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

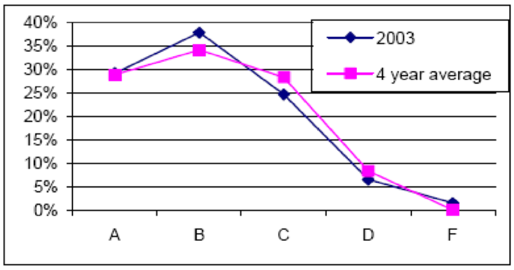

Fig 5.1 Comparison of grade distribution. The 2003 results were for the studio group. (Fig. 3 from Voigt et al, 2003)

> 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*.

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[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).

5.3.3 Approaches to learning and orientation to studying

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!