for me to work through the answer which they then copy down. Small group interaction is encouraged during tutorials, but some still do not take part.

During the interactive tutorials that are part of the EDEC courseware, most of the class will take part, usually working in small groups discussing the problem. Again, a few will not participate.

In the problem-based experimental work and simulations carried out in groups of two (or four!) virtually all take part, although work may be spread amongst the members of the group. Again, there are a few how just seem to go along for the ride and copy what others have done.

Thus different patterns of learning can be discerned from the assessment marks. Some who do well in the homework may do badly in the quizzes and tests (copying??) and vice versa. For around 20% of the class there is some discrepancy between the final examination marks and the coursework marks. And within the coursework marks there is always some discrepancy between the homework/tests and project work reports/lab logs. As mentioned earlier, no analyses of these differences has been carried out, and may be a fruitful line of research at a later date. Also, it should be noted that all the observations above are empirical.

However, it is clear from the overall assessment of the class, and the lowering failure rate since the full studio implementation has been available, that all types of learner are being catered for. As an example, consider this response from a female student in one of the feedback forms:

> *"I didn't get anything from the classes but learned everything from books".*

Normally, this could be taken as a criticism of the course; however, in this case it is taken as an example of how even those who do not claim to benefit from the studio environment still have enough 'learning space' to succeed, as she did.

So how is it possible to make some sense from all of this? Coffield et al (2004) do a good job in deflating some of the claims made by the proponents of various models of learning styles. On the other hand, they do agree that some of the claims do stand after rigorous analysis.

For example, Coffield et al are very scathing about some of the work of Felder and Lawrence, both quoted extensively above (Section 5.3.2).

> "Felder has written articles on the relevance of learning styles to the teaching of science to adults. After examining four different models – the Myers-Briggs Type Indicator, Kolb's Learning Style Inventory, Herrmann's Brain Dominance Instrument and his own Felder-Silverman instrument – he concludes (1996): 'Which model educators choose is almost immaterial, since the instructional approaches that teach around the cycle for each of the models are essentially identical'. We disagree strongly: it matters which model is used and we have serious reservations about the learning cycle".

They also go on to comment on the work of Lawrence:

> "For other commentators, the absence of sound evidence provides no barrier to basing their arguments on either anecdotal evidence or 'implicit' suggestions in the research. Lawrence (1997), for instance, does exactly that when discussing the 'detrimental' effects of mismatching teaching and learning styles. More generally, the advice offered to practitioners is too vague and unspecific to be helpful; for example, 'restructure the classroom environment to make it more inclusive rather than exclusive'".

Implications for pedagogy

However, Coffield et al are complimentary about some of the work of Entwistle (1990, 1988), also quoted above (Section 5.3.2), as well as Vermunt (1996). They opine that they have shown that attention needs to be given not only to individual differences in learners, but to the whole teaching - learning environment.

> "Both have demonstrated that while the motivations, self-representations, metacognitive and cognitive strengths and weaknesses of learners are all key features of their learning style, these are also a function of the systems in which learners operate. A central goal of their research is to ensure that lecturers can relate concepts of learning to the specific conditions in which they and their students work – that is, it is the whole learning milieu that needs to be changed and not just the learning preferences of individuals".

It is the objective of this thesis to prove that studio teaching does just that, and that it is successful in doing so.

Coffield et al also quote the work of Hattie (1999) who carried out a meta-analysis of educational interventions. This indicates that the effect sizes for different types of intervention are as shown in Table 5.5.

According to Coffield et al, "it seems sensible to concentrate limited resources and staff efforts on those interventions that have the largest effect sizes. Hattie's work would seem to indicate that

Intervention	Effect size
Reinforcement	1.13
Student's prior cognitive ability	1.00
Instructional quality	1.04
Direct intervention	0.82
Student's disposition to learn	0.61
Class environment	0.56
Peer tutoring	0.50
Parental involvement	0.46
Teacher style	0.42
Affective attributes of students	0.24
Individualisation	0.14
Behavourial objectives	0.12
Team teaching	0.06

Table 5.5 Effect sizes for different types of intervention (from Hattie (1999) quoted by Coffield et al (2004))

the highest effect size is from reinforcement, followed by student's prior cognitive ability. It could be argued that in the teaching studio the environment, peer tutoring and quality of instruction and teaching style are important factors. From the data presented in Chapter 3 it appears that the effect size of studio teaching of 0.4 is consistent with those interventions directly related to the methodology, such as peer tutoring and class environment.

One last point, along the train of thought raised by Coffield et al, is of the cultural differences between Hong Kong students and those in N America and the UK where most of the studies on learning styles have been carried out. Although not directly related to learning styles, Bradbeer et al (2004) show that student evaluation of teachers is somewhat dependent on cultural assumptions and that conclusions drawn from studies carried out in the N America or Europe cannot always be directly applied to different, especially non-Western cultures.

Coffield quotes Reynolds (1997), who criticised the research tradition into learning styles "not only for producing an individualised, decontextualised concept of learning, but also for a depoliticised treatment of the differences between learners which stem from social class, race and gender. In his own words, 'the very concept of learning style obscures the social bases of difference expressed in the way people approach learning ... labelling is not a disinterested process, even though social differences are made to seem reducible to psychometric technicalities'.". Coffield continues:

> "The main charge here is that the socio-economic and the cultural context of students' lives and of the institutions where they seek to learn tend to be omitted from the learning styles literature. Learners are not all alike, nor are they all suspended in cyberspace via distance learning, nor do they live out their lives in psychological laboratories. Instead, they live in particular socio-economic settings where age, gender, race and class all interact to influence their attitudes to learning. Moreover, their social lives with their partners and friends, their family lives with their parents and siblings, and their economic lives with their employers and fellow workers influence their learning in significant ways. All these factors tend to be played down or simply ignored in most of the learning styles literature".

How much more so when considering the cultural and social context half a world away!

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

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Appendix 1

Semester A Pre-test

Pre-test for BEMTE first year Semester A

This pre-test is **NOT** an examination. Do not worry if you do not understand a question - some are based on work to be done during the coming semester; just leave the answer line blank - this is preferable to guessing! The results will **not** be used for any assessment of your performance. It will only be used to ascertain the knowledge of electronics that you have before you start the course. This will help us to tailor the course to suit the needs of the class.

It will also be used as part of a long term research project to evaluate the effectiveness of the teaching methods employed. This means that you will be tested at regular intervals during the course. Some of these tests - the mid-semester test, for example, - will be used for assessment purposes. Other questionnaires will be used that do not affect your assessment. You will be informed before each test which ones are to be used for assessment and which are for research.

This exercise is in two parts. The first asks some questions which may be used to facilitate further research. The second asks some technical questions. There are two multiple choice answer sheets. **Use one for the first part, the other for the second part**. Please remember to put your student number on the answer sheets.

Please mark the attached mark sheet with a black pen or pencil, as indicated. Return the question paper along with the m/c answer sheets.

The test will last for 40 minutes.

Part 1. Respond to the following questions by marking your choices on the first m/c answer sheet. Be sure to put you student ID on it.

Question 1

Have you ever used a computer before? A) Yes B)No

Question 2

Do you feel comfortable using a computer? A) Yes B) No

Question 3

Are you familiar with using the Internet/WWW? A) Yes B) No

Question 4

Do you know how to use Excel or another spreadsheet? A) Yes B) No

Question 5

Do you know how to use Word or another word processor? A) Yes B) No

Question 6

Do you know how to use Dbase or another database? A) Yes B) No

Question 7

Do you regularly do you homework on a computer? A) Yes B) No

Question 8

Do computers help you learn? A) Yes B) No

Question 9

Do you enjoy working on a computer? A) Yes B) No

Question 10

On average, how many hours/week do you spend on a computer?

A) 1-5 B) 6-10
C) 11-15 C) 16+

Question 11

Do you own a computer? A) Yes B) No

Question 12

If you do own a computer does it have a CD-ROM capability? A) Yes B) No

Question 13

Are you familiar with the syllabus for this course? A) Yes B) No

Question 14

What grade do you expect to get in this course? A) B) C) D)

Question 15

Would you be happy to have some of your course based on a self-learning mode using a computer workstation? A) Yes B) No

Question 16

If you answered Yes to Question 15, what percentage of the course would you like presented in self-learning mode?

A) 10% B) 20%
C) 30% D) 40%
E) 50% F) 60%
G) 70% H) 80%
I) 90% J) 100%

Question 17

Do you own a modem? A) Yes B) No

Question 18

If you answered Yes to Question 19, would you be prepared to access any self-learning material via the modem in your home? A) Yes B) No

Question 19

What language would you prefer any self-learning material to be presented?

A) English only B) Chinese only C) A mixture of English and Chinese

Question 20

What language would you prefer to have lectures presented?

A) English only B) Chinese only C) A mixture of English and Chinese

Question 21

What language would you prefer to have tutorials presented?

A) English only B) Chinese only C) A mixture of English and Chinese

Question 22

What language would you prefer to have laboratory sessions presented?

A) English only B) Chinese only C) A mixture of English and Chinese

Part 2: Mark the second m/c answer sheet with the answer you think is correct

Question 1

Resistance is measured in A) Volts B) Amperes C) Ohms, D) Watts

Question 2

The resistance of a conductor is directly proportional to A) The length, B) The cross-sectional area, C) The velocity, D) The pressure

Question 3.

Which of the following is a good conductor? A) Porcelain, B) Mica, C) Copper, D) Rubber

Question 4

Which of the following is a good insulator? A) Aluminium, B) Ebonite, C) Iron, D) Steel

Question 5

Doped silicon is classed as A) A conductor, B) A semiconductor, C) An insulator, D) An impurity

Question 6

The resistance of a cable 9133 m long having a radius of 5 mm and a specific resistance of 1.72 x 10^{-8} Ωm is approximately A) 16 Ω, B) 10 Ω, C) 2 Ω, D) 0.6 Ω.

Question 7

Four resistors in series with values of 1.5 kΩ, 3.3 kΩ, 3.9 kΩ and 4.7 kΩ will have a combined resistance of A) 9.2 kΩ, B) 10.4 kΩ, C) 13.4 kΩ D) 15.6 kΩ

Question 8

A voltage of 0.0025 V expressed in microvolts is A) 25 μV, B)250 μV C) 2.5 μV, D) 2500 μV.

Question 9

A current of 0.5 A is measured at a circuit point over a period of 2 min. The charge that has passed that point is A) 10 C, B) 20 C, D) 40 C, D) 60 C.

Question 10

A power of 12 mW is equivalent to A) 12 x 10^{-3} W, B) 12 x 10^{-6} W, C) 12 x 10^{3} W, D) 12 x 10^{6} W.

Question 11

The power dissipated by a 60 Ω resistor having 120 V across it is A) 240 W, B) 30 W, C) 120 W, D) 2 W.

Question 12

360° expressed in radians is A) $\pi/4$ rad, B) π rad, C) 2π rad, D) 4π rad.

Question 13

The sin of $5\pi/6$ is A) 0.1, B) 0.5, C) 0.866, D) 1.0.

Question 14

π rad is expressed in degrees as A) 60°, B) 90°, C) 150°, D) 180°.

Question 15

A voltage sine wave having a maximum value of 24 V is plotted from 0° to 360°. The instantaneous value at 30° is A) 1.62 V, B) 1.86 V, C) 2.02 V, D) 12 V.

Question 16

The domestic mains supply has a value of 240 V. The peak value is approximately A) 280 V, B) 300 V, C) 320 V, D) 340 V.

Question 17

A waveform has a frequency of 250 Hz. The periodic time, in seconds, is A) 0.02, B) 0.04, C) 0.004, D) 0.008.

Question 18

4.5×10^7 pf expressed in microfarads is A) 45 μF, B) 450 μF, C) 4500 μF, D) 45×10^3 μF.

Question 19

A voltage of 25 V is applied to a 1.8 nF capacitor. The charge stored is A) 25 μC, B) 45 μC, C) 25 nC, D) 45 nC.

Question 20

A capacitor has a terminal voltage of 12 V and has a value of 400 μF. The energy stored is A) 20.6 mJ, B) 26.8 mJ, C) 28.8 mJ, D) 30.2 mJ.

Question 21

Two capacitor plates are separated by a dielectric 0.5 mm thick. If the terminal voltage is 6 V, the field strength in volts per metre is A) 600, B) 6×10^3, C) 12×10^3, D) 15×10^4.

Question 22

A 230 μH inductance expressed in millihenries is A) 0.0023, B) 0.023, C) 0.23, D) 2.3

Question 23

A coil has 400 turns. If a flux of 100 mWb acting through the coil is reversed in 0.04 s, the induced voltage is A) 200 V, B) 500 V, 1000 V, D) 2000 V.

Question 24

Two coils have a mutual inductance of 1.2 H. If the current in one of the coils increases from 0 A to 10 A in 30 ms, the average voltage induced in the other coil is A) 60 V, B) 180 V, C) 200 V, D) 400 V.

Question 25

A 0.98 H coil has a reactance of 1.4 Ω at an approximate frequency of A) 142 Hz, B) 227 Hz, C) 361 Hz, D) 473 Hz.

Question 26

A 0.01 μF capacitor is in series with a 4.7 kΩ resistor. The time constant is A) 47 ms, B) 47 μs, C) 0.47 μs, D) 470 ms.

Question 27

An 8 H inductance is in series with a 5 Ω resistor. The time constant is A) 0.6 ms, B) 64 ms, C) 1.6 s, D) 16 μs.

Question 28

A 0.025 μF capacitor is in series with a 1 kΩ resistor and a 30 V supply. At the instant of switching on the voltage supply, at t = 0 s, the current is A) 30 mA, B) 60 mA, C) 120 μA, D) 180 μA.

Question 29

A conductor carrying 50 A is at a right angle to a magnetic field having a density of 0.5 T. If the conductor length is 1.0 m, the force on the conductor is A) 25 N, B) 30 N, C) 50 N, D) 70 N.

Question 30

A conductor 100 mm long is moving with a velocity of 10 ms^{-1} at right angles to a magnetic field having a flux density of 0.5 T. the emf induced in the conductor is A) 0.1 V, B) 0.5 V, C) 1.5 V, D) 2.5 V.

Question 31

A coil of 500 turns is wound on a wooden ring having a mean circumference of 200 mm. If the current in the coil is 2 A, the magnetic field strength is A) 1000A m^{-1}, B) 1500 A m^{-1}, C) 2500 A m^{-1}, D) 5000 A m^{-1}.

Question 32

A 0.2 H inductance is supplied by a 100 V 50 Hz supply. The current is A) 0.62 A, B) 1.23 A, C) 1.59 A, D) 2.31 A.

Question 33

A 25 μF capacitance is supplied by a 140 V 50 Hz supply. The current is A) 0.2 A, B) 0.8 A, C) 1.1 A, D) 2.6 A.

Question 34

A 0.12 H inductance is in series with a 15 Ω resistor. They are supplied by a 150 V 60 Hz supply.

The current is approximately A) 1.93 A, B) 2.16 A, C) 3.147 A, D) 4.231 A.

Question 35

$x + jy$ is called A) An exponential number, B) An odd number, C) An even number, D) A complex number.

Question 36

An expression such as $OA(\cos \Phi + j \sin \Phi)$ is called A) A modulus, B) A trigonometric notation, C) A polar notation, D) An argument.

Question 37

A phasor written as $OA \angle\Phi$ is called A) A polar notation, B) A trigonometric notation, C) A rectangular notation, D) An exponential.

Question 38

The expression j^4 is equal to A) 1, B) -1, C) j, D) $-j$.

Question 39

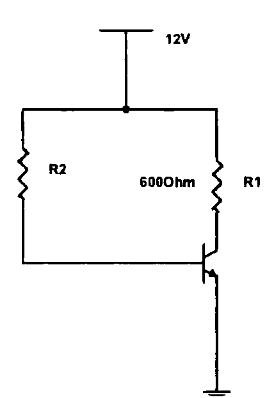
When $6 + j\,6$ is multiplied by $5 + j\,5$ answer is A) $j\,30$, B) $j\,60$, C) $6 + j\,30$, D) $6 + j\,60$.

Question 40

A 10 V battery has an internal resistance of 0.1 Ω. If it has a resistive load of 20 Ω, the terminal voltage is A) 8.5 V, B) 9.2 V, C) 9.5 V, D) 9.95 V.

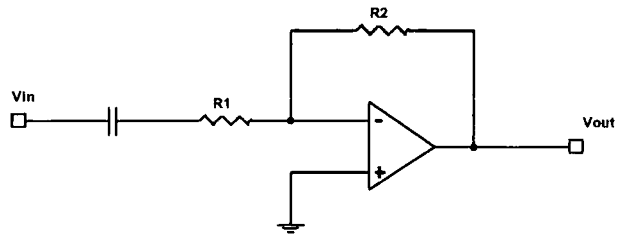
Question 41

The diagram shows the simplest practical npn transistor amplifier. The base current, I_B is 60μA, and the collector current is 10mA. Then the emitter current I_E is A) 10.06 mA, B) 10.6 mA, C) 10.0 mA, D) 16.0 mA.



Question 42

The diagram shows an inverting operational amplifier. If $R_1 = 50\ \Omega$ and $R_2 = 50\ \Omega$, the voltage gain is A) - 1, B) - 5, C) - 10, D) - 50.



Question 43

The number 111 in base 3 expressed in denary is A) 12, B) 13, C) 24, D) 26.

Question 44

The addition of binary numbers 100 and 1100 gives A) 1111, B) 10100, C) 11000, D) 10000.

Question 45

Binary 10111 subtracted from 101110 gives A) 10001, B) 10010, C) 10111, D) 11011.

Question 46

The truth table shown where A and B are the inputs and Q the output is for A) An AND gate, B) A NAND gate, C) An OR gate, D) A NOR gate.

A	B	Q
0	0	1
0	1	1
1	0	1
1	1	0

Question 47

Energy is measured in A) Coulombs, B) Joules, C) Watts, D) Amperes.

Question 48

If a force of 1 N moves an object a distance of 1 m in the direction of the force, the amount of work done is A) 1 pound, B) 1 coulomb, C) 1 volt, D) 1 joule.

Question 49

Absolute zero is A) - 100 °C, B) - 132 °C, C) -273 °C, D) - 300 °C.

Question 50

A lower alternating voltage can be produced from the mains supply by using a A) Voltmeter, B) Capacitor, C) Rectifier, D) Transformer.

Appendix 2

Analyses for A level scores by cohort and subject areas

t-test for A level scores
- all subjects
α = 0.05
t-Test: Two-Sample Assuming Unequal Variances
1996-7

	Non-ITS	*ITS*
Mean	8.15	7.951923
Variance	7.205093	4.885096
Observations	55	26
Hypothesized Mean Difference	0	
df	59	
t Stat	0.350763	
P(T<=t) one-tail	0.363508	
t Critical one-tail	1.671093	
P(T<=t) two-tail	0.727016	
t Critical two-tail	2.000995	

1997-98

Mean	7.191489	6.632813
Variance	4.296774	2.459614
Observations	47	32
Hypothesized Mean Difference	0	
df	76	
t Stat	1.361883	
P(T<=t) one-tail	0.088629	
t Critical one-tail	1.665151	
P(T<=t) two-tail	0.177258	
t Critical two-tail	1.991675	

t-Test: Two-Sample Assuming Unequal Variances
1998-99

Mean	7.741379	7.546875
Variance	1.546798	1.892893
Observations	29	32
Hypothesized Mean Difference	0	
df	59	
t Stat	0.579924	
P(T<=t) one-tail	0.282087	
t Critical one-tail	1.671092	
P(T<=t) two-tail	0.564174	
t Critical two-tail	2.000997	

t-Test: Two-Sample Assuming Unequal Variances
1999-2000

Mean	8.742857	9.128571
Variance	1.196639	2.152101
Observations	35	35
Hypothesized Mean Difference	0	
df	63	
t Stat	-1.24698	
P(T<=t) one-tail	0.108511	
t Critical one-tail	1.669403	
P(T<=t) two-tail	0.217021	
t Critical two-tail	1.998342	

t-Test: Two-Sample Assuming Unequal Variances
2000-2001

Mean	9.22093	9.344828
Variance	1.194075	2.287562
Observations	43	29
Hypothesized Mean Difference	0	
df	47	
t Stat	-0.37939	
P(T<=t) one-tail	0.353055	
t Critical one-tail	1.677927	
P(T<=t) two-tail	0.706111	
t Critical two-tail	2.011739	

t-Test: Two-Sample Assuming Unequal Variances
2001-2002

Mean	9.403226	8.870968
Variance	1.473656	5.416129
Observations	31	31
Hypothesized Mean Difference	0	
df	45	
t Stat	1.129016	
P(T<=t) one-tail	0.132437	
t Critical one-tail	1.679427	
P(T<=t) two-tail	0.264874	
t Critical two-tail	2.014103	

t-Test: Two-Sample Assuming Unequal Variances
- all subjects - all cohorts

Mean	8.408314	8.245998
Variance	0.750861	1.110914
Observations	6	6
Hypothesized Mean Difference	0	
df	10	
t Stat	0.291392	
P(T<=t) one-tail	0.388353	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.776707	
t Critical two-tail	2.228139	

t-test for A level scores
- technical subjects only
α = 0.05
t-Test: Two-Sample Assuming Unequal Variances
1996-97

	Non-ITS	*ITS*
Mean	5.731818	5.942308
Variance	6.677904	4.166538
Observations	55	26
Hypothesized Mean Difference	0	
df	61	
t Stat	-0.39661	
P(T<=t) one-tail	0.34652	
t Critical one-tail	1.670219	
P(T<=t) two-tail	0.69304	
t Critical two-tail	1.999624	

1997-98

	Variable 1	*Variable 2*
Mean	4.941489	4.632813
Variance	3.929926	2.209614
Observations	47	32
Hypothesized Mean Difference	0	
df	76	
t Stat	0.790011	
P(T<=t) one-tail	0.21599	
t Critical one-tail	1.665151	
P(T<=t) two-tail	0.431979	
t Critical two-tail	1.991675	

t-Test: Two-Sample Assuming Unequal Variances
1998-99

	Variable 1	*Variable 2*
Mean	5.431034	5.265625
Variance	1.298645	2.080393
Observations	29	32
Hypothesized Mean Difference	0	
df	58	
t Stat	0.499198	
P(T<=t) one-tail	0.309764	
t Critical one-tail	1.671553	
P(T<=t) two-tail	0.619528	
t Critical two-tail	2.001716	

t-Test: Two-Sample Assuming Unequal Variances
1999-2000

	Variable 1	*Variable 2*
Mean	6.428571	7.242857
Variance	1.046218	2.181933
Observations	35	35
Hypothesized Mean Difference	0	
df	61	
t Stat	-2.68123	
P(T<=t) one-tail	0.004711	
t Critical one-tail	1.670219	
P(T<=t) two-tail	0.009422	
t Critical two-tail	1.999624	

t-Test: Two-Sample Assuming Unequal Variances
2000-2001

	Variable 1	*Variable 2*
Mean	7.302326	7.724138
Variance	1.025471	1.778325
Observations	43	29
Hypothesized Mean Difference	0	
df	49	
t Stat	-1.44536	
P(T<=t) one-tail	0.077361	
t Critical one-tail	1.676551	
P(T<=t) two-tail	0.154722	
t Critical two-tail	2.009574	

t-Test: Two-Sample Assuming Unequal Variances
2001-2002

	Variable 1	*Variable 2*
Mean	7.370968	7.62069
Variance	1.082796	1.547414
Observations	31	29
Hypothesized Mean Difference	0	
df	55	
t Stat	-0.84044	
P(T<=t) one-tail	0.202151	
t Critical one-tail	1.673034	
P(T<=t) two-tail	0.404302	
t Critical two-tail	2.004044	

t-Test: Two-Sample Assuming Unequal Variances
- technical subjects only - all cohorts

	Variable 1	*Variable 2*
Mean	6.201034	6.404738
Variance	1.006575	1.714588
Observations	6	6
Hypothesized Mean Difference	0	
df	9	
t Stat	-0.30248	
P(T<=t) one-tail	0.38458	
t Critical one-tail	1.833113	
P(T<=t) two-tail	0.76916	
t Critical two-tail	2.262157	

t-test for A level scores
- language subjects only
α = 0.05
t-Test: Two-Sample Assuming Unequal Variances
1996-97

	Non-ITS	*ITS*
Mean	2.418182	2.009615
Variance	1.108923	1.032404
Observations	55	26
Hypothesized Mean Difference	0	
df	51	
t Stat	1.669774	
P(T<=t) one-tail	0.050546	
t Critical one-tail	1.675285	
P(T<=t) two-tail	0.101092	
t Critical two-tail	2.007584	

1997-98

	Variable 1	*Variable 2*
Mean	2.25	2
Variance	0.665761	0.451613
Observations	47	32
Hypothesized Mean Difference	0	
df	74	
t Stat	1.486673	
P(T<=t) one-tail	0.070675	
t Critical one-tail	1.665708	
P(T<=t) two-tail	0.14135	
t Critical two-tail	1.992544	

t-Test: Two-Sample Assuming Unequal Variances
1998-99

	Variable 1	*Variable 2*
Mean	2.310345	2.28125
Variance	0.918103	0.966734
Observations	29	32
Hypothesized Mean Difference	0	
df	59	
t Stat	0.116971	
P(T<=t) one-tail	0.45364	
t Critical one-tail	1.671092	
P(T<=t) two-tail	0.90728	
t Critical two-tail	2.000997	

t-Test: Two-Sample Assuming Unequal Variances
1999-2000

	Variable 1	*Variable 2*
Mean	2.314286	1.885714
Variance	0.618908	0.457143
Observations	35	35
Hypothesized Mean Difference	0	
df	66	
t Stat	2.444224	
P(T<=t) one-tail	0.008598	
t Critical one-tail	1.66827	
P(T<=t) two-tail	0.017196	
t Critical two-tail	1.996564	

t-Test: Two-Sample Assuming Unequal Variances
2000-2001

	Variable 1	*Variable 2*
Mean	1.918605	1.62069
Variance	0.546788	0.404557
Observations	43	29
Hypothesized Mean Difference	0	
df	66	
t Stat	1.824364	
P(T<=t) one-tail	0.036312	
t Critical one-tail	1.66827	
P(T<=t) two-tail	0.072624	
t Critical two-tail	1.996564	

t-Test: Two-Sample Assuming Unequal Variances
2001-2002

	Variable 1	*Variable 2*
Mean	2.032258	1.741935
Variance	0.298925	0.314516
Observations	31	31
Hypothesized Mean Difference	0	
df	60	
t Stat	2.063837	
P(T<=t) one-tail	0.021683	
t Critical one-tail	1.670649	
P(T<=t) two-tail	0.043366	
t Critical two-tail	2.000297	

t-Test: Two-Sample Assuming Unequal Variances
- language subjects only - all cohorts

	Variable 1	*Variable 2*
Mean	2.207279	1.923201
Variance	0.036469	0.053468
Observations	6	6
Hypothesized Mean Difference	0	
df	10	
t Stat	2.320306	
P(T<=t) one-tail	0.021375	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.04275	
t Critical two-tail	2.228139	

Appendix 3

Number of exam pass numbers for those passing both AS level Use of English and Chinese Language and Culture, excluding AS level Use of English and Chinese Language and Culture

Source: Hong Kong Examinations Authority

1996					
AL	4	3	2	1	0
AS					
3					
2		3	684	121	31
1	1	193	3989	990	425
0	9	6080	2820	1767	1522

1997					
AL	4	3	2	1	0
AS					
3				2	
2			659	149	33
1		154	4381	1005	425
0	10	6153	3297	1767	1513

1998					
AL	4	3	2	1	0
AS					
3					1
2		2	771	141	40
1		154	4632	1015	410
0	6	6440	3351	1868	1660

1999						
AL	5	4	3	2	1	0
AS						
3				1	1	
2				821	144	43
1		1	134	4875	1206	499
0	1	6	6767	3555	2086	1779

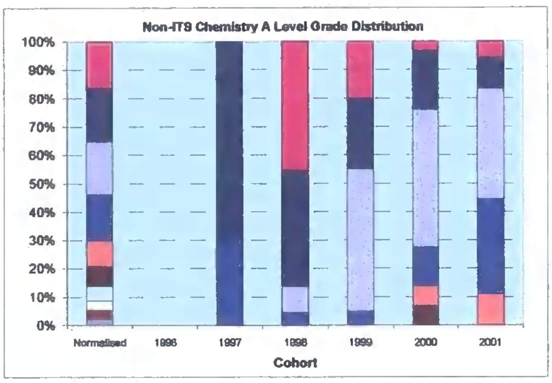
2000					
AL	4	3	2	1	0
AS					
3			2	2	1
2		1	874	147	51
1	2	130	5022	1215	504
0	1	7108	3672	2068	1874

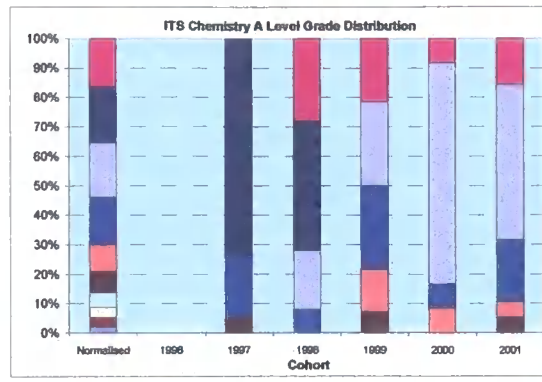
2001					
AL	4	3	2	1	0
AS					
4				1	
3			1	2	
2			1023	217	51
1		114	5091	1196	577
0	4	7474	3792	2023	1790

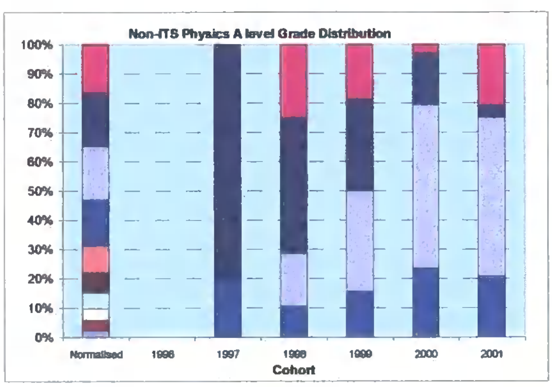
Appendix 4

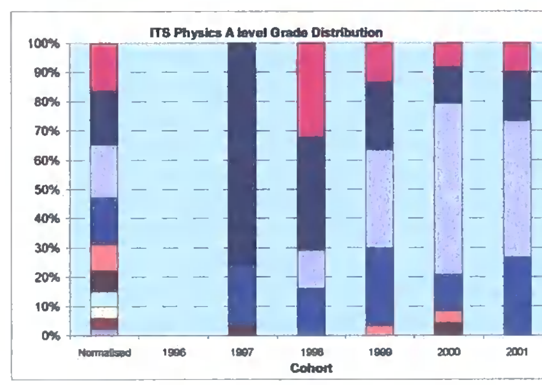
4.1 Grade distribution of each cohort for Physics, Pure Maths, and Chemistry compared to HKAE average.

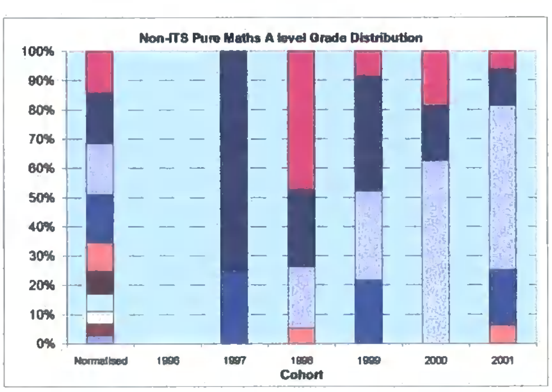
Source: Hong Kong Examinations Authority, City University of Hong Kong Registrars Office.

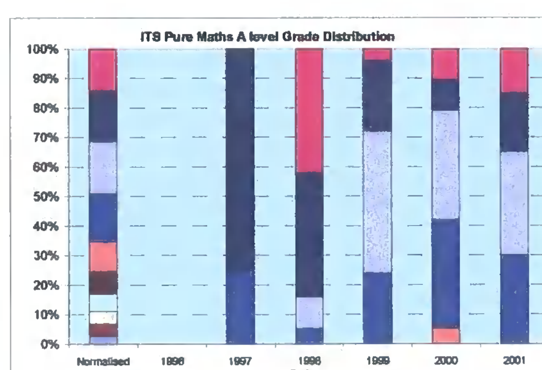










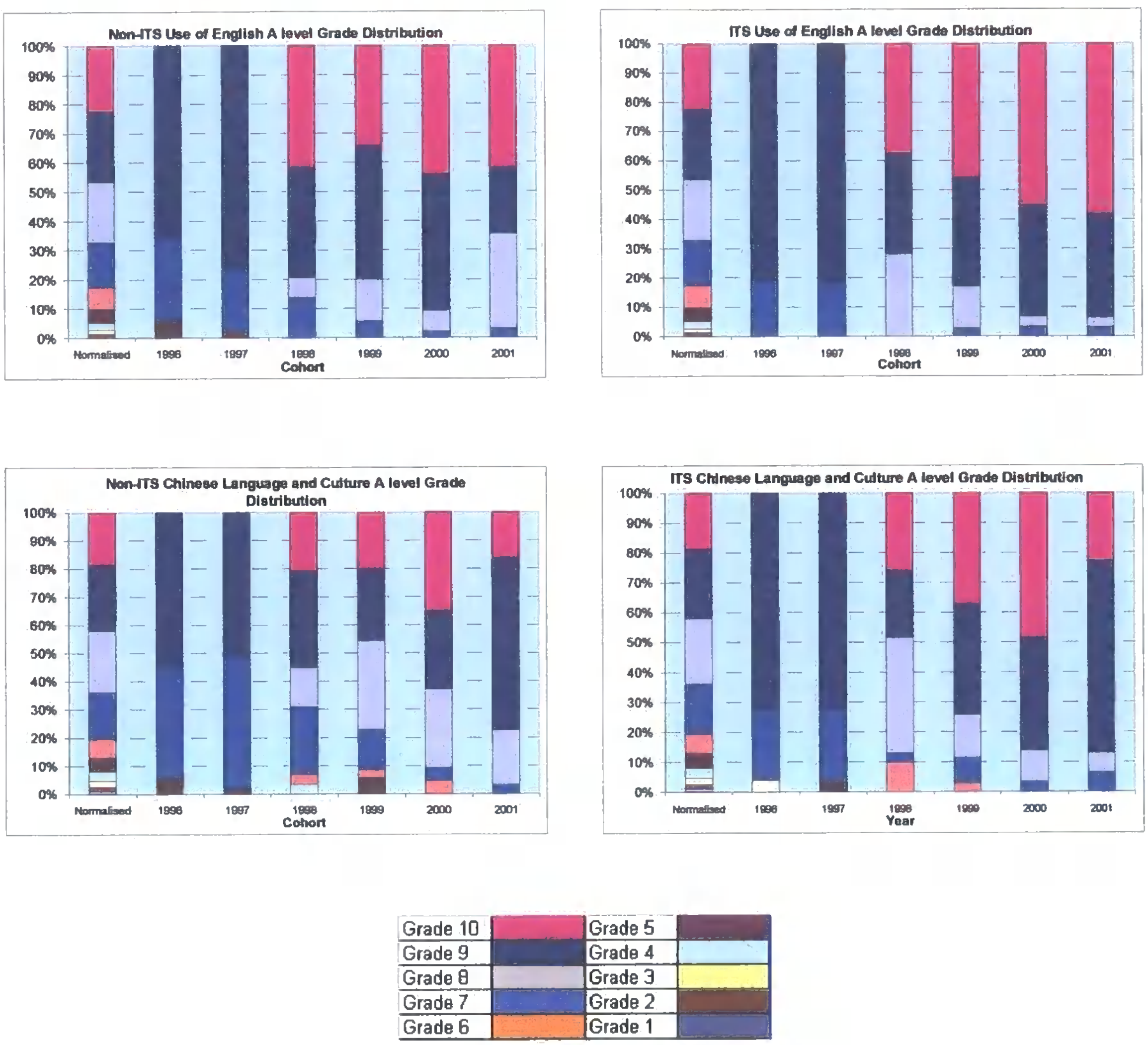


Grade 10		Grade 5	
Grade 9		Grade 4	
Grade 8		Grade 3	
Grade 7		Grade 2	
Grade 6		Grade 1	

Note: No figures were available for 1996 entry. "Coarse" letter grades were only available for 1997 entry; these have been converted to an equivalent "fine" score.

4.2 Grade distribution of each cohort for Use of English, and Chinese Language and Culture, AS level compared to HKAE average.

Source: Hong Kong Examinations Authority, City University of Hong Kong Registrars Office.



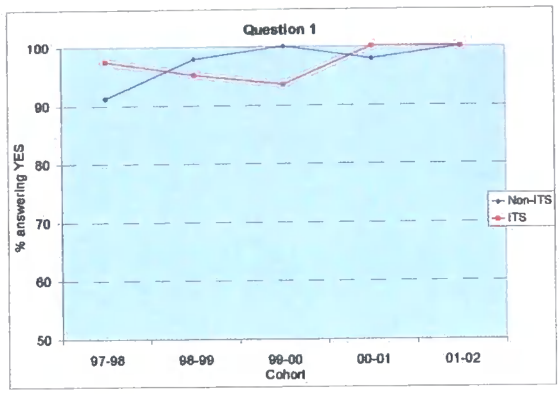
Note: For 1996 and 1997 entry "coarse" letter grades only were available. These have been converted to an equivalent "fine" grade score.

Appendix 5

Pre-test questions - part 1

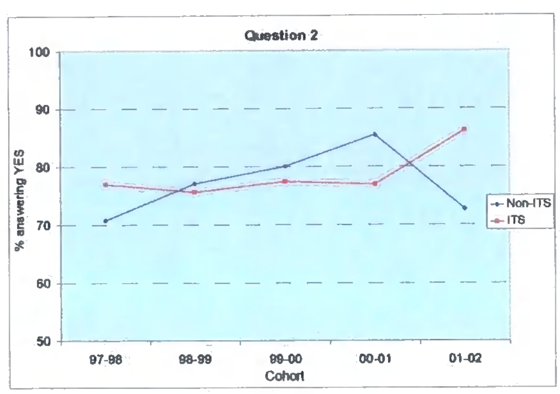
Question 1 Have you ever used a computer before?

	96-97		97-98		98-99		99-00		00-01		01-02	
	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS
Yes			52	38	47	39	60	29	47	39	33	29
No			5	1	1	2	0	2	1	0	0	0



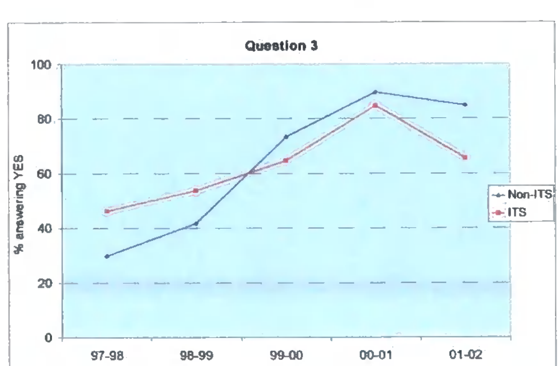
Question 2 Do you feel comfortable using a computer?

	96-97		97-98		98-99		99-00		00-01		01-02	
	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS
Yes			41	30	37	31	48	24	41	30	24	25
No			17	9	11	10	12	7	7	9	9	4



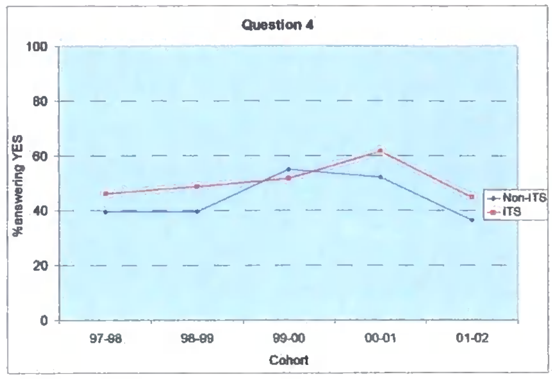
Question 3 Are you familiar with the Internet/WWW?

	96-97		97-98		98-99		99-00		00-01		01-02	
	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS
Yes			17	18	20	22	44	20	43	33	28	19
No			40	21	28	19	16	11	5	6	5	10



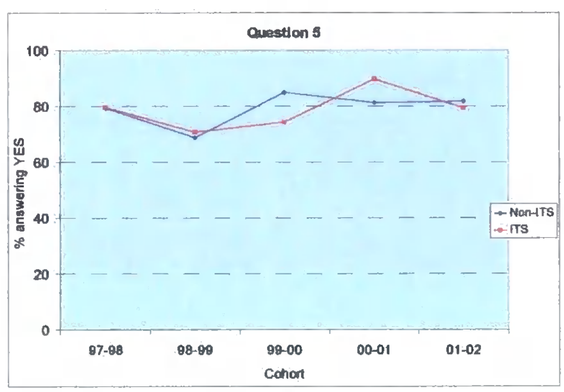
Question 4 Do you know how to use Excel or another spreadsheet?

	96-97		97-98		98-99		99-00		00-01		01-02	
	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS
Yes			23	18	19	20	33	16	25	24	12	13
No			35	21	29	21	27	15	23	15	21	16



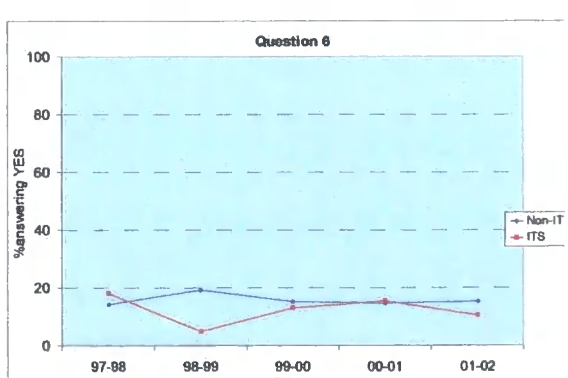
Question 5 Do you know how to use Word or another word processor

	96-97		97-98		98-99		99-00		00-01		01-02	
	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS
Yes			46	31	33	29	51	23	39	35	27	23
No			12	8	15	12	9	8	9	4	6	6



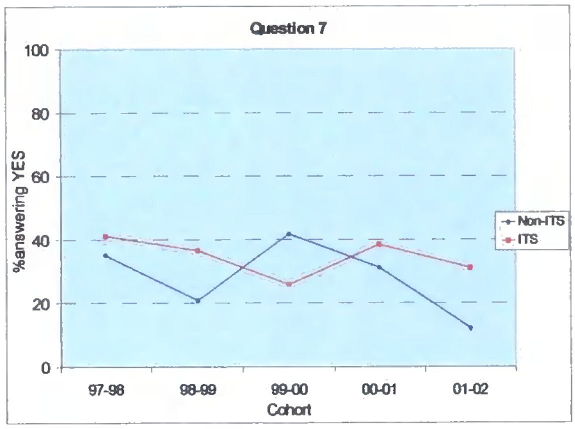
Question 6 Do you know how to use Dbase or another database?

	96-97		97-98		98-99		99-00		00-01		01-02	
	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS
Yes			8	7	9	2	9	4	7	6	5	3
No			49	32	38	39	51	27	41	33	28	26



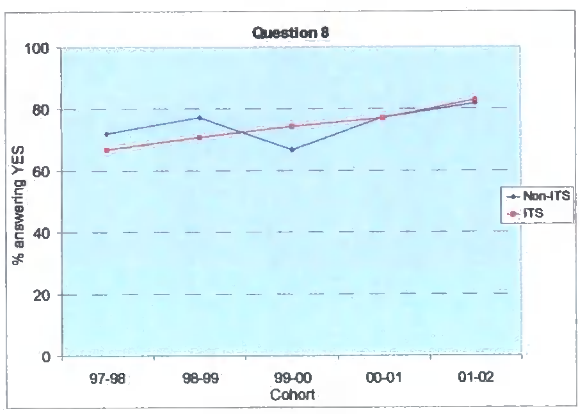
Question 7 Do you regularly do your homework on a computer?

	96-97		97-98		98-99		99-00		00-01		01-02	
	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS
Yes			20	16	10	15	25	8	15	15	4	9
No			37	23	38	26	35	23	33	24	29	20



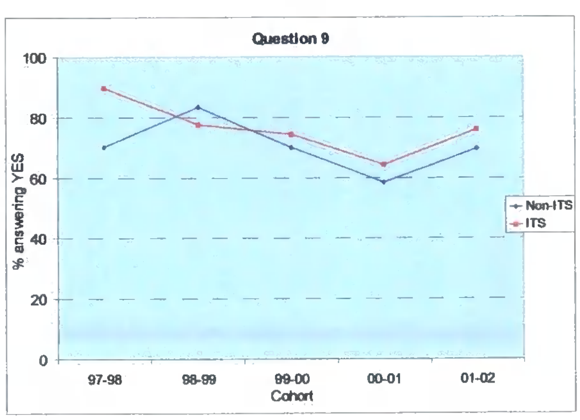
Question 8 Do computers help you learn?

	96-97		97-98		98-99		99-00		00-01		01-02	
	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS
Yes			41	26	37	29	40	23	37	30	27	24
No			16	13	11	12	20	8	11	9	6	5



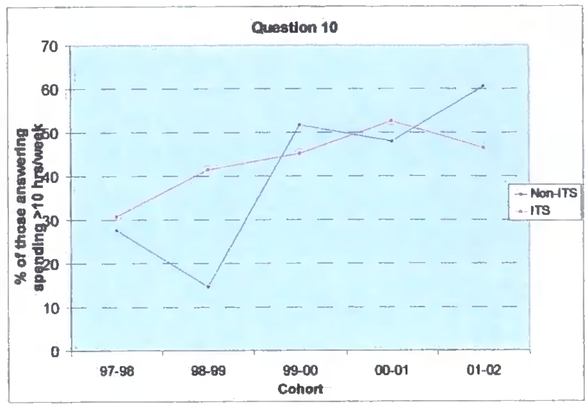
Question 9 Do you enjoy working on a computer?

	96-97		97-98		98-99		99-00		00-01		01-02	
	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS
Yes			40	35	40	31	42	23	28	25	23	22
No			17	4	8	9	18	8	20	14	10	7



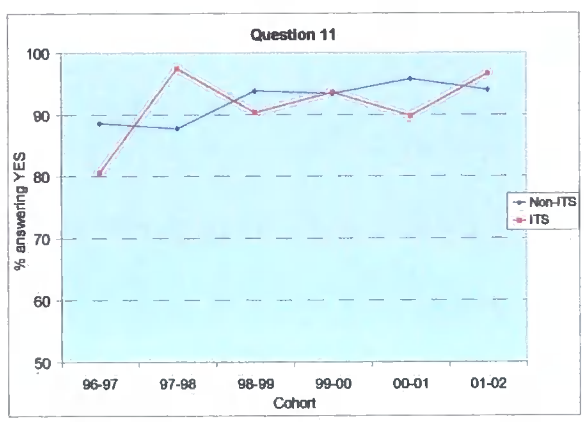
Question 10 On average, how many hours/week do you spend on a computer?

	96-97		97-98		98-99		99-00		00-01		01-02	
	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS
1-5			28	15	25	16	12	10	12	9	4	6
6-10			14	12	16	8	17	7	13	9	9	9
10-15			10	7	3	8	17	9	14	6	11	6
15+			6	5	4	9	14	5	9	14	9	7



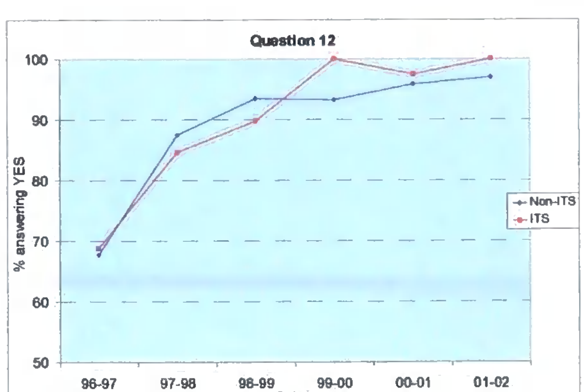
Question 11 Do you own a computer?

	96-97		97-98		98-99		99-00		00-01		01-02	
	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS
Yes	93	29	50	38	45	37	56	29	45	35	31	28
No	12	7	7	1	3	4	4	2	2	4	2	1



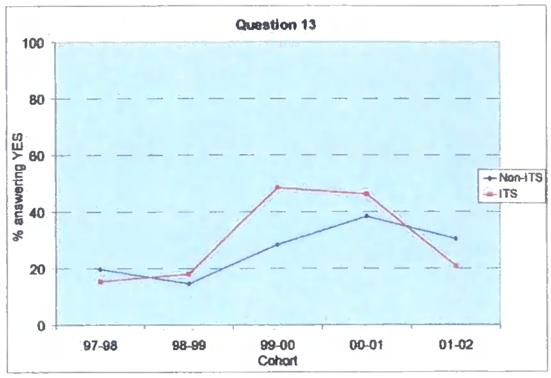
Question 12 If you own a computer, does it have a CD-ROM capability?

	96-97		97-98		98-99		99-00		00-01		01-02	
	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS
Yes	67	22	49	33	43	35	55	31	46	38	32	29
No	32	10	7	6	3	4	4	0	2	1	1	0



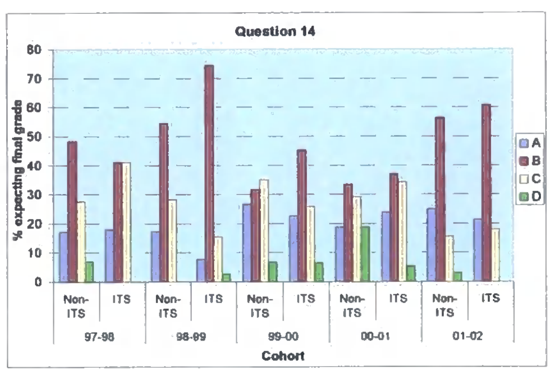
Question 13 Are you familiar with the syllabus for this course?

	96-97		97-98		98-99		99-00		00-01		01-02	
	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS
Yes			11	6	7	7	17	15	18	18	10	6
No			45	33	41	32	43	16	29	21	23	23



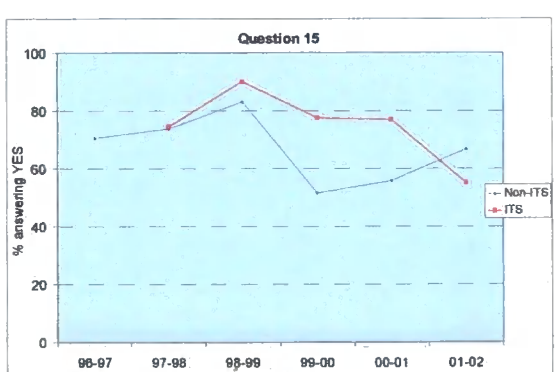
Question 14 What grade do you expect to get from this course?

	96-97		97-98		98-99		99-00		00-01		01-02	
	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS
A			10	7	8	3	16	7	9	9	8	6
B			28	16	25	29	19	14	16	14	18	17
C			16	16	13	6	21	8	14	13	5	5
D			4	0	0	1	4	2	9	2	1	0



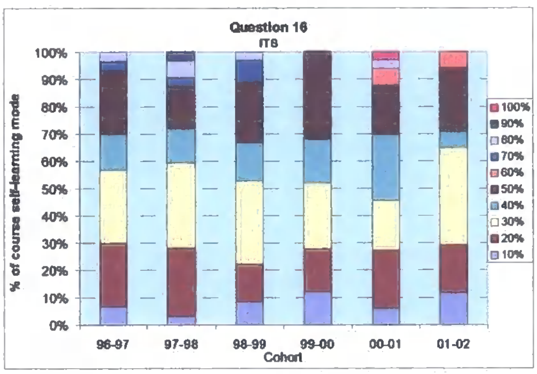
Question 15 Would you be happy to have some of your course based on a self-learning mode using a computer workstation?

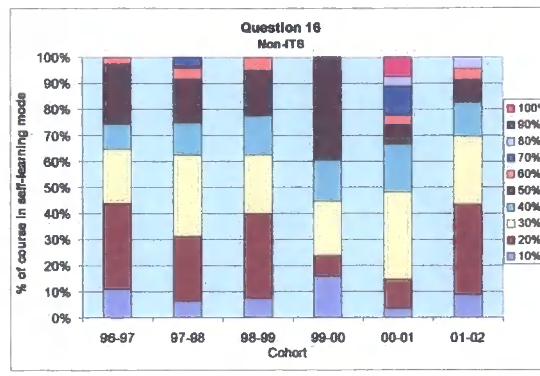
	96-97		97-98		98-99		99-00		00-01		01-02	
	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS
Yes	74	29	42	29	39	36	31	24	29	30	22	16
No	31	7	15	10	8	4	29	7	23	9	11	13



Question 16 If you answered YES to question 15, what percentage of the course would you like presented in self-learning mode?

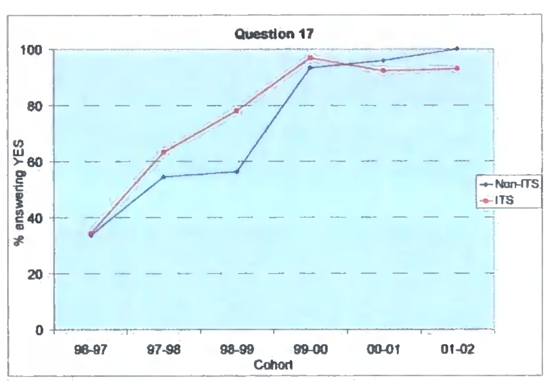
	96-97		97-98		98-99		99-00		00-01		01-02	
	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS
10%	9	2	3	1	3	3	6	3	1	2	2	2
20%	27	7	12	8	13	5	3	4	3	7	8	3
30%	17	8	15	10	9	11	8	6	9	6	8	6
40%	8	4	6	4	6	5	6	4	5	8	3	1
50%	19	7	8	5	7	8	15	8	2	6	2	4
60%	2	0	2	0	2	0	0	0	1	2	1	1
70%	0	1	2	1	0	3	0	0	3	0	0	0
80%	0	1	0	2	0	1	0	0	1	1	1	0
90%	0	0	0	1	0	0	0	0	0	0	0	0
100%	0	0	0	0	0	0	0	0	2	1	0	0





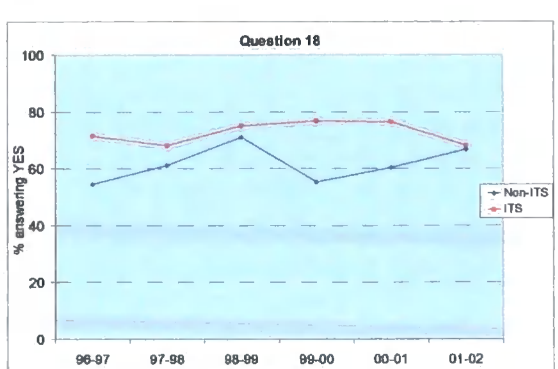
Question 17 Do you own a modem?

	96-97		97-98		98-99		99-00		00-01		01-02	
	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS
Yes	35	12	31	24	27	32	55	30	46	35	33	26
No	69	23	26	14	21	9	4	1	2	3	0	2



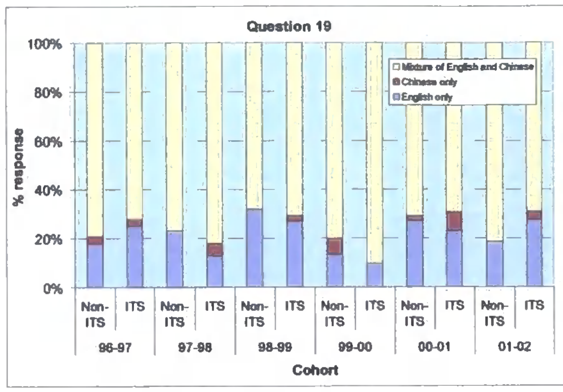
Question 18 If you answered YES to question 17, would you be prepared to access self-learning material via the modem in your home?

	96-97		97-98		98-99		99-00		00-01		01-02	
	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS
Yes	30	10	22	17	22	24	32	23	29	29	22	17
No	25	4	14	8	9	8	26	7	19	9	11	8



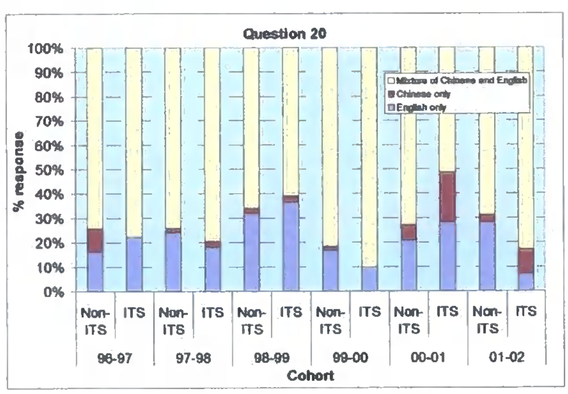
Question 19 What language would you prefer any self-learning material to be presented?

	96-97		97-98		98-99		99-00		00-01		01-02	
	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS
English	18	9	13	5	15	11	8	3	13	9	6	8
Chinese	3	1	0	2	0	1	4	0	1	3	0	1
Mixture	80	26	43	32	32	29	48	28	34	27	26	20



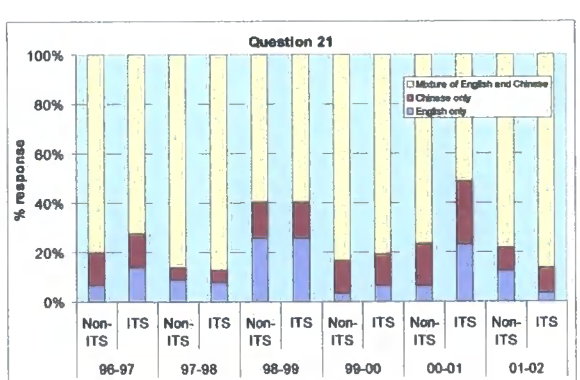
Question 20 What language would you prefer to have lectures presented?

	96-97		97-98		98-99		99-00		00-01		01-02	
	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS
English	17	8	14	7	15	15	10	3	10	11	9	2
Chinese	10	0	1	1	1	1	1	0	3	8	1	3
Mixture	78	28	43	31	31	25	49	27	35	20	22	24



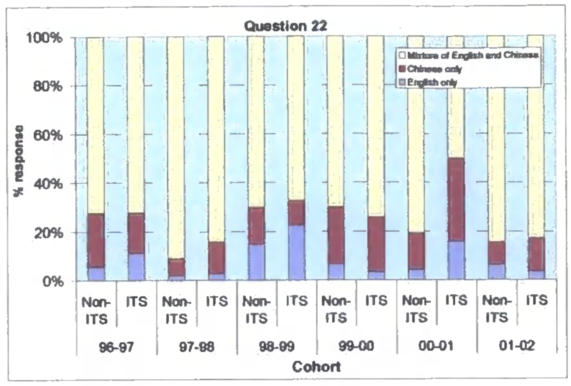
Question 21 What language would you prefer to have tutorials presented?

	96-97		97-98		98-99		99-00		00-01		01-02	
	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS
English	7	5	5	3	12	12	2	2	3	9	4	1
Chinese	14	5	3	2	7	7	8	4	8	10	3	3
Mixture	84	26	49	34	28	28	50	25	38	20	25	25



Question 22 What language would you prefer to have laboratories presented?

	96-97		97-98		98-99		99-00		00-01		01-02	
	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS	Non-ITS	ITS
English	6	4	1	1	7	9	4	1	2	6	2	1
Chinese	23	6	4	5	7	4	14	7	7	13	3	4
Mixture	76	26	51	32	33	27	42	23	38	19	27	24



Appendix 6

Results of assessments by year of cohort

The following pages show the results of the assessments carried out over the six-year period of the study reported. Each year shows the results in three ways, always comparing the inter-cohort analysis.

Box and whisker plots

The first is a box and whisker plot, with confidence intervals. The blue line series shows parametric statistics: the blue diamond shows the mean and the 68% confidence interval around the mean; the blue notched lines show the requested parametric percentile range.

The notched box and whiskers show non-parametric statistics: the notched box shows the median, lower and upper quartiles, and confidence interval around the median; the dotted-line connects the nearest observations within 1.5 IQRs (inter-quartile ranges) of the lower and upper quartiles; red crosses (+) and circles (o) indicate possible outliers - observations more than 1.5 IQRs (near outliers) and 3.0 IQRs (far outliers) from the quartiles. These plots and charts have been generated using the Comparative Statistics package that comes in Analyse-It, an Excel add-on.

Box-plots and parametric statistics

The first table below the box-plot chart shows the data used to draw the box-plots and parametric statistics for each year.

Standardised Effect Size calculations

The second table below the box-plot shows the calculation of effect size for each type of assessment, or outcome measure. It shows two sets of statistics. The first is the Raw Difference; the other, the Standardised Effect Size. These statistics have been generated using an online package authored by Robert Coe of Durham University. (http://www.cemcentre.org/ebeuk/research/effectsize/Calculator.htm)

The Raw Difference data includes:

Pooled standard deviation; this is the pooled estimate of standard deviation from both groups, based on the assumption that any difference between their SDs is only due to sampling variation.

p-value for difference in SDs; this is the 'p-value' for an F-test of whether their SDs are close enough to differ only by chance. It is the probability that a difference as big as this would have occurred if the samples were drawn from the same population. Conventionally, values less than

0.05 are taken to cast doubt on this assumption.

Mean Difference; this is simply the difference between the two means. If the outcome is measured on a familiar scale, this difference is interpretable as the size of the effect.

p-value for mean diff (2-tailed t-test); this is the 'p-value' for a standard t-test of whether the null hypothesis that the two means are equal is true. It is the probability that a difference as big as this would have occurred if the samples were drawn from the same population. Conventionally, values less than 0.05 are taken to cast doubt on this assumption, ie if $p < 0.05$, the difference is unlikely to have arisen by chance and is said to be 'statistically significant'.

Confidence interval for difference: lower and upper; the confidence interval is an alternative way to indicate the variability in estimates from small samples. The default calculation here is a '95% confidence interval'. If multiple samples of two groups of the same size as these, taken from a population in which the true difference was the value in cthe mean difference column, there would be variation in the differences found. However, for every 100 samples taken, for 95 of them (on average) the difference would be between the lower and upper confidence limits. The confidence interval is usually interpreted as a 'margin of uncertainty' around the estimate of the difference between experimental and control groups.

The Standardised Effect Size shows:

Effect Size (ES); this is the difference between the two means, divided by the pooled estimate of standard deviation. It calibrates the difference between the experimental and control groups (ie the effect of the intervention) in terms of the standard deviation.

Bias corrected (Hedges); the effect size estimate is slightly biased and is therefore corrected using a factor provided by Hedges and Olkin (1985).

Standard Error of E.S. estimate; this is a measure of the amount the effect size estimate would vary if you repeatedly took different samples.

Confidence interval for Effect Size: lower and upper; see above.

Effect Size based on control group SD; In some cases it may not be appropriate to use a pooled estimate of standard deviation, so the control group SD is used.

For an explanation of Effect Size in practical terms, reference is made to "Effect size", by Lee Becker of University of Colorado at Colorado Springs (http://davidmlane.com/hyperstat/effect_size.html). Effect sizes can be thought of as the average percentile standing of the average treated (or experimental) participant relative to the average untreated (or control) participant. An ES of 0.0 indicates that the mean of the treated group is at the 50th percentile of the untreated group. An ES of 0.8 indicates that the mean of the treated group is at the 79th percentile of the

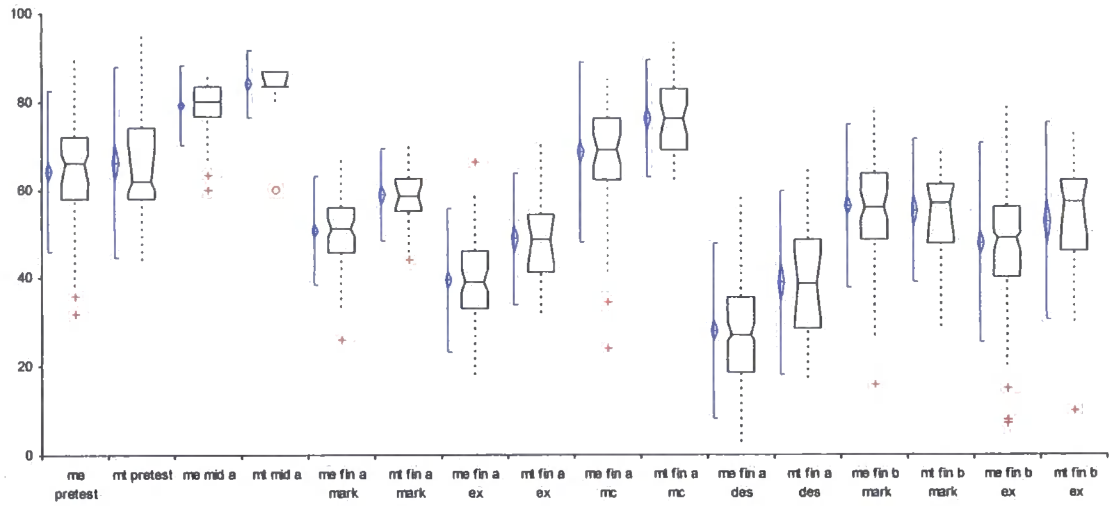
Effect Size	Percentile Standing	Percent of Nonoverlap
2.0	97.7	81.1%
1.9	97.1	79.4%
1.8	96.4	77.4%
1.7	95.5	75.4%
1.6	94.5	73.1%
1.5	93.3	70.7%
1.4	91.9	68.1%
1.3	90	65.3%
1.2	88	62.2%
1.1	86	58.9%
1.0	84	55.4%
0.9	82	51.6%
0.8	79	47.4%
0.7	76	43.0%
0.6	73	38.2%
0.5	69	33.0%
0.4	66	27.4%
0.3	62	21.3%
0.2	58	14.7%
0.1	54	7.7%
0.0	50	0%

untreated group. An effect size of 1.7 indicates that the mean of the treated group is at the 95.5 percentile of the untreated group (see table above).

Effect sizes can also be interpreted in terms of the percent of nonoverlap of the treated group's scores with those of the untreated group, see Cohen (1988, pp. 21-23) for descriptions of additional measures of nonoverlap. An ES of 0.0 indicates that the distribution of scores for the treated group overlaps completely with the distribution of scores for the untreated group, there is 0% of nonoverlap. An ES of 0.8 indicates a nonoverlap of 47.4% in the two distributions. An ES of 1.7 indicates a nonoverlap of 75.4% in the two distributions.

<u>Meta-analyses</u>

The meta-analysis calculations were made using an MSDOS programme developed by David Kenny, at the Department of Psychology, University of Connecticut (http://users.rcn.com/dakenny/meta.htm). Although only the Effect Size was shown in the main body of the thesis, the program calculates much more besides. The information shown for each calculation in this Appendix contains: the number of studies, the average effect size, the effect size standard deviation, t test of effect size, p value, fail-safeN, average d, average r, BESD (The Binominal Effect Size Display), homogeneity of effect sizes (chi square and p value), average Z with p value and fail-safe N, and average t with p value and fail-safe N.



	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
me pretest	105	64.210	11.1111	1.0843	62.059 to 66.360	66.000	14.000	62.000 to 68.000
mt pretest	35	66.229	13.0769	2.2104	61.737 to 70.721	62.000	16.000	60.000 to 70.000
me mid a	110	79.091	5.4541	0.5200	78.060 to 80.122	80.000	6.667	80.000 to 80.000
mt mid a	36	83.981	4.6339	0.7723	82.414 to 85.549	83.333	3.333	83.333 to 86.667
me fin a mark	95	50.693	7.5072	0.7702	49.163 to 52.222	51.200	10.100	49.400 to 53.400
mt fin a mark	34	58.694	6.3246	1.0847	56.487 to 60.901	58.600	7.250	55.600 to 61.600
me fin a ex	93	39.516	9.8683	1.0233	37.484 to 41.548	39.000	13.000	37.000 to 42.000
mt fin a ex	34	48.765	9.0756	1.5565	45.598 to 51.931	48.500	13.000	43.000 to 54.000
me fin a mc	95	68.312	12.3338	1.2654	65.800 to 70.825	68.966	13.793	65.517 to 72.414
mt fin a mc	33	75.967	8.0632	1.4036	73.107 to 78.826	75.862	13.793	72.414 to 79.310
me fin a des	93	28.080	12.0364	1.2481	25.601 to 30.559	27.143	17.143	25.714 to 30.000
mt fin a des	33	38.874	12.6811	2.2075	34.378 to 43.371	38.571	20.000	30.000 to 45.714
me fin b mark	109	56.239	11.1015	1.0633	54.132 to 58.347	55.950	14.850	53.250 to 59.250
mt fin b mark	29	55.031	9.8393	1.8271	51.288 to 58.774	56.850	13.450	48.200 to 60.750
me fin b ex	109	47.844	13.6098	1.3036	45.260 to 50.428	49.000	16.000	46.000 to 50.000
mt fin b ex	29	52.621	13.5209	2.5108	47.478 to 57.764	57.000	16.000	49.000 to 62.000

DATA ENTRY							RAW DIFFERENCE						STANDARDISED EFFECT SIZE					
Outcome measure	Treatment group			Control group			pooled standard deviation	p-value for difference in SDs	Mean Difference	p-value for mean diff (2-tailed T-test)	Confidence Interval for Difference		Effect Size	Bias corrected (Hedges)	Standard Error of E.S. estimate	Confidence Interval for Effect Size		Effect Size based on control gp SD
	mean	n	SD	mean	n	SD					lower	upper				lower	upper	
pretest	66.3	35	13.07	64.2	105	11.11	11.62	0.14	2.10	0.36	-2.39	6.59	0.18	**0.18**	0.20	-0.20	0.56	0.19
mid a	83.98	36	4.63	79	110	5.45	5.26	0.14	4.98	0.00	2.98	6.98	0.95	**0.94**	0.20	0.55	1.33	0.91
fin a mark	58.7	34	6.32	50.69	95	7.51	7.22	0.13	8.01	0.00	5.15	10.87	1.11	**1.10**	0.21	0.69	1.52	1.07
fin a exam	48.77	34	9.07	39.52	93	9.87	9.66	0.30	9.25	0.00	5.41	13.08	0.96	**0.95**	0.21	0.54	1.36	0.94
fin a mc	75.97	33	8.06	68.31	95	12.33	11.40	0.00	7.66	0.00	3.10	12.22	0.67	**0.67**	0.21	0.26	1.07	0.62
fin a desc	38.87	33	12.68	28.08	93	12.04	12.21	0.38	10.79	0.00	5.90	15.68	0.88	**0.88**	0.21	0.47	1.29	0.90
fin b mark	55.03	29	9.84	56.24	109	11.1	10.85	0.24	-1.21	<0.00	-5.69	3.28	-0.11	**-0.11**	0.21	-0.52	0.30	-0.11
fin b exam	52.62	29	13.52	47.84	109	13.61	13.59	0.51	4.78	0.09	-0.84	10.39	0.35	**0.35**	0.21	-0.06	0.76	0.35

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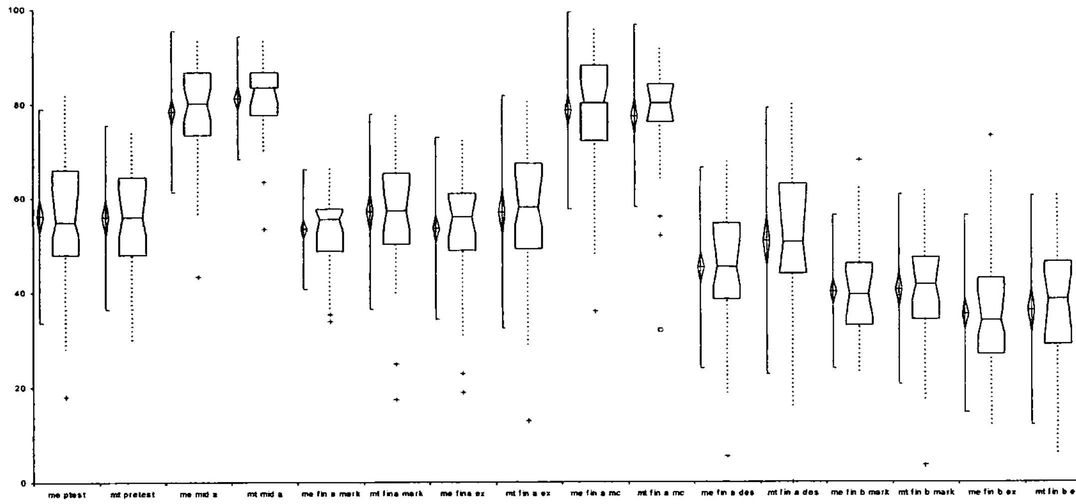

	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
me ptest	58	56.207	13.7990	1.8119	52.579 to 59.835	55.000	18.000	52.000 to 62.000
mt pretest	38	55.947	11.8046	1.9150	52.067 to 59.827	56.000	16.500	52.000 to 62.000
me mid a	60	78.278	10.4059	1.3434	75.590 to 80.966	80.000	13.333	76.667 to 83.333
mt mid a	38	81.140	7.9138	1.2838	78.539 to 83.742	83.333	9.167	80.000 to 83.333
me fin a mark	55	53.385	7.7154	1.0403	51.300 to 55.471	55.600	8.900	52.600 to 57.200
mt fina mark	38	57.053	12.5602	2.0375	52.924 to 61.181	57.300	15.150	53.000 to 63.000
me fina ex	55	53.509	11.6966	1.5772	50.347 to 56.671	56.000	12.000	52.000 to 60.000
mt fin a ex	38	57.000	14.9648	2.4276	52.081 to 61.919	58.000	18.000	54.000 to 65.000
me fin a mc	55	78.400	12.7099	1.7138	74.964 to 81.836	80.000	16.000	80.000 to 84.000
mt fin a mc	37	77.297	11.7777	1.9362	73.370 to 81.224	80.000	8.000	76.000 to 84.000
me fin a des	55	45.212	12.8615	1.7342	41.735 to 48.689	45.333	16.000	41.333 to 52.000
mt fin a des	38	50.912	17.0661	2.7685	45.303 to 56.522	50.667	19.000	44.000 to 61.333
me fin b mark	55	40.160	9.8437	1.3273	37.499 to 42.821	39.600	13.000	34.600 to 44.400
mt fin b mark	38	40.611	12.1441	1.9700	36.619 to 44.602	41.700	13.150	38.200 to 47.200
me fin b ex	55	35.382	12.6630	1.7075	31.959 to 38.805	34.000	16.000	31.000 to 40.000
mt fin b ex	38	36.158	14.6703	2.3798	31.336 to 40.980	38.500	17.250	31.000 to 44.000

DATA ENTRY							RAW DIFFERENCE						STANDARDISED EFFECT SIZE					
Outcome measure	Treatment group			Control group			pooled standard deviation	p-value for difference in SDs	Mean Difference	p-value for mean diff (2-tailed T-test)	Confidence Interval for Difference		Effect Size	Bias corrected (Hedges)	Standard Error of E.S. estimate	Confidence Interval for Effect Size		Effect Size based on control gp SD
	mean	n	SD	mean	n	SD					lower	upper				lower	upper	
pretest	55.95	58	11.80	56.21	58	13.80	12.84	0.12	-0.26	<0.00	-4.98	4.46	-0.02	**-0.02**	0.19	-0.38	0.34	-0.02
mid a	81.14	38	7.91	78.28	60	10.40	9.52	0.04	2.86	0.15	-1.05	6.78	0.30	**0.30**	0.21	-0.11	0.71	0.28
fin a mark	57.05	38	12.56	53.39	55	7.72	9.97	0.00	3.67	0.08	-0.51	7.84	0.37	**0.36**	0.21	-0.05	0.78	0.48
fin a exam	57	38	14.96	53.51	55	11.70	13.12	0.06	3.49	0.21	-2.01	8.99	0.27	**0.26**	0.21	-0.15	0.68	0.30
fin a mc	77.3	37	11.78	78.4	55	12.71	12.35	0.32	-1.10	<0.00	-6.32	4.11	-0.09	**-0.09**	0.21	-0.51	0.33	-0.09
fin a desc	50.91	38	17.07	45.21	55	12.86	14.72	0.04	5.70	0.07	-0.47	11.87	0.39	**0.38**	0.21	-0.03	0.80	0.44
fin b mark	40.61	38	12.14	40.16	55	9.844	10.84	0.09	0.45	0.84	-4.09	4.99	0.04	**0.04**	0.21	-0.37	0.45	0.05
fin b exam	36.16	38	14.67	35.38	55	12.66	13.52	0.17	0.78	0.79	-4.89	6.44	0.06	**0.06**	0.21	-0.36	0.47	0.06

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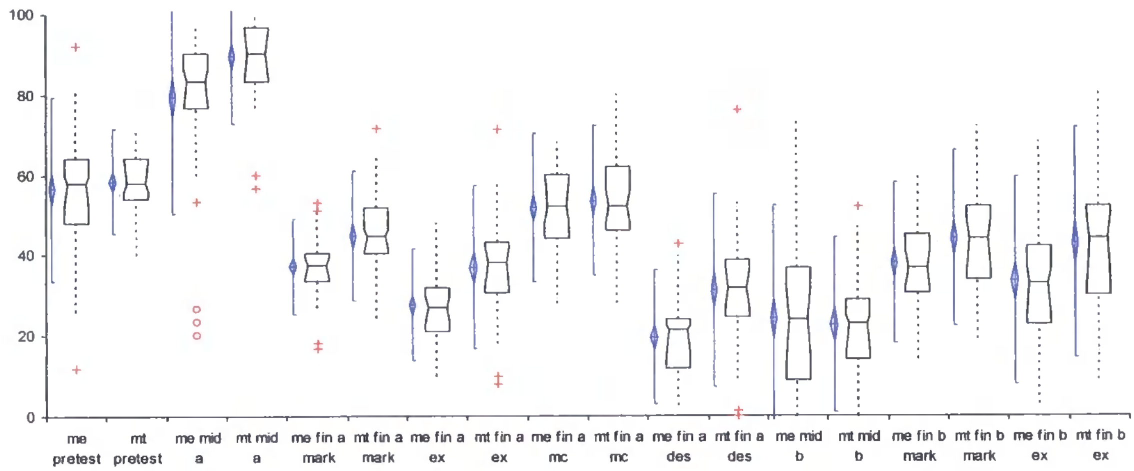
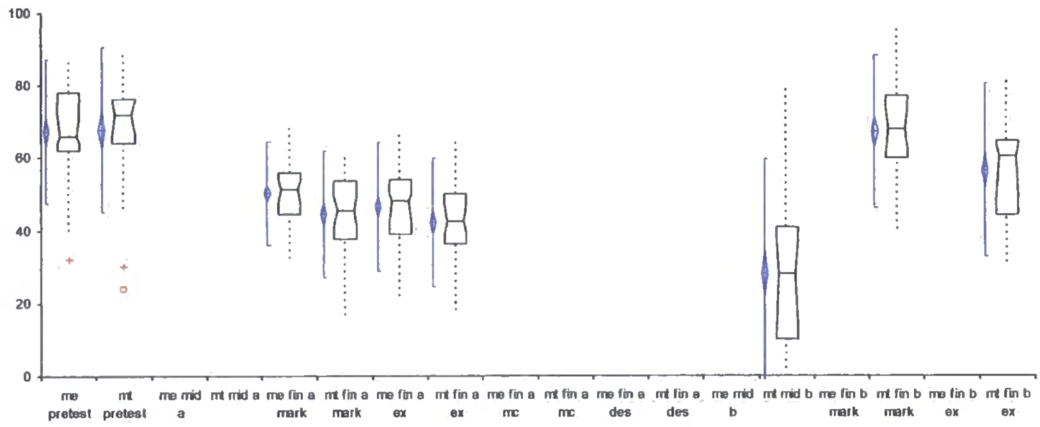


	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
me pretest	47	56.511	13.9032	2.0280	52.429 to 60.593	58.000	16.000	52.000 to 60.000
mt pretest	41	58.341	7.9234	1.2374	55.841 to 60.842	58.000	10.000	56.000 to 64.000
me mid a	47	79.220	17.4762	2.5492	74.089 to 84.351	83.333	13.333	76.667 to 86.667
mt mid a	39	89.573	10.2078	1.6346	86.264 to 92.882	90.000	13.333	83.333 to 96.667
me fin a mark	45	37.249	7.1980	1.0730	35.086 to 39.411	37.500	6.900	34.200 to 39.500
mt fin a mark	39	44.790	9.8527	1.5777	41.596 to 47.984	44.700	11.250	41.200 to 46.500
me fin a ex	45	27.556	8.3600	1.2462	25.044 to 30.067	27.000	11.000	23.000 to 30.000
mt fin a ex	39	36.897	12.2771	1.9659	32.918 to 40.877	38.000	12.500	32.000 to 42.000
me fin a mc	45	51.556	11.2241	1.6732	48.183 to 54.928	52.000	16.000	48.000 to 60.000
mt fin a mc	39	53.436	11.3689	1.8205	49.751 to 57.121	52.000	16.000	48.000 to 56.000
me fin a des	45	19.556	10.1504	1.5131	16.506 to 22.605	21.333	12.000	14.667 to 22.667
mt fin a des	39	31.385	14.5990	2.3377	26.652 to 36.117	32.000	14.000	26.667 to 37.333
me mid b	45	24.289	16.9660	2.5291	19.192 to 29.386	24.000	28.000	14.000 to 32.000
mt mid b	39	22.769	13.1619	2.1076	18.503 to 27.036	23.000	15.000	16.000 to 25.000
me fin b mark	44	38.023	12.0667	1.8191	34.354 to 41.691	37.000	14.250	32.000 to 41.000
mt fin b mark	37	44.108	13.2451	2.1775	39.692 to 48.524	44.000	18.000	36.000 to 49.000
me fin b ex	44	33.500	15.5705	2.3473	28.766 to 38.234	33.000	19.500	25.000 to 37.000
mt fin b ex	37	42.919	17.3067	2.8452	37.149 to 48.689	44.000	22.000	32.000 to 50.000

DATA ENTRY							RAW DIFFERENCE						STANDARDISED EFFECT SIZE					
Outcome measure	Treatment group			Control group			pooled standard deviation	p-value for difference in SDs	Mean Difference	p-value for mean diff (2-tailed T-test)	Confidence Interval for Difference		Effect Size	Bias corrected (Hedges)	Standard Error of E.S. estimate	Confidence Interval for Effect Size		Effect Size based on control gp SD
	mean	n	SD	mean	n	SD					lower	upper				lower	upper	
pretest	58.34	41	7.92	56.51	47	13.90	11.51	0.00	1.83	0.46	-3.06	6.72	0.16	**0.16**	0.21	-0.26	0.58	0.13
mid a	89.57	39	10.21	79.22	47	17.48	14.64	0.00	10.35	0.00	4.05	16.66	0.71	**0.70**	0.22	0.26	1.14	0.59
fin a mark	44.79	39	9.85	37.25	45	7.20	8.53	0.03	7.54	0.00	3.83	11.25	0.88	**0.88**	0.23	0.43	1.32	1.05
fin a exam	36.90	39	12.28	27.56	45	8.36	10.36	0.01	9.34	0.00	4.83	13.85	0.90	**0.89**	0.23	0.44	1.34	1.12
fin a mc	53.44	39	11.37	51.56	45	11.22	11.29	0.47	1.88	0.45	-3.03	6.79	0.17	**0.16**	0.22	-0.26	0.59	0.17
fin a desc	31.39	39	14.60	19.56	45	10.15	12.41	0.01	11.83	0.00	6.43	17.23	0.95	**0.94**	0.23	0.49	1.40	1.17
mid b	22.77	39	13.16	24.29	45	16.97	15.32	0.06	-1.52	<0.00	-8.19	5.15	-0.10	**-0.10**	0.22	-0.53	0.33	-0.09
fin b mark	44.11	37	13.25	38.02	44	12.07	12.62	0.28	6.08	0.03	0.48	11.69	0.48	**0.48**	0.23	0.03	0.92	0.50
fin b exam	42.92	37	17.31	33.50	44	15.57	16.38	0.26	9.42	0.01	2.14	16.69	0.57	**0.57**	0.23	0.12	1.02	0.60

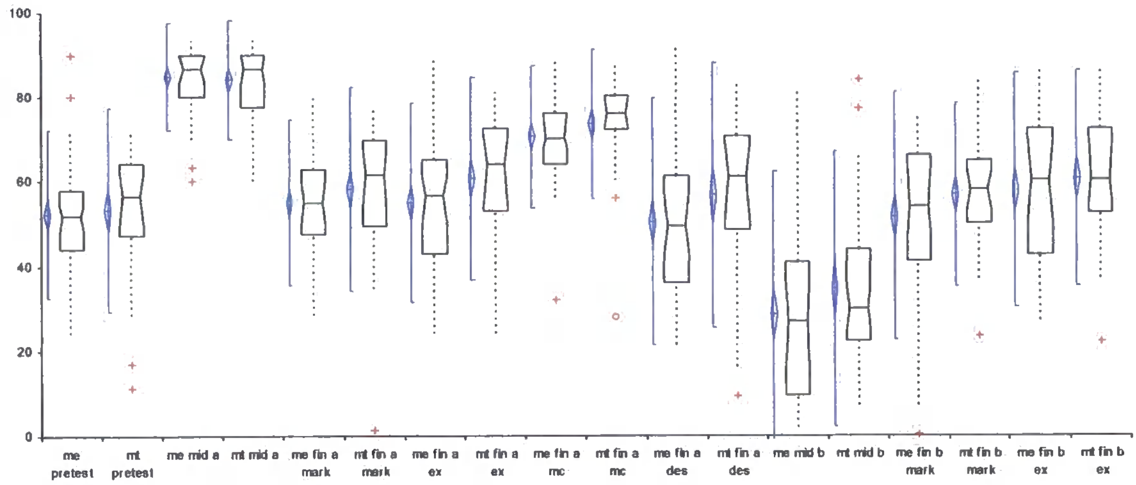
1999-2000



	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
me pretest	43	67.256	12.0793	1.8421	63.538 to 70.973	66.000	16.000	64.000 to 72.000
mt pretest	31	67.742	13.8443	2.4865	62.664 to 72.820	72.000	12.000	66.000 to 76.000
me mid a	2	0.000	-	-	- to -	0.000	0.000	- to -
mt mid a	2	0.000	-	-	- to -	0.000	0.000	- to -
me fin a mark	63	50.270	8.6452	1.0892	48.093 to 52.447	51.200	11.350	47.400 to 53.900
mt fin a mark	40	44.435	10.5353	1.6658	41.066 to 47.804	45.550	15.950	41.200 to 49.300
me fin a ex	63	46.413	10.8146	1.3625	43.689 to 49.136	48.000	15.000	42.000 to 50.000
mt fin a ex	38	42.211	10.7858	1.7497	38.665 to 45.756	42.500	13.750	39.000 to 47.000
me fin a mc	2	0.000	-	-	- to -	0.000	0.000	- to -
mt fin a mc	2	0.000	-	-	- to -	0.000	0.000	- to -
me fin a des	2	0.000	-	-	- to -	0.000	0.000	- to -
mt fin a des	2	0.000	-	-	- to -	0.000	0.000	- to -
me mid b	2	0.000	-	-	- to -	0.000	0.000	- to -
mt mid b	39	28.154	18.9536	3.0350	22.010 to 34.298	28.000	31.000	12.000 to 38.000
me fin b mark	2	0.000	-	-	- to -	0.000	0.000	- to -
mt fin b mark	38	66.969	12.6391	2.0503	62.815 to 71.124	67.755	17.033	61.600 to 73.620
me fin b ex	2	0.000	-	-	- to -	0.000	0.000	- to -
mt fin b ex	38	56.368	14.4174	2.3388	51.630 to 61.107	60.000	20.000	49.000 to 63.000

DATA ENTRY							RAW DIFFERENCE						STANDARDISED EFFECT SIZE					
Outcome measure	Treatment group			Control group			pooled standard deviation	p-value for difference in SDs	Mean Difference	p-value for mean diff (2-tailed T-test)	Confidence Interval for Difference		Effect Size	Bias corrected (Hedges)	Standard Error of E.S. estimate	Confidence Interval for Effect Size		Effect Size based on control gp SD
	mean	n	SD	mean	n	SD					lower	upper				lower	upper	
pretest	67.74	31	13.84	67.26	43	12.08	12.84	0.22	0.48	0.87	-5.55	6.51	0.04	**0.04**	0.24	-0.42	0.50	0.04
fin a mark	44.44	40	10.54	50.27	63	8.65	9.42	0.09	-5.83	<0.00	-9.61	-2.05	-0.62	**-0.61**	0.21	-1.02	-0.21	-0.67
fin a exam	42.21	38	10.79	46.41	63	10.81	10.80	0.50	-4.20	<0.00	-8.60	0.20	-0.39	**-0.39**	0.21	-0.79	0.02	-0.39

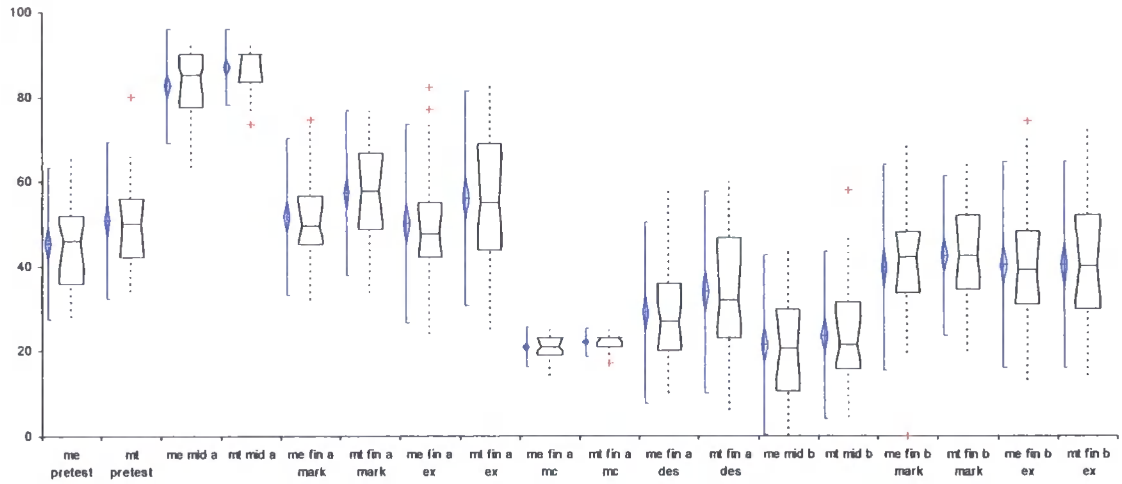
2000-1



	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
me pretest	43	52.279	11.9967	1.8295	48.587 to 55.971	52.000	14.000	48.000 to 54.000
mt pretest	33	53.345	14.6095	2.5432	48.164 to 58.525	56.604	16.981	49.057 to 62.264
me mid a	45	84.815	7.7380	1.1535	82.490 to 87.140	86.667	10.000	83.333 to 90.000
mt mid a	34	84.020	8.5587	1.4678	81.033 to 87.006	86.667	12.500	83.333 to 90.000
me fin a mark	50	55.028	11.9003	1.6830	51.646 to 58.410	55.050	15.400	49.900 to 60.500
mt fin a mark	40	58.273	14.6153	2.3109	53.598 to 62.947	61.350	20.150	53.900 to 68.100
me fin a ex	50	54.980	14.3292	2.0265	50.908 to 59.052	56.500	22.000	50.000 to 61.000
mt fin a ex	39	60.590	14.5054	2.3227	55.888 to 65.292	64.000	19.500	53.000 to 71.000
me fin a mc	44	70.364	10.2187	1.5405	67.257 to 73.470	70.000	12.000	68.000 to 76.000
mt fin a mc	34	73.412	10.7368	1.8414	69.666 to 77.158	76.000	8.000	72.000 to 80.000
me fin a des	45	50.311	17.6782	2.6353	45.000 to 55.622	49.333	25.333	42.667 to 57.333
mt fin a des	34	56.745	18.9735	3.2539	50.125 to 63.365	61.333	22.000	50.667 to 69.333
me mid b	46	28.804	20.3815	3.0051	22.752 to 34.857	27.000	31.500	16.000 to 36.000
mt mid b	35	34.629	19.7202	3.3333	27.854 to 41.403	30.000	21.500	25.000 to 36.000
me fin b mark	46	51.685	17.6799	2.6068	46.435 to 56.935	54.050	24.725	47.400 to 64.000
mt fin b mark	39	56.705	13.0189	2.0847	52.485 to 60.925	57.900	14.900	52.900 to 62.500
me fin b ex	43	57.767	16.6531	2.5396	52.642 to 62.893	60.000	29.500	50.000 to 70.000
mt fin b ex	39	60.513	15.2882	2.4481	55.557 to 65.469	60.000	19.500	55.000 to 70.000

DATA ENTRY							RAW DIFFERENCE						STANDARDISED EFFECT SIZE					
Outcome measure	Treatment group			Control group			pooled standard deviation	p-value for difference in SDs	Mean Difference	p-value for mean diff (2-tailed T-test)	Confidence Interval for Difference		Effect Size	Bias corrected (Hedges)	Standard Error of E.S. estimate	Confidence Interval for Effect Size		Effect Size based on control gp SD
	mean	n	SD	mean	n	SD					lower	upper				lower	upper	
pretest	53.35	33	14.61	52.28	43	12.00	13.19	0.12	1.07	0.73	-5.02	7.15	0.08	**0.08**	0.23	-0.37	0.53	0.09
mid a	84.02	34	8.56	84.82	45	7.74	8.10	0.28	-0.80	<0.00	-4.46	2.87	-0.10	**-0.10**	0.23	-0.54	0.35	-0.10
fin a mark	58.27	40	14.62	55.03	50	11.90	13.17	0.09	3.25	0.25	-2.31	8.80	0.25	**0.24**	0.21	-0.17	0.66	0.27
fin a exam	60.59	39	15.51	54.98	50	14.33	14.85	0.31	5.61	0.08	-0.70	11.92	0.38	**0.37**	0.22	-0.05	0.80	0.39
fin a mc	73.41	34	10.74	70.36	44	10.22	10.45	0.39	3.05	0.21	-1.70	7.80	0.29	**0.29**	0.23	-0.16	0.74	0.30
fin a desc	56.75	34	18.97	50.31	45	17.68	18.24	0.34	6.43	0.12	-1.82	14.69	0.35	**0.35**	0.23	-0.10	0.80	0.36
mid b	34.63	35	19.72	28.80	46	20.38	20.10	0.43	5.83	0.20	-3.15	14.80	0.29	**0.29**	0.23	-0.15	0.73	0.29
fin b mark	56.71	39	13.02	51.69	46	17.68	15.72	0.03	5.02	0.15	-1.79	11.83	0.32	**0.32**	0.22	-0.11	0.75	0.28
fin b exam	60.51	39	15.29	57.77	43	16.65	16.02	0.30	2.75	0.44	-4.30	9.80	0.17	**0.17**	0.22	-0.26	0.60	0.16

2001-2



	n	Mean	SD	SE	95% CI of Mean	Median	IQR	95% CI of Median
me pretest	33	45.273	10.8952	1.8966	41.409 to 49.136	46.000	16.000	40.000 to 50.000
mt pretest	29	50.897	11.2578	2.0905	46.614 to 55.179	50.000	14.000	42.000 to 56.000
me mid a	34	82.549	8.1674	1.4007	79.699 to 85.399	85.000	12.500	80.000 to 86.667
mt mid a	34	86.961	5.5273	0.9479	85.032 to 88.889	90.000	6.667	83.333 to 90.000
me fin a mark	34	51.624	11.2001	1.9208	47.717 to 55.532	49.345	11.340	46.010 to 55.200
mt fin a mark	36	57.166	11.8334	1.9722	53.162 to 61.170	57.740	17.905	50.190 to 65.970
me fin a ex	34	49.941	14.2381	2.4418	44.973 to 54.909	47.500	13.000	42.000 to 53.000
mt fin a ex	36	55.917	15.3816	2.5636	50.712 to 61.121	55.000	25.000	49.000 to 66.000
me fin a mc	34	20.941	2.8278	0.4850	19.955 to 21.928	21.000	4.000	20.000 to 23.000
mt fin a mc	36	22.056	1.9704	0.3284	21.389 to 22.722	23.000	2.000	22.000 to 23.000
me fin a des	34	29.000	12.9521	2.2213	24.481 to 33.519	27.000	15.750	21.000 to 31.000
mt fin a des	36	33.861	14.4542	2.4090	28.971 to 38.752	32.000	23.750	26.000 to 43.000
me mid b	38	21.485	12.9111	2.0945	17.241 to 25.729	20.714	19.286	13.571 to 29.286
mt mid b	35	23.735	11.9925	2.0271	19.615 to 27.854	21.429	15.714	17.143 to 27.857
me fin b mark	39	39.603	14.6874	2.3519	34.842 to 44.364	42.090	14.540	34.190 to 47.660
mt fin b mark	35	42.409	11.4623	1.9375	38.472 to 46.347	42.320	17.370	37.200 to 50.480
me fin b ex	37	40.135	14.6764	2.4128	35.242 to 45.029	39.000	17.000	32.000 to 48.000
mt fin b ex	35	40.229	14.7151	2.4873	35.174 to 45.283	40.000	22.000	32.000 to 50.000

DATA ENTRY							RAW DIFFERENCE						STANDARDISED EFFECT SIZE					
Outcome measure	Treatment group			Control group			pooled standard deviation	p-value for difference in SDs	Mean Difference	p-value for mean diff (2-tailed T-test)	Confidence Interval for Difference		Effect Size	Bias corrected (Hedges)	Standard Error of E.S. estimate	Confidence Interval for Effect Size		Effect Size based on control gp SD
	mean	n	SD	mean	n	SD					lower	upper				lower	upper	
pretest	50.90	29	11.26	45.27	33	10.90	11.07	0.43	5.62	0.05	-0.01	11.26	0.51	**0.50**	0.26	0.00	1.01	0.52
mid a	86.96	34	5.53	82.55	34	8.17	6.97	0.01	4.41	0.01	1.04	7.79	0.63	**0.63**	0.25	0.14	1.11	0.54
fin a mark	57.17	36	11.83	51.62	34	11.20	11.53	0.37	5.54	0.05	0.04	11.04	0.48	**0.48**	0.24	0.00	0.95	0.49
fin a exam	55.92	36	15.38	49.94	34	14.24	14.84	0.33	5.98	0.10	-1.10	13.06	0.40	**0.40**	0.24	-0.08	0.87	0.42
fin a mc	22.06	36	1.97	20.94	34	2.83	2.42	0.02	1.12	0.06	-0.04	2.27	0.46	**0.45**	0.24	-0.02	0.93	0.39
fin a desc	33.86	36	14.45	29.00	34	12.95	13.75	0.26	4.86	0.14	-1.70	11.42	0.35	**0.35**	0.24	-0.12	0.82	0.38
mid b	23.74	35	11.99	21.49	38	12.91	12.48	0.33	2.25	0.44	-3.58	8.08	0.18	**0.18**	0.23	-0.28	0.64	0.17
fin b mark	42.41	35	11.46	39.60	39	14.69	13.26	0.07	2.81	0.37	-3.35	8.96	0.21	**0.21**	0.23	-0.25	0.67	0.19
fin b exam	40.23	35	14.72	40.14	37	14.68	14.70	0.50	0.09	0.98	-6.82	7.00	0.01	**0.01**	0.24	-0.46	0.47	0.01

Meta-analysis results

Effect size measure is Cohen's d, Transformation: Hedges

1996-97 Semester A

Study number: 5	Subject N: 656	
Average effect size: .9084	Effect size sd: .1577	
t test of effect size: 12.8836	p value: .00029 df: 4	Fail-safe N: 212
Average d: .9137	Average r: .3727	BESD: .3137 to .6863
Homogeneity of effect sizes:	Chi square: 2.2938	p value: .68190 df: 4
Average Z: 9.8334	p value: .00001	Fail-safe N: 121
Average t: 10.1806	p value: .00001	Fail-safe N: 130

1996-97 Semester B

Study number: 2	Subject N: 276	
Average effect size: .1194	Effect size sd: .3257	
t test of effect size: .5186	p value: .73003 df: 1	
Average d: .1201	Average r: .0486	BESD: .4757 to .5243
Homogeneity of effect sizes:	Chi square: 2.4165	p value: .12006 df: 1
Average Z: .8055	p value: .42056	
Average t: .8069	p value: .41974	

1997-98 Semester A

Study number: 5	Subject N: 470	
Average effect size: .2443	Effect size sd: .1922	
t test of effect size: 2.8416	p value: .04925 df: 4	Fail-safe N: 6
Average d: .2463	Average r: .1203	BESD: .4399 to .5601
Homogeneity of effect sizes:	Chi square: 3.3080	p value: .50766 df: 4
Average Z: 2.5952	p value: .00945	Fail-safe N: 4
Average t: 2.5933	p value: .00951	Fail-safe N: 4

1997-98 Semester B

Study number: 3	Subject N: 246	
Average effect size: .3163	Effect size sd: .3620	
t test of effect size: 1.5137	p value: .28457 df: 2	
Average d: .3194	Average r: .1550	BESD: .4225 to .5775
Homogeneity of effect sizes:	Chi square: 5.3291	p value: .06963 df: 2
Average Z: 2.4197	p value: .01553	Fail-safe N: 2
Average t: 2.4440	p value: .01453	Fail-safe N: 2

1998-99 Semester A

Study number: 2	Subject N: 204	
Average effect size: -.4999	Effect size sd: .1613	
t test of effect size: -4.3827	p value: .22021 df: 1	
Average d: -.5037	Average r: -.2391	BESD: .6195 to .3805
Homogeneity of effect sizes	Chi square: .6078	p value: .43563 df: 1
Average Z: -3.4338	p value: .00060	Fail-safe N: 5
Average t: -3.4668	p value: .00053	Fail-safe N: 5

2000-01 Semester A

Study number: 5	Subject N: 415	
Average effect size: .2318	Effect size sd: .1912	
t test of effect size: 2.7108	p value: .05608 df: 4	
Average d: .2339	Average r: .1158	BESD: .4421 to .5579
Homogeneity of effect sizes:	Chi square: 2.8679	p value: .58018 df: 4
Average Z: 2.3566	p value: .01845	Fail-safe N: 3
Average t: 2.3513	p value: .01871	Fail-safe N: 3

2000-01 Semester B

Study number: 3	Subject N: 248	
Average effect size: .2577	Effect size sd: .0778	
t test of effect size: 5.7348	p value: .03837 df: 2	Fail-safe N: 23
Average d: .2602	Average r: .1297	BESD: .4351 to .5649
Homogeneity of effect sizes:	Chi square: .2480	p value: .88339 df: 2
Average Z: 2.0239	p value: .04298	Fail-safe N: 1
Average t: 2.0149	p value: .04392	Fail-safe N: 1

2001-02 Semester A

Study number: 5	Subject N: 348	
Average effect size: .4612	Effect size sd: .1042	
t test of effect size: 9.8996	p value: .00076 df: 4	Fail-safe N: 123
Average d: .4664	Average r: .2295	BESD: .3853 to .6147
Homogeneity of effect sizes;	Chi square: .7197	p value: .94888 df: 4
Average Z: 4.2627	p value: .00002	Fail-safe N: 19
Average t: 4.2796	p value: .00002	Fail-safe N: 19

2001-02 Semester B

Study number: 3	Subject N: 219	
Average effect size: .1316	Effect size sd: .1093	
t test of effect size: 2.0861	p value: .18798 df: 2	
Average d: .1330	Average r: .0670	BESD: .4665 to .5335
Homogeneity of effect sizes:	Chi square: .4319	p value: .80576 df: 2
Average Z: .9805	p value: .32684	
Average t: .9724	p value: .33086	

Pre-test all cohorts

Study number: 6	Subject N: 536	
Average effect size: .1562	Effect size sd: .1851	
t test of effect size: 2.0671	p value: .09548 df: 5	
Average d: .1578	Average r: .0763	BESD: .4618 to .5382
Homogeneity of effect sizes:	Chi square: 2.8548	p value: .72236 df: 5
Average Z: 1.6465	p value: .09967	
Average t: 1.6456	p value: .09984	

Mid-semester A test all cohorts (except 1999-2000)

Study number: 5	Subject N: 477
Average effect size: .4934	Effect size sd: .4026

t test of effect size: 2.7402	p value: .05445 df: 4	
Average d: .4974	Average r: .2235	BESD: .3882 to .6118
Homogeneity of effect sizes:	Chi square: 13.7851	p value: .00801 df: 4
Average Z: 5.1090	p value: .00001	Fail-safe N: 29
Average t: 5.2216	p value: .00001	Fail-safe N: 31

Final assessment mark Semester A all cohorts (except 1999-2000)

Study number: 5	Subject N: 466	
Average effect size: .6125	Effect size sd: .3627	
t test of effect size: 3.7762	p value: .02115 df: 4	Fail-safe N: 14
Average d: .6175	Average r: .2777	BESD: .3611 to .6389
Homogeneity of effect sizes:	Chi square: 11.3898	p value: .02252 df: 4
Average Z: 6.2331	p value: .00001	Fail-safe N: 46
Average t: 6.4114	p value: .00001	Fail-safe N: 49

Final examination mark Semester A all cohorts (except 1999-2000)

Study number: 5	Subject N: 495	
Average effect size: .5786	Effect size sd: .3241	
t test of effect size: 3.9921	p value: .01774 df: 4	Fail-safe N: 16
Average d: .5832	Average r: .2725	BESD: .3637 to .6363
Homogeneity of effect sizes:	Chi square: 10.4392	p value: .03364 df: 4
Average Z: 6.3717	p value: .00001	Fail-safe N: 48
Average t: 6.5526	p value: .00001	Fail-safe N: 51

Final multiple choice examination marks Semester A all cohorts (except 1999-2000)

Study number: 5	Subject N: 454	
Average effect size: .2518	Effect size sd: .3073	
t test of effect size: 1.8325	p value: .14414 df: 4	
Average d: .2539	Average r: .1165	BESD: .4417 to .5583
Homogeneity of effect sizes:	Chi square: 8.3843	p value: .07847 df: 4
Average Z: 2.5825	p value: .00981	Fail-safe N: 4
Average t: 2.6023	p value: .00926	Fail-safe N: 4

Final descriptive examination mark Semester A all cohorts (except 1999-2000)

Study number: 5	Subject N: 455	
Average effect size: .5812	Effect size sd: .3026	
t test of effect size: 4.2945	p value: .01401 df: 4	Fail-safe N: 20
Average d: .5862	Average r: .2677	BESD: .3661 to .6339
Homogeneity of effect sizes:	Chi square: 7.3340	p value: .11926 df: 4
Average Z: 5.8979	p value: .00001	Fail-safe N: 41
Average t: 6.0308	p value: .00001	Fail-safe N: 43

Mid-semester B test all cohorts (except 1999-2000)

Study number: 3	Subject N: 238	
Average effect size: .1225	Effect size sd: .1988	
t test of effect size: 1.0671	p value: .41097 df: 2	
Average d: .1237	Average r: .0616	BESD: .4692 to .5308
Homogeneity of effect sizes:	Chi square: 1.6064	p value: .44790 df: 2
Average Z: .9214	p value: .35682	

Average t: .9171	p value: .35910	

Final assessment mark Semester B all cohorts (except 1999-2000)

Study number: 5	Subject N: 471	
Average effect size: .1869	Effect size sd: .2301	
t test of effect size: 1.8157	p value: .14691 df: 4	
Average d: .1888	Average r: .0954	BESD: .4523 to .5477
Homogeneity of effect sizes:	Chi square: 4.5045	p value: .34201 df: 4
Average Z: 1.8547	p value: .06363	
Average t: 1.8585	p value: .06310	

Final examination mark Semester B all cohorts (except 1999-2000)

Study number: 5	Subject N: 466	
Average effect size: .2304	Effect size sd: .2309	
t test of effect size: 2.2313	p value: .09252 df: 4	
Average d: .2323	Average r: .1079	BESD: .4461 to .5539
Homogeneity of effect sizes:	Chi square: 4.1980	p value: .37987 df: 4
Average Z: 2.3511	p value: .01872	Fail-safe N: 3
Average t: 2.3575	p value: .01840	Fail-safe N: 3

Semester A all assessments except pre-test all cohorts (except 1999-2000)

Study number: 25	Subject N: 2311	
Average effect size: .5123	Effect size sd: .3296	
t test of effect size: 7.7719	p value: .00001 df: 24	Fail-safe N: 369
Average d: .5165	Average r: .2346	BESD: .3827 to .6173
Homogeneity of effect sizes:	Chi square: 55.4344	p value: .00027 df: 24
Average Z: 11.6774	p value: .00001	Fail-safe N: 863
Average t: 11.9359	p value: .00001	Fail-safe N: 903

Semester B all assessments all cohorts (except 1999-2000)

Study number: 13	Subject N: 1175	
Average effect size: .1888	Effect size sd: .2093	
t test of effect size: 3.2521	p value: .00702 df: 12	Fail-safe N: 23
Average d: .1905	Average r: .0924	BESD: .4538 to .5462
Homogeneity of effect sizes:	Chi square: 10.8112	p value: .54516 df: 12
Average Z: 3.0517	p value: .00228	Fail-safe N: 19
Average t: 3.0555	p value: .00225	Fail-safe N: 19

All assessments both semesters for all cohorts (except 1999-2000)

Study number: 38	Subject N: 3486	
Average effect size: .4016	Effect size sd: .3299	
t test of effect size: 7.5038	p value: .00001 df: 37	Fail-safe N: 519
Average d: .4050	Average r: .1860	BESD: .4070 to .5930
Homogeneity of effect sizes:	Chi square: 85.6230	p value: .00001 df: 37
Average Z: 11.2566	p value: .00001	Fail-safe N: 1216
Average t: 11.4680	p value: .00001	Fail-safe N: 1263

Appendix 7

RPI questionnaire responses

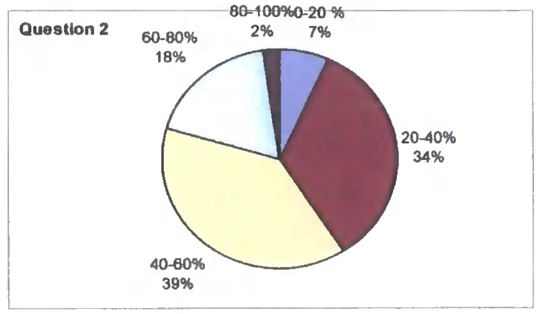
No fo respondents 45

Question1 Do you own a computer?

Yes	42
No	3

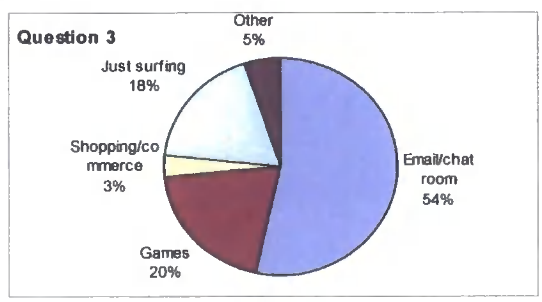
Question 2 What proportion of time do you use your computer for schoolwork?

	No.	%
0-20 %	3	6.82
20-40%	15	34.09
40-60%	17	38.64
60-80%	8	18.18
80-100%	1	2.27



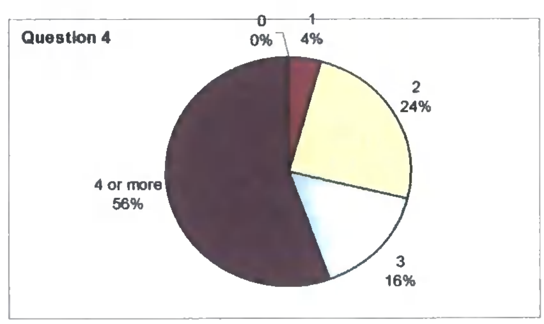
Question3: Other than schoolwork, what computer application takes up most of your time?

	No.	%
Email/chat room	32	53.33
Games	12	20.00
Shopping/commerce	2	3.33
Just surfing	11	18.33
Other	3	5.00



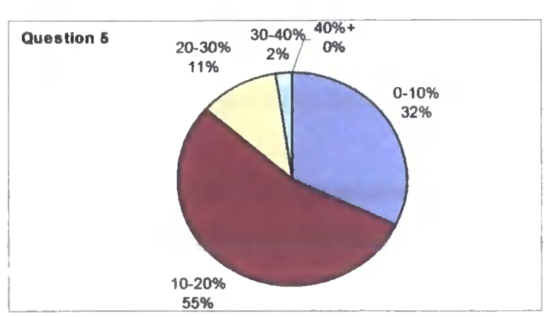
Question 4: How many studio-type courses have you taken before this one?

	No.	%
0	0	0.00
1	2	4.44
2	11	24.44
3	7	15.56
4 or more	25	55.56



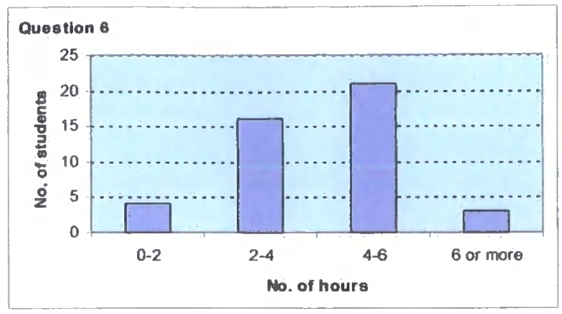
Question 5: On this course, when in the studio, what is the ratio of time is spent on presentations by the instructor to other coursework?

	No.	%
0-10%	14	31.82
10-20%	24	54.55
20-30%	5	11.36
30-40%	1	2.27
40%+	0	0.00



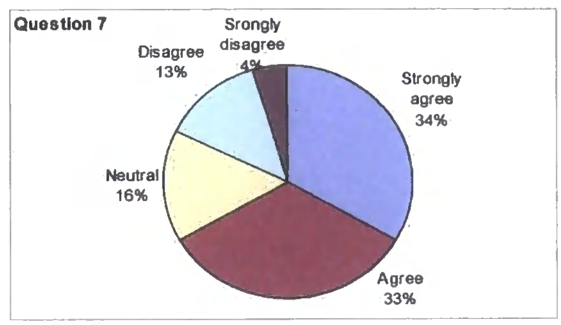
Question 6: On average, how many hours a week do you spend outside the scheduled studio classes on work related to this course? (Include any open shop time).

	No.	%
0-2	4	9.09
2-4	16	36.36
4-6	21	47.73
6 or more	3	6.82



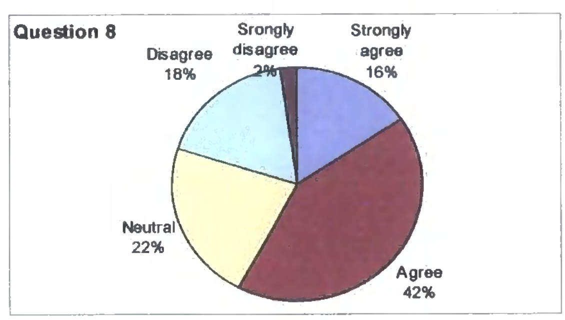
Question 7: It is easier for me to ask questions or express my ideas during discussions with my group in the studio teaching classes than to do the same in front of the lecturer and the whole class in traditional lectures.

	No.	%
Strongly agree	15	33.33
Agree	15	33.33
Neutral	7	15.56
Disagree	6	13.33
Srongly disagree	2	4.44



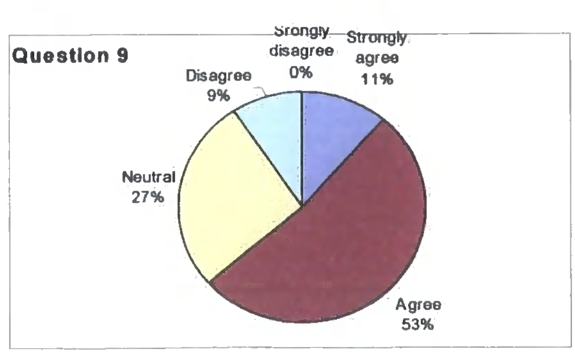
Question 8: After discussions with my group members, I have better chances to reinforce or correct my concepts quickly.

	No.	%
Strongly agree	7	15.56
Agree	19	42.22
Neutral	10	22.22
Disagree	8	17.78
Srongly disagree	1	2.22



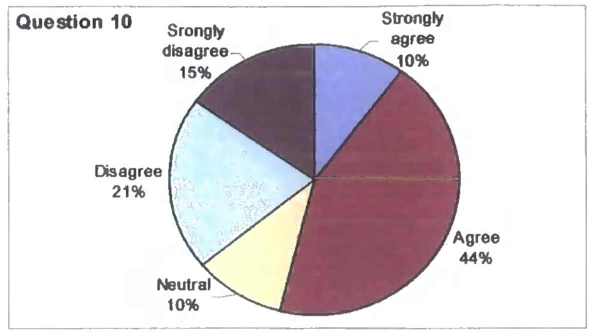
Question 9: I have more confidence to ask the lecturer questions or to express my ideas to the lecturer after discussing with my group members.

	No.	%
Strongly agree	5	11.11
Agree	23	51.11
Neutral	12	26.67
Disagree	4	8.89
Srongly disagree	0	0.00



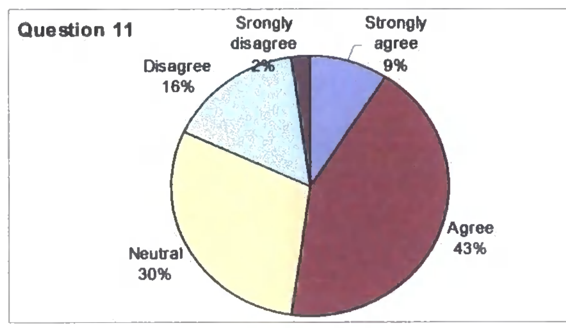
Question 10: I can learn more efficiently from the studio teaching approach.

	No.	%
Strongly agree	4	8.89
Agree	17	37.78
Neutral	4	8.89
Disagree	8	17.78
Srongly disagree	6	13.33



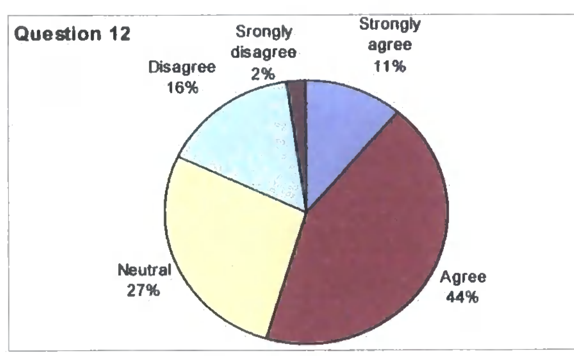
Question 11: In the studio, I have a chance ot know how other students handle the same problems, and can sometimes learn different ways of thinking, which cannot be achieved through the traditional system of assignment submitting and

	No.	%
Strongly agree	4	8.89
Agree	19	42.22
Neutral	13	28.89
Disagree	7	15.56
Srongly disagree	1	2.22



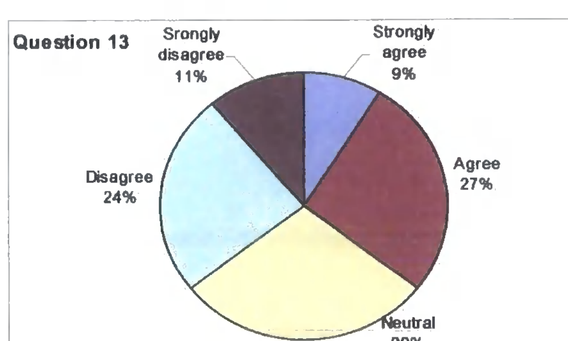
Question 12: If a lot of students have questions when solving a problem or they get things wrong in the same problem, studio teaching gives opportunities to the lecturer to repeat the orresponding facts, concepts or techiques right away.

	No.	%
Strongly agree	5	11.11
Agree	19	42.22
Neutral	12	26.67
Disagree	7	15.56
Srongly disagree	1	2.22



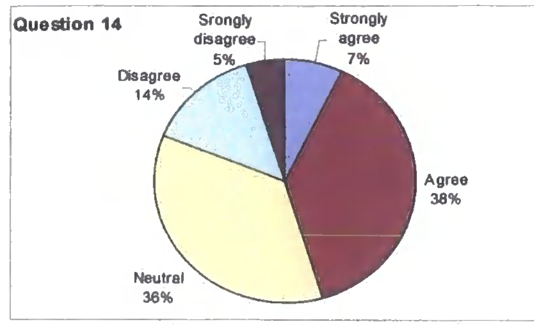
Question 13: It is easier for me to follow the materials delivered in a studio teaching approach.

	No.	%
Strongly agree	4	8.89
Agree	12	26.67
Neutral	13	28.89
Disagree	11	24.44
Srongly disagree	5	11.11



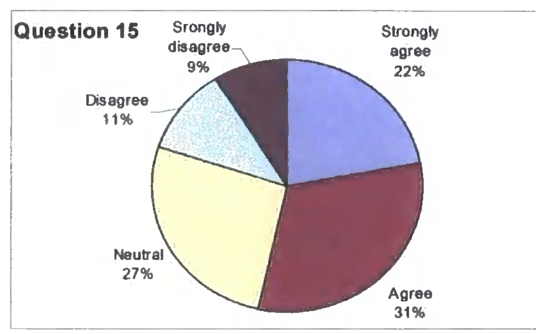
Question 14: The present studio teaching classes have successfully focused on student-centred leamiing rather than teacher-centred teaching.

	No.	%
Strongly agree	3	6.67
Agree	16	35.56
Neutral	15	33.33
Disagree	6	13.33
Srongly disagree	2	4.44



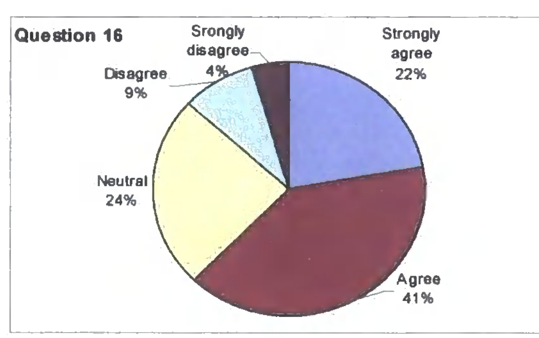
Question 15: If the same materials are taught by the same lecturer, I think I will learn more during studio teaching classes than in traditional teaching classes.

	No.	%
Strongly agree	10	22.22
Agree	14	31.11
Neutral	12	26.67
Disagree	5	11.11
Srongly disagree	4	8.89



Question 16: If the same materials are taught by the same lecturer both in studio teaching mode and traditional teaching mode, I prefer attending classes in the studio teaching mode.

	No.	%
Strongly agree	10	22.22
Agree	18	40.00
Neutral	11	24.44
Disagree	4	8.89
Srongly disagree	2	4.44



Question 17: My attendance in the studio teaching classes is:

	No.
0-20%	0
20-40%	0
40-60%	0
60-80%	1
80-100%	44

Question 18: I feel that I have been ?% enthusiastic in the activities in the studio teaching classes.

	No.	%
0-20%	2	4.44
20-40%	1	2.22
40-60%	8	17.78
60-80%	19	42.22
80-100%	13	28.89