EXPLORATION OF CRITICAL THINKING IN

ENVIRONMENTAL SUBJECTS.

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CERTIFICATE OF AUTHORSHIP/ORIGINALITY

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within this text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

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ACKNOWLEDGEMENTS

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ABSTRACT

This qualitative research study investigated the expression of critical thinking in environmental subjects at university level in Australia. It also explored the strategies used by lecturers to encourage student critical thinking. Initially an open-ended questionnaire was sent to lecturers and tutors in universities across Australia and the responses from thirty participants were analysed thematically. From these participants semi-structured interviews were arranged with six lecturers and eight students from three different universities. The third phase of the research process involved analysing subject outlines and student assignments. Findings were triangulated to create a picture of the teaching and learning practices of critical thinking in this field.

The three cases of Environmental Science, Environmental Engineering and Environmental Law were identified as having some common yet distinctively different themes in relation to critical thinking. In each discipline area three broad approaches to the expression of critical thinking were identified: scientific/technical, paradigmatic and reflective. The scientific/technical approach in science was most concerned with critique of experiments and studies, in engineering with problem solving and in law with the technical aspects of language and application of the law. The paradigmatic approach included critical analysis of the different theories, frameworks and paradigms of each subject. The reflective approach to critical thinking included students' self evaluation of their learning within a specific subject.

Notable differences between the three cases were the types of strategies used by lecturers to encourage student critical thinking. The Environmental Science lecturers were more inclined to use a wide variety of strategies, including provision of written material about critical thinking with critical thinking identified in marking criteria, discussion in class and guided exercises. The Environmental Engineering lecturers placed more emphasis on discussion in class than on providing written materials. The Environmental Law lecturers predominantly focused on the strategy of debating in class for the development of student critical thinking.

The findings of this study are significant in providing support for the argument that development of critical thinking is subject specific rather than generic. This calls into question the use of generic skills testing for university graduates as a reliable measure of their ability to think critically in their field. The findings indicate that it is necessary for subject lecturers to be explicit with students about their expectations regarding critical thinking, particularly in relation to assessment. Findings suggest guidelines for lecturers including strategies and attitudes that encourage or hinder student critical thinking. Findings also suggest that the nature of the field of environmental and sustainability subjects lends itself to developing critical thinking, which is considered to be important.

CHAPTER 1: INTRODUCTION

1.0 The Research

Critical thinking is expected of students in their university assignments, particularly by the time they graduate, however many students today struggle with this expectation. This research explored the oral and written expression of critical thinking by Australian university staff and students, and the ways in which lecturers encourage and assess student critical thinking. The focus was on science, engineering and law subjects in the interdisciplinary field of environmental and sustainability studies.

1.1 The relevance of the current investigation

That critical thinking is considered an important skill to be mastered during university studies in Australia was evidenced in the trial of the Graduate Skills Assessment test (ACER, 1999), which included a section on critical thinking. While there are problems with this form of testing critical thinking, for example the test can only rely on generic aspects of critical thinking, it establishes that there is an expectation that university education produces critical thinkers. This raises the issue of how to assess critical thinking. Is it best assessed through such generic skills tests, independent of subject content (Pithers and Soden, 2000), or within the assessment tasks of a subject (McPeck, 1990; Moore, 2004). The debate about whether critical thinking is a generic set of skills or developed from knowledge of subject content is discussed in Section 2.1.

Further recognition of the acceptance of critical thinking as an integral component of university education is the growing number of Australian universities which list critical thinking among the acquired graduate attributes for their students. Several examples are provided here, where the use of terms such as critical analysis and critical thinking is based on the assumption that there is a common understanding of their meaning. For example, according to the University of Wollongong website (2006) the first of the graduate attributes listed is: "A commitment to continued and independent learning, intellectual development, critical analysis and creativity". The website displays

examples of teaching strategies promoting critical analysis, provided by lecturers in some faculties. For example, in Financial Accounting 111 the lecturer assesses student critical evaluation of a topical issue, and the process is modeled in class. In a Health and Behavioural Science subject students are required to write a reflective document about their own personal activity program. This indicates that there are subject specific approaches to encouraging critical thinking, though there is an assumption that the meaning of the concept is commonly understood. However, theorists have different definitions of critical thinking (see Section 2.1).

The University of NSW statement on graduate attributes on their website (2006) includes the following expectation of graduating students, among others: "the capacity for analytical and critical thinking and for creative problem solving". Also the University of Melbourne website (2006) states an expectation that graduates will have, among other attributes a "capacity for independent critical thought, rational inquiry and self-directed learning." Many universities in Australia claim that their graduates have acquired the ability to think critically and value this attribute, yet there appears to be no clearly defined means of assessing this.

This study provides information that will assist lecturers in teaching, and students in learning about and practising, critical thinking in environmental science, engineering and law subjects at undergraduate level, particularly in an ever increasingly interdisciplinary context. It is particularly relevant to the international emphasis on sustainability studies. As explained below (Section 2.2.2) there is considerable overlap between environmental and sustainability studies, thus for the sake of consistency this thesis predominantly uses the term environmental subjects to encompass both fields.

1.2   Background to the research

This study has evolved from my previous involvement with action research projects about critical thinking at the University of Western Sydney (UWS). My background is in Language and Academic Skills (LAS) advising in the field of academic literacy. This

involves teaching students about what is expected in written assignments at university. Sometimes this is carried out in situations that are independent of specific subject content, such as cross discipline workshops, but increasingly involves collaborative teaching and learning situations with subject lecturers (Haggis, 2003; Jacobs, 2005; Jones, in Ravelli and Ellis, 2004).

My interest in critical thinking as a necessary ability, skill or understanding at tertiary level began because of student confusion about what was expected in assignments that asked for critical analysis, critical evaluation or critique of an issue or topic. Whilst it was possible to explain in general terms what is required, it was more difficult to anticipate what particular lecturers expected especially when I was not familiar with the content of a subject. A colleague had previously suggested that it might be possible to collaboratively investigate the role of critical thinking at undergraduate level with lecturers in the faculties. We attended the 5th International Conference on Thinking (1992) and learned that there was considerable debate about critical thinking, both in terms of what it is and how it is taught. Two major aspects of the debate focused on whether critical thinking skills are generic, or subject specific (McPeck, 1990; Norris and Ennis, 1990; Swartz and Perkins, 1990). The main proponents of the generic approach were Norris and Ennis (1990) with McPeck (1990) providing arguments for the need to first understand the content of subjects in order to develop critical thinking.

After attending the International Thinking Conference in 1992, my colleague and I initiated the formation of a network of academics, the Critical Thinking and Writing Network (CTWN) at UWS, to examine the question of student critical thinking (James and Scoufis, 1995). Based on lecturers' concerns about the apparent lack of critical analysis in student assignments (Bailey, 1992) and student queries about what was expected, an action research project (McTaggart, 1993) was undertaken across disciplines. This eventuated in the production of useful resources for students and lecturers. The project invited lecturers in all faculties to recommend student assignments that demonstrated critical analysis as they perceived it and these assignments became the basis of separate interviews with the student author and the lecturer. A number of resources were developed between 1995 and 1999 for student and staff use: a book (Carmichael, Craigie, Driscoll, Farrell, James and Scoufis, 1995),

video (James, Scoufis, Farrell and Carmichael, 1999) and interactive CD Rom (Scoufis, James, Carmichael and Farrell, 1999). Several colloquia were conducted at the university to stimulate debate and the sharing of ideas and strategies aimed at encouraging the development of student critical thinking. However, the discipline area of Environmental Studies was not included in these projects and hence is the focus of the current research. My interest in environmental and sustainability issues stems from experiences in the area in which I live. Many situations that have arisen require critical thinking by all interested stakeholders, including environmental professionals.

The importance of education about environmental problems today cannot be underestimated. Many people are aware of issues such as global warming, climate change and the effects of the hole in the ozone layer, subjects often referred to in the daily papers or on the news (Eamus, 2002; Harding, 2002; Suzuki 2003). However, the study of various aspects of the environment has been an expanding educational movement (UNESCO, 2002) which is not necessarily encompassed under the one discipline area in the university setting. Environmental studies related disciplines have emerged from well established fields of study which are based in the physical world, involve highly technical tools and measurements and value scientific objectivity in the approach to data (Beder, 1996). Many students who have completed their education in these fields have become the environmental advisers of government at all levels and may be regarded as experts in their profession.

1.3   The context of this research

This research is pertinent to the issue of whether the students who graduate into the role of environmental and sustainability professionals are encouraged to be critical in their thinking while studying at university. Are they adequately equipped to meet the growing challenges of the associated economic and political pressures that they may encounter in their professional lives? How can this be assessed? Students need to be given the opportunity to develop their critical thinking abilities during their studies in order to solve problems and evaluate information effectively.

An initial pilot study was undertaken at UWS in 2000 to discover the role of critical thinking in several environmental subjects. It was to form the basis for this Masters Honours research project involving lecturers and students in other universities in Australia. The pilot study commenced with the collection of recommended assignments in environmental studies subjects, demonstrating critical analysis as the lecturers perceived it (Carmichael, 2001). The student authors and the staff members who marked the assignments were interviewed about the role of critical thinking in assignment writing. The method of data collection for the pilot study was similar to that used in the CTWN projects.

The three discipline areas of the current study, Environmental Science, Environmental Engineering and Environmental Law, were specifically chosen to expand on the information from the previous pilot study. I also decided to include subjects which incorporated education for sustainability within the three disciplines mentioned because of the connection between environmental and sustainability studies. For example, a number of university engineering educators have written about the integration of the concept of sustainability into undergraduate engineering core subjects and courses (Bryce, Johnstone and Yasukawa, 2004; Lourdel, Gondran, Laforest and Brodhag, 2005; Mulder, 2006). Mulder refers to an interdisciplinary sustainability project between four European institutions on the theme of water and comments that "during the project the students became aware of their specific disciplinary contribution" (p.140). The importance of awareness of the different paradigms in different disciplines has become an issue in interdisciplinary studies. This understanding is relevant to the critical thinking expected in different disciplines and different subjects (Jones, Merritt and Palmer, 1999).

1.4   The aim of this research

This research aims to explore the role of critical thinking in environmental and sustainability education in Australian undergraduate university courses. Although the terms critical thinking, critical analysis and critical practice do have somewhat different meanings, critical thinking is the term used in this thesis. Critical analysis is used in the

thesis in relation to students' expression of critical thinking in their assignments. Thus an awareness of the need for critical thinking in university environmental and sustainability subjects has lead to the following exploratory research questions:

How is critical thinking expressed in environmental and sustainability subjects?
How is student critical thinking encouraged in these subjects?

The next chapter reviews the relevant literature concerning critical thinking and environmental studies to place this research project within the context of existing studies and theories. Chapter 3 explains the qualitative methodological approach taken for the research, methods for collection of data and an outline of the interpretation of the data. Chapter 4 analyses and interprets the findings from a questionnaire distributed to lecturers of environmental subjects in universities across Australia. Chapter 5 analyses the themes from interviews with selected lecturers and students from environmental subjects within three discipline areas. Chapter 6 analyses documents from different environmental subjects, including subject outlines and student assignments. Chapter 7 discusses the analysis of all the findings and their significance. Chapter 8 is concerned with the implications of the findings for the practice of teaching and learning critical thinking in environmental subjects from a discipline perspective, and offers directions for further research and application of findings in the university setting.

CHAPTER 2: LITERATURE REVIEW

2.0 Introduction

This chapter will present an overview of the literature on critical thinking and environmental studies to place the research study in context. The review of literature provides various definitions of critical thinking and key ideas in the ongoing debate about critical thinking. A review of literature that is more relevant to the expression and assessment of student critical thinking at the subject level in university courses is the focus of this chapter, rather than literature relating to generic courses and skills tests. The relationship between environmental education and education for sustainability is also examined and the importance of critical thinking in this field supported. Issues concerning the encouragement of student critical thinking are raised, particularly within an interdisciplinary course.

2.1 What is critical thinking?

Critical thinking is an ability or set of skills that is highly valued in university studies (Bailey, 1992; Cotton and Hackett, 2003; Dix, 1994; Moore, 2004; Phillips and Bond, 2004), yet many students are confused about what it means and how to develop critical thinking in the academic setting. This confusion is exacerbated for those who come into western universities from other cultures and for those who are the first generation in their family to attend university and have little experience of what is expected (Ballard and Clanchy, 1991; James and Scoufis, 1995). Perhaps the confusion arises because students have not encountered the term critical thinking at school, or perhaps it is because their lecturers and tutors have not explained their expectations about critical thinking clearly.

However, this is not an easy task when there is no single definition of critical thinking. For example, critical thinking has been defined variously by theorists as:

"…a process, not an outcome. Being critical thinkers entails a continual questioning of assumptions…central to critical thinking is the capacity to imagine and explore alternatives to existing ways of thinking and living…" (Brookfield, 1987, p. 6-8);

"…the ability to analyse, criticise, and advocate ideas, to reason inductively and deductively, and to reach factual or judgmental conclusions based on sound inferences based on unambiguous statements of knowledge or belief" (Freeley, 1996, p.1);

"…the formation of logical inferences" (Halpern, 1996);

"…reasonable, reflective thinking that is focused upon deciding what to think or do" (Norris and Ennis, 1990, p.1);

" I think that the phrase 'critical thinking' refers to a certain combination of what we might think of as a willingness, or disposition (call it an 'attitude', if you like) together with the appropriate knowledge and skills, to engage in an activity or problem with reflective skepticism" (McPeck 1990, p.42);

"…counter-thinking, opposition and challenge, as well as support. We need reasons that are meaningful to us, some persuasive logic, to move our minds from one set of ideas or beliefs to another" (Paul, 1994, p. vii);

"…analytic habits of thinking, reading writing, speaking, or discussing…go beneath surface impressions, traditional myths, mere opinions, and routine cliches; [it is] understanding the social contexts and consequences of any subject matter; discovering the deep meaning of any event, text technique, process object statement, image or situation; [and] applying that meaning to your own context " (Shor, 1993, cited in Lankshear, 1994, p.9);

"…a way of bringing more rigorous analysis to problem solving or textual understanding…[which] can be broken down into a set of thinking skills, a set of rules for thinking that can be taught to students" (Pennycook, 2001, p.4).

There are almost as many definitions of critical thinking/reasoning/analysis as there are people willing to offer one, although some grouping of definitions could be made reflecting the following themes:

1. Ability to identify assumptions/premises behind arguments and information
2. Ability to evaluate information, according to sound criteria
3. Ability to reach one's own conclusions
4. Reflection on one's own thinking/practice

A movement to teach thinking skills began in USA in 1981 (Ruggiero, 1995), as opposed to leaving it to students to learn by osmosis, when the US Department of Education expressed concern about students' lack of critical thinking and problem solving skills (p. xix). This emphasis on learning to think critically was also reinforced by Paul (in Elder and Paul, 1994, p. ix) with his critique of the then current educational system which was "around the world, at all levels…typically didactic, one-dimensional" and based on the assumption that "recall is equivalent to knowledge". He argues that unless people learn to be critical thinkers, there will be no "global social and economic development and prosperity" or preservation of a "precarious environment" (p. xi). Another well-known author on the subject of teaching thinking is Edward de Bono (1976), who has divided thinking skills into six categories, one of which is critical thinking (1990, 1994). Because de Bono (1994) does not believe critical thinking to be the only valid form of thinking required today, he critiques the "elevation of the 'critical intelligence' to the highest level of human endeavour"(p.223) in western education. De Bono is emphatic that western education does not teach students to think, that it has failed by assuming thinking will be learned by osmosis. While this is a reasonable critique, his explanation of critical thinking is focussed on generic skills. In categorising different types of thinking, de Bono limits critical thinking to "analysis" and "judgement" and to finding out what is wrong or in error, which does not allow for positive evaluation or the inclusion of reflection in the critical thinking process.

2.1.1   Generic theories of critical thinking

In tandem with this movement to teach critical thinking, the literature on the topic has become prolific since the mid 1980's when generic courses in critical thinking started to become somewhat institutionalised at the tertiary level, particularly in the United States. The establishment of such courses resulted from the belief that critical thinking is a generic set of skills, based on philosophy and logic, which are transferable across disciplines (Melville Jones, 1997; Norris and Ennis, 1990; Swartz and Perkins, 1990). In these courses students learned, for example, to identify the premises of an argument, including the hidden premises, and evaluation of an argument. Study skills books have

provided instruction about using critical reasoning as, for example, a way of analysing the logic or value of an argument, or the reliability of a source of information (Herrick, 1991; Maker and Lenier, 1996). Examples are taken from real life situations, deemed to be pertinent to most people, and such examples are often the basis for testing critical thinking. Such tests include the Cornell Critical Thinking Test developed by Ennis and Millman (1989) and the graduate skills assessment by the Australian Council for Education Research (ACER) developed in 1999. However, it is possible to critique such tests in much the same way standard IQ tests have been critiqued, that is there is inherent cultural and class bias in the content of test questions. The issue of whether critical thinking is best tested generically is relevant to this debate (Moore, 2004; Moore and Hough, 2005). A number of authors question the teaching and testing of generic skills in the university setting (Haggis, 2003; Lea and Street, 1998) and take an "academic literacy" approach. This emphasises learning to think and write within the context of individual subjects, rather than as separate skills.

2.1.2   Subject or domain specific theories of critical thinking

Several authors, McPeck (1990) being the major proponent, have taken the position that critical thinking is developed within a subject, and is directly related to the way in which the discipline is taught. For instance, it is suggested that it is through the types of assessment tasks set, for example those which require presentation of an argument or problem solving, rather than the rote learning of facts, that students develop their critical and higher order thinking abilities (Biggs, 1999; Tomlinson, 1997). This has been referred to as subject-specific or domain-specific critical thinking and is not seen to be so easily transferable across disciplines (McPeck, 1990; Moore, 2004). In fact, the contention is that it is only when students have a reasonable grasp of the content knowledge of different subjects that they will be in a position to critically analyse information and develop their own thoughts on the matter (Jones, Merritt and Palmer, 1999).

While there is some evidence to support the claim that students can improve their critical thinking through courses that focus on generic critical thinking skills of

assessing argument, problem solving and decision making (Swartz & Perkins, 1990; Halpern, 1996), other evidence suggests that critical thinking is more 'subject' or 'domain' specific. McPeck (1990) refers to the fact that at least 50 empirical studies have been carried out since the 1970's, which support the concept that reasoning skill and transfer of it are 'domain specific' (p.49). He makes a strong connection between methods of assessment and critical thinking and believes that if assignments are to demonstrate original ideas and argument then questions must reflect this.

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A more discipline based approach to understanding knowledge, and thus potentially encouraging critical thinking, is in keeping with the development of student understanding of the discourse of a discipline (Fairclough, 1989; Gee, 1990; Lankshear, 1994). This requires an acknowledgement of the frameworks, philosophical/political paradigms and language that is often assumed in a discipline and not made explicit to students (Kress, 1985). It is through learning to understand and use the discourse of a discipline that students are in a better position to be able to think critically and express their critical analysis in their written assessment tasks (Carmichael and Farrell, 1997; Farrell, James, Carmichael and Scoufis, 1997). Critical applied linguistics has become a recent movement which values the role of language in the expression of critical thinking, with a "key focus…[being] to ask broad questions about language and power" (Pennycook, 2001, p.28). This approach sits within the context of integrating academic literacies within the content of subjects (Jacobs, 2005). From the field of applied linguistics, Moore (2004) offers an argument in support of a more discipline-specific approach to the understanding of critical thinking, based on discourse analysis (Caldas-Coulthard and Coulthard, 1996; Fairclough, 1995; Halliday, 1985) of three different text excerpts. These texts demonstrate the differences in the essence of critical thinking between fields of study, in that case philosophy, educational psychology and anthropology. Moore (2004) demonstrated this by comparison of the "object of the evaluation, the content of evaluation and the register of evaluation" (p. 8). Further explanation of the approach taken by Moore is discussed in relation to the method of document analysis used in this thesis (see Section 3.3.3).

Some writers and researchers have focused on reflective thinking (for example, Boud, Keogh and Walker, 1985; Boud, 1999) as a means of developing critical thinking,

including evaluation of student's own performance/professional development. The emphasis is on forms of student assessment that require students to consider their reactions and thoughts about their coursework. For example, students in the discipline areas of nursing, performing arts and teacher education are expected to reflect on their own performance in practice (Carmichael et al, 1998) and through self reflection and critique, develop and improve that practice. Various authors have acknowledged that student learning is enhanced through awareness of cognitive processes and thinking about their learning (Biggs, 1988). It is generally accepted that the manner in which students approach a task determines the quality of the outcome. Furthermore, a deep learning approach (Biggs, 1999) may foster greater understanding of content and thus encourage critical analysis (Brookfield, 1987; Li and Body, 1993, cited in Bain, Lietzow and Ross, 1994; Ramsden, 1993).

2.1.3   Teaching critical thinking

However, academic staff may find it difficult to change their approach to teaching from an authoritative, lecturing mode to the more flexible, interactive mode that may provide opportunities for students to question and challenge ideas (Duron, Limback and Waugh, 2006). This may be one reason for the preference of generic courses in critical thinking, where critical thinking remains another content area in which the lecturer is the authority. Interestingly, Brookfield used the phrase "critical teaching" in 1987 to emphasise the importance of the role of the teacher in the process of the development of student critical thinking (p. 80). He refers to a number of strategies suggested by Meyers (1986, cited in Brookfield, 1987) for fostering critical thinking, including allocated reflection time during class and small group work. However, he recognises that "all these … models of critical teaching and tools of learning analysis are contextually variable" (p. 88). Paul (1994) suggests that because teachers themselves are sometimes not critical thinkers they do not encourage this ability in their students, and simply expect them to recall facts. Furthermore, he states that students need to learn to first "think" within the discipline if they want to learn about the discipline.

Johnson, Johnson and Smith (1996) agree that teaching style influences student learning in their statement that "faculty can teach a subject by giving answers or by asking

questions" (p. 4). Moreover, they acknowledge that "fear blocks faculty and students from engaging in intellectual conflicts" (p. 2), and that many deans and departments do not encourage deviation from the norm because it often reflects badly in student evaluations of a subject. This point is also emphasised by Haas and Keeley (1998) who indicate that students who receive entertaining delivery of information in lectures, which does not require them to be active learners, are more likely to provide positive evaluations of the subject. They outline a situation in the Department of Economics at Bowling Green State University, USA, where a group of academics met regularly to discuss readings about critical thinking, with the aim of encouraging incorporation of some of the ideas into their teaching. Many, who believed that critical thinking is important in university education, were not confident to define the term clearly. Even after four years some were still hesitant to "teach critically" because of the pressure of student evaluations. Some effort to change the evaluations was undertaken, although the link between faculty resistance to teaching critical thinking and student resistance to learning to think critically was the focus of that paper.

2.1.4   A broader approach to critical thinking

Barnett (1997) critiques many approaches to critical thinking including the generic versus subject specific debate, as well as the more recent trend towards "economic regeneration", by which he means that the "corporate world has to move on and needs critical minds to help it do so" (p.3). The implication here is that critical thinking is seen as a valuable ability in an employee, and that this has become a trend in the education of business students. Barnett questions the use of critical thinking skills for economic gain and argues that critical thinking should also involve thinking at a broader societal level, and often in collaboration with others, such that a person becomes a "critical being" who not only thinks critically, but acts critically. He believes that the debate has not gone far enough.

Based on reading and experience, my definition of critical thinking could be expressed as the ability to evaluate information, in context, in order to make informed decisions and take a position on issues, with an open mind to possible changes and alternative

approaches. I consider that social, environmental, economic and political/philosophical awareness also plays a role in the ability to think critically, and that this broader understanding of the world is crucial for effective decision making. Such understanding appears to be generic, because it could be applied to any discipline, but it is also reliant on in-depth content knowledge.

However, as has been found through my involvement in previous critical thinking research (Carmichael, Craigie, Driscoll, Farrell, James and Scoufis, 1998) there are a number of processes students may undertake to develop their critical thinking skills, which are predominantly generic but also vary according to the discipline area being studied. For example, these processes may include: question analysis, immersion in the topic, making links with work and life experiences/other subjects, understanding different points of view, questioning information, evaluation and developing a position based on argument (James, Scoufis, Farrell, and Carmichael, 1999).

The different processes, skills or understandings of critical thinking required in different disciplines became apparent in the research projects mentioned above. Interviews and focus groups revealed that students and lecturers in the various discipline areas at the University of Western Sydney described critical thinking in contrasting terms (Carmichael et al, 1995). For example, in the fields of Science and Mathematics they tended to perceive critical thinking to be a skill closely related to problem solving. Those in the fields of Humanities and Arts theory described the need to immerse themselves in and situate themselves in the debates and arguments of the authors they were reading. Critical thinking was perceived to be related to a deep examination and questioning of the ideas and theories of different authors. Those studying Education, Nursing and Dance were often more concerned with critical reflective thinking, in relation to their practice, though they also needed to be able to critique theorists. Of a total of seven faculties, six were involved in the project: Commerce, Nursing, Education, Science, Humanities, Visual and Performing Arts. Through the in-depth interviews it was possible to conclude that differences in approach to critical thinking are present and these were reflected in the assignments provided. For example, in the subject of Industrial Relations Law, in the field of Commerce, the ability to argue well

was considered to be the key to effective critical thinking. The following is an excerpt from a student assignment:

"There is no right to strike only a freedom of liberty; in S210 the commission <u>may</u> break an order to cease industrial action. The use of the word may is significant as it imparts a <u>discretion</u>. However whilst it gives the commission discretion, there are no prescribed grounds on which this will be made. Conspicuous factors are required to exist for an order to be granted - how will anyone know? This is left open. In cases where these orders have been made (very few have been issued) no reasons have been issued therefore it will be on a case by case basis, allowing for less predictability and stability. This area is a volatile and political one and this may make the commission loathe to express their ideas of factors. A right to strike should not hinge upon anyone's discretion" (p. 21).

The lecturer's comment about this student's essay reinforced the contention that in this field critical thinking is closely linked to developing an argument.The student's comment supports this:

A democratic right should not be left to someone's discretion and that is what is inherent here. This was a significant issue. I argued that because there was a lack of predictability there was also a lack of stability (p. 21).

On the other hand, in a Computing Science group report the key concept of critical thinking appeared to be more closely aligned with problem solving. An excerpt from the Executive Summary of the students' report on the Bush Fire Service reads as follows:

"We have identified the problem that the Bush Fire Services Department faces as being one of [gathering and assessing] ...highly important data. This data is crucial since life and property are at risk and decisions need to be made in situations of normal administrative nature, in small fire situations, and in State controlled section 41(f) emergencies. Decisions based on data need to be made on a routine basis and in an emergency based on timely and accurate data collected from the decentralised organisational structure" (p. 144).

The lecturer's comment about the students' critical thinking, as expressed in their report, was in terms of their grasp of the problem. The students who wrote this report commented on the processes which they felt had developed their critical thinking and eventual successful outcome:

This real life situation is not the same as a textbook scenario. We've had to put in a lot of effort to enhance our skills and analyse what the real situation is and talk to different people about what the real needs of the customer were and what we should be doing and shouldn't be doing (p.144).

In the field of Nursing both students and lecturers who were interviewed mentioned critical thinking as reflection. It was perceived that the key to critical thinking in Nursing was for students to think for themselves, and this relied on them having practised critical reflection during their course. Lecturers emphasised that students need:

- *to reflect critically on their own practices as nurses;*
- *to be socially reflective - to think about the impact of their nursing practices on the wider social framework;*
- *to be critically reflective of the role of nursing and nursing practice to-day;*
- *to critically consider the relevance of the theories/concepts to which they are exposed, to nursing practice* (p.103)

One student commented: *I kept asking myself what does the lecturer want in posing this question? What is she looking for? I looked at what was implied by the question and not just at the question at face value. The lecturer wants you to harness work experience and knowledge, to develop your own view and support it with case material* (p. 108).

While these examples may provide some indication of a different approach to, and possible assessment of, critical thinking in different discipline areas, further analysis needs to be done to confirm this for environmental studies subjects. Part of the current research study will involve document analysis of student assignments and subject

outlines in the three discipline areas of Environmental Science, Environmental Engineering and Environmental Law. The purpose of this document analysis is to establish whether there are different perceptions and expressions of critical thinking in these three interrelated discipline areas of tertiary environmental studies.

2.2 Why is critical thinking so important in Environmental and Sustainability subjects?

2.2.1 Background

Today it is more important than ever that the decision-makers and their advisers, with regard to environmental issues and the human impact on the environment, are critical thinkers who are not bound by economic growth paradigms. The serious threats to the planet of climate change, clearing of native forests, loss of habitat, water and air pollution, soil erosion and other forms of environmental destruction (Postel, 1996; Suzuki, 2003; Wackernagel and Rees, 1996) require graduates in this field to be able to assess situations in terms of ecological sustainability for the future. This is particularly the case in terms of aspiring toward a non-violent future, incorporating empowerment of the learner and collaboration between different sectors of society and between countries (Hutchison, 1996; Pezzoli, 1997).

Pezzoli (1997) presents an overview of the history and literature about sustainable development. He raises the difficulty of clearly defining *sustainable development* because of the political overtones. It should be borne in mind that the issue of sustainability is as complex as that of critical thinking, and that there are a number of different definitions of the term, according to the author's world view (Beder, 1996; Harding, 2002). There is tension between those with an economic orientation, who define sustainable development as "the integration of the environment into the economic system" (Beder, 1996, p. 9), and environmentalists who "believe that the environment has value beyond its ability to provide for human needs or wants…" (p. 12). Stables (2001) agrees that the meaning of sustainability is "always dependent on the context in which it is used"(p. 127), and outlines four different philosophical assumptions that will

inevitably influence what is meant by the term. Even the somewhat clearer definition of ecologically sustainable development (ESD) is open to different interpretations. This definition places the focus on ecology: "using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased" (Commonwealth of Australia, 1990, p. 6, cited in Harding, 2002, p.17). Yet in this definition concepts such as "quality of life" are very subjective.

Pezzoli (1997) outlines the history of "environmentalism", or the environmental movement, believed to have started in 1970 with Earth Day. However, he points out that there is evidence of authors who expressed concern about the impact of industry on health in the late 1800s in the USA. He refers to the 1972 establishment of the United Nations Environment Program (UNEP) and the Cocoyoc Declaration, in 1974, which recognised the difficulty of reconciling the earth's resources with the need for 'economic growth'. He claims that this led to the concept of cleaning up 'the mess' (p. 551), a view which has influenced government approaches to environmental problems until more recently.

The 1987 document known as the Brundtland Report recognised that sustainable development was concerned not only with the impacts of development on the environment, but also with the "impacts of ecological stress - degradation of soils, water regimes, atmosphere and forests - upon the economy" (Pezzoli, 1997, p. 552). It recognised the interdependence of ecology and the economy. In 1992 the Earth Summit, organised by World Commission on Environment and Development (WCED) at Rio de Janeiro, led to Agenda 21, the Rio Declaration and a Statement of Principles on Forests. There was a call for the eradication of poverty, and a belief that wealthier countries should pay for the clean up. This was referred to as a 'partnership' of countries. Pezzoli refers to the challenge for Environmental Science, which has come about because "the rise of industrialism has shifted humanities' dependence on energy currently coming from the sun to energy stored in non-renewable sources (eg. fossil fuels)….societies have shifted from predominantly 'closed loop systems' (consume - process- reuse) to 'open loop systems' (one way flows of resources in and wastes out)" (Smit & Nasr, 1992, cited in Pezzoli, 1997, p. 561). Pezzoli concludes that the way forward is through

an interdisciplinary approach, that universities must work with industry and government and function within multidisciplinary research and training centres.

Environmental education is a rapidly growing field both within and outside of tertiary institutions. According to Gough (1997), environmental education first occurred in the United Kingdom in 1965, in the United States in 1966 and in Australia in 1970. Although the term generally refers to primary and secondary curriculum, it is also used in relation to university level curriculum. The NSW Government (2002) published a working paper which outlined the need for educational institutions, from early childhood to universities, to enhance student learning about sustainability across the state including increasing the number of places available in tertiary environmental education courses and effective evaluation of such courses (p. 26). An aim of the environmental programs was to ensure that learners do not simply accumulate knowledge, but actually change their behaviour to minimise their impact on the environment. Similar ideals are to be found in a Commonwealth of Australia discussion paper (1999). At university level for instance, there has been an emphasis on learning for sustainability in the field of engineering. The manual for the accreditation of professional programs (IEAust, 2005) outlines generic attributes expected of graduate engineers. Professional engineers are expected to demonstrate competencies including: "understanding of social, cultural, global and environmental responsibilities and the need for sustainable development" (p.6).

Gough (1997) emphasised the link between science and environmental education with the statement that "the relationship between science education and environmental education was implicit" (p.5). She defines environmental education in terms of the interconnection of human beings with the environment, including the need for humans to overcome negative impacts on the environment and to work toward preservation of its integrity.

Such an approach to environmental issues is supported by the concept of ecological footprint (Wackernagel and Rees, 1996), which is a mathematical tool for determining the impact of human activity on the earth. This can be established at an individual, group, societal, national or global level. Thus it is possible to reduce environmental

problems by reducing the ecological footprint. Various authors support this type of approach, for example, Laird, Newman, Bachels and Kenworthy (2001, p.21) claim that the "challenge is to choose the path we want that will create better economies, better communities and better environments (globally and locally)". This is a worthy ideal that many would agree with. However, Trainer (1994) takes a more critical approach. He believes that the developed world has exceeded its ecological footprint and needs to reduce its standard of living. He claims that this is necessary in order for the developing countries to be able to raise their standard of living, since the developing countries have suffered from exploitation by the first world. His argument challenges the economic concept of the need for continually increasing Gross National Product (GNP) to support an increasing standard of living, especially if it is to extend to all populations. He produced figures that demonstrate that the world's resources cannot extend that far, and calls for a reduction in consumption in the developed world.

2.2.2 Teaching and learning about environmental issues

Teaching and learning about environmental issues needs to take into account the impact information may have on students. For example, if the information presented to students is all 'gloom and doom' they may feel overwhelmed and prefer to ignore the issues. It is suggested by Hutchison (1996) that students benefit from being actively involved in changing their environment rather than being subject to an "overburdening of intractable problems" (p. 38). Hutchison refers to the concept of 'alternative futures', which means that the future is not determined, that teachers and learners can be involved in developing new ideas and creating change for the future. The example is given of the hole in the ozone layer. Predictions are that it will become larger and that this will have significant consequences, such as more skin cancers, but more recent news has revealed that it may be closed in fifty years time (ABC Online, 2002). This is somewhat encouraging for environmental and conservation groups who have been applying pressure on governments for a number of years since the 1987 Montreal Protocol to reduce Chloroflurocarbon (CFC) emissions. With the current critical issue of the Kyoto agreement for reducing greenhouse gas emissions it becomes crucial that students of

environmental education feel empowered to take action to influence the future positively. Hutchison (1996) calls this a 'critical futurist perspective' (p. 37).

Critical analysis of information is of paramount importance, such that information should not be accepted as a given fact, that is, unchangeable. This idea is supported by Janse van Rensberg (1994), who emphasises the influence of the type of language used in the transfer of information and the importance of active learning processes including reflection (reflective thinking and dialogue), problem solving and empowerment of the learner. She favours a "reflexive" approach to environmental research and education, where learners are encouraged to develop solutions instead of simply receiving information that emphasises environmental problems.

"Education for sustainability", according to Huckle and Sterling (1996) is a more humanitarian, less scientific or "objective" form of environmental education. It evolved as a reaction to the thinking and teaching of environmental education, perceived to be within the "positivist" framework. The term education for sustainability has been used since the 1990's and has some of the following characteristics, according to Sterling (in Huckle and Sterling, 1996):

- Should be applied and grounded in the local economic, social and ecological context and community, followed by regional, national, international and global contexts (think global act local)
- Primarily grounded in, but not limited to, social development and human ecology
- Learner - centred and socially orientated
- Greater emphasis on interdisciplinary and transdisciplinary enquiry, recognising that no … issues exist in isolation
- Empowering… engaged and participative rather than passive; the emphasis is on learning rather than teaching…action research with its emphasis on critical reflection…
- Ideologically aware and socially critical (pp. 22 - 24)

Several of the differences between the environmental education framework and education for sustainability appear to be the inclusion of the human factor in the

thinking about environmental issues, both as the perpetrator and victim of damage, greater interdisciplinarity and a more learner focussed approach to teaching in education for sustainability. A greater emphasis on critical reflection in the latter is indicated because of the participatory learner focus. The apparent shift from the approach of scientific information transmission and highly structured paradigms to education for sustainability, which emphasises reflective learning, empowerment of students and involvement of the community in decision making, has been noticeable over the past ten or more years. However, there has been a blurring of this process as environmental educators recognise the limitations of a didactic one-way teaching approach concerning environmental issues. Because of this blurring of differences between the two approaches, this study has investigated subjects in both the environmental studies field and the field of sustainability education.

It would appear that sustainability education was to some extent a reaction to the traditional scientific approach of environmental education (Tilbury and Cooke, 2005), however the range of definitions of sustainable development creates confusion (Carvalho, 2001; Harding, 2002; McGregor, 2004). There is also critique of the way in which the concept of sustainability has been reinterpreted. McGregor (2004) argues that sustainable development is the dominant discourse in the environmental field and that this does not allow the more alternative ideas that equate with ecocentrism with its focus on the environment to play such an important role in the discourse, and therefore in people's actions. Also Carvalho (2001) believes that the commonly accepted perception of sustainable development, namely a balance of environmental, social and economic interests, has been used to further develop the wealthier countries of the world. She emphasises the dominance of this concept of sustainable development and demonstrates how it has been an excuse for exploitation of developing countries by the more developed countries throughout history.

2.2.3   Critical thinking and environmental issues

The more reflective and active learning processes referred to above are in keeping with the approach to critical thinking outlined by Barnett (1997). Moreover, his critique of business ethics and of the assumption that growth is the core of economic success, is also relevant. This understanding is essential in order to allow the development of a truly ecologically sustainable approach to preservation of this planet. For example, Balakrishnan, Duvall and Primeaux (2003) argue that ethical decisions in the world of business need to favour society, the environment and lastly economic interests. They question the concept of the benefits of economic growth, as did Trainer (1994) and Orr (1996). Orr attributes the undermining of biodiversity on the earth to "our inability to question economic growth, the distribution of wealth, capital mobility, population growth, and the scale and purposes of technology…" (p. 71). According to Luke (1997), Bookchin had constructed a similar critique in the 1950's of "endless growth, unregulated waste, overspending of energy, overproduction of useless things…and a consumer society imposing itself on a conserver society" (p.179). Orr (1996) emphasises the connection between "conservation biology and political action" (p. 72), which is also reminiscent of the approach to critical thinking taken by Barnett (1997). It is not new that critical thinkers have been questioning the issues around advanced industrialisation and its effects on the environment and communities (Beder, 1996; Harding, 2002). However, to what extent is this occurring in the classrooms of environmental and sustainability subjects? Are students encouraged to extend their critical thinking this far?

In various universities around the world this issue is being taken seriously. For example, several engineering lecturers have more specifically focused on developing student critical thinking (Tomlinson, 1997; Belski, 2001). Tomlinson (1997) explained a change of approach within an environmental engineering subject over three years in a Queensland university undergraduate course. Students moved from passive listening

and note taking in lectures to working in teams on group projects involving problem solving. Focus group evaluations indicated that students felt their critical thinking skills and problem solving skills had improved despite an adjustment period. The lecturer supported this assessment. A similar finding particularly regarding the benefits of group work as a positive strategy for developing student critical thinking in an undergraduate science course was reported by Hager, Sleet, Logan and Hooper (2003). Belski (2001) agrees that it is no longer appropriate for higher education students to be passive recipients of information. With the technological developments of today it is important that education develops student critical thinking, decision-making and problem solving.

2.3   How can students be encouraged to develop critical thinking abilities?

A key element of the current research is to determine successful methods that have been used by lecturers in the discipline areas of Environmental Science, Environmental Engineering and Environmental Law to develop student critical thinking. Furthermore, the students themselves may have devised processes to enhance their critical analysis abilities. Sharing of these ideas would be a valuable learning tool in the teaching and learning process.

For students to be able to grasp the issues and frameworks necessary for effective critical thinking in and beyond their discipline, they need to be "enculturated" into the discourse of that community (Gee, 1990; Gee, Hull and Lankshear, 1996). They need to become familiar with the discourse of that discipline, something which may be at odds with their own home or community based discourse, to be able to discuss and write within the field and effectively critique ideas and concepts. This is an important issue for students from minority groups and other language and cultural backgrounds (Haggis, 2003; Jacobs, 2005), therefore "model" assignments could be the basis of resource materials, as recommended by Lukeman (1992). It was the aim of the first CTWN project at UWS (Farrell et al, 1997) to provide a resource for student and lecturer use, with model assignments for each of the faculties involved. However, this becomes more difficult for students who are studying an interdisciplinary or

transdisciplinary field such as environmental/sustainability education. As has been explained by Jones et al (1999), students need to understand the different discourse communities they are encountering, some of which are founded on a positivist, scientific view of knowledge, such as science, engineering and law, and others which are more constructivist and holistic in their approach, for example applied sciences, environmental management, environmental health, social ecology. The latter are more likely to include subjects such as communications, philosophy, management and other more humanities based subjects requiring a different discourse altogether.

For students to be able to engage in effective critical thinking they need to know what is expected in their discipline, which relevant frameworks and ideologies are valued in that discipline, and what processes they can undertake to further their knowledge about the topic of their assignment. This information is mostly discovered through wide reading or viewing of different perspectives on the topic. Students also benefit greatly from the collaborative process of discussing different viewpoints with peers, lecturers, tutors and other "experts", when exploring the development of their argument or position, and from this may move on to challenging paradigms and theories in their field (Carmichael et al, 1998; Hansmann et al, 2003). Moreover, the way in which students are assessed and the types of assignments they are given may also influence the development of critical thinking abilities (Biggs, 1999; Boud et al, 1985; McPeck, 1990). Hence, investigation of assignments and marking criteria was undertaken in the current research.

There have been projects in engineering subjects examining teaching practices and curriculum changes with a view to developing student critical thinking (Belski, 2001; Tomlinson, 1997) and discussion of the difficulty of student critical thinking in the interdisciplinary field of environmental higher education (Jones et al, 1999). However, there does not appear to be a comparative interdisciplinary study to examine the approaches to critical thinking in different subjects in the field of environmental studies in Australia. This has resulted in a study which attempted to answer the research questions:

How is critical thinking expressed in university environmental subjects?

How is student critical thinking encouraged in these subjects?

This chapter has reviewed relevant literature about issues concerning the teaching and learning of critical thinking. It has also briefly reviewed the field of environmental and sustainability studies and the need for critical thinking in this interdisciplinary area. The following chapter will explain the qualitative methodological approach taken in the research process. It will also explain the methods for data collection and analysis that were undertaken for the study.

CHAPTER 3: METHODOLOGY AND METHODS

3.0 Introduction

The previous chapter reviewed literature relating to critical thinking and environmental studies. In this chapter I will identify the methodological orientation of the research and describe the methods used to collect and analyse the data. Because the study is concerned with uncovering the ways in which critical thinking is expressed in environmental studies, and the strategies used for encouraging student critical thinking, it is based on the interpretation of human perceptions and written materials. This positions the methodology as qualitative in nature as opposed to quantitative (Higgs, 1997; Creswell, 1998; Denscombe, 1999). It is not based on the empirical, analytic or statistical assumptions of quantitative research but rather on interpretation of responses to interactions with those involved in the situation, as well as interpretation of relevant documents. The current research study fits with an explanation by Creswell (1994) that "one of the chief reasons for conducting a qualitative study is that the study is exploratory…and the researcher seeks to listen to informants and to build a picture based on their ideas" (p. 21).

In order to structure this chapter I have used the terminology and hierarchical framework proposed by Blaxter, Hughes and Tight (1996, p. 63). According to their framework this study belongs to the category of qualitative "research family". It takes the "research approach" of case study and uses the "research techniques" of open-ended questionnaires, semi-structured interviews and document analysis. Each of the terms listed is discussed in more detail below.

3.1 Qualitative research

This research was an investigative survey of the critical thinking practices of tertiary environmental studies. The qualitative paradigm (Creswell, 1998; Denscombe, 1999),

was chosen because it best suited the purpose of the research. This was to explore and interpret the expression of critical thinking and the ways in which it was taught to students in this field. Historically qualitative research evolved as an alternative to the quantitative scientific research paradigm, which relied on testing hypotheses and the statistical representation of factual knowledge. Instead qualitative research aims to answer questions, explore social understanding and presents in-depth information (Denscombe, 1999). The two paradigms differ according to the philosophy or ideology of the researcher and the purpose of the research (Creswell, 1994). McIntrye and Grudens-Schuck (in Foley, 2004) attribute different views to different "political and social values" (p. 169). In qualitative research there is an expectation that researchers will have different approaches and interpretations of their findings according to their view of the world. They are more consciously subjective and interpretive of their findings and also more likely to discuss their philosophical/ideological stance and how this may influence their interpretations.

Although quantitative and qualitative research methods are used for educational research, Freebody (2003) claims that scientific methodology that represents teaching ideas or practices in a numerical form does not provide other teachers with adequately detailed explanations. He and Higgs (1997) both claim that quantitative research in education has not necessarily been found to be helpful for practitioners. One aim of the current research was to uncover practices regarding the teaching and learning of critical thinking and it was anticipated that qualitative research would provide more practical information for tertiary environmental educators, because it would be more in-depth and detailed.

Qualitative research is characterised by smaller samples, in-depth surveys and interviews and a "process of 'discovery' rather than the testing of hypotheses" (Denscombe, 1999, p. 25). Creswell (1994) elaborates on the different methods associated with each of the paradigms and on the differences in format, or presentation of information, in the reported research and recommends using only one paradigm for any research study. However, other authors such as Blaxter et al (1996) and Stake (in Denzin and Lincoln, 2003) indicate that it is possible to use both paradigms provided there is meaning to the interrelationship between them. These authors refer to the use of

triangulation to gain information from a variety of perspectives. Often this involves several procedures or techniques such as observation, interviews and document research.

Triangulation of results is often characteristic of qualitative research methods, in order to gain information from a variety of perspectives. It is a form of validation of findings or a "process of using multiple perceptions to clarify meaning" (Stake, in Denzin and Lincoln, 2003, p. 148). This research used triangulation of the findings of three different research techniques (see below Section 3.3), themes from questionnaire responses and interviews and analysis of relevant documents. Questionnaires were considered to indicate a broad overview of the expression of critical thinking and informed subsequent data collection. Interviews provided a more in-depth verbal picture from lecturers' and students' perspectives and subject outlines and assignments a written verification of this. Although observation is a common technique for gathering data in qualitative research, it was not used in this study due to time limitations. My use of a questionnaire to make initial contact with lecturers involved some numerical analysis, however due to small numbers and the open-ended questions it does not lend itself to statistical analysis but rather to category and thematic analysis. The advantage of providing open ended questions is that "responses [are] more likely to reflect the full richness and complexity of the views held by the respondent[s]" (Denscombe, 1999, p. 101). Despite the limitations of the questionnaires it was found that the initial information collected in that phase of the research was useful.

The purpose of undertaking qualitative, interpretive research is to understand the meaning of the participants' perceptions of critical thinking, and to interpret how critical thinking is expressed and encouraged in environmental subjects. On the other hand, I accept that there may be other interpretations of the data collected in this study and this is to be expected in qualitative research. For example, Freebody (2003, p. 69) places importance on the methods of data collection and analysis being "meticulous" and being available to others for "scrutiny" and "disagreement." Further explanation of research techniques and samples of analysis are provided below.

3.2 Research approach - Case study

Blaxter et al (1996) identified four qualitative research approaches, one of which is a case study. They specify that the case study is suitable for "small-scale" research which focuses on one or several specific examples. Since this research is focused on three discipline areas within the environmental field of study, it is appropriate to consider it as three case studies of critical thinking in specific disciplines in university courses in Australia. Creswell (1998) referred to case studies as one of five traditions within qualitative research. He described the case study as involving "the widest array of data collection as the researcher attempts to build an in-depth picture of the case" (p. 123). Creswell (1998) also provided information about analysis of data including finding "patterns" and generalisations that "people can learn from the case either for themselves or for applying it to a population of cases" (p. 154). He emphasised the need for a detailed description of the case. This research project followed a number of the procedures recommended by Creswell (1998) for a case study, with the exception of observation (see Section 3.3).

A more detailed view of the case study is explained by Stake (in Denzin and Lincoln, 2003). He defines the case as a "specific, unique, bounded system" but also admits that the term case study can be used to describe both the research process and the written report or "product of the inquiry" (p. 136). He further categorises case studies according to the focus of the researcher as "intrinsic, instrumental or collective" (p. 136 - 138). This study would appear to be closest to a collective type of case study because it explores three discipline areas within environmental studies and does not focus on only one of these. It investigates three cases. Stake also makes the point that the author of a qualitative case study needs to provide enough detail to enable the reader to interpret the outcomes for themselves, which may be a different interpretation from that of the researcher. He sees the case study as an "opportunity to learn" (p. 154) rather than a representation of the broader population.

I acknowledge that there may be inherent bias in this study, because only those lecturers who already had a strong commitment to critical thinking may have been motivated to

respond to the questionnaire in the first instance. However, while the responses are not necessarily representative they are a source of valuable information. The thematic analysis of questionnaires, interviews and written subject documents provided insight into critical thinking in this field.

3.3 Research techniques: methods of data collection and analysis.

3.3.1 Open-ended questionnaires

An open-ended questionnaire (Denscombe, 1999) was devised, developed extensively from the interview questions from the previous pilot study (Carmichael, 2001) and included additional questions relating to environmental protection and sustainability (see Appendix A). Such questions assisted in drawing out responses that could be further explored in interviews with lecturers and students, and through document analysis. They guided the subsequent development of the interview questions and closer examination of the documents.

An additional outcome of the questionnaire was the location of volunteers for the second phase of the research, the semi-structured interviews. A tear-off slip at the conclusion of the introductory letter for the questionnaire was provided for this purpose. My use of the questionnaire to make initial contact with lecturers in Australian universities resulted in some numerical analysis of responses, though due to small numbers and the open-ended nature of the questions, the data collected was more suited to category and thematic analysis rather than statistical analysis. I found that the information collected in that phase of the research was informative and helped to create a picture of the expression and practice of the teaching and learning of critical thinking in this field.

The questionnaires were trialled with a small number of colleagues working in the field and questions were reworded to increase the clarity of expression before the research study began. The questionnaire was then distributed to 300 staff teaching environmental subjects in various universities across Australia with return addressed envelopes, or by

email. Lecturers who volunteered to be further involved in the research were informed by phone and email that this included an interview, necessitated contacting several students whose assignments demonstrated critical analysis, and requested that they provide a copy of the assignment/s when they attend an interview.

The thirty returned questionnaires were analysed according to three discipline areas: Environmental Science, Environmental Engineering and Environmental Law. Content patterns or themes in answer to each question were identified and responses were categorised according to the main theme in the answer. This was done manually and I checked the allocation of category a number of times to establish consistency. When answers did not match with any of the themes they were categorised as "other". Appendix B contains a summary of the answers to the various questions and the category assigned to each theme or pattern. Chapter 4 offers an explanation of the responses to the questionnaire, tables representing the categorisation of responses and an interpretation of the findings of the questionnaire. Where appropriate, differences between the disciplines were noted and possible broader emerging themes were summarised.

3.3.2 Semi-structured interviews

Semi-structured interviews with lecturers from three universities in NSW, two metropolitan and one regional university, were considered to be essential for this study. The interviews allowed for free flowing discussion and extra questions to be raised. For example, to fully explore the expression of critical thinking several questions from different perspectives were needed to encourage discussion, and this was also necessary to enable lecturers to enlarge on the detail of strategies used to develop students' critical thinking. As Freebody (2003, p. 133) explained, "semi-structured interviews begin with a predetermined set of questions but allow…what is relevant to the interviewee [to be] pursued." Freebody recommended that the whole interview should be transcribed to enable the researcher to decide which aspects to analyse.

Students from each of the universities, whose assignments were recommended by the interviewed lecturers as containing critical thinking, were also interviewed. Their interview questions were designed to complement the information gained in the lecturer interviews. The questions began by asking about the recommended assignments (see questions in Appendix C). In both the lecturer and student interviews a question asking for a definition/explanation of critical thinking was one of the later questions so that rapport was established and the interviewee had been given time to engage with the topic to provide richer answers.

Interviews were arranged with six lecturers by phone and they were asked to contact students for interview. The lecturers were from each of three universities that had been selected from a larger number of volunteers (see Section 5.0) due to proximity because of time and funding constraints. The six lecturers were evenly distributed among the three discipline areas of science, engineering and law. The interviews commenced with a discussion about the student assignments. Eight students contacted me and their interviews were arranged for a mutually convenient time. All interviews took place in the relevant university setting in a private, relaxed environment and questions were designed to draw out more detailed information from participants than had been possible in the questionnaires.

Most of the interviews with both lecturers and students were tape-recorded and transcribed in full. The recording of one interview with an Environmental Law subject lecturer was based on notes since it was unable to be tape-recorded. The lecturer and student interviews for Planning and Environment Law were part of the previous pilot study. Lecturer interviews often lasted for an hour or more while student interviews were more likely to last for less than an hour.

Analysis of the interviews involved many hours of listening to tapes, typing the transcripts, reading and re-reading the transcripts and revisiting the key concepts in the context of each subject. Transcripts of interviews were analysed for key ideas in answer to each question (see Appendix D for samples). These were further analysed for patterns or themes within each interview, then within and between subjects. Comparison of themes in the interviews for the three discipline areas was undertaken to establish

whether there were differences in perceptions of critical thinking, or teaching and learning strategies directly related to critical thinking. While the analysis of interview transcripts appeared relatively straightforward they proved complex because of the various perceptions. I found it was necessary to accept this complexity and to present the material in a narrative form to locate themes. This process revealed rich data for analysis. Interpretation of the questionnaires, interviews and documents was triangulated for the discussion chapter (Chapter 7). The triangulation of these different expressions of critical thinking provided insight into the understanding of critical thinking and the ways in which students develop their skills in each discipline area. As Coffey and Atkinson (1996, p. 14) point out "the more we examine our data from different viewpoints, the more we may reveal - or indeed construct - their complexity." However, I found that the face-to-face interaction with interviewees was the most informative aspect of the data collection process and created the most meaningful background for interpretation of the findings.

3.3.3 Documents

Since students value what is linked to assessment, and types of assessment can influence the development of critical thinking (McPeck, 1990; Tomlinson, 1997), it was considered important to examine subject outlines, any readings about critical thinking provided to students and the recommended assignments. The latter were further analysed through discourse analysis (Cotton and Hackett, 2003; Hyland, 2005; Moore, 2004; White, 2001) of sample texts from the students' assignments.

According to Coffey and Atkinson (1996, p. 10) in a qualitative context "what 'analysis' actually means is complex and is contested by qualitative researchers." This is well represented by my experience of analysis of a questionnaire, which resulted in tables of themes often expressed in percentages, interviews in terms of themes that were best represented in a narrative form, and documents which in this study took a different form for the different types of documents. As mentioned above the focus of the document analysis was subject outlines, additional readings, and student assignments (see Chapter 6). The subject outlines were analysed in terms of the use of terminology such as critical

thinking, critical evaluation or critical analysis. Sections of subject outlines such as objectives and references to critical thinking in terms of assignments were recorded and tabulated according to discipline. Whether or not extra readings or resource materials about critical thinking were offered was also recorded. This was a more numerical approach to analysis.

For the student assignments I decided to use discourse analysis for part of one assignment from each subject, the text of the Conclusion. Although there were more than six student assignments available, for the sake of balance the analysis of an assignment with a clear conclusion was chosen from each subject (see Section 6.2). Discourse can be presented in written or spoken language and according to Fairclough (1995) "discourse analysis is analysis of how texts work within sociocultural practice" (p. 7). Often sections of conversations or written texts are analysed because "discourse analysis may be concerned with any part of human experience touched on or constituted by discourse" (Gee, Michaels and O'Connor, in Le Compte et al, 1992, p. 228). These authors acknowledge that it is difficult to interpret a text however the following approach to discourse analysis was undertaken and repeated a number of times for consistency (see Appendix E for samples of analysis).

Since "evaluation" was commonly accepted as an important aspect of critical thinking by participants in this study and in the literature (Cotton and Hackett, 2003; Moore, 2004), a focus of the discourse analysis was the students' expression of evaluation of information in their assignments. The object of critique refers to what is being evaluated or critically analysed, and the content of the critique refers to what is being said about the object (Moore, 2004). In this study 'content' will be limited to whether the student's evaluative comment is positive or negative. The analysis of evaluative language, provided in the sample texts, is concerned with three main aspects: affect, judgement and appreciation. These aspects are based on Appraisal Theory and appraisal is related to attitude (Hood, in Ravelli and Ellis, 2004; Martin, 2000, cited in Hyland, 2005). Affect is concerned with the expression of the writer's emotional response, judgement with the evaluation of human behaviour and appreciation with the evaluation of other than human behaviour, including processes, plans and policies (Hood, in Ravelli and Ellis, 2004; White, 2001). Cotton and Hackett (2003) found this the most

useful approach to examining student writing in her research into student writing, although she applied a more in-depth and detailed analysis to assignments in the social sciences. On the other hand, Moore (2004) applied discourse analysis to three short texts and found differences in critical thinking according to discipline. This latter approach to discourse analysis appeared appropriate for this study, where a part of the assignment that was often identified as containing critical thinking was the Conclusion.

The next chapter is the first of three chapters reporting on the findings from the data collected, and offering some preliminary analysis and emergent themes. They cover the three phases of the research. The first phase of the research was related to analysis and interpretation of lecturers' responses to the open-ended questionnaire. The second phase of the research involved six interviews with lecturers and eight interviews with students in each of the target disciplines: Environmental Science, Environmental Engineering and Environmental Law. Finally, the third phase of the research was concerned with analysis of the documents supplied by lecturers and students in the various subjects. Triangulation of these three phases of the research is to be found in Chapter 7.

CHAPTER 4: FINDINGS FROM QUESTIONNAIRES

4.0 Introduction

This first phase of the findings concentrates on the open-ended questionnaires, of which three hundred were distributed either by email or post (see Appendix A for questions). This chapter is structured such that each of the key questions is analysed in the order in which it appeared on the questionnaire. The questions broadly sought to understand lecturer perceptions of critical thinking, how much evidence of student critical thinking they expected to find in assignments and how they encourage students to develop their critical thinking. Thirty completed questionnaires were returned. Analysis of responses to questionnaires is based on interpretation of patterns or themes. In some cases the responses were coded into more than one category/theme and this will be indicated when appropriate. Where percentages are mentioned, for ease of comparison, this will refer to a rounded percent. Summaries of the thirty responses to each survey question from Question 2 – 11 and codes according to themes are available in Appendix B.

The small number of responses, in this case ten percent of the total distributed, is not uncommon for questionnaires (Denscombe, 1999). Most of the responses came from lecturers who taught Environmental Science subjects (seventy percent including three interdisciplinary lecturers). Three of the lecturers who completed questionnaires taught subjects which were from two different discipline areas, one covering both environmental science and engineering subjects and two covering both environmental science and law subjects. These were grouped together as "Interdisciplinary". The smaller numbers of responses in discipline areas other than Environmental Science presented difficulties for comparison of the different discipline areas, however it was possible to identify some patterns across the three target disciplines within environmental education. In Chapter 5, the interviews should provide more in-depth information in relation to the similarities and differences between disciplines within environmental studies.

Since this is an interpretive, qualitative study (see Chapter 3), and the number of responses is small, there is no statistical analysis of the results. However, in order to make comparisons there are some numerical and percentage representations of answers with the coding of responses based on interpretation of categories. It is noteworthy that of those who responded, seventeen of the thirty lecturers were willing to be further involved in the project and to be interviewed. This level of commitment to the development of student critical thinking is also reflected in the number of subject outlines that were sent back with the questionnaires (N = 21), though in one case four subject outlines were submitted by the one lecturer (see Chapter 6).

Universities represented in questionnaire responses were: a regional university in Queensland, five metropolitan universities in Sydney (NSW), a regional university in NSW, a metropolitan university in Western Australia, a metropolitan university in Tasmania, and a metropolitan university in Melbourne (Victoria).

A variety of subjects/areas were represented in the area of Environmental Science, including: Environmental Geology, Environmental Chemistry, Environmental Health, Environmental Management, Biological Experimentation, Geography & Environmental Studies, Environmental Technology, Environmental Studies, Soil and Water Management, and Environmental Issues (a transdisciplinary subject).

Some subject areas for Environmental Engineering included: Engineering for Urban Environments, Site Remediation, Environmental and Sanitation Engineering, and Water Resource Management.

Subject areas for Environmental Law included: Environmental Law, Planning and Environment Law, and Environmental Law and Ethics.

Coding and Preliminary Data Analysis of Questionnaires

4.1 Discipline areas

In response to Question 1: "What discipline area of environmental studies do you teach?" the choices of responses were limited to Environmental Science, Environmental Engineering and Environmental Law. However, due to the use of email for the distribution of some questionnaires, one questionnaire was returned by a lecturer of Environmental Economics. Three lecturers' questionnaire responses covered two areas of study, and were considered "Interdisciplinary". Furthermore, one response for Environmental Studies/ Environmental Health, a subject within an Applied Science degree, was recorded as Environmental Science.

The broad discipline areas that were represented in the returned questionnaires were as follows:

Environmental Science - N = 18

Environmental Engineering - N = 6

Environmental Law - N = 2

Environmental Economics - N = 1

Interdisciplinary environmental studies - N = 3

Total questionnaires returned – N = 30

4.2 Lecturers' perceptions of the importance of critical thinking in environmental education

Responses to the second question about the importance of critical thinking in each subject were coded into one of 3 main categories:

A)   Most/extremely/essential

B)   Very/significant/central/course objective

C)   Quite/introduced in first year/other

Eighty three percent of questionnaire responses indicated that critical thinking was extremely important/essential or a very important aspect of each environmental subject.

This was established when categories A and B were combined (see Table 4.1). Some lecturers referred to the need for student critical thinking because environmental issues and the concept of sustainability are evolving and constantly changing. Others stated that it is important for tertiary learning, problem solving, scientific enquiry, professionalism or in order to gain higher grades.

Table 4.1   Perceived importance of critical thinking in an environmental subject (Question 2)

Subject area	A	B	C	Total
Env. Science	6 (33%)	9 (50%)	3 (17%)	18
Env. Engineering		4 (67%)	2 (33%)	6
Env. Law	1	1		2
Env. Economics	1			1
Interdisciplinary	2	1		3
Totals	9 (30%)	16 (53%)	5 (17%)	30 (100%)

An indication of the interpretation of themes and the coding of answers will be given by providing sample statements from questionnaires. For example, one lecturer in the discipline of Environmental Science wrote: *"extremely [important] - because knowledge in the area [is] in a 'state of flux' - variety of conflicting explanations for some phenomenon; students need to develop skills to decide about these explanations, both as students and future environmental scientists."* This response was coded category A. Another lecturer wrote *"because sustainability encompasses not only the science of natural environment, but philosophy, values of society…argument for/against sustainability requires critically analysing all views."* This response was coded category B. These explanations suggest a close link between the importance of critical thinking and environmental studies. This concept is explored further in later questions, and in the interviews.

An example of a response from an Environmental Science lecturer that was coded category C included: *"While first year of necessity involves some rote learning to bring students to a common level for dialogue, [there is]still a requirement to introduce critical thinking/analysis"*. Another response that was coded C stated: *"Moderately important. It is possible to be awarded a Pass or Credit grade based on recall of information and general technical competence, but highest marks are reserved for those*

whose work (especially lab and assignments) gives evidence of critical thinking." This response raises the question of whether critical thinking is only achievable for Distinction (D) and High Distinction (HD) students, something that will be discussed later (see Section 7.3.3). The first response appears to acknowledge the importance of the development of student critical thinking, but does not place high expectations on student critical thinking in the first year of undergraduate study.

One Environmental Engineering response that was coded category C was as follows: "*Quite. I want students to think about the implications of their water and wastewater solutions in terms of sustainability etc. Not much luck!"* The other response stated that: *"Whilst the subject is instructional, I would like students to think critically about urban infrastructure."* Both of these responses are very subject specific, and appear to consider that student critical thinking is a bonus rather than an integral part of the subject.

For some comparison of themes between disciplines, the following could be noted. From the discipline area of Environmental Science eighty three percent of lecturers indicated that critical thinking is "essential or very important" while in the discipline area of Environmental Engineering none of the lecturers considered critical thinking to be "essential". However, sixty seven percent of lecturer responses indicated that critical thinking was "very important". An Environmental Law lecturer stated that: "*It is essential that students look behind the law…for instance are the objectives of a particular statute expressed or implicit? How are they achieved? Is achievement likely? Why/why not? Can any improvement be suggested?"* This is a very discipline specific approach to critical thinking and was coded category A. Thirty three percent of Environmental Engineering lecturers considered critical thinking only "moderately" or "quite" important, whereas seventeen percent of Environmental Science indicated this. However, one lecturer of Environmental Engineering did state that critical thinking is *"a basic aim of tertiary education."* Proportionally more reasons for the importance of critical thinking in the discipline of Environmental Engineering related to environmental issues than in either of the other discipline areas.

Most of the participants regarded the importance of critical thinking to be related to environmental problems, tertiary education and/or lifelong learning, part of scientific

enquiry or professional practice. One response referred to *"critical thinking [as] a part of interdisciplinary study"*.

4.3 Lecturer expectations of critical thinking in student assignments

Lecturers were asked in the third question: "Do you expect to see evidence of critical analysis in student assignments? How does this vary according to year of study?" Apart from one Environmental Science lecturer who did not respond to this question, the responses indicated that sixty three percent of this sample, across all disciplines, expect students to demonstrate critical analysis in assignments, at least by later years of study (see Table 4.2). This is based on the combination of those who expect evidence of critical analysis in all assignments (category A), or increasingly from first year (category B) and mainly or only in later years (category C). Only half of the respondents expected this process to be evident from first year (categories A + B).

Responses were coded into 6 categories:

A) Yes, all assignments
B) Yes, increasingly from first year
C) Yes, mainly/only in later years
D) Varies according to student capability
E) Other
F) No response

Table 4.2   Lecturers' expectations of critical analysis in assignments, according to year of study (Question 3)

Subject area	A	B	C	D	E	F	Total
Environmental Science	3	6	2	5	1	1	18
Environmental Engineering		2	1		3		6
Environmental Law	1				1		2
Environmental Economics	1						1
Inter-disciplinary		2	1				3
Totals	5 (17%)	10 (33%)	4 (13%)	5 (17%)	5 (17%)	1 (3%)	30

An example of a response that was coded category A is as follows: *"Only teach 1st year.* *[I] expect to see evidence of critical thinking in all assignments."* This response was from an Environmental Science lecturer. An example of a response that was coded B stated: *"Yes, more sophisticated with each successive year (4 year course)"* (Environmental Engineering). An Environmental Science response that was coded C stated: *"Yes, but understand it will not always be there. Expect more in higher levels of study."*

One of the sub categories of code E related to the demands of the subject or assignment. One of the lecturers whose response was coded into this sub category stated: *"Expect to see evidence in all years, but this depends on the subject. 1st year forensic science (with case studies) requires more critical analysis than 2nd year physical chemistry, which emphasises familiarity with technical concepts and various types of technical competencies"* (Environmental Science). The other response from an Environmental Law lecturer stated: *"This relies on the subject. In Environmental Law for LLB students, critical analysis is expected in research essays but not in take home assignments with hypothetical fact scenarios."*

Another sub theme for responses of category E was not as clear as those above, though there is indication that the lecturer hopes that student assignments will demonstrate critical analysis. The three responses for this category were from Environmental Engineering lecturers and the first claimed that: *"I would like to see some aspect of critical assessment. Not much luck".* The other two do not indicate their level of expectation, rather that there is simply some expectation: *"I try to encourage critical analysis"* and the other *"making inferences based on statistical analysis and critique of published literature".*

4.4 Lecturer estimates of percentages of student assignments demonstrating critical analysis

In the questionnaire, the lecturers were asked to estimate the percentage of student assignments they marked containing critical analysis, according to the year of study from first to fourth year. Four lecturers did not respond to this question. In examining

the remaining answers the pattern that emerged was that some perceived that students demonstrated critical analysis in assignments more than eighty percent of the time. Others estimated between thirty five and eighty percent of the time and others less than thirty five percent of the time (see Table 4.3, below). Most of the responses related only to the year/s being taught by a particular lecturer at the time of filling in the questionnaire, which means that many were only partial answers. Therefore, the total number of responses varied with regard to each year.

From Table 4.3 (below) it can be seen that half of the lecturers who taught first year estimated that less than thirty five percent of their student assignments demonstrated critical analysis. Responses indicate that this is still the case for second year student assignments. However, by third year only twenty six percent of lecturers estimated such a limited percentage of assignments containing critical analysis, and by fourth year only seven percent estimated this to be the case. In addition, by third year forty two percent of lecturers estimated that between thirty five and eighty percent of their student assignments demonstrated critical analysis and another third of the lecturers estimated that over eighty percent of assignments contained critical analysis. By the fourth year of study seventy one percent of lecturers estimated that critical analysis was evident in over eighty percent of their student assignments.

Overall the pattern of responses suggested that most lecturers perceived that students are more consistently demonstrating critical thinking in assignments by their third or fourth year of study at university, albeit at different rates. In first and second year it is less likely that lecturers perceive a high percentage of student assignments containing critical thinking.

Table 4.3 Lecturers' estimation of percentage of assignments demonstrating critical thinking according to year of study (Question 4)

Estimation	1st year	2nd year	3rd year	4th year
More than 80% of assignments	4	3	6 (32%)	10 (71%)
35 - 80% of assignments	4	4	8 (42%)	3 (21%)
Under 35% of assignments	8 (50%)	7 (50%)	5	1
Total	16	14	19	14

An analysis across rows in the summary of responses to Question 4 (see Appendix B) was also undertaken, to establish whether there may be different trends between the discipline areas. Although the numbers of responses were small for the disciplines other than Environmental Science it was considered to be important to look for patterns which may differentiate the disciplines within the broader field of environmental studies. This revealed that twenty two percent of Environmental Science lecturers perceived that a limited number of their students' assignments showed evidence of critical thinking, across all years (see Table 4.4 below). On the other hand, fifty percent of Environmental Engineering lecturers estimated a limited or very limited amount of critical analysis in their student assignments, one stating that there were only 10% and another only 3%, and these were only in later years of study.

For Table 4.4, responses were coded into the following five categories, according to lecturer estimations:

A) Across all years 80 - 100% of student assignments contain critical analysis
B) Evidence of critical analysis in student assignments increases from first year
C) Critical analysis in student assignments is developing, but mostly in later years
D) Evidence of critical analysis is limited, or very limited (demonstrated by 35% or less of student assignments across all years)
E) No response

Table 4.4 Estimation of percentage of assignments containing critical thinking (according to discipline area)

Subject area	A	B	C	D	E	Total
Env. Science	3 (17%)	5 (28%)	4 (22%)	4 (22%)	2	18
Env. Engineering		3		3 (50%)		6
Env. Law		1			1	2
Env. Economics			1			1
Inter-disciplinary	1		1		1	3
Totals	4 (13%)	9 (30%)	6 (20%)	7 (23%)	4 (13%)	30

When codes A and B are combined, forty five percent of the responses from lecturers in the Environmental Science discipline indicated that students demonstrate critical analysis in assignments from first year onwards. If codes A, B and C are combined for Environmental Science responses, sixty seven percent of lecturers indicate that students demonstrate critical analysis in assignments by later years of study. With regard to category A one lecturer, who teaches both Environmental Science and Law subjects, actually defined the different expectations of critical thinking as follows: *"In first year 2 - 3 fairly contrasting views may be OK. In third - fourth year I expect a fairly involved 'literature review' approach."* This lecturer estimated finding evidence of critical thinking in all of student assignments from 1st - 4th year level.

When interpreting responses from the different discipline areas (Table 4.4) it was found that Environmental Engineering lecturers estimated lower percentages of student assignments demonstrating critical analysis. Of the five engineering lecturers who responded to this question none estimated that more than eighty percent of their student assignments demonstrated critical analysis, even in their final year, fourth year. These lecturers did not have high expectations either (previous question above), which raises the question of the influence of lecturer expectations on perceived evidence of critical analysis. This may also be affected by their definition of critical thinking or the nature of the subject. On the other hand, three Environmental Science lecturers, and one who taught both science and law, estimated ninety to one hundred percent of first year assignments demonstrated critical analysis.

Interpretation of the degree of consistency between the expectations of each lecturer and the estimated percentage of assignments demonstrating critical analysis, was undertaken by comparing responses to Questions 3 and 4. The responses were coded into the following categories (see Table 4.5):

A) Consistent
B) Reasonably consistent
C) Inconsistent
D) Other

Consistency was interpreted in terms of how closely the lecturer's expectations matched the estimation of perceived critical analysis in student assignments. This necessitated a comparison of responses to questions 3 and 4 (see Appendix B). If categories A and B are combined, it could be said that seventy percent of the lecturers' responses were either consistent or reasonably consistent.

Table 4.5 Consistency of responses across expectations and perceived percentage of critical analysis in student assignments (comparison of Questions 3 and 4)

Subject area	A	B	C	D	Total
Env. Science	9	5	2	2	18
Env. Engineering	4		1	1	6
Env. Law		1		1	2
Env. Economics		1			1
Interdisciplinary					
Totals	14 (47%)	7 (23%)	4 (13%)	5 (17%)	30

Those that appeared to be inconsistent (category C) included one response from an Environmental Science lecturer which stated: *"...by year 3 [I] expect critical thinking in assignments graded HD. Still possible to get a pass without".* This same respondent then estimated that there were fifty percent of assignments in year 3 demonstrating critical analysis - this could imply that half the class was awarded HD for their assignment or that these grades have other differentiating criteria. Another Environmental Science lecturer's expectations were that *"generally only in high quality students"* yet his/her estimation of student critical analysis in assignments was: *"N/A (only teach 1st year)".* The implication could be that there were no high quality students in first year, or the lecturer may have decided not to answer the question. One Environmental Engineering lecturer stated that *"We expect high levels of critical thinking in early subjects as opposed to the norm. This expectation is set early..."* Yet there was an indication of limited evidence of critical analysis in student assignments from first to fourth year.

The responses for category D ("other") were mostly those that had indicated an expectation but not given an estimation of the percentage of student assignments which

contained critical analysis. For example, the Interdisciplinary lecturer who taught both Science and Engineering responded: *"Yes. The depth of critical analysis is relatively low for a first year unit compared with a final year unit. The depth varies in terms of literature accessed and the analysis and interpretation of data",* but no estimations were given. In contrast, the Engineering response for theme D indicated that expectations included *"making inferences based on statistical analysis and critique of published literature detailing limitations and possible extensions"* with no reference to the year of study. However, the estimated percentage of critical analysis in student assignments rose from under twenty percent in first year to sixty or seventy percent in fourth year.

4.5 Lecturers' working definitions of critical thinking

It may be that the different range of expectations and perceived percentage of student assignments containing critical analysis had some relationship to the lecturer's definition or understanding of the term. The questionnaire did include a question asking for each lecturer's definition of critical thinking. However, as was stated in the Literature Review (Chapter 2) there are many different definitions of critical thinking offered by theorists. It is stated in Chapter 2 that: *some grouping of definitions could be made, reflecting the following themes:*

- *Ability to identify and question assumptions/premises behind arguments and information*
- *Ability to evaluate information, according to sound criteria*
- *Ability to reach one's own conclusions*
- *Ability to reflect on one's own thinking/practice (p. 9 - 10)*

The responses to this question by lecturers were coded into the following categories, which are based on the themes of the definitions found in the literature. Some definitions given in questionnaires fitted with more than one category, and were <u>coded according to both categories</u>.

A) Question/challenge assumptions/paradigms/information
B) Systematic assessment/analysis/evaluation of information (from different sources)
C) Come to conclusions, make recommendations

D) Thinking independently

E) Other

Table 4.6 Lecturer definitions of critical thinking (Question 5)

Subject area	A	B	C	D	E	Total
Env. Science	4	9 (50%)	3	1	3	20 (N=18)
Env. Engineering	1	4 (67%)	2	1		8 (N=6)
Env. Law	2		1			3 (N=2)
Env. Economics		1				1 (N=1)
Interdisciplinary	1	1	1		1	4 (N=3)
Totals	8 (27%)	15 (42%)	7 (20%)	2 (7%)	4 (13%)	36 (N=30)

Although the themes of definitions quoted in the Literature Review were similar to
those of the lecturers who responded to the survey questionnaires, one element was
noticeably missing, that of reflective thinking about one's own thinking, learning and/or
practice. This is explored further in the interviews (Chapter 5).

An example of a response to this question that could be considered to have themes from
more than one category is: "*Analysis of events/features/statements/data in the light of
existing theories/philosophies/values in the literature, then identifying your own stand
or interpretation."*
This was coded in two categories (B + C).

Examples of the category "other" (E) included:
"*Ability to identify faults and flaws in a piece of work and suggest a way to remedy this,
eg. where class members present experimental designs for proposed project and these
are critiqued".* Another stated:
"*Capacity to integrate knowledge and ideas from different sources, which need not all
be from the same area of knowledge, eg. students' analysis of water sample can be in
terms of inorganic ions but then interpreted in terms of water flows, chemical and
biological processes, landuse, legislation…".* All of these responses were from

Environmental Science lecturers. An Interdisciplinary lecturer whose response was coded "other" wrote: *"Ability to see clearly, big picture as well as details, balance arguments etc."* (Environmental Science and Engineering)

The table above does not do justice to some of the interesting definitions given. The following are some examples of complete answers, with the code indicated:

"Questioning information. Looking for sources. Thinking comparatively. Seeking context of ideas. Awareness and engagement."
(This example was a response from Environmental Science that was coded into category A.)

"Making judgement about some event or thing based on criteria, plus being open minded about the criteria used to make judgement, eg spraying of crop in upper catchment; frog numbers in lower catchment declining; conclusion - may be connection - more evidence needed..."
(This example was a response from Environmental Science that was coded into category B.)

"Ability to examine an issue from several view points and logically arrive at a conclusion."
(This example was a response from Environmental Engineering that was coded into category C.)

"Thinking independently (on your own) based upon the facts (data) available - to draw meaningful conclusions, clearly realising the limitations of the conclusions."
(This was a response from an Environmental Engineering lecturer that was coded into category D.)

There were some noticeable differences between the discipline areas. For example, fifty percent of the Environmental Science definitions compared to sixty seven percent of Environmental Engineering responses matched the theme of analysis and evaluation. This was not the case for any of the Environmental Law responses. The second most

frequent theme in Environmental Science was questioning and challenging assumptions and information, whereas for Environmental Engineering it was coming to conclusions. The Environmental Law responses were more often related to questioning and challenging assumptions and information. Some definitions supplied by those teaching Environmental Science were more technical and scientific, while others in Applied Sciences were more holistic and learning focused.

Across the disciplines the definitions given mostly referred to the theme of "systematic assessment/analysis/evaluation of information (from different sources)." Eight responses referred to the theme of "questioning or challenging assumptions and information" and six referred to the theme of "coming to conclusions and making recommendations". Two lecturers mentioned "thinking independently" which is not the same as, though may be related to, reflective thinking. Several responses mentioned "problem solving" and a small number of definitions were discipline specific or subject specific, such as: *Analysing urban facilities both existing and proposed such as the M5"* (Environmental Engineering).

The four lecturers who had estimated that ninety to one hundred percent of their student assignments demonstrated critical thinking gave definitions which often placed emphasis on scientific or technical approaches to critical thinking:

"Ability to assess validity of information, discuss implications of actions on environment" (1st year subject, Environmental Science).

"An ability to identify, study, evaluate, analyse, draw conclusions, and make recommendations within an objective framework" (1st - 3rd year, Environmental Science).

"Thinking systematically, logically, strategically with 'gap analysis' in mindset" (1st - 3rd year, Environmental Science).

"Seeing a situation from alternative points of view, in particular [how] it relates to problem solving and challenging assumptions" (1st - 4th year, interdisciplinary Environmental Science and Environmental Law).

4.6 Strategies for encouraging student critical thinking.

The responses to the question about how lecturers encourage critical thinking in student assignments and in the classroom situation were coded into the following categories. Some responses were coded according to <u>more than one category,</u> since several strategies were employed:

A) Entire unit/subject focus is critical thinking

B) Explain/discuss/debate critical thinking in class

C) Critical thinking is encouraged by the types of tasks - "guided"

D) Critical thinking is encouraged by the types of tasks - "challenging"

E) Marking criteria/written instructions and feedback

F) Other

Table 4.7 Strategies for encouraging student critical thinking (Question 6)

Subject area	A	B	C	D	E	F	Total
Env. Science	1	9 (50%)	5 (28%)	2	4	2	23 (N=18)
Env. Engineering		4 (67%)		1	3	1	9 (N=6)
Env. Law		1		1		1	3 (N=2)
Env. Economics						1	1 (N=1)
Inter-disciplinary	1	1		1			3 (N=3)
Totals	2	15 (50%)	5 (17%)	5 (17%)	7 (23%)	5	39 (N=30)

Fifty percent of the lecturers explained critical thinking in class, or encouraged the students to discuss or debate to develop their critical thinking. Twenty three percent of lecturers included critical thinking in their marking criteria or written instructions for assessment tasks, which alerted students to its importance. Thirty four percent of respondents encourage student critical thinking through the type of assessment tasks they ask students to complete, half of this group indicating "guided" tasks and the other half indicating more "challenging" tasks.

Examples of tasks that were interpreted as "guided" included: "*Not a lot - try to set essay topics, tutorial topics that are more than just a description of a subject*". This response was from an Environmental Science lecturer. Another Environmental Science lecturer explained guided tasks as: *"a) Teach basic natural scientific method, b) Expand this teaching through application to problems in problem based learning framework, c) Presenting solutions with peer reviewed evaluation, d) Put these ideas and skills into practice through industrial placements."*

Some lecturers presented more challenging tasks and these included: *"Hand out critical readings which go beyond traditional engineering aspects."* An Environmental Science lecturer wrote: *"asking students to relate what they are learning in environmental chemistry to what they hear in the media and to identify popular misconceptions; ask students to interpret chemical data in a wider context: photochemical pollution, landuse patterns etc."* According to one of the Environmental Law lecturers *"we provide students with readings (articles) which they are required to analyse and discuss"*.

Those responses that were coded as "other" did not fit the above categories and were perhaps more discipline specific. Two lecturers' responses indicated that critical thinking was integral to the subject they taught, for example one stated: *"my entire unit focuses on critical thinking in science preparation."* A lecturer of an undergraduate Environmental Law subject stated: *"I expect critical analysis of topics chosen, based on a core argument, with recognition of counterargument."* One of the "other" responses suggested that, for postgraduates it was the *"one on one supervision approach"* that develops critical thinking.

In exploring differences in patterns of responses between discipline areas, it can be seen that discussion and debate in class was the most frequently used strategy for encouraging critical thinking in Environmental Engineering and in Environmental Science. The next most frequently used strategy for Environmental Science lecturers was the use of guided or challenging assignment tasks, whereas for Environmental Engineering lecturers it was the provision of marking criteria or written instructions. The Environmental Law and interdisciplinary lecturers offered various strategies.

Successful strategies and techniques for encouraging student critical thinking will be more closely examined in the chapter based on interviews.

4.7 Importance of environmental protection and broader social issues

A question concerning protection of the environment and other broader social issues was asked. This was in order to determine the importance of the concept of the interaction between impacts on the physical environment by humans, and the resultant impacts of these on the broader society, in environmental subjects.

The responses to Question 7 were coded according to the following categories, with each response associated with one category only:

A) Both environmental and broader social concepts were important
B) Only ESD/sustainability was important, broader social issues were covered elsewhere
C) Only social issues were an important/key concept
D) ESD/sustainability partially dealt with
E) Other

Table 4.8 Environmental and social issues as key concepts of subjects (Question 7)

Subject area	A	B	C	D	E	Total
Env. Science	7 (39%)	7	1	2	1	18
Env. Engineering	3 (50%)			1	2	6
Env. Law	2					2
Env. Economics		1				1
Interdisciplinary	2				1	3
Totals	14 (47%)	8 (27%)	1	3	4	30

Seventy four percent of responses to this question emphasised that environmental protection, often referred to as ESD, was important (categories A + B). Only forty seven percent of lecturers also acknowledged broader social issues as key concepts in their subject, while some suggested that other subjects dealt with this. One lecturer did not respond to this question and two critiqued the question itself, one stating: *"I do not understand this question".* The other lecturer replied, *"protection is not always a social*

issue" and "other broader social issues is double barrelled". However, this respondent did continue to say *"broader social issues - key concept in addition to generic thinking and communicating skills"* and the response was coded C.

An example of category D was *"Not key concept per se. The 'key concept' is to impart understanding of the diversity of life, of how ecological systems function etc. and we have open discussions on topics such as genetic engineering and social acceptance."* This response was drawing a distinction between protection of the environment and knowledge about biodiversity. A very different response, reflecting the category "other", included: *"Process knowledge is integrated in all subjects (in the program). In Environmental Health about 20% of units have a >90% focus; in Environmental Management 30% of units have >90% focus on this area."* This was an Environmental Science response that referred to the process approach to sustainability, including critical thinking (see interviews in Chapter 5).

Three Environmental Engineering questionnaires had responses that rated these concepts as important. One of these responses also pointed out that civil engineers reject Ecologically Sustainable Development (ESD) because they see it as the responsibility of environmental engineers. Another response indicated that ESD was only partially dealt with, stating *"less than 10 - 15%"* (category E). One of the Environmental Law lecturers stated that *"protection of the biophysical environment is a key concept. But at the outset, the broad nature of 'environment' is considered, including the social environment"* (category A). For the lecturer in Environmental Economics, ESD was considered a key issue and the response stated that: *"Protection is important but more important are issues of environmental improvement and achievement of ESD"* (category B). The concept of "broader social issues" was not mentioned by this lecturer.

4.8 Assessment of critical analysis in assignments

The two parts of Question 8 were analysed separately, because it was found that some respondents only addressed one part of the question. Often the first part of the question was avoided or omitted. The remaining responses for part (a) which related to how

lecturers assess critical thinking in assignments were coded into the following 5 categories:

A) Quality/breadth of argument/analysis/evaluation
B) Originality/expression of own ideas
C) Synthesis of a range of viewpoints
D) Other
E) No answer

Table 4.9 Assessment of critical thinking in assignments (Question 8a)

Subject area	A	B	C	D	E	Total
Env. Science	6 (33%)	1	3	2	6	18
Env. Engineering		1		1	4 (67%)	6
Env. Law				1	1	2
Env. Economics				1		1
Interdisciplinary	2				1	3
Totals	8 (27%)	2	3	5 (17%)	12 (40%)	30

A noticeable pattern across disciplines in the responses to part (a) of Question 8 was the high percentage of responses which did not address this part of the question. This could have been because the second part of the question was easier to answer, or because it is difficult to verbalise exactly how one assesses critical thinking in student assignments. Otherwise the most common theme, for twenty seven percent of responses, was assessment of the quality of argument, analysis or evaluation.

In Environmental Science assessment of critical thinking in student assignments appeared to be predominantly in terms of quality and depth of argument, and by the presence of originality or independent ideas and synthesis of various viewpoints. One example of an answer that was coded A is: *"I look for a good argument, complexity and depth of understanding"* (Environmental Science and Law).

The two responses for the category "other" in Environmental Science were very different. One stated:

"Not quite clear what is meant." The other admitted: *"Currently I have no formal criteria."* Both of these responses appeared to disregard the issue of assessment of critical thinking.

Only two Environmental Engineering lecturers responded to this part of the question: *"No specific mechanism - inherent in the nature of assignments"* and the other *"I want them to express their ideas".* These were coded (D) and (B) respectively. The remainder (67%, N=6) did not answer this part of the question. One Environmental Law lecturer mostly assessed evidence of critical thinking according to the students' ideas, and a lecturer who taught law and science indicated assessment of the quality of a student's argument. The Environmental Economics lecturer's response was as follows: *"Understanding the paradigms and policy analysis rather than a broad survey of unconnected research"* (coded "other").

Responses to part (b) of Question 8 concerning the amount of reading students are expected to do for assignment preparation were coded into the following themes. Each response was only relevant to one category:

A) Yes

B) Depth of understanding more important than number of sources

C) Yes, though not always the case/guided

D) Set number of references

E) No

F) No answer/other

Table 4.10 Lecturer expectations regarding student reading for assignments (Question 8b)

Subject area	A	B	C	D	E	F	Total
Env. Science	4	5	1	3	2	3	18
Env. Engineering	1	1	1			3	6
Env. Law	1					1	2
Env. Economics		1					1
Interdisciplinary	2					1	3
Totals	8 (27%)	7 (23%)	2 (7%)	3 (10%)	2	8 (27%)	30

A wide range, and in some cases a set range, of references was considered to be important in most subject areas except for Environmental Economics. On the other hand, it was also considered to be important that students do not summarise superficially from many sources but rather demonstrate a more in-depth understanding of key points from their reading. A total of twenty seven percent of lecturers did expect a wide range of readings, yet another twenty three percent indicated that it wasn't necessarily the number of readings, but the depth of understanding and inferences that counted most. For example, one lecturer stated: *"Number of references not as big a factor as the inferences made and their justifications"* (Environmental Science) and another wrote: *"critical thinking does not always demand 'sources'."* Seventeen percent of lecturers would have liked a wide range but found they had to guide students in this or set the number of references (categories C and D together). Only two lecturers answered "no" to this question (category E).

Category F included five lecturers who did not respond to the question, and three whose responses were coded as "other". The "other" responses were:
"Not quite clear what is meant." (Environmental Science)
"Referencing is very important." (Environmental Science)
"Range of resources relies on topic. Students can choose their topic subject to my approval. Empirical research, including interviews with government officials etc is highly recommended." (Environmental Law)

4.9 Theoretical frameworks and assumptions of subjects

Question 9 was asked in order to establish whether lecturers were consciously aware of the possible theoretical frameworks and assumptions that they may expect their students to decipher in the course of studying the subject. The following question (Question 10) takes this a step further in recognising that not only do students need to be cognisant of the frameworks and assumptions but also be encouraged to critique them. This awareness was found to be helpful in developing critical thinking for students in several other discipline areas in the previous research project mentioned in the Literature Review (see Section 2.1.4).

Responses for Question 9 were coded into the following categories:

A) Sustainability

B) Technically based/science/theory of evolution

C) Learning, including thinking/critical thinking, professional practice

D) Other

E) No

F) No answer

Table 4.11   Perceived frameworks and assumptions of subjects (Question 9)

Subject area	A	B	C	D	E	F	Total
Env. Science	3	5	4	4	1	1	18
Env. Engineering	1			3	1	1	6
Env. Law				2			2
Env. Economics				1			1
Inter-disciplinary	1			1		1	3
Totals	4 (13%)	5(19%)	4 (13%)	11 (37%)	2	3	30

The category coded "other" (D) had the greatest number of responses. However, three major themes emerged from the remaining positive responses (categories A + B + C). These included: aspects of sustainability; science or scientific process/technical basis and the theory of evolution; and learning theory including critical thinking in preparation for professional practice. The most dominant of these related to a scientific framework, and were predictably from Environmental Science lecturers. Two lecturers replied "no", indicating that they did not perceive that there were assumptions or frameworks underlying their subject. Several lecturers appeared to have interpreted framework as the "topics" or "objectives" in the subject outline. Two referred to an "interdisciplinary approach". Since this question created some difficulty for respondents, and was not easy to code it was more closely explored in the interviews.

Examples of responses that were coded according to category (A) include: *"The idea of sustainability - students come to their own perspective after being presented with the information and encouraged to develop the necessary analytical tools"* (Environmental

Science). Another lecturer wrote: *"All of my units have a set of objectives defined for them. I suppose an underlying assumption is that environmental protection and sustainable management is a good thing to strive for. My unit objectives include - 'develop critical thinking skills'..."* (Environmental Science and Law).

Examples from category (B) stated: *"Only in some do I expound them - mostly technically based"*, *"Theory of evolution is accepted as a solid working rule"* and *"The subject is based on the assumptions and methodologies of science…"* All of these examples are taken from Environmental Science.

Examples of category (C) responses include: *Academic group have developed a set of core competencies, including communication and presentation skills, critical thinking, learning group processes and project management which underpins course. Has resulted in 'core competencies manual'."* (Environmental Applied Science).

Several responses indicated some difficulty understanding the question. For example one lecturer only answered: *"not sure what is meant".* Another lecturer began their answer with *"Not sure what you mean"* but then continued to clearly explain that there was an assumption that *"humans have an obligation to minimise environmental impacts and that humans are irreversibly damaging the environment. This environment is critical to our long term survival."* This response was coded as (A). A third began their answer with *"Not sure what you are asking here"* and then proceeded to explain a framework of *"science proceeds by disproof, not proof, so we can never, ever be sure whether our paradigm of the world is correct."* This response was coded as (B).

Since most of the remaining responses were so diverse that they were coded "other" (D), it is worthwhile examining them more closely.

"Other" for Environmental Science lecturers included statements such as:
"Environmental problem solving requires an interdisciplinary/transdisciplinary approach."
"Not sure what is meant."
"From Macro – Micro analysis contexts."

"Yes, as in all paradigms there are many assumptions. Society is built on metanarratives and absolutes, why should uni be any different?"

"Other" for Environmental Engineering lecturers included:

"Meaningful inferences"

"Set topics are covered"

"Varies according to unit objectives."

"Other" for Environmental Law lecturers included:

"Yes, a contextual interdisciplinary approach", and *"Yes, subject outline addresses objectives of subject and weekly topics."*

The Environmental Economics lecturer's response (coded as "other") was as follows:

"Environmental problems are the result of management failure and resource misallocation."

The Interdisciplinary lecturer's response that was coded "other" stated: *"students must work with 'real world' situations for their project".* This lecturer taught both Science and Engineering.

Sub themes of interdisciplinarity and a connection with the world at large are indicated in this category.

4.10 Encouragement of student critique of frameworks and assumptions

Lecturer responses to Question 10, concerned with encouragement of student critique of frameworks and assumptions in subjects, were coded in the following manner (see Table 4.12):

A) Students apply their own perspective/own evaluation or through a questioning process (student initiated)

B) Through discussion/debate in class and textbook exercises or matrix analysis (teacher initiated)

C) Confidential student evaluations of the subject in standard survey form

D) Do not/no answer

E) Other

Table 4.12 Strategies for encouragement of critique of frameworks and assumptions (Question 10)

Subject area	A	B	C	D	E	Total
Env. Science	5	8	1	3	1	18
Env. Engineering		1		2	3	6
Env. Law		1	1			2
Env. Economics					1	1
Interdisciplinary		1		2		3
Totals	5 (17%)	11 (37%)	2 (7%)	7 (23%)	5	30

Five Environmental Science lecturers appeared to welcome the students critiquing the frameworks and assumptions of their subject (category A), though they expected the students to initiate this. This approach was not expressed in responses from lecturers of the other discipline areas. Another thirty seven percent of lecturers, across disciplines, provided opportunities in class either through discussion and debate, such as *"often I will deliberately put an opposing view"*, or through providing textbook exercises that encouraged critical thinking, or matrix analysis. Two lecturers considered that the standard student evaluation of the subject provided sufficient opportunity for feedback on the framework.

Seven other lecturers either did not answer, or believed that the assumptions were not challenged or did not encourage critique.

Five responses were coded "other" (E).

An example of one category A response is as follows: *"There is no single definition of sustainability, and… students should develop and apply their own perspectives in light of the available research"* (Environmental Science). An example of a category B response includes: *"Through discussion and hypothetical role plays, etc"* (Environmental Law). An example of a category C response from an Environmental Engineering lecturer is as follows: *"School and individual lecturer review within a Quality Assurance/Quality Control process."* However, this does not allow for student input other than at the conclusion of the semester. Category D is illustrated by the

response: *"The assumptions [are] not challenged in this subject (other subjects exist for this purpose), but their applications are. The difficulties of analysing complex, dynamic systems are emphasised, and social and political dimensions are considered"* (Environmental Science). The "other" (category E) response to this question for an Environmental Science lecturer included:

"Not sure what is meant."

The Environmental Engineering lecturers' responses indicated that one favoured *"peer review/discussion"* in class (coded category B). Another lecturer used readings by a challenging writer, Sharon Beder, to encourage students to question the frameworks and assumptions. One lecturer appeared to believe that because *"the topics are pre-set"* (coded category E) they did not allow for student questioning, and a fourth felt that it was the responsibility of lecturers to critique frameworks through the quality control mechanisms in place in the university. The remainder did not answer.

One Environmental Law lecturer actively promoted discussion and debate in class, and the other referred to the student evaluation forms as a means of critique of the underlying framework of the subject. The Environmental Economics response (category E) was somewhat prescriptive, stating:

"Ability to analyse an issue and to prescribe the appropriate policy correction in terms of Environmental Economics, eg. Salination of the Murray-Darling Basin being the result of failures in information, markets, property rights, policies and paradigms."

Two of the Interdisciplinary lecturers did not answer this question and the third replied:
"I often ask students fundamental questions like: Why are you studying Environmental Science? Or what are we trying to achieve with such and such a technique or approach?" This lecturer taught Science and Law and the response was coded category B.

4.11 How expectations of critical thinking are conveyed to students

The final question was based on the assumption that some explanation of critical thinking will help students to understand its importance (see reference to previous

research project, Chapter 2). It asked: "Do you make your expectations about critical thinking explicit to students? How?" The responses to this question were coded according to the following categories, and a number of answers were <u>coded into more than one category,</u> since some lecturers used a number of strategies:

A) Explain discuss/debate in class
B) Written assignment instructions, learning outcomes or subject objectives
C) Through providing marking criteria, with a mark for critical thinking
D) Provision of readings or written explanations about critical thinking
E) No
F) No answer
G) Other

Table 14.13 Strategies for making expectations about critical thinking clear to students (Question 11)

Subject area	A	B	C	D	E	F	G	Total coded themes
E. Science	9	5	7	4	2		2	29 (N=18)
E. Engineering	2	1			1	1	2	7 (N=6)
E. Law	2							2 (N=2)
E. Economics							1	1 (N=1)
Inter-disciplinary		1	1			1	1	4 (N=3)
Totals	13 (43%)	7 (23%)	8 (27%)	5 (17%)	3 (10%)	2 (7%)	6 (20%)	44 (N=30)

Only three lecturers admitted that they did not make expectations about critical thinking explicit to students (coded E). Two did not answer and the remaining eighty three percent on the whole considered that they did make their expectations clear in one or a number of ways. Because lecturers may have included a number of strategies for making their expectations about critical thinking explicit to students, some of the responses were coded according to more than one category. Forty three percent of the lecturers appeared to explain, or encourage the students to debate, the concept of critical thinking in class (category A). For example, this was expressed as: *"students are*

expected to discuss their thoughts and feelings about their capability in doing research and in learning about the process of research" (Environmental Science); *" Yes. I tell them I want their ideas"* (Environmental Engineering); *"I explain that Environmental Law is polycentric and that values, community, expectation, economics etc play a greater role than in many other traditional areas of law."* However, for this approach to be entirely successful it depends on students attending class, being confident to participate in discussion and would perhaps be difficult for students from other language backgrounds.

Another common strategy used by twenty three percent of lecturers was to write about their expectations in assignment instructions or in the learning outcomes or objectives of their subject outlines (category B). One example of this was: *"Yes, upfront in 'educational aims' on handout"* (Environmental Science). Another response from an Interdisciplinary lecturer was coded as categories B and C: *"Yes, stated in unit objectives. Plus notes on expectations for written work and what P, Cr, D & HD mean, plus marking guides"* (Science and Law).

Twenty seven percent of lecturers indicated that they provide marking criteria, with a mark for critical thinking, and an additional seventeen percent of lecturers provided readings or written explanations about critical thinking. The responses that were coded "other" varied greatly. Several indicated that they were aware that they could perhaps provide more overt explanations of their expectations. Another implied that students would understand what was expected by the feedback on their assignments, for example *"Depth and breadth of argument, range of sources consulted"* (Environmental Science and Engineering). The Environmental Economics response was coded "other" (G) and stated *"Yes, by encouragement and the analysis of real world issues (such as salination of the Murray-Darling)."*

The "other" responses from Environmental Science lecturers included one which simply replied *"Yes"* and another who stated: *"I have not done this before but I think a prescriptive instruction is required."* The first answer regarding being explicit about expectations, while positive, did not elaborate and the second response perhaps made this decision after actually doing the questionnaire.

One "other" response (category G) from an Environmental Engineering lecturer was: "*Not as much as I should".* A second response stated: *"Yes, using progressive assignment/assessment tasks and regular feedback."*

Summary and reflections

The main themes to emerge from the questionnaire were related to perceptions of the importance of critical thinking in environmental studies, perceptions of the meaning of critical thinking as an ability or process, and strategies that were used to encourage student critical thinking, both in class and in written tasks.

The majority of participating lecturers considered critical thinking to be very important in their subjects, although the Environmental Engineering lecturers appeared to place marginally less importance on critical thinking than did those in the other discipline areas. Explanations for the importance of critical thinking provided by lecturers could be grouped into two sub themes: environmental issues and graduate attributes. Firstly, the nature of environmental problems and the constantly changing information available in this field was seen to require critical thinking. Secondly, although the term "graduate attributes" was not used by any of the participants, it was implied in such notions as development of critical thinking for professional practice and as an essential ingredient of tertiary learning.

Individual perceptions of the meaning of critical thinking varied greatly, however the themes that emerged from the definitions revealed a focus on abilities and processes. For example, an ability to analyse and evaluate information was the most common perception of critical thinking, especially in the discipline of Environmental Engineering. The Environmental Science lecturers agreed with this but also placed emphasis on the processes of questioning and challenging paradigms and information, as well as reaching conclusions. The latter processes were more favoured by the Environmental Law lecturers. This could indicate a discipline difference in the approach to critical thinking which will be explored in more detail in the next chapter.

The perception of critical thinking as a process implies that all students are able to engage in it to some extent and the data revealed that most lecturers expect student critical thinking to develop during the course of a degree. Expectations of finding critical thinking in student assignments fairly closely matched what was found, although this was not at the level one would expect by the time students graduate, particularly in the Environmental Engineering area. Some lecturers appeared to expect only higher level assignments to contain critical thinking, such as those which gained distinction or high distinction grades. This implies that critical thinking is either already developed or is a natural ability which only some students possess. On the other hand, a small number of Environmental Science lecturers claimed to find evidence of critical thinking in all of their students' assignments from their first year to their final year.

It was hoped that an increased understanding of the perceptions of critical thinking would be gained from reference to lecturers' approaches to assessment of critical thinking in assignments. However, almost half of the participants gave no indication of how they do this, an interesting result in itself. Many referred to the quality of the student's argument or analysis, though there was not much explanation of how quality was measured apart from the complexity and depth of argument. This is compatible with another theme related to assessment where students need to engage in wide reading to find a variety of viewpoints and to examine readings in depth. The implication is that the more a student is immersed in in-depth reading, the more likely they are to produce good quality arguments with supporting evidence.

Most of the lecturers indicated that they have definite strategies for encouraging student critical thinking and they believe they make their expectations explicit to students. Half of the participants used the classroom situation to encourage discussion and debate and to explain their expectations regarding critical thinking. A third emphasised the use of tasks that either guided or challenged student thinking, some of which were completed in class and not necessarily assessed. Others used written communication about critical thinking in subject objectives, assignment instructions and/or provided marking criteria with a mark for critical thinking. A small number also provided readings or references about critical thinking while a few did not appear to have any definite strategies. Some indication of how effective these various strategies are for students will be reflected in

the student interviews in Chapter 5, however, it is significant that some participants did not appear to place importance on implementing strategies for developing student critical thinking.

The diversity of definitions of critical thinking may have affected the responses to questions, and will be explored in more depth in the next chapter. Chapter 5 is based on interviews with lecturers and students from two subjects in each of the environmental discipline areas being examined as case studies: Environmental Practice and Epidemiology (Environmental Science); Site Remediation and Environmental and Sanitation Engineering (Environmental Engineering); Environmental Law and Planning and Environment Law (Environmental Law). Further analysis of the findings chapters will be presented in Chapter 7.

CHAPTER 5: FINDINGS FROM INTERVIEWS

5.0 Introduction

The previous chapter coded responses and presented preliminary analysis of the findings from the questionnaires. In this second phase of the research a more in-depth view of the way in which critical thinking is expressed in environmental subjects was explored through interviews with lecturers and students in two subjects from each of the discipline areas: Environmental Science, Environmental Engineering and Environmental Law. Information was also gained from these interviews about how student critical thinking is encouraged by lecturers within their subjects. The interviews were with some of the lecturers who had indicated their interest in further involvement in the research project in their questionnaire response. These lecturers were asked to contact students who had written assignments which lecturers perceived had demonstrated critical thinking. The discipline areas and the subjects involved in this phase are outlined in the following table (Table 5.1) where lecturers and students who were interviewed have been given pseudonyms. Interviews were tape recorded and transcribed.

The structure of this chapter falls into three sections, according to the three case studies. The first section (5.1) is the narrative of the interviews from the discipline area of Environmental Science which includes the subjects of Environmental Practice and Epidemiology. Section 5.2 is the narrative of interviews from the discipline area of Environmental Engineering including two subjects: Environmental and Sanitation Engineering; Site Remediation. Section 5.3 is the narrative of the interviews from the discipline area of Environmental Law including two subjects: Environmental Law; Planning and Environment Law. Direct quotations from the interviews are italicised and interviewee emphasis is underlined.

Table 5.1: Discipline areas and subjects for interviews

Discipline Area	University	Course/s	Subject/s	Lecturer	Student/s
Environmental Science	A	B. Applied Science in: Environmental Health or, Environmental Management or, OHS	Environmental Practice	Paul	Maeve Sue Mikaela
			Epidemiology	Colin	Maeve Sue
Environmental Engineering	B	Bachelor of Civil Engineering	Environmental and Sanitation Engineering	Prem	Roberto Vittorio
	C	Bachelor of Environmental Engineering	Site Remediation	Anneke	Stuart
Environmental Law	C	Bachelor of Laws	Environmental Law	Alex	Jeremy
	A (pilot study)	Bachelor of Laws	Planning and Environment Law	Matt	Jasper

5.1 Discipline Area: Environmental Science

The two lecturers and three students who were interviewed from the discipline area of Environmental Science were from various courses of Applied Science at one metropolitan university in NSW. The open ended questions used for semi-structured lecturer and student interviews are available in Appendix C. The two subjects represented in this discipline area were Environmental Practice and Epidemiology. All students were final year external/distance students. External students in the subject Environmental Practice, a one year long subject, communicated with each other and the lecturer via Web CT, email and phone. They also had an on campus, "residential", meeting in the mid-semester break. Internal students worked independently over the year, with some lectures at the beginning of the semester. In Epidemiology the same forms of communication were open to external students, except for Web CT, and this course was also offered to internal students who met regularly for lectures.

The main points from each interview are included and arranged such that each of the two subjects will be presented separately, including both the lecturer and student interviews. Samples of how these main points were derived, based on transcripts of interviews, is provided in the Appendices (see Appendix D). The analysis of data will be based on themes that emerged from questions and discussion in the interviews, and were examined in the following order: (a) a brief description of the subject from the lecturer's point of view; (b) the broad framework and/or set of assumptions underlying the subject; (c) the lecturer's working definition of critical thinking; (d) the strategies used by the lecturer to encourage critical thinking; (e) the lecturer's expectations regarding critical thinking; (f) ways in which critical thinking is assessed; (g) comments about why the sample assignments were recommended as containing critical thinking.

Student interviews were examined according to responses to questions in five broad areas: (a) why students thought their work was recommended; (b) their perception of the framework and/or assumptions of the subject; (c) their definition of critical thinking; (d) how they were encouraged to develop their critical thinking, and how they developed it themselves; (e) their views of lecturer's expectations regarding critical thinking. Perceptions of issues relating to critical thinking will be compared and contrasted between students and lecturers, and between subjects and disciplines.

5.1.1 Environmental Practice (3rd /final year subject)

Lecturer interview: Paul

This subject was a two semester project based subject with seven assignments including a project proposal, literature review, a Web CT group discussion component, final project report and a reflective document. In his interview Paul explained that students are expected to be independent learners, whether they are enrolled as internal or external students. He did not give many lectures, several at the beginning of the semester for internal students and in the mid semester break for external students. Because there is not much opportunity for in-class discussion a web based discussion forum, in Web CT, was used. In his words: *"[I] use questioning through Web CT…I ask them to focus on a*

bit of reading and to relate it to their own project...They get something like six weeks or so of discussion amongst themselves, private on Web CT...Their job is at the end of the [first] semester to post back, in a section where everyone can see, a summary of their discussions – where it's gone, how broad it got, what it covered, but also maybe giving the rest of the group some agreed principles they may have about that issue in relation to their practice." This involves collaboration, sharing strategies, and is the same process for both internal and external students. In relation to internal students he stated that the focus at the beginning of semester is on their project. He said: *"because it's a project subject, the first few weeks we spend together, trying to support internals to get out there and find a client."*

There were various theoretical frameworks and assumptions in this subject, including Action Learning and Sustainability. Although Paul did not elaborate on this in his interview, in the subject outline a model was presented for student use in approaching their projects, one which encouraged observation, reflection, planning and "doing" in a cyclic process similar to action research methodology with reference to Kemmis and McTaggart (1988). Students were encouraged to put their "knowledge into action," as part of the process of completing their projects and think of themselves as "change agents".

In his interview Paul also indicated that environmental protection, sustainability and broader social issues were central to his subject. In his words: *"Students need to relate their project to the broader environmental health, environmental management, occupational health...ecologically sustainable development (ESD) and wider health frameworks"*. He asserted that every student's project related to environmental protection and sustainability and some also included broader social issues. His definition of environmental protection was concentrated on the *"biophysical threats to the environment, sometimes social threats"* often within a *"tight regulatory framework"*. He considered sustainability to involve more of a *"human element"* and political forces. He also referred to the issues of *"intergenerational, equity and precautionary principles"*. For Paul broader social issues included cultural diversity, the distribution of wealth and government intervention regarding environment and sustainability.

When asked to define critical thinking Paul replied: *"My definition is along the lines of exposing dominant practices, dominant meanings and unravelling what is taken for granted...putting the spotlight on an organisation and the way it works, how it operates. How, for the government especially, [do] productivities match its aims?...as a professional – what decisions would I make if I worked here?"* Furthermore, in terms of students critiquing the frameworks and assumptions he had described, Paul believed that the students need to *"present back to us how it is they worked within those frameworks, as opposed to me saying this is the framework you will work within...."* He asked them questions about *"how they operate, what their experience in project management is like."* He referred to six professional competencies, of written communication, verbal communication, critical thinking, learning, group process and project management and how students need to give evidence of their improvement in these areas in the assessable reflective document. Paul suggested that students keep a diary or journal as a way of tracking their development of, for example, critical thinking. In terms of the reflection process he stated that *"all the assignments build on each other...Web CT... can provide a kick off to the reflective document...if they do not have an experience to demonstrate their development of a competency...they can tackle some experience through some theory, or model or framework."* He elaborated that *"we would rather they explain their experiences in relation to a framework that speaks to them."* No mention was made of any student critique of the concept of sustainability or ESD.

Paul had not taught first year for a while but in relation to his expectations of third year students he stated that critical thinking was expected of all students, and this was made clear to them. He explained: *"I certainly have an expectation...[critical thinking] should be on the radar by third year, and I get to sort of work with them a bit and press it, in relation to something real important as opposed to something abstract...which is really the most fruitful way it can be explored."* He also avoided a "tight" definition of critical thinking and said: *"really I just want them to be able to question what is not questioned. There's a phrase I give them at the beginning of the semester: 'make the familiar strange'. This gives them a way of looking at the day to day or dominant/ traditional norms and asking: why is it so? What made it that way? What is my role?"*

Paul perceived that he encouraged student critical thinking in a number of ways, such as by giving generous feedback on their assignments, for example he would often ask *"what's the best plan of action for you? Why? What are the causes? How did they come about?*." He considered this to be important so that they *"go away and have another look at it"*. He added that critical thinking is also implied throughout their class activities and assessment tasks. He wants *"reflection at a deeper level [and] ramifications for students own practice, those kind of questions."* The final assignment is focused on this, as it is a reflective document where students are expected to reflect on their development of the competencies mentioned above. He makes his expectations explicit to students: *"they're directed to readings, they have exercises around elements of critical thinking and they're asked to account for it at the end. In that way it's explicit, it's an assessment."* He also offers a lecture on critical thinking in the residential workshops and there is a sample of critical writing in the resource book which is deconstructed and annotated to demonstrate how it provides critique (see Appendix E). However, he indicated that this did not ensure that all students demonstrated critical thinking. As he said: *"some of the projects just don't go near that element, avoid it. It makes it harder for me to assess…."* In fact in his questionnaire Paul estimated that only 20 – 40% of his student assignments contained critical thinking.

For Paul assessment of critical thinking in student assignments was integrated into a marking schedule, which he provided. As he said: *"I have a marking schedule that has in it a reminder for me, and for them, that I'm looking for those kind of features in their assignment, because they have access to the marking schedule. The little boxes are for them to check off for themselves if they've done the minimum, and for me to compare one assignment against the other."* According to Paul the assessment of critical analysis may be *"in terms of their discussion perhaps of their results, and the implications of their study…I'd be looking there at their critical thinking and critical analysis of their own results…and implications for the future. Sometimes there's an opportunity in the literature review to critically assess and argue a position."*

When discussing the student assignments, Paul identified different features about each in relation to how they demonstrated critical thinking. In regard to the first student assignment by Maeve, which was a project based report on the topic of World Health Organisation (WHO) activities in Fiji, he stated that Maeve was recommended for interview because she demonstrated critical thinking most of the time. In his words: *"she's a student with a fairly inquiring mind."* For example, Paul explained that she had critiqued the government, the WHO and her client. He said she *"found…[that] the government in the country…do what they normally did, [that is] not change their practices, but say they fit that rhetoric [of "Healthy Islands]."* Furthermore, he explained that Maeve had *"critiqued not only the WHO approach, but also the approach of some of our academics who are working over there…it was brave of her to follow through the way she did and then …to negotiate with her client."* Paul emphasised that she raised many questions and problems to be solved, in that *"her final report had a lot of recommendations and issues for the client."* He felt that Maeve had shown critical thinking in *"the process…of her generating the report. In her earlier literature review [she] outlines the principles of the concept … and, in her Discussion…using her own data …explains the flaws in the practices of those principles."*

The following are some of Paul's comments about the second student assignment, written by Sue, of a project proposal on the topic of Manly Lagoon catchment. Paul said that she introduced a historical element to her literature review and methodological approach, and had a well thought out project design. He explained that *"it kind of stands out from the other proposals…[she] tries to get at some of the historical elements to her study. So she's kind of asking the question why? Why is this catchment run like it is now?"* He added that it was the design of her project that demonstrated her critical thinking, because it *"had elements of talking to locals that have been in the region for decades, wanting to get their views on how it's changed and why. Whether she knew it or not that was where she was more critical."* In terms of where more critical analysis could be found in the assignment, Paul commented that *"she's come up with a particular set of criteria she will use [for the value of the river]…, for example, recreational, educational, set out some parameters of some possible responses, even before she's got the data…from the range of literature."*

The third student assignment, by Mikaela, was a literature review on the topic of occupational health and safety regarding manual handling in a particular workplace. Paul had recommended this student's work, but stated that *"it only comes close to critical analysis through understanding and challenging of the literature…she can pull out the main themes of the literature, and describe how various authors on that topic agree or disagree on the topic. She does a pretty good job at that kind of integrating and doesn't mind taking a position here and there. I try and ask them to take a position, that shift is quite significant indeed."* Her final report was unmarked at this time but Paul had seen a development of Mikaela's critical thinking in the later assignment.

Student interviews

Interviews with students commenced with open ended questions and discussion about the particular assignment which had been recommended by their lecturer as demonstrating critical thinking. In each case these were assignments which had achieved a high distinction (HD) or in one case a credit (Cr). All three Applied Science students, Maeve, Sue and Mikaela were external students in their final year of study, two of whom were mature age students currently working. The following are main points made by the students during interviews with examples some of which are in the student's own words.

Maeve

Maeve felt she had been recommended by Paul as having produced an assignment which demonstrated critical thinking, because in her assignment she *"criticised basically what should be happening…[I was] critical of others' works,[had my] own ideas about community empowerment, inventing things myself, read widely and made it gel into a comprehensive argument."* She believed that she thinks critically about everything, but in this case she focused on the WHO program of "Healthy Islands", and she was critical of many aspects of the program for presenting its achievements in a somewhat misleading manner. She elaborated on this, *"I guess I recognised that…a lot of people pretend they're not trying to change the culture. I think inside they are going to be influencing that culture…I'm not necessarily saying this is something bad, but the*

project has to have some sort of result. [It] tended to have been glossed over in all documentation of the project...It was really 'suss' finding that out...". Her interpretation of 'empowerment' was clearly very different from what was being represented as positive results of the program.

When asked where in the assignment she had demonstrated critical thinking, Maeve acknowledged that there was critical thinking throughout it. She perceived that there were issues to confront on many levels. For example, she stated that *"there turned out to be a number of contradictions...that couldn't be reconciled. ...A lot of the discussion in my final document was taking up the key points that the WHO shouldn't be involved in the project – the conclusion that it may or may not have been what communities wanted."* She established that cultural expectations may have influenced the lack of success of the program in Fiji. She also stated that she tried not to *"overanalyse the culture"* in Fiji, but she was critical of the sexism because *"women weren't really involved with community empowerment."* Her critique covered social and political issues.

With regard to frameworks and assumptions in Environmental Practice, Maeve explained that the subject tends to follow the assumptions of Environmental Health generally, which are based on action research. As she said *"you are not the expert, [you are] learning as you are going along, critical thinking."* However, she had her own critique of this approach to project work and elaborated, *"the trouble with this is that you can explore forever and not really come up with anything, or it's an excuse not to come to a conclusion."* She gave an example from her own findings with regard to issues of applying theory to practice without critically analysing whether it is effective. She explained, *"[for them] the theory of empowerment... has to be part of everything...even if it's not working...[they] change a little thing or two because fundamentally <u>it must be right.</u>"* Her critical analysis of the situation raised the issue of whether 'empowerment' is too close to subtle imperialism.

Protection of the environment, sustainability and broader social issues were also seen by Maeve to be integral to the whole degree. Her interpretation of protection of the environment included human health and was anthropocentric, and *"not just for the sake*

of nature." She defined sustainability as *"creating a world where people are provided for and people are not taking more than they need."* For Maeve, broader social issues covered *"sexism, racism, systemic issues – economics, governance, distribution."* She thought that the course in Environmental Management went beyond the traditional approach to science, and that this encouraged critical thinking. In her words it is not *"strict environmental science where you learn that x and y happen to the water, but you actually look at the social and environmental consequences. That's pretty essential to thinking critically...we were encouraged to think about broader social issues."*

Maeve's definition of critical thinking involved questioning the status quo and developing optimum solutions to problems. As she stated it is, *"thinking about things, exploring issues in the way you think they need to be explored – not just sticking to schemas. More critical thinking will lead to better answers."* In her interview she also commented that children are not encouraged to think critically at school. When asked how she developed her own critical thinking Maeve related this to her political awareness. She commented, *"it's all part of really taking a look at the world...and it's my political outlook that makes me look critically at the way things work today."* Maeve explained that being critical means being a change agent *"there's actually an alternative to it. Having some belief you can be part of that change."* This corresponds to the concept of a "critical being" which was proposed by Barnett (1997).

In response to a question about how she was encouraged to develop critical thinking, Maeve explained that she enjoyed working independently. In perceiving herself as a politically aware person, with a desire to be part of a change process, she did not appear to need a lot of encouragement to be a critical thinker. However, she noted that Paul *"encouraged me to go off on tangents and gave me confidence to follow up my own ideas."* She appreciated his feedback and commented that he also gave her tips on *"who to read and tips on right direction."* Maeve also believed that students were encouraged to challenge assumptions in the subject Environmental Practice. She elaborated on this,*"[we are] definitely [encouraged] by Paul ...if you are just trying to look at individual people's lives you have to be able to somehow generalise and look at trends and look at actual results. The two should be used together, which is what I ended up doing, and was encouraged to do...too much emphasis is placed on actually finding out*

what the problem is and not enough follow up is done in changing and overcoming the problems."

In response to a question about different expectations for student critical thinking, according to the level of study, Maeve considered that students develop their critical thinking over time, and she also implied a link between critical thinking and environmental subjects. She stated: *"when I first started uni, to me it was about critical thinking, whatever anyone else said, and when I got involved in other political things. In terms of me personally, it's definitely increased over the years...to be critical you have to know what people are saying...also the subjects I've taken are a lot more environmental."*

Sue

Sue gave the impression that she was a very conscientious student when referring to her classmates at a recent residential who were teasing her for staying up late working on her assignment. Although she laughed about this she did comment that most of these students were *"happy with a pass"* and joked that they all get the *"same bit of paper."* She also described herself as being passionate about learning, and spending a lot of time on her assignments.

Sue's assignment was a project proposal about the degradation and pollution of Manly Lagoon. She felt that this assignment illustrated critical thinking, because it was an unusual slant on the topic in that she had chosen to apply the concept of environmental flows to an urban catchment and felt that this was *"relatively novel. [Normally] it's rural, it's to do with off stream diversions, dams, that sort of thing and having enough flows just to keep the ecosystem going. It's of course much to do with economics. Whereas in an urban environment we don't have agriculture, we don't have potable water. So there's no reason to – apart from community, which is reason enough. The value is there but it's not a financial value. So urban catchments have been ignored."* These comments demonstrate critical thinking about the importance of applying the concept of environmental flows to an urban catchment when there may not be an economic outcome, but instead an improvement to water quality that satisfies other values.

Sue's own curiosity and sense of challenge were the stimulus for her to do this topic for her project. As she said, *"it isn't information you can get easily...I guess that gave me the impetus to do it and do it reasonably well."* She felt she had demonstrated critical analysis in the choice of topic by *"assessing the need for it, justifying the need...convincing someone else."*

Sue perceived that in the subject Environmental Practice the main frameworks were concerned with the processes of learning, in her own words *"how we approach and think [about] something and justify it."* She saw that there was a critical analysis process in *"finding a client, justifying it, rationalising it, following it through... That's been encouraged constantly. We reflect on it, we do those circular routes that spiral...."* However, even though Sue was not critical of the action learning approach, she did indicate that she preferred the scientific approach in subjects. She stated that she liked to do the *"more science based and factual based [subjects] because if I know my stuff I can... argue for it. It's just a matter of reading enough to be able to make an assessment."* The reason given related to her level of confidence in that she believed she could do well in a more scientifically based subject.

Sue believed that protection of the environment, sustainability and broader social issues were all essential concepts in the subject Environmental Practice. For her, *"environmental science is all about sustainability...not so much broader social issues, social science subjects [are for that], building a better environment for us."* Her understanding of these terms was fairly specific, for example she described protection of the environment in terms of water quality, relating this to those who are responsible for maintaining it, *"[it involves] different concepts, for example Manly Lagoon includes water quality, Council and government, everyone's responsibility."* She referred to sustainability as *"intergenerational, intragenerational [and] for the future. Looking after everything - water, air etc."* She saw this as an underlying theme of the whole course. Broader social issues were more specifically referred to as *"equity with health and education"* and were dealt with in other subjects.

Sue's understanding of the concept of critical thinking was in terms of processes, but she also emphasised questioning things. In her words, *"planning, assessing along the way, looking back (reflection), based on as much information as you can accumulate, [developing an] argument/point of view...critical thinking has a lot to do with doubt."* Sue believed that she developed her critical thinking herself by reading and listening and that it was something she did in her work and everyday life. As she said, *"I read heaps, I've always read heaps...listen to people...[but] I don't do it consciously...Obviously when we are asked to do a reflection report...we're going to be going over the processes...and when we finish a project, or in any aspect of life, you look back ...."* She explained that Paul gave students encouragement to develop their critical thinking ability by providing written information in the subject outline and readings in a resource book. She believed that this encouragement was important because it was their *"final project and we're all coming from different angles and different disciplines. All they are doing in this is making sure we're aware of the processes...how to improve your processes"*. Her view of the emphasis on critical and reflective thinking in this subject was tied to it being a third year subject.

Sue thought that there was a change in expectations about student critical thinking abilities from first to third year, and that this became more obvious in the second year of her degree. For example, she remembered one second year lecturer in particular who encouraged students to think critically because he *"loved a challenge and for people to challenge him."* She also found that particular types of assignment encouraged more critical thinking such as when *"you're setting up your own studies, even if you're not carrying them out, having to explain why you're doing it...."* This type of assignment was first asked for in second year. It can be seen from Sue's comments that she believed that the research process encouraged her critical thinking.

Mikaela

Mikaela's recommended assignment for Environmental Practice was a literature review for a project on manual handling in a particular industrial setting, the State Rail Authority. Mikaela felt that her assignment demonstrated critical thinking because of the depth of the literature review, *"[there were] elements in the assignment...you*

couldn't just expect it to be what the author said, you had to actually delve into it." She had read an enormous amount of literature, referring to the ninety references she had included in her assignment out of a possible two hundred. She explained that this had resulted in a lot of thinking and narrowing the scope, *"you had to get references that were more global and then others that were more local, and then down to a specific project. So you had to think critically to get that funnel effect."*

Mikaela described her perception of the main frameworks and assumptions of the subject in terms of action learning/research, with the emphasis on reflection. She stated that the subject was *"heavy on the reflective process, more than any subject I've done before…We had to keep a reflective journal, the paradigm of the [subject was the] structure of action research which has all the reflective bits in it."* Also she had used an action research method for her project, which created difficulties in writing it up because of the assumption that it would be written like a scientific report. According to Mikaela, *"the problem I'm having is they've given a very structured marking schedule…[which] fits the traditional scientific method. I'm up to my 5th draft of methodology because…a lot of my project was inferential stuff, where I had to listen to what people were saying. Sometimes it was the way people interacted…so, much of the information I got was from just being in the environment and asking and watching their responses."* She explained that *"the safety culture of the organisation, which was part of what I was doing…isn't something that you can look at a document and find out, it's how it is interpreted within the organisation…observations and reflections…going out to sites and visiting and watching what people did."* The writing up of a qualitative project had apparently not been seriously addressed, according to Mikaela.

In terms of her project broader social issues in the workplace were seen to be a focus in the subject Environmental Practice, rather than environmental protection or sustainability. As she stated, *"I'm looking after the occupational environment… not just the natural environment but the built environment, and that they are both sustainable."* She further explained that this *"relates to the people in the community living in those environments, rather than the environments themselves,"* but she emphasised that the whole course *"addresses all of those areas."*

Mikaela defined critical thinking as *"a process of deductive reason. You're given a set of facts and you work your way through them to come out with a solution at the end. The critical bit is where you actually look at each point...delve a bit deeper."* She related this to her project where she would ask questions about safety issues and could tell when employees in the organisation were not giving accurate answers. For example, *"they're saying one thing, but you can see the eyes going round, they're thinking something else and they're just telling you this."* The client for the project also proved to be very difficult at the end of the project, in that her findings and recommendations were not to be released for publication at all, even to the lecturer who was marking the assignment. She had thirty pages of recommendations for the client. Mikaela was very critical of the client because of this secretive attitude, which also had serious implications for the practice of manual handling in their workplace.

Mikaela believed that *" lots of feedback"* was important for developing critical thinking and that in the Environmental Practice subject Paul gave *"more feedback than we usually get."* She also stated that in terms of critical thinking Paul *"provided more detailed marking and the term was mentioned. We actually had a reading on critical thinking."* Although there was very little in class discussion, the Web CT component allowed discussion. However, Mikaela critiqued this component of the subject because it was difficult to formulate a group summary, because they had to *"draw together emails and to make it something that...was representative of what everyone said."* Although in a different format her comments are reminiscent of student criticism of the group process in many other subjects, and should perhaps not be seen as a failing of the Web CT resource. Finally, she also mentioned that a reflective document was one of the assignments and that it had been helpful for developing reflective thinking.

Mikaela felt that because she did not follow the normal sequence of subjects per semester, due to being an external student, changes in lecturers' expectations about critical thinking were not very obvious. However, she felt that because this subject was a year-long subject, and final year subject, it was the only subject where the expectations were different. She stated that: *"this year is to demonstrate whether you are safe to be let out on the workforce, and they've often failed people because they felt they are not quite ready."*

5.1.2 Emerging themes from Environmental Practice

The main theme to emerge in this subject relates to the action learning/research framework of the subject. This had an influence on the perception of critical thinking which was applied at many levels including the socio-political context, paradigms and students' own work. Reflective thinking was highly valued by the lecturer and students, and was assessed through a reflective document assignment. Critique of the framework of the subject was encouraged and all students were expected to demonstrate critical analysis in assignments. Web CT was used to encourage debate and written support material about critical thinking was provided.

The lecturer and three students who were interviewed in this subject had similar perceptions of the broad frameworks and assumptions in the subject Environmental Practice. These were seen to be based on learning processes, or action learning, in relation to their major project. Emphasis was placed on the development of critical thinking as a learning process, and most interviewees made particular reference to the readings on critical thinking and the benefit of the final reflective document. The students all emphasised action research, including reflection, as an underlying qualitative framework of the subject, which nonetheless was critiqued by two of the students. For example, Maeve perceived that the approach does not allow for solving problems rather for exploring them, which was her critique of the paradigm itself. On the other hand, Mikaela complained of the lack of guidance regarding writing up a report for an action research project. Their comments indicate that they were encouraged to evaluate the framework and assumptions of the subject. The lecturer and three students considered environmental protection, sustainability and broader social issues to be key concepts in the subject, though to differing degrees. For example, Mikaela was specialising in OHS and put much more emphasis on the broader social issues and built environmental impacts, while Sue was more concerned about the natural physical environment, which was the theme of her proposal about Manly Lagoon.

Perceptions of critical thinking emphasised an understanding that it was embedded in the approach to the subject. Furthermore, according to definitions given, the meaning of critical thinking appeared to fit into two themes. One theme was concerned with questioning, thinking 'outside the box' and thinking within a socio-political context, and the other theme was that critical thinking is part of the processes of learning particularly relevant to third year study. The assessed reflective document was referred to as a part of the learning process relating to critical thinking.

In regard to the assignments, Paul expected to find evidence of critical analysis as they were third year students. However, in his questionnaire he had only estimated that twenty to forty percent of student assignments demonstrated critical thinking despite it being one of the competencies, part of the marking criteria, and readings being supplied. The amount of critical thinking Paul perceived to be demonstrated in the recommended assignments varied, from one where it was seen to be throughout the whole assignment, particularly in the Discussion, to one which occasionally took a position on an issue in a very thorough literature review.

Maeve was the only student who agreed with Paul about where critical thinking was to be found in her assignment, in that she perceived that her assignment had critical thinking throughout. Sue's perception differed from Paul's in that she thought it was her choice of topic that demonstrated her critical thinking, whereas Paul thought it was her use of interviews with locals who knew the history of the site and the design of her project. Mikaela's perception also differed slightly from Paul's in that she thought it was the only depth of her literature review that showed critical thinking whereas Paul also thought she sometimes took a position on issues. She certainly was capable of taking a position, and did so in her interview when discussing her client's attitude to her recommendations.

All of the students thought Paul encouraged students to develop their critical thinking, emphasising his generous feedback on assignments and referring to his encouragement to question everything, even aspects of the subject. The reflective document was considered to be a useful assignment in terms of developing critical thinking. The

students also mentioned that researching the literature for their project, and the process of the project itself, was helpful for developing critical thinking.

5.1.3 Epidemiology (2nd year subject)

Lecturer interview: Colin

Colin valued scientific objective thinking and admitted that he had some disagreement with a number of his colleagues in his department with regard to this approach. He particularly disagreed with their emphasis on student reflection without background knowledge, and gave an example of how such an approach could lead to a belief that the earth is the centre of the universe. He stated: *"[I view] scientific inductive reasoning as a philosophy. I think objectivity should be common to all disciplines...apply a system to your thinking...[which] demands a certain amount of knowledge before you start...to me that's inductive reasoning, and that's the system I prefer students to accept."* While Colin had an obvious focus on student learning, it was from within a traditional scientific framework.

In describing the subject Colin stated that *"Epidemiology is very open ended. They can literally use any of the accepted databases on disease or environmental factors to study a problem and they can spread the acquisition of that knowledge over space and time. So they might be pulling in knowledge of case studies from different times and different eras on it.... They can delve back in time to bring up these sort of case histories or they can, and they are encouraged to do this, look at what's happening with similar disease patterns...in other countries."* This was seen as an opportunity for developing critical thinking and Colin perceived that there is a need for critical thinking in Epidemiology. This is because the content of the subject is *"involved in the area of quantifying risk, environmental risks, [and] you've got to find innovative ways of approaching those problems."* This subject had a focus on statistical analysis and Colin mentioned that the statistical methods were constantly changing, which he believed was another opportunity for critical thinking.

Colin believed in a questioning process for learning, incorporating small group work as often as possible, with rotation of presenters, and he spoke about the limitations of large group lectures. In the applied science courses the students were often taken outdoors, with a compulsory camp at the beginning of the first year to help establish rapport

between staff and students. Colin described the benefits of taking students outdoors in terms of this being a space *"where people are more relaxed and tend to interact, and can see things that stimulate thinking."*

Although it was clear that Colin's approach to the subject was within a scientific framework, his explanation of the frameworks and assumptions of the subject in his interview was in terms of learning theories. In his words the frameworks were: *"I suppose specific paradigms like the theory of Comenius and the ideas of Maria Montessori. In fact they had the same ideas, but I've found that men don't seem to want to base their teaching on Maria Montessori…men like to follow teachings of men, and women do tend to be more comfortable with teachings of women."* He was referring to the notion of moving students from *"simple to complex"* ideas, from *"concrete to abstract"* concepts and from the *"known to the unknown"*.

Colin's perception of critical thinking was that: *"critical thinking is an ability to evaluate and understand something not purely from a superficial viewpoint. By challenging yourself from a deeper viewpoint, this enriches understanding and can lead to more meaningful solutions to problems. This is part of the problem-based approach to things. Prerequisites are knowledge and reflections."* His emphasis on problem-based learning, and experiential learning, recurred throughout the interview and seemed to provide a firm link between concrete learning activities and abstract critical thinking. While his main framework was a scientific approach, Colin was also interested in the students' learning processes, including their development of critical thinking. He considered that the critical thinking debate is primarily about the idea of process and content and that *"science subjects are often seen as non-process subjects, which should not really be correct. It's the way they are taught which is the problem,… students [should] go to the literature and try and get some background as to the way other people are thinking, they will develop their own critical thinking as well."*

In terms of encouraging student critical thinking Colin stated that "*it is very difficult to teach critical thinking, and it is best taught by example. Institutions require, for example, cost effective innovations, thinking outside the square and trying new things."* He gave the students some guidelines or *'triggers'* to think about when they are faced

with a problem, to help them develop their critical thinking. For instance, he said that he raised the following general ideas with students: *"Firstly, there are elements of a problem, how can we work through this? Secondly, when you have a lot of factors they need to be prioritised. Thirdly, when you realise you have deadlines to meet; critical thinking can be a way of reaching a more rational, calm approach. Fourthly, when you read something that isn't quite logical, you need to ascertain what's missing."*

Colin also specified some other definite strategies, which he felt encouraged students to think critically. These included his approach to classroom interactions, providing written instructions and the types of assignments he set. He felt that it was important to create an egalitarian classroom situation *"in which students not only feel they are free to speak, but they are encouraged to speak."* Students who he considered to be good critical thinkers were often asked to answer questions first if possible, because *"[most] students tend to remember the first thing they hear."* He also made an effort to clarify in written instructions for assignments and in class that critical thinking was an integral part of their work. The assignments Colin chose for each of the second year subjects he taught were research/analysis based and were not reliant on simple recall of facts, for example the project proposal, rapid epidemiological assessment and portfolio. Even the unit exercises in the first five weeks of Epidemiology were "open book", in-class exercises, and his subjects had no final exam. Furthermore, Colin emphasised the importance of lecturer feedback on student assignments. He stated: *"when I assess students' work I try to get it back to them as soon as possible, so they have early reinforcement...I also try to write a lot of comments, especially constructive comments."*

Colin expected students to develop their critical thinking ability from first year onwards and stated in his interview that *"this develops slowly through Problem Based Learning (PBL)"*. In his interview Colin also said that *"critical thinking is part of PBL"* and that by third year all students should be *"well into that mode of thinking"*.
In his questionnaire he had expressed an expectation that there would be evidence of critical thinking in all assignments, but implied that this was not always achieved. He explained that PBL *"takes at least 3 years of study to fully potentiate,"* yet he estimated that he found evidence of critical thinking in 100% of first, second and third year assignments, because it is a *"requirement in all PBL assignments."* In his interview, he

described his assessment of critical thinking in student assignments as determining whether the student had *"built it into the assignment, shown the processes of thoughtful analysis, shown a level of innovation and informed reflection".* This is *"a skill that is rewarded in terms of marks."* However, he also commented that developing critical thinking skills can create a *"dilemma"* for international students when they return to their own country after finishing their degree, as it may not be as acceptable in their culture.

The two student assignments that Colin recommended were by Maeve and Sue, who were also interviewed for the Environmental Practice subject. Maeve had written a project proposal on the topic of HIV/AIDS, specifically with regard to young women in Fiji. This assignment was considered to be an example of good critical analysis by Colin *"because she'd done an extremely good literature survey"* which helped her to contextualise the situation, and her analysis was broad. *"She tried to analyse what was happening in Fiji, not only in epidemiological terms, but in social and cultural terms."* He then quoted from Maeve's assignment: *"Women are less likely to access health services to diagnose and treat HIV/AIDS. There remain many cultural barriers and expectations surrounding women's sexuality. Women become psychologically disempowered to seek …treatment…".* He realised that this assignment had been challenging for Maeve, especially because of the secrecy surrounding the issue and the fact that she was a foreigner, but was impressed that she had managed to work out how to approach this sensitive issue successfully.

He also pointed out that Maeve was aware of the economic factors with regard to women seeking treatment for HIV/AIDS. *"The woman may not be working…she might have to go and ask her husband to go to a doctor, and he's going to ask her what she wants it for. So this was very perceptive [of Maeve]…she wasn't afraid to go into that type of thing…I think that's probably what critical thinking is. Students come to me and say they don't feel very comfortable with what they are doing - [then] I feel they might be getting to a point where they are starting to think critically…".* He believed that Maeve had demonstrated critical thinking throughout the assignment and that *"she'd taken an ethical approach to the whole thing…she didn't rely on subjectivity and her own reflection, she tried to think of other people's perceptions."*

Sue's assignment was a project proposal on the topic of Osteoporosis. Colin had recommended this assignment because of her critical and innovative thinking *"because she not only managed to go through a process showing critical thinking, she actually managed to find out something new through the study. That's not really a requirement at undergraduate level, but it shows some real solid thinking about the problem."* She had researched the literature well, which he thought was *"the first step in critical analysis...it's a case of inductive reasoning...through doing that she's come up with a new perspective on this health state [Osteoporosis]."* He also felt that Sue had shown critical thinking in her actual choice of topic.

Other aspects of her assignment that Colin indicated demonstrated critical thinking included her use of models identifying risk factors. He stated that *"her study design was good...[and] I tried to force her to take it a step further. I think criticism by the lecturer is important in encouraging critical thinking, provided it is constructive criticism."* He commented that Sue had been able to demonstrate *"some social benefit at the end of the study."* Colin also believed another aspect of critical thinking is to be able to narrow the topic and Sue had been able to do this.

Student interviews

Maeve

Since Maeve was also interviewed for the subject Environmental Practice, most of her general comments are recorded in the previous subject interview. However, her comments about her assignment for this subject and any other comments specific to this subject will be noted here. As mentioned above, her assignment was a project proposal on the issue of HIV/AIDS awareness among women in Fiji.

In terms of how this assignment showed evidence of critical thinking Maeve thought that this was demonstrated in the choice of topic and the way she approached it. As she said: *"in some ways it was an identification that ...[HIV/AIDS] was an issue...particularly for young people. [It was] not something spoken about...So coming up with some sort of research design that could actually get some decent information*

[required critical thinking] …and presenting the paper in such a way that explores AIDS as a health issue, rather than a sexual taboo." She believed that she had demonstrated critical thinking throughout the assignment, and *"definitely in the Discussion."*

She considered that the framework in this subject was not action research, but more science based, as she said: *"old school…[a] more scientific approach."* Maeve had critiqued the action research paradigm in the other subject, but did not critique the scientific framework of this subject.

As she had explained in the discussion about the subject Environmental Practice, Maeve considered herself to be an independent learner and critical thinker. As an external student she apparently initiated very little contact with Colin, since she had worked out her project design for the other subject with Paul and was confident to proceed to work out a design for the research proposal for Epidemiology.

Sue

Sue was also interviewed for the first subject, Environmental Practice, thus her comments about her assignment for Epidemiology and her perceptions of the subject itself will be the main focus here. The assignment was a project proposal about the issue of osteoporosis, something she felt strongly about in terms of a need for increased awareness for women in general.

In relation to this assignment Sue thought that she had done a well researched literature review but added *"it was just sheer research. I did some interviewing…but I can't say there's anything original.…I worked for a pharmaceutical company for some time…[and knew] where to get interesting, good stuff."* The aspect of the assignment that Sue felt most showed critical thinking was her questionnaire design. She added, *"I also did a bit of a checklist. …It was based on something else, I developed it. It is information that was out there, quick little quizzes, but I combined a lot more into it to make it a bit more scientific.…"* Colin would have agreed with this as he had commented that *"it was an excellent set of risk factors."*

Lecturer feedback on assignments was considered to be important for Sue in order to improve her critical thinking and she felt that Colin had given very informative feedback. She described this process, *"when I was coming up with my topic we had to...suggest what we were going to do and do an outline. Then [Colin] reviewed it and would suggest on it. Most often [in other subjects] I get assignments back with ticks on them... and I don't care if I get a D or and HD I can still improve on that."* Sue really appreciated the lengthy, detailed email responses from Colin as an external student because some of her experiences in other subjects were not so positive. Sue explained, *"I've emailed teachers, gone on for about half a page about problems I'm having, and got back [responses such as] 'no probs, just do it'."*

In answer to the question about frameworks and assumptions Sue responded that Epidemiology involved *"a lot of analysis"* and application of scientific thinking. She had previously indicated that this was her preferred approach to learning and believed that she could develop her critical thinking through wide reading and evaluation of ideas and information (see p. 9). She also felt that Epidemiology includes other aspects than just science, and stated that *"[it has] more emphasis on broader social issues such as aboriginal health, inequalities. Also the environment, that is WHO definitions of health [have a] holistic approach."*

Sue believes they are encouraged to challenge assumptions in this subject, but also attributed her critical thinking skills to her work experiences. She explained that she was able to critique studies in Epidemiology *"because I worked in a pharmaceutical company.... I find their morals a bit [suspect]...and the morals of doctors. I was working on clinical trials...we had to pick an example, newspaper articles on anything you could relate Epidemiology to. So I had a cutting on clinical trials and the abuse by the Americans back in the 50's ...Cambodia more recently. In Australia it was tough to do clinical trials in the early days, but when AIDS came about it got a lot easier...so we put the morality back into the hospitals and the groups overall. So a hospital would have an ethics committee who would make up their minds ...I think you've got to meet certain things [criteria] overall. So basically I did a bit of a spiel on that...."*

5.1.4 Emerging Themes from Epidemiology

The main theme to emerge from this subject was the emphasis on an objective scientific framework. This influenced the perception of critical thinking and its application in the subject in that critical analysis was mostly concerned with the reliability, validity and study design of the articles in the literature. The importance of extensive reading emerged and was also considered to be a prerequisite for reflective thinking. However, reflective thinking was not assessed separately. Learning theories and an egalitarian classroom were a focus of encouraging development of student critical thinking and written support materials were provided.

The lecturer and both students were very clear that this subject had a scientific and quantitative approach to the study of epidemic diseases, and that knowledge and use of statistical analysis was important. Unlike the Action Research approach of Environmental Practice it could be said that the subject Epidemiology took a positivist scientific approach. Colin had given the impression in his interview that his approach was considered different from a number of the other lecturers in his field of teaching in Applied Science at this university, who took an action learning approach. However, he did emphasise that the subject had a framework of theories of learning where he would start with concrete ideas and, through class discussion, move students to more abstract ideas.

Critical thinking was considered to be a part of problem solving and experiential learning for Colin, and also the result of students reading extensively about a topic. He emphasised the importance of gaining knowledge from the process of researching the literature as a stimulus for critical thinking. Students considered they had put together a solid argument to justify the need for their study, through their thorough literature reviews, and that this demonstrated critical thinking. They also thought their project design, in particular their questionnaires, contained critical thinking, though one mentioned that critical thinking was evident throughout her assignment, especially in the Discussion section and in the choice of topic itself.

Despite Colin's written instructions in the subject outlines (see Section 6.1.1), the readings about critical thinking and the types of assignments he had set, neither student appeared to place importance on these things with regard to the development of their own critical thinking in this subject. They both believed they had developed their critical thinking abilities themselves, through other life experiences. Since neither of these students were internal students they would not have experienced many classroom situations in this subject. However, Sue greatly valued the written feedback from Colin in terms of developing critical thinking. The emphasis on a thorough literature review was evident in their writing.

5.1.5 Preliminary analysis of interview themes in Environmental Science

Differences and similarities of themes in lecturer interviews

The main theme demonstrating a difference between the two lecturers related to the underlying frameworks of their subjects and the effect this had on their perceptions of critical thinking. This also had a noticeable effect on their attitude to reflective thinking. However, the theme most strongly demonstrating similarity between the lecturers related to a focus on student learning and the ways in which they encouraged student critical thinking. Both lecturers provided opportunities for students to express their views, tasks that reinforced this and supplied students with written material about critical thinking.

Paul had an orientation to qualitative research methodology, in particular action research, in the subject Environmental Practice. With this came a focus on reflective thinking as part of the process of critical thinking and a strong connection between critical thinking and environmental issues, including broader social and political impacts. In his subject students were expected to question and evaluate an organisation in terms of its practices, including the resultant impacts on people and the environment. Paul perceived that the reflective process, which is an important element of action research, provided opportunities for critical thinking. An acknowledgment of the significance he placed on this was the inclusion of an assignment in which students

were to reflect on their own projects and learning. He also encouraged students to think of themselves as *"change agents"* and provided a reading on the skills required. Students were also encouraged to critique the subject and its framework Paul was more explicit about critical thinking in his subject outline.

Colin had a scientific approach to his subjects and critical thinking was seen to be essential to PBL. He emphasised the need to critically evaluate readings. He was not interested in subjective reflection and emphasised that objective reflection is only possible with background knowledge. For him inductive reasoning and asking interrogative questions were important for critical analysis. The main object of critique seemed to be articles or readings, in terms of whether their conclusions matched their aims, the suitability of the research design and statistical validity of results. This was a more quantitative approach to critical thinking with a need for *"innovation"* to overcome problems.

Critical thinking was considered to be very important by both lecturers and they expected students in third year to be familiar with the concept of critical thinking. This may be because the degree programs required development of six particular competencies for the student's profession, one of which is critical thinking. Both saw critical thinking as process, however each had a different interpretation of how the process worked. Both believed in the value of a well researched literature review and good design for student projects.

Both lecturers provided exercises or situations that fostered critical thinking, such as explanations or discussions in class or on Web CT. They set assessment tasks which required critical thinking, and provided readings which either presented different interpretations of critical thinking or explanations of how to read and write critically. Both lecturers provided detailed feedback for students, especially on marked assignments and both considered environmental protection, sustainability and broader social issues to be key concepts in their subjects. Some of the strategies used by Paul to encourage student critical thinking that were particular to his subject included: having an assessment task of a reflective document and asking questions through the Web CT. On the other hand, Colin put a lot of emphasis on equality between student and teacher

and deliberately allowed the students who were more obvious critical thinkers to answer questions first in class.

When speaking about the students' assignments Paul was interested in multiple objects of critique. For example, in reference to one assignment Paul used terms such as *"critique of concepts, ideas and practices"* of the organisations, government and the culture involved. He perceived that critical thinking was most evident in the processes, the Discussion section of the report and the Recommendations. In relation to the other assignment Paul thought critical thinking was demonstrated because the questioning of why a lagoon was so degraded, and investigation of its historic background. Sue had also used a wide range of methods to carry out her project.

Colin's comments about Maeve's assignment in his subject were that it showed social and cultural awareness and was *"contextualised"*. He did not comment about whether there was critique of the culture or the government but rather he perceived her critical analysis was mostly in the literature review of her report, while acknowledging critical thinking was evident throughout the assignment. With regard to Sue's assignment, Colin commented that it was her topic choice and design of her questionnaire in the Epidemiology project proposal, as well as her processes, which were evidence of her critical thinking. She also showed awareness of the *"social benefits"* of educating women about osteoporosis.

Differences and similarities in student perceptions

Themes about critical thinking from the students' perspectives were thinking outside the box, developing an argument, in-depth research, problem solving and reflection. Maeve explained critical thinking as thinking outside the box, and throughout her interview gave the impression that this also included presenting an argument and solving problems. She would have agreed with Sue in that she felt she had put forward a strong argument in both of her assignments, which justified why there was a need for change. For Sue, critical thinking amounted to all of the processes she had used in developing her point of view, including research and reflection. Mikaela's definition

was more scientific. She used the term deductive reasoning, and included both problem solving and in-depth research.

All three students felt they had benefited from the lecturer's feedback in terms of developing their critical thinking, however one would have liked more guidance and two students felt they had developed their critical thinking themselves to a large extent. The reflective document in Environmental Practice had helped develop critical thinking. The main themes concerning the ways in which students developed their critical thinking were through the feedback from lecturers and the types of assignments they were given, including reflective documents. The research projects gave them the opportunity to do some in-depth literature searching, to gain different perspectives and to design their own project tools, such as questionnaires. There was also opportunity for problem solving and developing an argument. These students did not mention the benefits of classroom discussion because they were external students and would have only occasionally been involved with classroom discussions.

5.2 Discipline Area: Environmental Engineering

The two environmental engineering subjects investigated in this section are taught at different universities, one at an inner metropolitan and the other at a regional university, in NSW. The first subject, Environmental and Sanitation Engineering, is a subject which can be taken in the fourth year of the degree and relates engineering principles to *"real life"* situations. Both students who were interviewed were completing a Civil Engineering degree. The second subject, Site Remediation, was also a subject which could be taken in the final year and the lecturer and one student, who had just completed an Environmental Engineering degree, were interviewed.

5.2.1 Environmental and Sanitation Engineering (final year subject)

Lecturer interview: Prem

Prem described this subject as one in which students need to learn how to design water treatment plants, and she perceived this to be the underlying assumption of the subject. However, she did not believe that a one semester subject was enough for most students to achieve this at a high level, so she was more interested in them developing an *"understanding of the design principles."*

However, Prem emphasised that environmental protection, sustainability and broader social issues were key concepts in the subject. She took a proactive stance on protection of the environment. That is, she said that we need *"to have an understanding that our activities have an effect…and even when we are pressured by issues such as poverty and globalisation and war…if you forget about the environment, you don't have anything to fight for."* She also made a clear link between the course and critical thinking. As she said: *"In Environmental Engineering there's big scope for critical thinking. We are part of the environment. I want students to appreciate the effect of what we do on the environment. Some students see this aspect as social science. I push the boundaries [in this regard]."*

Prem made the point that her definition of critical thinking was not a theoretical definition. She emphasised questioning, viewing information from different perspectives, and coming to one's own conclusion, based on evidence. As she explained *"critical thinking is not accepting something on face value, looking at it from all aspects, like 'left wing/right wing' and really discussing the issue, making their own opinion after the analysis, and discussing it at length. Even if the final discussion statement is the exact opposite to what was stated before…they have to provide evidence for that, say why."* Throughout her interview, particularly in relation to student assignments, Prem referred to reflection as an important aspect of critical thinking. She wanted students to reflect on, for example, their field trip to a STP, and not just critique it from a technical perspective. While the technical issues were considered to be important she also wanted students to think about it from their own point of view. She valued expressions such as *"I've changed my opinion, based on what I've read, what I've heard, what I've actually gone through analysing it."*

The strategy Prem used most for encouraging student critical thinking was classroom discussion. She enjoyed challenging the students at the beginning of the semester by putting a controversial question on the board and allowing free discussion of the issues. The two examples she gave were: *"Why are we running out of landfill?"* and *"When we have a sewerage plant discharging into the ocean, say Bondi or North Head, what do you all think?"* She wanted these questions to generate debate, and referred to one student who had said: *"I don't see any problem because the ocean provides dilution."* Other students said *"now that I am thinking about it I don't think it's a good idea because I think it all comes back. The ocean is also an ecosystem."* In these class discussions Prem did not express her views until the end of the discussion. She also asked the students to write half a page about *"what they actually know…I collect this half a page at the beginning of the semester and give it back at the end…I try and create awareness that we live in society.…One student said 'this is the first time in this course…I've really started looking at my way of life and questioning.'"* Prem referred to the challenging subject in first year engineering which was based on sustainablity and critical thinking. She believed this subject had developed students' critical abilities.

Another strategy that Prem had experimented with was to write more explicit instructions for assignments regarding critical thinking. She tried this in her other subject and found that the number of student assignments demonstrating critical thinking rose from an estimated 20% to 60%. She wrote critical analysis into the instructions for the main assignment and into its learning objectives. The expressions she used included: *"You are required to...critically evaluate the process with respect to developing a sustainable option for now and the future"* also *"to critically evaluate the current operations and waste management"* and *"to develop critical thinking patterns to solve waste management issues..."*. She concluded the instructions with the statement: *"This is an individual assignment, and the marks will be given for your* **critical evaluation** *of the waste management scenario, not just for collecting information."* These very explicit expressions of Prem's expectations encouraged more students to engage in a critical approach to their assignments, and she felt it had shown positive results.

In relation to the two assignments Prem had recommended she made the comment that *"these students were not necessarily high level students."* She referred to Roberto's assignment, which was a report on a STP, as one where there was critical thinking throughout *"in some parts more and in some less."* She also liked the fact that he evaluated the design of the water treatment plant and discussed how it could be improved. In her words: *"he did that as part of reporting about each process, which I thought was very good."* However, she had hoped that he would provide more detail in his analysis and said that his reflection and personal comments could have been more in depth.

With regard to Vittorio's assignment she added that he had researched references well and had *"used references, other books and texts to critically discuss the technology."* She emphasised that Vittorio had not been a student who put a lot of effort into assignments. In her words, he *"would do the minimum. He needed the experience of going out and reading and self learning to be able to be more confident."* Prem was impressed with his discussion of the political perspectives and said that she *"didn't penalise him for using the first person, because I didn't specify this. I left that open, I really wanted to see what they thought."* She also added that she would have provided a

lot of comments, or feedback, on the assignment because she said *"I like giving comments."* She also spoke about his personal reflection which was typified by statements in the assignment such as: *"I expected there to be a conveyor belt removing the particles caught on the screens. …but by seeing the operation of grit removal first hand provided me with a valuable learning experience."*

Student interviews

The semi-structured interviews with students began with a discussion about the assignment that had been recommended by their lecturer for demonstrating critical thinking. These were assignments that were of Pass and High Distinction level respectively.

Roberto

Roberto believed that his assignment had been recommended by Prem because his report had a good structure and he had explained the STP water treatment processes well. He added that he had taken notes when he visited the plant and that this had helped him to write his report, *"in the planning, it led me to expand more."* However, he was also able to reflect on his report and comment that he could have improved on his referencing. The part he thought was critical was where he *"[wrote] about what we learned about the whole process [and] analyse each part…we had to think hard about the process, what's the aim of the process, what's the whole idea of writing such a report?"* He thought that Prem was happy with his conclusions.

He believed that the frameworks for the subject were that students were expected to understand the technical aspects of waste water treatment because they may need this when they become a professional engineer. Even though Roberto had done another subject about hydrology he did not believe all students had done this so there was not an expectation of assumed knowledge in this area. He said that challenging information or *"add[ing] information from your point of view…depends on your understanding of the topic. If you don't understand the whole topic, if you haven't done full research of the topic, you won't be able to challenge."* He also recognised that the subject was *"very*

important…[and] helpful for Civil and Environmental Engineering. You need it to understand more about the environment - what causes pollution, and how can you reduce that pollution?"

Roberto's understanding of critical thinking was from the perspective of the processes he had gone through in putting his report together. He started with brainstorming, which he said was to *"collect ideas."* Then he asked himself questions: *"How are you going to find information? Where? How are you going to structure your ideas?"* He could see a strong link between research and the development of critical thinking and referred to his own inexperience in first year where he made the mistake of not narrowing the information to that which was relevant. In his words: *"I found irrelevant information and just put it in the report - big circle around it."* He admitted that that feedback had actually been helpful, and he also found reading the marking criteria a useful guide. He had found first year difficult because he was not used to consulting the marking criteria, or focussed on answering the question. With this report on the STP he acknowledged that it had helped his critical thinking because: *"we had to think about what were the conceptual issues, practical issues, environmental issues, and how it affected the neighbours around it. We had to think more."*

He thought students were encouraged to develop critical thinking in this subject by the actual wording of the question for this assignment and by brainstorming in groups. He admitted that working in groups can have its difficulties, for example *"they might like your ideas, they might dislike your ideas",* but this was something they needed to come to terms with for their future professional life.

In terms of lecturers' expectations of students' critical thinking ability, Roberto thought it was hard to determine exactly what was expected, but he did mention a first year subject which focussed on sustainability which had expected them to think. He explained that they had to *"bring ideas, put your point of view and talk, expand on the topic."* He said that it had been difficult to think critically and to think *"like an engineer",* because he had not experienced this at school. However, he had found it beneficial in terms of understanding the different expectations at university and the requirement to think and think critically about issues.

Vittorio

Vittorio's assignment was also about the STP. He believed that his assignment had been recommended because of his quality presentation, including graphics, and *"true and factual information"* with an accurate summary of what he had observed at the STP. He did consider that his recommendations were where he had demonstrated critical thinking, because they were a combination of his *"own personal opinions and collaborative thinking."* The collaborative thinking was the result of discussion between those who had visited the STP on the field trip. In particular he mentioned that they *"thought the smell would be a problem for those who lived in close proximity to the plant"*, namely the prospective new residents of the new development site nearby. Furthermore, he thought that his analysis of processes in terms of *"purpose…[and] reasons for maintenance, running effectively"* demonstrated his critical analysis.

Vittorio did not perceive that there were any frameworks or assumptions for this subject and even stated that *"there was no prior knowledge to study the subject".* He must have already completed the pre-requisites as part of his Civil Engineering course and thus did not see this as relevant. However, he did acknowledge that students needed to be aware of water treatment and where it occurs in Sydney. He explained that it was the processes of water treatment that the subject focused on, and that this was approached from a scientific understanding of assessing water quality. In his words: *"You are looking at water quality, it is more scientific."*

Vittorio was very clear about the role of engineering in terms of the environment and the community, though this seemed to be from a course perspective rather than a subject perspective. He believed that engineers need to be aware of the impacts of their decisions; they need to *"think smart and do things that will benefit society and not destroy the environment. In future we're going to have to be more conservative, more sustainable in what we design."* Vittorio's understanding of sustainability was to *"save resources for future uses and future generations."* He also acknowledged that engineers have to think of social issues, that is *"people".* He mentioned this in his assignment when referring to both the smell of the STP and its relationship to health, and the risk of

a chemical spill or leakage from the site to nearby residential land or the ecosystem and the effect this would have on people.

His understanding of critical thinking was related to problem solving, evaluating and exposing the truth. In his words it is: *"analyse problems more closely, extra research, effectively find solutions and reasons for the problem. You've got to be critical in the way you think - look at what points are good, what points are not so good, what are factual, what might maybe fully the truth. It's more about self understanding, the way you perceive points, so you've got to basically use your own knowledge…"*.

Vittorio had found the handouts given in class helpful, but more in retrospect after the field visit to the STP. This was mostly in terms of understanding the processes of water treatment. He did not feel that the students challenged the lecturer much because she was *"pretty much correct most of the time."* However, he believed that the engineering course had encouraged him to practice thinking more critically. He had also worked out for himself that he had become *"wiser"* as he progressed from first year to fourth year, and that he had *"started to pick up on ideas or ways to approach a problem."* He had also recognised that *"as you get older you start to question a bit more. The questioning of beliefs and asking why?"* He thought that researching on the internet had also developed his critical thinking and that he was aware of evaluating different websites. For example, he stated: *"If I want to look up sewerage treatment I won't be looking at international treatments because their standards are probably different to what we have. It's a bit of basic logic…you begin to research into … government authorities."*

5.2.2 Emerging Themes in Environmental and Sanitation Engineering

Because this was a technical subject, critical thinking was generally perceived of from a more technical point of view. Critical thinking, according to the lecturer, included questioning information from various perspectives and arriving at conclusions about it based on the evidence. The students' understanding of critical thinking was based more on the processes they had used. Reflective thinking in class and in written assignments was valued as an indication of independent thought. The development of students'

critical thinking was encouraged in the in-class discussions, and to some extent through the written instructions for assignments. Students believed they had developed critical thinking in a variety of ways, through a first year subject with a focus on sustainability and through processes such as brainstorming, group work and experiential learning from site visits.

This subject is predominantly technical in that students are expected to learn the processes of water treatment, which also has a scientific emphasis because of water quality assessment. However, they are also expected to be able to evaluate the effectiveness of that water treatment in terms of its environmental and social impact, especially in terms of water quality, and presumably in terms of economic impacts. Interestingly, there was not much discussion about the economic costs of water treatment in NSW, apart from a mention in both assignments that the STP equipment is very expensive to maintain. Vittorio also mentioned that funding for more staff in emergencies would be useful.

The lecturer and both students appeared to consider environmental protection and sustainability as the key concept or assumption of the subject, within the context of learning about processes of water treatment plants. Critical thinking about the design of an STP or the effectiveness of mitigation of environmental impacts was seen to be important by Prem. Both students appeared to have incorporated some reflection into their assignment writing. Prem's explanation of classroom discussions, and the comments made by the students, indicated that there is some reflective and critical thinking occurring.

Prem's perception of critical thinking involved questioning information about engineering processes, looking at different perspectives and coming to a conclusion about that information with evidence to support it. She thought that both the recommended students' assignments showed critical thinking about STP processes and she mentioned Vittorio's reflective writing in particular. Roberto's understanding of critical thinking was more in terms of the processes he had used to write his assignment, such as brainstorming and researching information. He had learned from first year that this also involves being able to narrow down the topic and only use relevant references.

Vittorio described critical thinking in terms of solving problems, evaluating, exposing truths and questioning.

Prem enjoyed encouraging student critical thinking in classroom discussion and debate and had found that when she included more explicit instructions regarding critical analysis for assignments, there were more student assignments containing critical analysis. The two students who were interviewed had different interpretations of what had encouraged them to develop their critical thinking. Roberto attributed this to the group work, though he did acknowledge that the wording of the question assisted, as did the marking criteria and the first year subject on sustainability. Vittorio thought the class handouts and field trip were the main stimuli for developing his critical thinking. However, all three of them indicated that the process of researching the literature was in itself a useful strategy for developing critical thinking.

In terms of assessing the assignments, Prem thought that the students had evaluated the design of the STP throughout the whole report and had critically discussed the technology of water treatment. She also commented on *"self learning"* which was demonstrated in reflective writing. Both of the students would have agreed with Prem about their evaluation of the technical processes, but also commented on the structure, presentation and recommendations of the assignments.

5.2.3 Site Remediation (final year subject)

Lecturer interview: Anneke

This subject was a fourth year subject that introduced students to the options for remediation of contaminated sites. In her interview Anneke referred to the fact that students need to be able to evaluate the technologies available in terms of their sustainability. In her words: *"not just chemicals to solve problems, but whether it's sustainable. Maybe good engineering has to solve problems, but there are consequences, they have to start thinking in the broader context. I think an environmental engineer should have the skills of not just doing what everyone does, but*

questioning." Part of this thinking involved students deciding whether the remediation process will have a worse effect on the environment than the impact of the contamination.

Anneke explained the framework of her subject in terms of her *"way of teaching".* She took a different approach to what she perceived to be the stereotypical method of teaching engineering, which was to teach facts, formulae and figures with an emphasis on problem solving. This approach was based on her experience of teaching at another university where she felt students were *"spoonfed"* and where the expectation was that civil engineers were not responsible for the environment, this was left to environmental engineers. In her words, *"due to the nature of the subject the students have to get into decision making...Here's a contaminated site. Who's responsible? What are the legal aspects? What technologies are available? What are you going to do?...I get them to challenge the normal approach, thinking out of the box and the implications. And I teach that engineering is often solving problems by creating more problems."*

Anneke's definition of critical thinking was very broad and involved questioning, researching different perspectives and justifying conclusions. She also included the context of sustainability. In her words: *"[a] good amount of skepticism, questioning, getting different opinions. Don't take the textbook as truth. Knowing that we never know everything. Embracing the process of finding out more. Not being afraid to say I haven't covered everything. Putting things in a broader context - social, environmental, economic. Bringing in well founded opinion."* Although she does not mention it here Anneke also included reflection on learning in her discussion about critical thinking (see below). Furthermore, she referred to a difference between a male and female way of thinking. She saw the linear, structured way as male and a more *"whole circle"* way as *"something the girls like."* She added *"I think we need to accommodate the girls in engineering and change that."*

In order to encourage her students to further develop their critical thinking skills, Anneke explained what she expected to her students and included reflection, brainstorming of solutions and discussion in her lectures. She admitted that she taught in a situation which was amenable to this style of teaching, because the class groups

were not large and the teaching fraternity appreciated innovation. Anneke also asked the students to do exercises in class that involved reading research papers and, in small groups, presenting evaluation of the paper. She also made her expectations explicit with regard to the assignment. For example she said *"I explain what I am looking for, how to find resources [and that] they need to evaluate them. In my lectures I try to talk to them so they will respect me but not put me on a pedestal of knowledge. I'm trying to encourage them to question the way things have been done, to live up to their own values."* Anneke included two specific aspects to the assignment process which could stimulate critical thinking. The first was to ask the students to add a half page to the end of their assignment which reflected on the resources they had used and what they had learned from doing the assignment. The second was to peer assess another student's assignment for its strengths and weaknesses.

Because Anneke had mostly taught 4th year and postgraduate students she had higher expectations of their critical thinking ability. She said she liked to *"adapt to the class, take them a step further from where they are at. It's hard when they are at 4th year level."* She had also recently taught 2nd year students and had found that their critical analysis skills were better than she had expected. However, in her questionnaire she had estimated that she only saw 10% of assignments containing critical analysis in her 4th year class. She had found that many students did not reference in-text and were likely to *"copy and paste from the internet."* She indicated that engineers in the workplace were inclined to do this as well. To improve this situation she took students to the library to explore resources and taught them how to reference properly.

She emphasised the importance of continuous learning and for this reason used an in-class exam for this subject's final assessment, with a mix of question types, some with calculations and some written aspects. These were assessed in terms of the thinking involved in the answer. According to Anneke, *"I know what I'm looking for - I'm really looking for the strategy/thinking and reward that. I reward them if they guided me through and really explained what they did."* In terms of the assignment Anneke admitted that she had *"vague, subjective"* criteria but stated that *"even when I read something a second time I come up with the same thing…it's almost an intuitive process."*

With the two assignments she had recommended as containing critical thinking, Anneke had found that each student had demonstrated critical analysis throughout the assignment. The first assignment by Stuart was about organic solvent extraction as a method for removing contaminants from soils, and the other student's assignment was about remediation of marine oil spills. She commented on the structure of Stuart's assignment, which she said shows *"the student has thought about the structure of what they want to cover before they start writing",* and the way in which he evaluated the information and *"processed it".* He had also written an effective Discussion, Conclusion and half page of reflection. She commented on his conclusions as being critical in that he had criticised the *"approach…, solvent extraction, which is something which is environmentally questionable."* In the other assignment she considered that the student had effectively examined the socio-economic and environmental aspects within an otherwise technical assignment. As she said, *"I remember her weighing it up - should we do anything about an oil spill? Should we treat it and have the impact of the treatment or should we just leave it and have the impact of the contamination? Valuable."*

Student interview

Stuart

Stuart had just completed his degree and had begun working at a local STP. He was a High Distinction level student who could have continued his studies as an Honours student, but chose not to at that time. His assignment was about extraction of contaminants from soil using solvents and it was based on a case study. He was surprised that his assignment was recommended, though he thought he had shown critical analysis in the Discussion where he had made an effort to be critical. In the interview he said that his conclusions about solvent extraction from soil were that *"it was a sustainable technology. While it might be a bit expensive it didn't create further problems…[It is] sustainable as long as it is managed properly."* He acknowledged that he had not just reported information but had thought about it critically. He also admitted that if he had had enough space he could have written a much longer reflection at the end of the assignment. One point that he made was that although he did not finish the

assignment until the day it was due, he had started it weeks before and it had been *"in my brain mulling over"* since then.

He saw the frameworks of the subject in terms of the three elements of contamination, site evaluation and clean up technologies. He explained this further in that students were to find out what had caused a contamination and what were its consequences. The questions that he mentioned for site evaluation that students had to think about were *"what do you do? What do you think? What's appropriate?"* In the discussion about clean up technologies he referred to the issue of budget constraints, and suggested that it would be possible to *"lobby and show that the long term benefits would outweigh the costs."* He then commented that there is now more awareness of sustainability, but that there needs to be a *"change of attitude"*. He added *"I don't think it's possible to be sustainable by destroying the world."*

Stuart was pleased that the Environmental Engineering degree he was doing had a focus on sustainability. As he said: *"our department has been really good at bringing things back to what is sustainable environmentally, socially and economically, which has to be a really big positive."* He did comment that this was not quite as much the case for Civil Engineering where students are *"more told, or shown how to do it…don't have to think about things".* He considered social issues, such as public health or safety, were also more important in Environmental Engineering.

Stuart's definition of critical thinking was inclusive of analysis, evaluation and asking questions. In his words: *"Analysing a source, or number of sources, deciding on its merits. A way of evaluating something, the pros and cons and what's missing? What should be there? What shouldn't be there? Looking for problems or positives. Finding faults in things, is it biased?"* He believed that they had been encouraged to challenge everything by Anneke and to be aware of bias, including in the media, and to think through the *"consequences of everything."* They were encouraged to look at *"the big picture"* and to ask questions. He also commented that site remediation is fairly new and constantly changing, unlike more traditional engineering subjects, and that the subject therefore lends itself to critical thinking.

Stuart believed that early subjects in the degree, such as the standard science subjects, were so technically based that they did not allow much room for critical thinking. However, he did say that subjects vary, as do lecturers, in terms of the amount of critical thinking expected. He also recognised that it was expected that students would *"improve, develop over time"* with critical thinking. Furthermore, he felt that he had improved by practice, in that the more he *"looked at things critically, the more effective"* he had become. He commented that the more effort he put into his assignments the better his critical analysis. As he said, *"In lots of essays there is the option of not really thinking about it, regurgitating what you read. Or you can evaluate it."* He felt that the research and information were important to being able to think critically because it is difficult to be critical without an understanding of the topic.

5.2.4 Emerging Themes for Site Remediation

One important theme to emerge in the lecturer's interview was the inclusion of skepticism in the concept of critical thinking and her application of this to the paradigm of the scientific model and its inherent linear thinking. More emphasis was placed on circular thinking and reflection with questioning of impacts as another important factor. Decision making was seen to be more relevant than simply applying technical knowledge. Classroom discussion and the approach to teaching were considered to be conducive to developing student critical thinking.

Both Anneke and Stuart seemed to agree that the subject Site Remediation had critical thinking and sustainability as essential themes. Stuart considered that the Environmental Engineering degree was based on sustainability, but that some subjects that were more traditionally scientific did not allow as much opportunity for critical thinking as this subject. Both of them emphasised questioning in their definitions of critical thinking. Despite this they identified different, yet compatible, frameworks for the subject. Anneke referred to her *"way of teaching"* versus a more *"spoonfeeding"* approach. On the other hand, Stuart emphasised the processes of learning about site remediation: understanding contamination, evaluating the site and the value of different clean up technologies.

Stuart saw critical thinking as analysis, evaluation and questioning. In his assignment Stuart had demonstrated critical thinking in arriving at his conclusion that the techniques of solvent extraction were sustainable as long as the process was adequately managed. He believed that Anneke had encouraged them to always challenge everything and look at the *"big picture"*. He differentiated between students who *"regurgitate"* and those who *"evaluate"*.

Anneke explained critical thinking as skepticism, questioning, researching different perspectives and justifying conclusions. She encouraged development of student critical thinking mostly in the classroom situation through in-depth explanation of what she expected in their assignments, and through discussion, brainstorming and debate. She also believed an egalitarian classroom was necessary, wherein the students would respect her but not put her on a pedestal. Students completed a task where they worked in small groups reading a research paper, critiquing this and presenting their critique to the class. Moreover, she also included a reflection requirement at the end of their assignment where the students were to reflect on their use of resources and learning from the process of doing the assignment. They were also marked for evaluating another classmate's assignment.

She assessed student critical thinking in terms of how they think through concepts and processes, and she believed that the two assignments she had recommended had critical thinking throughout with a focus on sustainability. She thought Stuart's assignment especially demonstrated critical thinking in his conclusions and the reflective section he wrote, and that the clear structure reflected his clear thinking.

5.2.5 Preliminary analysis of interview themes in Environmental Engineering

Differences and similarities of themes between lecturers

Although not as obviously delineated, there was a different approach to thinking in terms of technical information, linear scientific thought and expression of critical

reflection between the two environmental engineering lecturers. Anneke used the word "skepticism" in her definition of critical thinking and applied this to the approach of positivist science with its focus on technical detail as opposed to a more holistic approach to decision making. Although both lecturers actively promoted critical thinking in the classroom, Anneke described a more learner-focused approach to teaching.

The definitions of critical thinking provided by Prem and Anneke were very similar, except for the inclusion of skepticism by Anneke. Both included questioning, different perspectives on a topic, reaching conclusions and justifying them, and reflection. However, Anneke questioned the value of the linear thinking of many engineers with the focus of solving problems at a technical level, without reference to the socio-political context. Sustainability, the concept of balancing environmental, social and economic factors, was an underlying assumption or theme for both lecturers, and both of them mentioned that Environmental Engineering lends itself to critical thinking, because it is a relatively new field.

In terms of assessing critical thinking both lecturers looked for it throughout an assignment and Anneke emphasised how she expected to find evidence of their thinking. Both lecturers had fairly low estimations of the percentage of student assignments containing critical thinking, Prem estimating 30% and Anneke 10%. This was despite them having higher expectations and the fact that their students were final year students. However, Prem did notice that when she included more explicit mention of critical thinking in assignment instructions the percentage rose to approximately 60%.

Both lecturers encouraged student critical thinking largely through classroom discussion and brainstorming. Prem encouraged personal reflection in class and in assignments, where students were to express what they thought about, for example, the STP field trip. She referred to the benefits of the first year sustainability subject which developed students' critical thinking. Anneke also encouraged reflection, and included as a section of the major assignment a paragraph of reflection about the resources accessed and what was learned from this process. Both lecturers used groupwork to encourage discussion

and one student, Roberto, commented on the benefits of this. Both subjects included a field trip with a report as the assignment, however the difference in emphasis was shown by the fact that for Prem's subject this was worth 20% while for Anneke's subject it was worth only 5%.

Noticeable differences between Prem and Anneke's approach to critical thinking included Anneke's reference to the differences between male and female thinking. She also used an exercise where students worked in groups to critically analyse a research paper, and felt that this encouraged student critical thinking. She did not provide the students with marking criteria prior to marking in case they did not follow the written instructions for an assignment but only wrote to the criteria. Prem, on the other hand, did provide marking criteria with the subject outline and one of her students felt that this had helped his critical thinking. Anneke had included a requirement for students to write a reflective half page in their major assignment, and had awarded marks for their peer review of another student's work. She thought that this would help develop their critical thinking.

Prem emphasised the technical aspects of her subject when talking about the frameworks and assumptions, while Anneke referred to the teaching and learning aspects of her subject. Anneke aimed to work toward establishing an egalitarian classroom where the students would not expect her to have all the answers and while Prem did not mention this she did try to leave her comments on controversial issues until after the students had finished their discussion. Vittorio, one of Prem's students, had commented on how the lecturer was *"generally correct"*. This suggests that perhaps the students did not perceive that she was expecting them to develop their own thinking on a topic.

Differences and similarities in student perceptions

The three students who were interviewed had different perceptions of critical thinking, though each was grounded in the processes they had used to produce their assignment. However, a common theme was agreement that researching the literature was helpful

for developing their critical thinking as was discussion in class, particularly in smaller groups. The only comments about reflection were made by Stuart, who appeared to feel this was a beneficial part of his assignment.

Another noticeable difference between the engineering students was that Stuart always worked at a high level whereas Roberto and Vittorio did not, according to their lecturer. The latter two had apparently done particularly well in the assignment about the STP because it was based on a field trip, which they both appreciated, and had included researching literature and evaluating the processes at the plant in terms of efficiency and the impacts of the plant on the environment and nearby community. This seemed to provide adequate opportunity for critical analysis. It was the type of assignment which they felt encouraged critical thinking.

The three students had somewhat different interpretations of critical thinking, for example Roberto defined it in terms of the processes he had used to complete his assignment, such as brainstorming in groups and researching. He had asked questions while writing the assignment but these were questions relating to his own processes, including where to find information. On the other hand Vittorio emphasised problem solving and evaluating, as well as exposing the truth as aspects of critical thinking. Stuart referred to analysis and evaluation of the literature based on its merits and taking into account any bias, a somewhat similar approach to that of Vittorio.

In terms of developing their critical thinking the three students appeared to have benefited from searching the literature and evaluating the information. Roberto and Vittorio both agreed that researching and understanding a topic was necessary to be able to challenge information. Roberto mentioned the marking criteria and brainstorming in groupwork in Environment and Sanitation Engineering as being useful for developing critical thinking, and also referred to a first year subject about sustainability which encouraged critical thinking. Feedback on a first year assignment had provided something to reflect on as well. Vittorio placed more importance on sustainability and thinking *"smart"* so as to avoid destruction of the environment. For him critical thinking appeared to be closely linked to sustainability. He found the subject handouts and the field trip helped develop his critical thinking. Stuart thought that the Site Remediation

subject itself encouraged critical thinking for a number of reasons, including the newness of the subject content and Anneke's questioning approach. He commented that sustainability did not mean destruction of the environment. He also thought that simply practising thinking critically and putting more effort into assignments improved his critical thinking ability.

5.3 Discipline Area: Environmental Law

The two subjects that were investigated in this discipline area were Environmental Law and Planning and Environment Law. One lecturer and one student were interviewed for each of the subjects.

5.3.1 Environmental Law (final year subject)

Lecturer: Alex

The subject Environmental Law was a final year subject which focused on relevant legislation, for example the Environmental Planning and Assessment (EPA) Act 1979 and Environmental Protection and Biodiversity Conservation Act 1999 with a possibility of planning laws if there was time. It was presented in seminar format of two hours face to face teaching and learning per week. The last three seminars of the semester were presented by the students themselves, based on their own major research essay which was worth 65% of the total subject marks. Alex commented that environmental law is not focused solely on environmental protection. In his words: *"[it] is essentially anthropocentric [that is humans are central to the environment], notwithstanding that it is interesting to raise the challenge of an ecocentric framework [where humans are part of the environment]."* He gave an example of how this could raise debate in the classroom, especially when some of the students have an ecocentric perspective. He referred to the issue of the changes in the Land and Environment Court where it used to be necessary to have a business interest in a development to be heard, whereas more recently people can be called *"friends of the court"* and speak on environmental issues. He encouraged students to challenge the anthropocentric paradigm and believes that *"if you don't challenge, it's like turning a paradigm into law…it should be acknowledged."* He pointed out that the students in the first semester were law students, and in the second semester they were science students and made the comment that *"law students are more confident to discuss and debate."*

Alex's definition of critical thinking was discipline specific, with an emphasis on evaluation and questioning of the law in context. He thought that critical thinking necessitated *"constant consideration of expressed and implied objectives behind aspects of the law, and consideration of whether or not those objectives are achieved. If not - why not?"* He believed he made his expectations explicit to students through the objectives in the subject outline, and they were also *"implicit throughout the subject."* He stated that *"the students learn about the limited potential of the law in reaching various objectives, and the importance of politics."* Since this subject was conducted by seminar presentation, there was adequate opportunity for discussion and debate of issues. Alex emphasised that students were encouraged to *"express their own views and to question"*. He explained that critical analysis is very important in the study of law, because the law is not *"clear, there is greyness and embedded rationale"* and students need to be aware of this. He further explained his perspective about the study of environmental law in the statement *" a lot of Environmental Law is statutory, with an emphasis on biodiversity law…I tend to approach law from a social-contextual (transdisciplinary) point of view."*

Alex had mostly taught students in their final year and had found that *"later year students think more independently."* In response to a similar question in the questionnaire he had also pointed out that the expectation of critical thinking was to some extent dependent on the subject and even on the type of assignment, particularly in research essays in his subject. Alex explained his approach to assessment of critical thinking in discipline specific terms. He expects students to *"go beyond mere description of the law and its application, to consideration of the purpose of aspects of the law, whether the purposes are desirable and on what basis does one decide on their desirability?"* This implies that students not only need to understand the legislation about environmental issues and how it works, but to assess whether it really achieves environmental protection for the land/client in question. Alex raised the issue of ESD, which he defined according to pollution legislation. He stated that the concept of ESD is the underlying concept of his subject but that he has *"a cynical attitude"* overall. He added that *"ESD has attracted a lot of rhetoric - it is a good concept but achievement on the ground is another matter…The trouble with ESD in law is that it is merely something decision makers and planners 'consider', not 'embrace or adopt'."*

A research paper was the major assignment for this subject and students chose their own topic, in consultation with the lecturer. He commented that some students *"choose straightforward legal issues because this is easier",* but Jeremy had chosen a difficult topic. However, Alex was aware that critical analysis came *"naturally"* to Jeremy from his contributions in class and that he was a hard worker. He believed that critical analysis was demonstrated throughout the entirety of Jeremy's assignment.

Student interview

Jeremy

Jeremy was a high level student who had completed this subject in the final year of his four year Honours course. He had also adapted his research paper, on the topic of "public nuisance" for publication. However, for this research study his original paper was discussed in the interview.

Jeremy's assignment examined the legal complications concerning a person's right to sunlight on their property. Jeremy believed that his assignment was recommended *"because of its high mark, rather than the critical thinking...".* He did admit however, that higher marks could *"correlate"* with how well a student raises questions. He explained that in his essay the *"critical analysis comes after I outlined each of the relevant principles of the tort of public nuisance. I note the problems, and the potential difficulties that may be involved in applying the principle."* He acknowledged that many students become focused on the practical aspects of the law whereas it is *"the problems of applying the law...that actually demonstrate the critical analysis."* He added that it is often the philosophical issues with regard to the law which raise critical questions, that is *"philosophical issues are more concerned with the broader socio-economic and political contexts of how laws operate, and why we have that law; what that law is for."* He thought it was helpful to have a philosophical *"bent".*

Jeremy explained that in the early seminars for this subject the students are encouraged to think in terms of challenging their *"preconceived ideas"* about how environmental

law functions. He described how the *"focus of environmental law has shifted as society has developed, and …the social, political and biological views of the environment have changed greatly."* By this he meant that the previous emphasis on environmental law being only under the statutory jurisdiction of judges has changed because judges could not make changes to the law as quickly and appropriately as the government could. He explained that judges can also *"have very different views…a lot of them have economics training, and they can come up with an economic bent. Others can be very right wing, or can place a very high premium on environmental considerations, and others that the individual has the right to do what they want on their own land…That's one of the reasons the judges haven't been able to deal with environmental law."*

Jeremy also pointed out that sustainability and protection of the environment were stronger concepts in his science degree than in law, but acknowledged that law students are *"encouraged to realise that those values are behind the law, and [that there are] good reasons for this."* However, he did have a critique of the law in relation to environmental issues and said: *"some laws are bad in that they ignore the reasons, misinterpret them."* His understanding of environmental protection was similar to his understanding of sustainability and included a variety of approaches. He differentiated between those who want to control the environment for development purposes, those who want to *"ensure that an environmental resource remains a useful resource"* and others who believe that the environment should be preserved for its biological diversity or cultural and aesthetic qualities. His personal opinion was that land use would be more effectively controlled in private ownership than public ownership.

Similarly to Alex, Jeremy made it obvious that he did not like giving definitions *"because you could be wrong"*. However, he explained critical thinking in terms of analysis and logic, which he thought involved the application of logic to problems to evaluate whether there is consistency in the legal approach and to uncover *"unknown"* relationships. For example he said: *"there's often great value in showing two or more concepts are actually related, or correlated, or that several ideas are actually part of the one idea…such as with fault liability."* He thought that he had had useful *"training"* in the application of logic in his science degree but did not feel the necessity to have *"training in the rules of logic,"* rather to put it into practice. He also commented that all

students are capable of developing logic if they are *"encouraged and stimulated"* but admitted that students can complete their degree without it.

Jeremy thought that many subjects in law encouraged students to *"think about problems"* and that discussion was the main strategy employed to do this. In this subject he especially appreciated the seminar approach and felt that Alex *"[presented] guided discussions… [which] encouraged students to express views, analyse."* He believed that in this subject, and in the course, the students were encouraged to challenge *"ideas and assumptions that are commonly held about legal issues and environmental issues."* He added *"if you don't have any idea about the way law operates in society, you don't have any way of assessing what good law is, what bad law is."* He gave an example of this, *"they may say that promoting economic efficiency, particularly relevant in the environmental context, is a good idea. You can challenge this."* He admitted that many students are averse to doing this because they just want their *"piece of paper"* at the end of their degree and they believe they do not need to put in this extra effort to gain a pass.

As was indicated above, Jeremy spoke about critical thinking mostly in terms of logic and analysis/evaluation, which he believed he had learned to do in his science degree. He stated: *"Some may say it's an innate ability. To me you actually develop through exercising the skills, seeing how others do things. Imagination - whether or not imagination has some correlation to your ability to analyse. The lecturers want to see consistent argument and logical argument."*

Jeremy made a clear statement that lecturers do not have high expectations in the first year. He also pointed out that students are different in terms of their approach to critical thinking. He stated that: *"as a whole students become more confident. Some don't develop much - they find it boring because they see it as a waste of time to critique. They just want to know what the law is and apply it."*

He mentioned that student reflection is also an expectation in law, reflection on their own experience of being in a law practice and reflection on the actual *"operation"* of the law. Jeremy continued to say that *"there's different degrees to which people reflect on themselves, some people don't seem to at all. It has been suggested that the ability to*

reflect on one's own abilities and limitations is one of the most unique aspects of consciousness. For example, brain damaged individuals tend to have this ability compromised, changed, lost. It's often the function that is compromised first, which suggests that it may be among one of the higher order functions."

5.3.2 Emerging Themes for Environmental Law

A theme that became apparent in this subject was that critical analysis involved questioning the effectiveness of environmental laws to protect the environment. This involved questioning of the paradigms and ideology behind the law as well as logical analysis of the application of the law. There was a strong suggestion in this subject that environmental law is limited in the way in which it is constructed and interpreted, for example the token commitment to ESD. Definite strategies were used to encourage student critical thinking such as guided debate in class and particular challenging assignments. Reflection on one's own learning was seen to be higher order thinking by the student, though not necessarily interconnected with critical analysis.

Alex clearly established that the subject was based on an assumption that environmental law is anthropocentric. He expected and encouraged students to challenge this from an ecocentric framework and was always pleased to have students raise this as an issue in the class discussions. Jeremy agreed that students in this class were encouraged to challenge the common assumptions about environmental law but did not specifically mention the anthropocentric paradigm. Both Alex and Jeremy saw environmental protection as an important assumption in the subject, though Jeremy pointed out that this was more obvious in his science course than in his law course generally speaking. He added that some environmental laws actually ignore the fact that they were established to protect the environment. This is a similar theme to a comment from Alex that planners and politicians only need to take environmental protection into "consideration", according to the law, rather than take it seriously. Both of them were aware of the limitations of the law in terms of effectively protecting the environment, and that it can misrepresent the objectives behind the law.

Both Alex and Jeremy were hesitant to give definitions, and both consistently used the term critical analysis rather than critical thinking. Alex was more focused on evaluation and questioning of the law in his perception of critical analysis while Jeremy spoke about analysis and logic. However, Jeremy did explain that students need to evaluate the logic of problems and to uncover the unknown relationships between ideas. The latter could be seen as a questioning process in itself, and in his interview Jeremy made reference to the questioning of the effectiveness or value of a law. Both of them also referred to questioning as important for critical analysis. A common theme in their perception of critical analysis appears to be evaluation of the law and questioning of its effectiveness in doing what it is supposed to be doing, despite each of them using different terminology. Alex mentioned that students need to be aware of the potential influence of politics, and the limitations inherent in the law.

Although Alex did not mention reflection as part of the process of critical analysis, Jeremy referred to reflection in relation to students developing their own thinking abilities. He described this as a part of the course where students have to do work experience in a law practice, and they are expected to reflect on their experience, how they adapted to the situation, and on ways in which the law functions. He made the point that some students are not very reflective about their own experiences.

Alex had an expectation that students would demonstrate critical analysis by their final year of study, but felt that this varied according to the subject and even the type of assignment. He made this expectation clear in the subject outline and believed it was implicit throughout the entire subject. Jeremy indicated that in general the lecturers in law expected students to develop their critical analysis over time. He again commented that some students consider it a waste of time to critique, they are only interested in putting the law into practice.

Both Alex and Jeremy agreed that the seminar style of face to face teaching encouraged discussion and debate, which in turn encouraged critical analysis. According to Jeremy this was the preferred style of teaching in the law course and this supports Alex's observation that the law students he had taught were more comfortable in a debating

situation than science students he had taught. Nonetheless, it would appear that the seminars were helpful for all students. On the other hand, Jeremy commented that some students are mostly interested in simply knowing what the relevant law is and how to apply it. He indicated that they do not want to go to the extra effort of questioning the effectiveness or value of that law. They do not want to challenge the assumptions behind the law and the practice of the law because they believe they can pass their degree without doing this. Both Alex and Jeremy agreed that some students in this subject chose topics that were only related to basic law and its application.

5.3.3 Planning and Environment Law   (3rd year subject)

Lecturer interview: Matt

Matt had not described the subject himself but comments from the student, Jasper, gave some insight into the content and approach in this subject (see below). The importance of language and good language skills was emphasised by Matt. He made the comment that *"in law if you change one word you can totally change the whole meaning,"* and he considered the *"mastery of words"* and *"precision"* to be more important in law than in any other discipline. He compared his previous experience with Economics where he believed that *"slaving over the words is not so vital."*

Matt's definition of critical analysis, rather than critical thinking, emphasised *"good logic in the analysis."* He also revisited his previous point about the importance of language and stated that *"once you start thinking about every word, every sentence, what every sentence means and what every word in that means, then that's at the heart of critical analysis. A lot of students who don't engage very well in critical analysis will have sentences that don't really link to the previous sentence…[students] need to understand what they're reading and to go beyond copying and plagiarising."* He also referred to being *"able to come to some conclusions, based on the ideas discussed"* and that these conclusions need to be based on evidence.

The strategies Matt used for developing student critical thinking were mostly through discussion in class and by providing feedback, both oral and written. He also commented that the way the law course was conducted was conducive to encouraging students to think critically. He added that *"you ask students questions and they give an answer that's imprecise. Then you force them to see the confusion, that they don't know what they're talking about."* He hoped that by demonstrating the importance of thinking, students would improve. However, he admitted that this only happens *"occasionally."* In terms of whether the type of assignment, and the instructions, might have encouraged critical analysis, he did not consider this relevant for Jasper's assignment because Jasper had chosen his topic himself, in consultation with Matt.

Matt made it clear that he expected students to improve in many ways from first year onwards. He stated: *"I think that the expectation of coming to grips with ideas and being precise is something that we all are training them in from the start."* He emphasised the fact that it is assumed that law students are reasonably high level students, because of the high university entrance score needed to study law. He commented that the students who have the most difficulty are those from other language backgrounds. The implication in his interview was that most law students should be capable of critical analysis.

In answer to the question about what he had expected in this assignment, he indicated how he would assess assignments in general. He stated: *"really basic things that I expect, which a lot of students in even later year subjects are not very good at, is correct spelling, correct grammar, punctuation, paragraphs that are sensible and a structure to the whole thing....If you get a student who can do all of that and can do it properly then they've already got an acceptable assignment. Even without having regard to the quality of what they actually say, if they've got an appropriate structure it's going to give them a reasonable mark. But for a good mark you've got to look at the quality of what they're saying, and that the conclusions follow from the evidence."*

Jasper's assignment had received a mark of 38/40 and was considered a good assignment based on an individually devised topic. However, Matt did not have much to say about the success of the assignment or where critical analysis was demonstrated. He

commented that *"it was quite a good topic",* and in terms of the sources Jasper had used Matt said: *"it's probably just a normal list of sources...but on reading it it's fairly clear he actually has read, hasn't just glanced at the cover."*

Student interview

Jasper

Jasper was a third and final year Law student who had chosen to do this subject more for the planning aspects of the subject than for the environmental law aspects. However, he discovered that this was not the main thrust of the subject. He said: *"I hoped we were going to cover planning regulations a lot more because I thought that would be a useful skill to know, like how the local governments decide these things. We did cover that, but the lion's share was on environmental law.... I can't say I thoroughly enjoyed the subject matter. I am now aware of the different laws...[and] I am interested in environmental issues, but it's not really something I want to do subjects in...[though] I wouldn't mind being involved in the litigation side of things, procedural law and how these groups can protect the environment."*

Jasper's assignment was on the topic of the eligibility of individuals and environmental groups, like the Australian Conservation Foundation (ACF), to sue organisations for breach of environmental laws. He said he was interested in this topic because *"[it] also applies to other subjects. So I thought this was a useful thing to know."* He thought it had been given a High Distinction because of his inclusion of primary sources and his reference to the practices in other developed countries. In his words: *"I think the best parts were where I examined the high court cases of an issue and then compared it to the more recent Federal Court decisions.... [I evaluated the law] when I compared it with overseas decisions...this was where I'm signalling where we might be going and why we might be going in that direction."* He added that because *"standing to sue in environmental litigation is a global phenomenon, I was able to look at what other countries were doing...I did a lot of reading."* He believed that he had used a critical approach in his assignment because he examined *"what the cases are saying, why they*

are saying that, why we've reached that point, why we might need change and what that change might look like and why." He was clearly interested in the future, and had a questioning approach to the topic.

Jasper did not believe that there were any theories or frameworks or underlying assumptions for this subject, because *"every issue can be argued either way."* He acknowledged that it was the quality of the argument that was of most importance. Jasper gave the impression that in Planning and Environment Law there was a greater expectation that students would think critically because of the nature of the subject. He explained that *"the discussions were more geared towards critically analysing why the law is like that, or why a regulation took a certain form, which hasn't been the case for a lot of other subjects."* Broadly speaking Jasper thought that environmental law had become a lot more *"fashionable in recent years. There's more firms…forming environmental law departments because…more law-breakers need more representation. There's a lot more money in it now. I wouldn't say there's less written about it than other areas, it's about even I'd say."* In comparing Planning and Environmental Law with other subjects Jasper thought it allowed for more critical thinking than say *"Company Law or Tax Law where it's just cram everything we can into 13 weeks and then you can think about it at the end of the semester."*

Jasper defined critical thinking in terms of questioning. In his words: *"I would think it is looking at the reasons behind a particular position and not just accepting it; questioning a particular position; looking at the negative points regarding that position."* He demonstrated this in describing his approach to the regulations regarding *"standing to sue"* in his essay (see above).

When asked about how the lecturers encouraged student critical thinking Jasper replied: *"I'd say they don't. The way they encourage you is with marks after you've done it."* However, he did refer to one lecturer who he claimed used to be a high school teacher, who *"really wants you to do well and gives you a very good indication of what she's looking for. She encourages it in that respect."* Jasper did recognise that he had improved in his critical thinking compared to previous years when he had *"been relying on secondary materials for the essays…. I wasn't looking at what the judges had said*

and making up my own mind, I was looking at what other people had said and accepting their point of view."

Jasper did not think it was the level of study that determined lecturers' expectations regarding critical thinking. He felt that this depended more on the subject and the lecturer him/herself. He did state that *"in first year they didn't expect too much. I guess law is so different from a lot of other disciplines and they knew people were trying to come to terms with just being in first year...but that changed a lot as you went on. I think it depends on the nature of the subject...where [even in final year subjects] just the sheer volume and complexity [of the information meant that]...you only had enough time to get out of it principles, not enough time and space to argue it."* To illustrate this he gave Tax Law as an example of one subject which did not allow time to think critically.

5.3.4 Emerging Themes from Planning and Environmental Law

Although the subject outline indicated otherwise, the interview with the lecturer did not reveal any particular attitudes toward ESD, interdisciplinary themes or connection between environmental law and socio-political contexts. Instead the main themes relating to critical analysis were focused on the technicalities of language use, logical analysis and reaching conclusions based on evidence. In terms of assessment of critical analysis the main theme related to precise and correct use of language and it was acknowledged that this caused difficulties for students from language backgrounds other than English (LBOTE). The student's perception of critical analysis was related more to questioning. The seminar approach was seen to lend itself to discussion and debate, though the lecturer took a teacher centred approach to the expression of critical thinking. Another theme was that law students do not need to be taught critical thinking because they have entered university with a high entrance score.

The subject outline indicated that the framework and assumptions revolve around the understanding and evaluation of the law in relation to protection of the environment, including natural resources and heritage. For example, the second week topic was about

ethics and the rights of nature, and that section of the course was called: *"Interdisciplinary Perspectives"*. However, in his interview the lecturer did not refer to this and spoke about the need for students to have good language skills. He made a direct link between this and the demonstration of students' critical thinking. The student did not think there were any assumptions in this subject, other than the need for students to develop a strong argument and some expectation to critically analyse environmental laws.

Both the lecturer and student used the term critical analysis instead of critical thinking. For Matt critical analysis was displayed in quality logic and analysis. This was in turn reflected in a student's assignment through the structure and precise language, that is the ability to read, understand and write about planning and environment law issues in his/her own words. To be able to link ideas and come to conclusions was important in demonstrating critical analysis. On the other hand Jasper emphasised the questioning process, examining what is behind a position and finding the problems with that position.

While the lecturer expected students to develop their critical thinking from first year onwards, the student believed that most lecturers did not expect much critical thinking in first year and while they might expect improvement, this varied according to the subject and the lecturer. He gave examples of various subjects which either lent themselves to critical analysis, Planning and Environment Law being one of them, and the majority of other subjects where too much information had to be learned to allow time for thinking, or critical thinking. The implication was that because most law students enter university with a high university entrance score (UAI), they should all be capable of critical analysis, though there was some acknowledgement that this is more difficult for LBOTE students given the emphasis on correct language.

The lecturer had very definite methods of question and answer in class, which he indicated that others in the faculty followed. Small seminar groups are more conducive to discussion and debate and consequently Matt would expect students to demonstrate thinking in their answers. He gave feedback in class, from a teacher centred perspective, and on essays. Jasper, on the other hand, did not perceive that in general the lecturers in

law explicitly encouraged critical analysis. He implied that while it may be an expectation it was only through feedback, after the assignment was handed back, that students would find out whether they had been critical. He did acknowledge that this subject had an emphasis on critical analysis in the class discussions, unlike a number of other subjects.

5.3.5 Preliminary analysis of interview themes in the discipline of Environmental Law

Differences and similarities of themes between lecturers

Perceptions of critical analysis were quite different in each subject in the discipline of Environmental Law. In the first subject the emphasis was on questioning and evaluating the law in terms of its effectiveness regarding protection of the environment. The underlying themes relating to critical analysis emphasised the limitations of the law and the paradigm behind it. However, in the second subject the major focus was critical analysis as logical analysis and reaching conclusions with the technicalities of language playing an important role.

The main difference between the two lecturers' approaches to Environmental Law was their perception of critical analysis, and their emphasis in their interview on the importance of environmental protection. For example, Alex's definition of critical analysis was in terms of questioning and evaluating environmental laws. He emphasised the assumption of the anthropocentric paradigm in current environmental law, and how he wanted students to challenge this from an ecocentric perspective. In contrast, Matt's definition was more generic and included logic and analysis, and being able to discuss issues to reach conclusions. He emphasised the importance of higher level language skills as a necessary component of critical analysis in law. In his interview Matt did not relate critical analysis to environmental protection, his perception of assumptions for the subject also revolved around writing skills and the importance of precise expression in the discipline of law.

Alex had mostly taught final year students and noted that they showed independent thought by then, but he indicated that in general his expectations of students demonstrating critical analysis varied according to the subject and even the type of assignment, rather than the year of study. On the other hand, Matt implied that all law students should be capable of critical thinking because of the high university entrance score required for law, and he expected them to improve from first year. According to Matt, the only students who might have difficulty were those from another language background.

With regard to assessment, Alex stated that he was looking for more than description of laws but rather evaluation of the purpose of a law and whether it was effectively doing what it claimed to do. Jeremy had done this, throughout his assignment. Alternatively, Matt reiterated his previous statements about writing skills and emphasised good grammar, spelling, punctuation and especially structure. In his comments about Jasper's assignment he did not mention these aspects and in fact had very little to say about why he recommended the assignment, other than the topic was appropriate and that Jasper had obviously read the references. This was surprising when the assignment appeared to have critically analysed the inadequacies of the Australian rules for standing to sue, compared to overseas legislation.

In terms of encouragement of student critical thinking Alex took a slightly different approach to Matt in that he appeared to actively encourage debate and discussion amongst the students, particularly in relation to the paradigms mentioned above. He actually stated that he encouraged students to question issues and express their own opinions, which was a more learner centred approach. This theme was reinforced in Jeremy's interview. Matt took a more teacher centred approach in asking students questions and leading them through the thinking process by his somewhat challenging responses. Matt also mentioned that he gave feedback, both orally and on assignments.

However, there were several similarities in the approaches of the two lecturers. For example, both lecturers generally preferred the term critical analysis to critical thinking. Alex mentioned the role of politics in his definition of critical analysis and Matt included the concept of the role of politics in making environmental laws in his subject

outline. Both lecturers also made reference to having an approach that was transdisciplinary or interdisciplinary. Both considered the seminar style of weekly class to be appropriate for the development of student critical thinking because of the opportunity for discussion. Alex's subject had a two hour weekly seminar, and Matt's subject had a three hour weekly seminar and both lecturers expected students to demonstrate critical thought by their final year.

Differences and similarities in student perceptions

Jeremy and Jasper had somewhat different perceptions of critical thinking, Jeremy focusing more on analysis and logic, and uncovering the unknown. On the other hand, Jasper's definition was more related to questioning, and *"look[ing] for reasons behind a particular position."* Jeremy also referred to the need for reflection in the course when students work in a practice and have to write about their experience, though he did not relate this to critical analysis. Jeremy and Jasper both tended to use the term critical analysis rather than critical thinking. In addition, they both recognised that the seminar situation and the subject matter of environmental protection legislation were conducive to developing student critical analysis.

They had different impressions of how they were encouraged to develop their critical skills. Jasper, for example, said that the law lecturers did not encourage critical analysis, except via their feedback on essays. Jeremy specifically mentioned the fact that Alex presented guided discussions and encouraged the students to express their own views and analyse legal and environmental issues. In terms of their assignments they both felt they had incorporated critical analysis throughout the assignment, but described this specifically in relation to their topics. Jeremy indicated that he had applied critical analysis after every principle he discussed regarding public nuisance and that he had raised the potential difficulties in applying the law. In relation to how he had expressed critical analysis in his assignment, Jasper emphasised that he had used primary sources and had compared Australian legislation with overseas decisions, which allowed him to evaluate that legislation and ask questions about the future. He also admitted that he had done a lot of reading. Jasper reflected on his own development of critical analysis from

first year, in that now he came to his own conclusions about issues whereas previously he had relied on secondary sources.

The next chapter presents an analysis of the written expression of critical thinking in documents. The documents include subject outlines provided by the lecturers as well as student assignments. This third phase of the research completes the findings and provides a triangulation of data with the questionnaires and interviews (see Chapter 3).

CHAPTER 6: FINDINGS FROM DOCUMENT ANALYSIS

6.0 Introduction

The data from questionnaires and interviews were coded according to categories in the previous two chapters, followed by preliminary analysis. In this chapter selected documents from the three target discipline areas within environmental education are analysed. Subject outlines and student assignments were the documents chosen to further explore the lecturers' and students' written expression of critical analysis. Subject outlines were reviewed in terms of whether they mentioned or explained critical thinking, either in the aims or objectives, assessment tasks, marking criteria or in specific readings or resources listed in the outline, or in extra reading information provided separately. Assignments were primarily analysed in terms of the object and content of critique as well as how critical thinking was expressed as evaluative language, using discourse analysis as described in Chapter 3.

In the first section of this chapter the subject outlines are grouped according to discipline areas, with a total of sixteen from Environmental Science, two from Environmental Engineering and three from Environmental Law. Various terms were applied to critical thinking including such phrases as *critical analysis, critical evaluation and critical appraisal*. In this chapter, the term critical thinking is used to cover all of the above. Subjects are titled in terms of the major aspect of the topic, rather than their actual subject name, in order to maintain a degree of anonymity. However, where the lecturers were interviewed the subjects are fully named. The subject outlines are reviewed in terms of references to critical thinking in:

(A) aims and objectives, or course description,

(B) instructions and assessment tasks,

(C) criteria for marking assessments, and

(D) extra readings or resources in terms of explanation/s and approaches to critical thinking.

In the second section of the chapter, the Conclusions of six of the recommended student assignments are analysed, two from each of Environmental Science, Environmental Engineering and Environmental Law. The Conclusion was identified as a section of an assignment that often contained evidence of critical analysis. The student assignments that were recommended by the lecturers were examined with regard to the following aspects:

(A)   grade achieved

(B)   object of critique/evaluation

(C)   content of critique/evaluation

(D)   and the expression of critique/ evaluative language.

The terms critique and evaluation are used interchangeably in this section of the Findings because critical thinking is commonly interpreted as evaluation (see Chapter 4), and because the term 'evaluative language' is used in Appraisal Theory to represent critique (see Chapter 3).

6.1 Subject Outlines:

6.1.1   Discipline of Environmental Science

Twelve of the environmental science lecturers sent copies of their subject outlines, however, in one case four subject outlines were sent by one lecturer. Also five lecturers sent copies of other reading and resource material about critical thinking for student use in their subject.

i. Environmental Management (second year subject)

(A) The learning outcomes for this subject included one which focused on students developing the ability to critique articles and think critically about environmental problems.

(B) Assignments were based on a field trip, practical sessions and tutorials, with a final exam. Questions for tutorials and lecture topics were worded to encourage students' critical thinking about environmental issues, for example: the issue of taking an anthropocentric versus ecocentric approach, issues about population and the environment, and political issues.

(C) Marking criteria included a category for critical thinking.

(D) A very extensive reading list was provided for students with certain topical readings assumed as background information for examinations, including challenging authors such as Sharon Beder. However, there were no readings recommended about critical thinking/analysis.

ii. Environmental Science (first year subject)

(A) Critical thinking was not mentioned in the aims or objectives, however problem solving was clearly required.

(B) Assessment included a final exam, presentation, essay and practical tasks to be done at home. Presentations were peer assessed and lecturer assessed, and the essay was required to demonstrate *"critical discussion"* about the item they had chosen to examine from the popular press or scientific magazines. The subject was of one year duration and in the second semester students were assessed via oral debates and practical/field trip reports, together with a final exam. Very clear instructions about debating were also given.

(C) Criteria for marking were initially explained in terms of grades. Only Distinctions (D) and High Distinctions (HD) referred to some aspect of critical thinking, yet in the questionnaire this lecturer estimated that critical thinking was demonstrated in all of the students' assignments in the subject.

(D) A short list of textbooks and additional library books was provided with useful internet sites included. However, there were no overt references provided for students to further explore the concept of critical thinking.

iii. Geology and Environment (year long subject)

(A) In the subject objectives it was mentioned that, among other skills, students needed to demonstrate willingness to uncover different ideas, and to be able to be critical of them. The first semester of the subject included a critical review exercise and discussion in class, and mentioned library research as a *"very important aspect of the subject."* The subject outline for the second semester included in its objectives that students *"should learn to: critically evaluate published information"* and be *"open minded towards ideas and other people's views, but scientifically critical in their assessment of these."*

(B) The first semester outline of the subject referred to an examination worth 50%, with a report on fieldwork related activities, worth 35% and an inventory report (15%).

(C) No marking criteria were provided.

(D) No extra readings about critical thinking were referred to.

iv. Biology (second year)

(A) In the general objectives it was clear that students were expected to *"be able to… criticise scientific reports"* with regard to their *"experimental design"*. In the outline of lecture topics *"critique of experimental design"* was mentioned.

(B) A quarter of the assessment marks are given to *"critical evaluation of an experimental design"*, with another quarter of the total marks awarded to a laboratory exercise and the remainder to an examination.

(C) Marking criteria were supplied for the possible grades for the task of *"critical evaluation of an experimental design"*, though no overt mention of critical thinking was included. It was implied in the HD description where it was stated: *"all obvious faults in experimental design and interpretation identified…"*. Similarly it was implied in the description of a D grade.

(D) No references or readings about critical evaluation were supplied.

v. Geography and the environment (first year)

(A) Despite a very comprehensive set of information, there was no mention of critical thinking as an objective or skill for students to master in the subject outline.

(B) Assessment was based predominantly on essays and an exam worth 25%, with workshop preparation, such as answers to set questions, also being marked. Assignment questions promoted critical thinking, especially those which asked for debate, specifying points for and against. However, this was implied rather than stated.

(C) Criteria for marking of essays were very focused on quality of argument and evidence provided, and while there was no actual phrase "critical thinking/analysis" mentioned, it was implied.

(D) Several readings relevant to the issue of sustainability were suggested for each tutorial or workshop, but no references were given about critical thinking.

vi. Environment and technology (postgraduate)

(A) The subject outline was written directly to students in an informal manner, using the first and second person. To illustrate: *"Energy is used as one of the themes of the unit because it is a marvelous example of a technological tool that now shapes the society we live in, yet causes enormous environmental problems. We will look at conventional energy supply…and at renewable energy."* The first aim included *"critical evaluation"* of the role of technology in environmental issues, including the positive and negative aspects. Technology was seen to be *"an application of science"*, and different approaches and arguments about environmental damage were enumerated with emphasis on students developing their own argument.

(B) Assessment included minor and major essays, poster, class exercises, group project and seminar. Assessment of essays was clearly outlined with explanation of what the lecturer was expecting, including *"critical appraisal"* of literature, with *development of argument.*

(C) No marking criteria was supplied for this subject.

(D)   No references were given for critical evaluation/appraisal.

vii. Environmental chemistry

(A)   The learning outcomes did not mention critical thinking, though they did include understanding of human impacts on water, soil and air. The subject was completely scientifically based.

(B)   Assessment was via laboratory reports and exams (including essay and problem solving format). Exam papers that were supplied indicate an emphasis on technical scientific knowledge, with some questions lending themselves to promotion of critical thinking. For example, *"The 'greenhouse effect': a potential environmental disaster, but also an essential part of life on Earth. Discuss this statement, making specific reference to the processes that contribute to the energy balance of the atmosphere."*

(C)   No marking criteria were supplied, apart from the marks allocated in the examination papers.

(D)   No extra readings or resources about critical thinking were mentioned.

viii. Integrated practices (Applied Science – first year)

(A)   The subject was based on experiential learning and problem solving. One of the aims was to develop the students' skills in critical thinking and reflective writing. Outcomes included *"critical reading and writing."*

(B)   Assessment was based on an individual journal which included reflection, plans for action and identifying key concepts. There was also a personal learning project with critical reading and writing, as ESD group project, a learning statement and interview demonstrating evidence of critical reflection and critical discussion of knowledge.

(C)   No criteria for marking were supplied.

(D)   Books of readings/study guides included sections on critical thinking, explanations of critical reading and writing, and strategies for development of critical thinking were available to students. A lecture/workshop was also provided on critical reading.

ix. Aquatic environments (Applied Science - first year)

(A) The objectives listed general competencies that students were expected to begin developing. One of these was critical thinking.

(B) Assessment included quiz/review of readings, a tutorial exercise on a literature review, a scientific report, a group seminar and a portfolio. No instructions for assignments were supplied for students in the subject outline.

(C) No marking criteria were supplied.

(D) A number of references relating to ecology and water quality were included, and a workshop interpretation of data included a section on critical thinking.

x. Terrestrial environments (Applied Science – first year)

(A) Content of the subject outline included mention of critical reflection, and the learning paradigms of problem based learning and experiential learning.

(B) Assessment included individual reports, portfolio, group seminars and an individual final report. No specific instructions were supplied.

(C) No marking criteria were supplied.

(D) A broad list of texts and references included two books on critical thinking/analysis.

xi. Community studies (Applied Science - second year)

(A) The subject outline did not specifically mention critical thinking but emphasized the *"socio-cultural dimensions"* and *"community perspectives"* as a means of studying inter-relationships between the community and the environment. A paragraph in the subject outline related this subject to other subjects studied in the relevant degrees.

(B) Assessment involved Web CT discussions, a group report and seminar and individual assignments on environmental issues. Details of each topic for discussion on Web CT included questions and readings. Questions promoted critical thinking, for example: *"Has communication killed communities?"*.

Clear instructions were given for each of the other assignments, though critical thinking was not mentioned.

(C) Marking criteria were not supplied.

(D) A comprehensive list of readings was included, particularly relating to environmental health, sustainability and the strengths and weaknesses of quantitative/qualitative research. There were no specific readings on critical thinking.

xii. Issues and change (Applied Science – second year)

(A) Critical thinking was not mentioned in the subject objectives, however this subject included an aim to "build awareness of differing worldviews and paradigms in tackling real world complexity". This implies a need for critical thinking.

(B) Assignments included an essay, group work, weekly exercises and a group presentation. The essay question was: "Ecologically Sustainable Development – an oxymoron or achievable goal? Write a critical essay." In the second assignment students were expected to "critique the model", provided in the subject content.

(C) Marks were not specifically allocated to critical thinking.

(D) A course reader and many supplementary references were provided for students. None related specifically to critical thinking, though many authors may have challenged student thinking, for example, Sharon Beder, Paulo Friere and Tim Flannery.

xiii. Soil and water management (second year)

(A) Aims included reduction of *"environmental degradation…"* and subject outcomes included students understanding issues and *"gaining insights into how [these]…can be managed more effectively"*. No specific mention of critical thinking was made, though it was implied. This subject took a traditional scientific approach to environmental studies.

(B) Assessments were: workbook for field trip, project proposal, laboratory report, quiz, presentation, project report.

(C) No marking criteria were supplied.

(D) A reading list relevant to each topic was provided, with no reference to critical thinking.

xiv. Environmental issues (Interdisciplinary Science and Law - first year)

(A) One of the objectives was to develop student critical thinking. It was stated that "your ability to think critically will be assessed in all of the unit assessments".

(B) The assessment tasks included the following: oral presentation, two reports to a politician, and an exam. The reports were to show "evidence of critical thinking and problem solving". A sample of the first report was provided for students. Their second report was to be a "modified" version of their first report demonstrating incorporation of feedback from the tutor and a "statement of critical reflection".

(C) Marking criteria were set out according to grades (HD to Fail). Both HD and D levels were to demonstrate an ability to "select and utilise references critically. An ability to question the authority of sources or at least reveal the assumptions informing them…" Assessment tasks were to demonstrate "evidence of critical selection of referencing material (eg. variety of viewpoints)" and an "independent and critical approach".

(D) The graduate attributes for the university were supplied, including:
"Ability to think clearly, critically and creatively". Further resources listed links to the textbook bibliographic information, a reader and online reports and articles. These appeared to be targeting environmental issues with none specifically about critical thinking.

xv. Environmental practice (Applied Science - third year subject)

(A) This subject is predominantly offered as an external subject. According to the subject outline this subject is an "In Practice" subject with an emphasis on experiential learning and the development of professional skills through an

Action Learning project. The emphasis is on lifelong learning within the context of adult education, and within the context of action learning as a potential "change agent". Both critical thinking and reflective thinking, for example evaluation of their own learning and development as a professional, were considered to be important and were included in assessment. The supplied letter of introduction, which followed the overview of topics and due dates for assessment items, was taken to be the outline of the subject. After the introductory welcome paragraph the following paragraph appeared:

"Final year students are expected to be able to think critically...The assignments have been set to, amongst other things, assist you to develop your critical assessment skills and apply them to the environmental health, environmental management, and occupational health and safety professional areas."

(B)   The assessment tasks in this year long subject included: a project proposal, a literature review, a Web CT group discussion component, a project seminar, a final project report and a reflective document which asked for critical reflective thinking about individual student learning in the subject.

(C)   The criteria for each task differed somewhat, however for the Literature Review included: critically appraise the literature, compare and contrast one view against other views, develop a position based on the literature review. In the assignment instructions for the project seminar one criteria to be addressed was *"ability to use critical thinking skills"*. This was described as for example, an ability to:

- *"differentiate between fact and fiction,*
- *examine assumptions including your own*

(D)   The book of readings for this subject included topics for Web CT discussion (including viewing the video "Rats in the Ranks") and, amongst other things, a detailed approach to critiquing the literature with examples of successful student writing.

xvi. Epidemiology (Applied Science - second year subject)

(A)   The Aims/Objectives included: "The subject equips the health practitioner with a set of tools for the rapid evaluation of interrelated health and environmental decision making…the program is problem based." While this does not specifically mention the term critical thinking it is implied by the statement made in the lecturer's interview that Problem Based Learning (PBL) includes critical thinking.

(B)   The subject outline made it clear that the approach was problem-based and that there were a variety of assessment tasks with no examinations. Students were expected to complete five exercises based on in-class work and readings from a Study Book, to submit a project proposal and present a group protocol on rapid risk assessment in this one semester subject. Students were involved in peer assessment of group presentations in terms of the clarity of the presenter's ideas and the quality of content. Apart from the connection between PBL and critical thinking, no overt mention of critical thinking was made in assessment task instructions.

(C)   Marking criteria were not provided for this subject but assessment for a subsequent subject taught by this same lecturer included a major assignment of a portfolio, in which students were required to read book chapters or articles, summarise them and then critically analyse them. In the subject outline for that subject it specifically stated: "In this regard, 'critically' implies investigating if the article answers the questions who, what, where, when, how and why, and assessing if it represents a thorough piece of reporting or recording of information. Ask yourself if the message comes across clearly (could the writer have used a graph in preference to a table to clarify the data being presented?) and question whether the scientific quality of the work is sound (is well-supported by references?). Remember, though, that before you can constructively criticise others, you <u>must</u> have developed adequate knowledge to measure their endeavours against."

(D)   A book of readings was provided which included definitions and explanations of Competencies, including critical thinking and chapters about critical thinking by

well known authors in the field, such as Edward De Bono and Stephen Brookfield.

6.1.2 Preliminary analysis of subject outlines for Environmental Science

Of the sixteen subject outlines provided, nine reflected a positivist Environmental Science approach while seven were from Applied Environmental Science. Analysis of these documents was organised according to references to, or overt mention of, critical thinking/analysis or an implication that critical thinking was required. Some did neither.

(A) Nine of the subject outlines overtly used terminology in their aims or objectives such as: "critical thinking, critical analysis, critical evaluation and critical reflection" (see Table 6.1). Five outlines implied critical thinking was required, by stating concepts such as: "problem solving, socio-political dimensions to issues, awareness of differing worldviews, gaining insights…." Two did not clearly make reference to critical thinking as an objective and these subject outlines were from a more positivist approach to Environmental Science.

(B) Six subject outlines overtly mentioned critical thinking in the instructions for and types of assessment tasks. Another four subject outlines implied that critical thinking would be encouraged by, for example, supplying questions for tutorials worded so as to promote critical thinking, exam questions requiring critical thinking, essay questions and Web CT questions promoting critical thinking. Six subject outlines did not appear to do this either explicitly or implicitly.

(C) Seven subject outlines clearly stated that marks would be allocated for critical thinking/analysis/evaluation in the criteria for assessment of assignments. Another two outlines indicated that critical thinking would only be expected in Distinction or High Distinction assignments. Seven subject outlines did not mention critical thinking in terms of assessment or marking criteria.

(D) Five subject outlines were accompanied by books of readings or handouts which contained information about what critical thinking is according to various theorists, or how to improve critical thinking, or how to read and write critically. Another three outlines included challenging books, as mentioned above, in their reading/resource lists. Eight outlines did not seem to provide any particular readings or suggested readings to further expand the students' understanding of critical thinking.

Table 6.1   Number of subject outlines making reference to critical thinking in Environmental Science.

	Critical thinking overtly required	Critical thinking implied	Critical thinking not mentioned	Total
(A) Aims/objective	9	6	1	16
(B) Assessment	6	4	6	16
(C) Marking criteria	7	2	7	16
(D) Readings	5	3	8	16

Environmental Science subjects could be further subdivided into seven Applied Environmental Science and nine traditional Environmental Science subject areas. There were some interesting differences between these two areas. The subject outlines that were supplied from Applied Environmental Science were more likely to overtly mention critical thinking in subject objectives or to indicate that critical thinking was expected in assignments, than those from the more traditional Environmental Science subjects. Another noticeable difference was the provision of readings or references in the Applied Environmental Science subjects that were specifically about critical thinking, while none of the traditional Environmental Science subjects provided readings on critical thinking.

Marking criteria for the subject Environmental Practice included terms such as *"critically appraise the literature"* and *"develop a position",* with a marking schedule of which critical thinking was one component. Although the marking criteria for Epidemiology was not supplied, another subject that was taught by this lecturer used the terms *"critical analysis of all readings"* as part of the instructions for the assignment. A

book of readings was supplied for each of Environmental Practice and Epidemiology, containing explanations of critical thinking and different perspectives on how to develop it.

6.1.3 Discipline of Environmental Engineering

There were only two subject outlines supplied for Environmental Engineering, Sanitation and Environmental Engineering; Site Remediation.

i. Sanitation and Environmental Engineering (final year).

(A)   The subject outline described the objectives of the subject in terms of students developing an understanding of *"environmental issues, implications of certain processes such as construction within a natural system...management strategies to combat air, water, soil and noise pollution...environmental legislation, concepts and design of water pollution control mechanisms."* No specific mention of critical thinking/analysis was made in the subject objectives, though reference was made to the first year subject Engineering for Sustainability, which it was noted in the previous chapter had an emphasis on critical thinking. In relating the subject to the overall course aims, it was stated that *"this subject will help students to become responsible professional engineers with due regard to the social and environmental contexts."*

(B)   The assessment consisted of laboratory reports, exams and an individual report on either a visit to a construction site (in their area) or to a treatment plant. While the individual report guidelines were detailed and clear there was no explicit mention of critical thinking/analysis. This may have been assumed in the section for a construction site visit where students were to address the issue of environmental impacts, and success of mitigation, and where they were to mention concerns of local resident groups. Furthermore, it may have also been assumed in the section for a sewerage treatment plant (STP) visit where students had to *"link [the] theoretical perspective to the actual treatment plant...recommendations with*

respect to design, operation and maintenance…evaluation of...mitigation of environmental factors."

In the assignment instructions students were also asked to *"rank [the] degree of severity of impact on the existing environment"* and *"mention if there are any local groups which have concerns about the site or industry and what those concerns are."* These instructions would have potentially required some critical thinking. Moreover, the lecturer for this subject was interviewed and spoke about incorporating more overt reference to critical thinking in the instructions for the major assignment in her second semester subject. She claimed that this appeared to have increased the proportion of student assignments containing critical thinking from 20% to 60%.

(C)   Examinations were the main form of assessment, comprising 60% of the subject mark. Laboratory reports were worth 20% and the field trip report 20%. Assessment criteria for the field trip report did not specify critical thinking or critical analysis, however this was implied in several of the criteria. For example, reflective and/or critical thinking is implied in the following:

- *What are some of the aspects at the plant (STP) that are new to you?*
- *Your recommendations with respect to design, operation and maintenance.*
- *Evaluate the purpose of the treatment plant with respect to mitigation of environmental factors of the region.*

(D)   There appeared to be no references or supplied readings specifically addressing critical thinking.

ii. Site Remediation (final year)

(A)   In the subject outline there was no mention of critical analysis. However, there was a Guest Lecture by Greenpeace and the EPA, who would presumably have presented a different viewpoint on the topic Sydney Olympics Clean-Up (a case study).

(B)　Assessment tasks for this subject included: a field trip report worth 5%; session quizzes worth 15%; an individual assignment worth 30%; and a class exam worth 50%. The students could choose whether to write up their individual assignment as an essay or technical report as it was a secondary research project. There was no mention of critical thinking in instructions.

(C)　In the "Assignment Marking Sheet" that accompanied the returned assignments one criterion stated: "originality of your work & intellectual contribution (critical evaluation)". This aspect was worth 10% of the assignment mark. Another criterion, also worth 10%, was based on the student's "ability to integrate the concept into ecologically sustainable development (social, economic and environmental consequences)."

(D)　No extra readings or references about critical thinking were provided or recommended.

6.1.4　Preliminary analysis of subject outlines for Environmental Engineering

The two subject outlines that were reviewed for Environmental Engineering did not overtly use the term critical thinking or critical analysis in the subject objectives or subject/course description. However, it was implied. One subject outline implied that critical thinking was required in the assignment instructions, and in a marking criterion that asked for *"evaluation"* of the STP students visited. The other lecturer overtly included *"critical evaluation"* in the criterion on the marking sheet which was returned with the marked assignment. Neither of the subject outlines indicated that readings or written explanations about critical thinking were provided.

Analysis of the subject outlines provided for Environmental Engineering can be found below (see Table 6.2).

Table 6.2   Environmental Engineering references to critical thinking in subject outlines.

	Critical thinking overtly required	Critical thinking implied	Critical thinking not mentioned	Total
(A) Aims/objective		2		2
(B) Assessment		1	1	2
(C) Marking criteria	1	1		2
(D) Readings			2	2

6.1.5   Discipline of Environmental Law

There were three subject outlines supplied for Environmental Law. These were Environmental Law, Planning and Environment Law and Environment Law/Environmental Law and Ethics.

i. Environmental law (final year subject).

(A)   In the subject outline the Introduction included critical thinking/analysis. It stated that: *"The goal of [this subject] is to enable candidates to develop a basic, critical understanding of the law in relation to environmental management in Australia, with particular emphasis on NSW, including the limitations of legal instruments in achieving environmental management and policy objectives."* The subject outline was very clearly set out with an emphasis on the learning objectives. These had a subheading as follows: *"Note: These objectives are important. They determine the methods of teaching, learning and assessment."* The learning objectives began with: *"a student should be able to demonstrate: A critical appreciation of the role of each sphere of government in Australia in environmental management."* The objectives also included: *"a critical appreciation of the law relating to environment impact assessment, and the respective roles in this process played by the Commonwealth and NSW Governments"* and *"a critical appreciation of the role and nature of heritage protection systems at the Commonwealth and State levels."* The first and last objectives mentioned the word "critical":

At the conclusion of the list of topics in the subject outline was a paragraph about the *"tertiary literacies"* that the subject would encourage students to develop. These included: *"a commitment to continued and independent learning, intellectual development, critical analysis and creativity."*

(B) The assessment tasks included: a take-home assignment (25%); a research essay (65%); class participation and a presentation of the findings of their research essay (10%). A comprehensive set of challenging questions accompanied each seminar topic and its readings. For example, *"What advantages and disadvantages are there in placing very restrictive planning controls...over private land in order to preserve valuable natural habitat, rather than bringing the land into public ownership? ...Are there any alternative ways to ensure such habitats are duly protected?"... "How useful is heritage law for protecting the natural environment?"*

(C) There appeared to be no marking criteria supplied.

(D) A lengthy list of extra readings was also supplied in the subject outline, however there appeared to be no readings or written explanation of critical thinking/analysis supplied to students.

ii. Planning and environment law (final year subject).

(A) The subject outline gave an excellent portrayal of what the subject content was and how the subject would progress. A description of the content of the subject included the following: *"environmental ethics...and the role of politics in the formulation of environmental policy."* The objectives of the subject included several that indicated development of student critical thinking was required. It was stated that: *"Through participation in this subject, it is expected that students will be able to:*

iii) evaluate the regulatory regimes for the protection of the environment;

iv) critically evaluate the methods by which government and quasi government decisions may be challenged and be able to determine the most appropriate avenues to be pursued for effective action..."

(B)   Assessment tasks included a research essay (40%); final exam (40%); class participation (10%) and a presentation (10%). Instructions for the research essay included the following: *"Assessment will be based on content and clarity of the material presented and also on the ability of students to integrate and critically evaluate relevant law and policy."* Although students were encouraged to choose their own topic, a series of suggested topics was listed in the subject outline providing opportunities for critical thinking, for example: *"Discuss and analyse a local planning instrument (eg. for Parramatta)."* The presentations were based on individual cases related to planning and/or environment law and a comprehensive reference list was provided, together with information about relevant legislation. Students were also assessed on their participation in classroom discussions. Classes were conducted seminar style, which allowed for more questions and discussion of issues, and the subject description emphasised the interdisciplinary approach of early sessions.

(C)   Marking criteria were provided for the presentation with an emphasis on structure, content and analysis and features of presentation such as *"voice, confidence, interaction"*. However, critical analysis was not one of the criteria.

(D)   While there was an extensive reading list there were not any references for critical thinking/analysis.

iii. Environment law/Environment law and ethics (fourth year and postgraduate subject).

(A)   This subject was offered to both internal and external students. The Introductory Course Outline does not mention critical analysis or critical thinking except in terms of questions for assignments.

(B) The questions for the assignments were very focused on critical analysis of ethical issues and/or the concept of ESD, and the effectiveness of environmental legislation. For example, *"Critically evaluate the role of public participation and its operation under the Environmental Planning and Assessment Act 1979 and the Protection of the Environment Operations Act 1997."*

(C) Marking criteria were supplied for this subject which included *"Critique"* and *"Originality"* as criteria for assessment.

(D) There were no references to readings about critical thinking/analysis in the references supplied to students in the subject outline.

6.1.6 Preliminary analysis of subject outlines for environmental law.

Of the three subject outlines for Environmental Law, two overtly mentioned critical thinking as an objective and the third implied it in the approach to assessment. Only one outline overtly referred to critical thinking in the assessment instructions and in marking criteria. The others did not mention it at all (see Table 6.3, below). None of the subject outlines included references to books or readings about critical analysis.

Table 6.3   Environmental Law references to critical thinking in subject outlines.

	Critical thinking overtly required	Critical thinking implied	Critical thinking not mentioned	Total
(A) Aims/objective	2	1		3
(B) Assessment	1		2	3
(C) Marking criteria	1		2	3
(D) Readings			3	3

6.1.7 Overview across disciplines

Although only a limited number of subject outlines were provided some trends were noticeable. In general there were very few which made no overt mention of critical thinking, namely four of the Environmental Science subjects and one Environmental Engineering subject. Most of the Environmental Science subject outlines (15/16) either

explicitly or implicitly addressed the issue of critical thinking in their aims, objectives or course description. Ten of these subject outlines mentioned critical thinking/analysis in instructions for assignments or implied that critique was expected, while seven of the outlines included critical thinking as an element of marking criteria. Five subjects provided readings or references about critical or reflective thinking and writing, and these were the Applied Science subjects.

The Environmental Engineering subject outlines did not overtly use the term critical thinking in aims or objectives but placed most emphasis on including it in instructions for assignments, or as a marking criterion. There was no evidence of a written explanation of critical thinking or recommended readings on this. The Environmental Law subject outlines provided aims and objectives which included critical appreciation or evaluation of environmental law, and one also included critical analysis as part of assignment questions and marking criteria. However, none of them supplied students with a written explanation of critical analysis.

6.2: Student assignments

This section of the thesis contains some discourse analysis of student assignments, as explained in Chapter 3, of some of the differences between the discipline areas within environmental education, and provides some examples of student critical writing. Two assignments were chosen from each discipline area and their Conclusions are presented here as sample texts for preliminary discourse analysis in order to discover whether there are noticeable differences between the students' written expression of critical thinking in the three target disciplines (see Tables 6.5 and 6.6, below). Although each assignment demonstrated expressions of critical thinking in various sections throughout the assignment, the Conclusions were chosen for discourse analysis because they were a reasonably consistent representation of the students' evaluations of their topic. Each evaluative expression is underlined and samples of analysis of these expressions can be found in Appendix E. It should be noted that discourse analysis of the texts was repeated a number of times until a consistent interpretation was reached. However, it is accepted that this is still my interpretation, which could differ from that of another researcher.

Six of the conclusions of student assignments were more closely analysed with regard to the following aspects:

(A)   grade received,

(B)   object of critique,

(C)   content of the critique and

(D)   type of evaluative language used.

6.2.1 Environmental Science (Applied)

Student Assignment 1. Subject: Environmental Practice
Literature review on Risk Management of Manual Handling, **by Mikaela.**

(A) HD (32/35)

(B) The object of this student's critique is the occupational health and safety hazard of manual handling and the new approach of Risk Management. She acknowledges that manual handling is a serious workplace issue, with the most common injury being back injury, and is not satisfied with the lack of clarity about how Risk Management can be applied and evaluated.

(C) Six negative and two positive evaluative statements.

(D) In the Conclusion she wrote:

"Risk Management is a contemporary approach to addressing workplace hazards. It is part of a recent <u>move toward adoption of a systematic approach to (OHS)</u> and integration of OHS management into the core management of enterprises. Although Risk Management <u>provides a uniform approach to the management of risks</u> associated with workplace hazards, there is <u>considerable variation in the literature as to the stages of Risk Management to be used.</u> There is also <u>little published information as to how a risk management system should be evaluated.</u>

<u>Manual handling injuries in Australia represent a significant source of economic burden</u> (NOHSC National Occupational Health and Safety Commission, 2003). <u>The lack of consistency in terminology relating to manual handling</u> in the literature appears to prevent a clear estimation of the extent of the coordinated management strategy to address this hazard.

A Risk Management approach to reduce injuries associated with manual handling tasks has become the central theme of the legal framework pertaining to the management of manual handling hazards in NSW. <u>This is despite the paucity of published literature into the scientific merits</u> of this approach and the <u>lack of demonstrable evidence that it contributes to the reduction of manual handling injuries</u>. "

Student Assignment 2. Subject: Epidemiology

Research protocol: HIV/AIDS transmission among women in Fiji, **by Maeve.**

(A)   HD

(B)   The object of the critique in this assignment is the lack of information/awareness of the risks of transmission of HIV/AIDS among young women. This is closely linked with the need for "gender sensitive HIV/AIDS prevention programs", particularly in a society such as Fiji where many young women face discrimination on the grounds of race and gender. This student is also critical of health services which are "designed and implemented in a profession which remains highly patriarchal". She critiques the fact that, in Fiji, the discussion of sex is taboo, and relates this to the increased risks to young women.

(C)   Four negative and three positive evaluative statements.

(D)   In the Conclusion she stated:

"There is growing evidence that <u>HIV/AIDS poses a greater threat to women whose needs have traditionally been excluded by prevention programs.</u> This is particularly true for young women who are becoming sexually active <u>in circumstances where they are particularly vulnerable</u>. As such<u>, research</u> vis-à-vis the needs and perspectives of young women in regard to the HIV/AIDS virus and protective sexual behaviour<u>, is urgent</u>. In Fiji, where the virus is relatively new and has a low incidence amongst the population<u>, such research may pave the way for preventative action to be taken before the disease reaches the epidemic proportions it has in other parts of the developing world.</u>

This small research project does not aim to answer all questions relating to women and HIV/AIDS in Fiji. However, with a minimal budget and an accessible sample population <u>it provides a cost effective way in which to assess some aspects of the situation, provide feedback to service providers and set directions for future research</u>. Importantly it will <u>raise the issue of women's increased risk</u> of HIV/AIDS

transmission in the Pacific and <u>challenge those working in public health and traditional medicines to address the issue</u>."

6.2.2   Environmental Engineering

Student Assignment 3.   Subject: Sanitation and Environment Engineering,
***Report of field trip to St Marys STP*, by Roberto.**

(A)   59% (Pass)

(B)   The object of critical analysis in this assignment was the impact of the processes at the St Marys STP on the environment. Roberto presented a description of the various processes and in several instances followed this with a comment about its effectiveness and any environmental issues. His conclusion focused on the importance of STP's.

(C)   Three positive and one negative evaluative statements.

(D)   In his Conclusion Roberto stated that:

"Wastewater treatment plant is complex system that is highly <u>needed to maintain a sustainable environment and free from pollution</u>. A <u>plant is costly</u> to maintain and run, it is a <u>big responsibility to manage </u>such a system.

<u>We have to consider wastewater treatment as water use </u>because it is so interconnected with the other uses of water. Much of the water used by homes, industries, and businesses must be treated before it is released back to the environment. <u>Treatment plants reduce pollutants in wastewater to a level nature can handle.</u>"

Student Assignment 4.   Subject: Site Remediation.
***Organic solvent extraction*, by Stuart.**

(A) 92.4% (HD)

(B) The object of Stuart's critique was organic solvent extraction, as a viable decontamination process. He concluded that it was viable in terms of almost complete removal from soils and sludges, however he was aware that it was an expensive process and could have unknown future repercussions on the environment.

(C) Five positive and two negative evaluative comments.

(D) Stuart did not include a Conclusion section in his assignment, however, at the conclusion of his Discussion Stuart wrote:

"Solvent <u>extraction processes will serve a useful purpose until</u> they are superseded by a new technology. <u>The cost and short-term consequences of remediation may discourage its use</u>, but it <u>remains a non-destructive means of removing toxicity</u> from soils and sediments. The process is <u>well understood</u>, unlike some other technologies, and <u>can reliably remove contamination quickly</u> and effectively. There is no reason to limit the use of this technology, as <u>there appears to be no long-term consequences</u> of its use. However, <u>researchers should aim to develop a less disruptive and more environmentally benign</u> means of remediation with the same flexibility."

6.2.3 Environmental Law

Student Assignment 5.   Subject: Environmental Law.
***Securing Access to Sunlight*, by Jeremy.**

(A) HD

(B) The object of critique in this essay was the legal issue surrounding an individual's access to sunlight, in the context of the individual wishing to use sunlight for the purpose of solar heating and for electricity generation.

(C) Five negative evaluative statements.

(D) Jeremy's concluding paragraph stated that:

"It is evident that public nuisance, despite having been chastised as possessing an excessively liberal ambit, <u>is too narrow to afford any reasonable degree of protection to landowners concerned with ensuring that the sun's rays reach their property.</u> The <u>usefulness of this legal doctrine in this context is further weakened</u> by the fact that even if liability for public nuisance is established, the <u>vagaries of equity</u> render the <u>type of relief which will be awarded unpredictable</u>. For instance, a landowner who succeeds in holding his neighbour liable for public nuisance as a result of the shading of his PV array is <u>not assured of injunctive relief</u>, and may have to make do with damages."

Student Assignment 6.   Subject: Planning and Environment Law.
***Standing to sue in environmental litigation,* by Jasper.**

(A)   38/40 (HD)

(B)   Jasper's essay critically analysed Australia's "standing to sue" regulations in relation to environmental issues. After examining the status of individuals and groups, such as the Australian Conservation Foundation (ACF) in relation to standing in Australia, Jasper's essay examined the situation in other countries. He concluded that the situation at present in Australia is not adequate and discounted the common concern about greater leniency opening the way for more "frivolous litigation" by examining the situation in Switzerland.

(C)   Seven negative and one positive evaluative comments.

(D)   In his conclusion Jasper clearly indicated that there is need for reform in Australia. He stated:

"That <u>the current state of standing requirements in this country are unsatisfactory</u> has been acknowledged by both the ALRC and the current High Court. Clearly the <u>legislature needs to make some form of uniform standing available</u> to help clarify the position of potential litigants. The <u>liberalization of standing requirements would help</u> to ensure that the government remains accountable to the public. <u>The arguments against loosening the rules of locus standi simply do not stand up</u> to the evidence from other common law countries (as well as the US and Switzerland) that no flood of recreational litigants were waiting at the court's door to flood the judicial system with frivolous

litigation. The <u>courts seem willing to stretch the flexibility of the rules</u> to include important organisations that serve the public interest<u>, but their place in court is far from secure.</u> What <u>is needed is some form of uniform legislative guidelines</u> to aid the court in exercising its discretion <u>instead of the special interest hodge-podge that lends itself to judicial inconsistency."</u>

6.2.4   Preliminary discourse analysis and interpretation of student assignments in Applied Environmental Science

Although there were five student assignments available for document analysis in environmental science, one from each of the subjects Environmental Practice and Epidemiology are more closely analysed here. Both of these subjects happened to be from an Applied Science course. See Tables 6.4 and 6.5 (below) for an overview of the differences between the targeted discipline areas within environmental education.

(A)   Both of the assignments had been marked as High Distinctions.

(B)   The assignments showed evidence of critique, particularly of government approaches to environmental health and management problems. Mikaela's literature review assignment, which critically analysed the Risk Management approach to manual handling, paved the way for her to then critique the manual handling processes in a large government corporation, the SRA, in her project report. The Conclusion of her literature review summarises her main concerns about the Risk Management approach. Maeve's assignment critiqued the patriarchal attitude of health organizations, the community and the government in Fiji, in relation to HIV/AIDS awareness and education. The critique was evident throughout the assignment, most particularly in the Conclusion, and demonstrated a contrast of theory and practice (see Table 6.4).

(C)   Most of the evaluations in both assignments were negative, each concluding that there was a need for improvement in the situation. These two assignments offered solutions to the problems presented, in urging governments and related

organizations to improve the situation for the target groups, that is the health of workers and young women respectively (see Table 6.5).

(D)   This section is interpreted below, together with the other discipline areas, to allow for some comparison (see Table 6.5).

6.2.5   Preliminary discourse analysis and interpretation of student assignments in Environmental Engineering.

There were three assignments available for analysis in Environmental Engineering, two from Sanitation Engineering and one from Site Remediation. Preliminary discourse analysis and interpretation of the key features from two assignments, one from each subject, is presented below.

(A)   One gained a Pass and the other gained a High Distinction grade.

(B)   Both of the student reports in this field were focused on the impacts of certain processes in terms of environment, society and economics. Thus the object of critique was both the processes and those responsible for those processes. Ultimately the government would be responsible for the impacts of the STP processes, though Roberto directed his recommendations largely to the individual citizen. On the other hand, Stuart placed responsibility for improving the solvent extraction process on *"researchers"* (see Table 6.4).

(C)   While each of these reports concluded with positive evaluations of the processes they were examining, they both had some negative critical comments to make about the potential environmental harm, or the social implications and the costs involved (see Table 6.5).

(D)   This section is interpreted below, together with the other discipline areas, for some comparison (see Table 6.5).

6.2.6 Preliminary discourse analysis and interpretation of student assignments in Environmental Law.

(A) Both of the student assignments in the field of Environmental Law had gained a High Distinction.

(B) The object of critical analysis was the inadequacy of the law in terms of access to sunlight for an individual who hopes to put solar panels on their home in one case, and for environmental organisations to sue the government or developers for environmental damage in the other case (see Table 6.4).

(C) Both were generally negative in their evaluations of the law and were recommending reform, though in Jeremy's Conclusion this was implied rather than stated (see Tables 6.4 and 6.5).

(D) The evaluative language was analysed and interpreted in Table 6.5 (below).

6.2.7 Comparisons across discipline areas

The following tables compare the Conclusions of two assignments from each of the targeted cases within environmental studies. While it is acknowledged that the Conclusion is only one potential section of an assignment where students could express critical thinking, all of the assignments did present arguments supported by evidence from the literature. Roberto was the only student whose assignment did not provide a lot of evidence from the literature. He specified that he had gained most of his information about processes at the STP from the field trip visit, though he had not indicated whether this was from personal communication or from Sydney Water pamphlets/website. However, he did use several diagrams that were not referenced, which was noted by the lecturer, and he included numerical data without a clear indication of the source.

Table 6.5 concentrates on the object of critique, but also compares the field of study and genre of the six texts taken from Conclusions of selected assignments.

The final component of the discourse analysis of assignments relates to the evaluative language used by the students. In this study it will refer to the way in which the students expressed their critical thinking in the written form. The evaluative expressions were interpreted in terms of whether they were evaluations of affect, judgement or appreciation which is classified as Attitude (see Section 3.3.3). The expressions were also interpreted according to whether they were positive or negative evaluations, which is classified as Content. Finally, in order to establish a connection with the key concepts and discourse of Sustainability, terms relating to environmental protection, social issues and economic issues were noted (see Table 6.5 below).

Table 6.4 Preliminary discourse analysis of select assignments (two per discipline area).

Student pseudonym and grade for assignment.	Object	Field of study	Genre
Environmental Science			
1. Mikaela (HD)	Evaluation of literature on the Risk Management approach to manual handling, government legislation and practice.	Applied Environmental Science - Occupational Health and Safety	Literature review (to be incorporated into project report).
2. Maeve (HD)	Evaluation of government and health practitioners approach to prevention of HIV/AIDS among young women in Fiji.	Applied Environmental Science - Environmental Management	Project proposal, including pilot study.
Environmental Engineering			
3. Roberto (P)	Evaluation of impacts of STP processes, including environmental impacts. This indicated an evaluation of government practices.	Environmental Engineering	Report on field trip.
4. Stuart (HD)	Evaluation of organic solvent extraction process, and evaluation of one organisation's practice in the case study.	Environmental Engineering	Scientific Report
Environmental Law			
5. Jeremy (HD)	Evaluation of legislation regarding access to sunlight. This included evaluation of government legislation.	Environmental Law	Academic Essay
6. Jasper (HD)	Evaluation of the regulations regarding standing to sue in environmental litigation – and implied evaluation of government created legislation.	Environmental Law	Academic Essay

Table 6.5 Differences in expression of evaluation and sustainability discourse.

Student name	Content of critique: positive or negative evaluation	Attitude: affect, judgement, appreciation	Reference to the elements of Sustainability
Environmental Science			
Mikaela	Two positive and six negative evaluations	One judgement and seven appreciations of an approach to OHS.	Manual handling injuries are a drain on the economy. (*economic*) The approach has not been proven to reduce injuries. (*social*)
Maeve	Four negative and three positive evaluations	One affective statement, four judgements and two appreciations of the research potential.	HIV/AIDS is a potential health epidemic in Fiji. (*social*) Research is cost effective and will prevent an epidemic. (*economic*)
Environmental Engineering			
Roberto	One negative & three positive evaluations	Two judgements & two appreciations of the processes at the STP.	The STP reduces pollution in the water. (*environment*) People cause this pollution yet benefit from the STP. (*social*) The STP is costly to run. (*economic*)
Stuart	Two negative & five positive evaluations	Two judgements & five appreciations of the solvent extraction process.	The process is costly. (*economic*) It works well so that land can be re-used. *(social)* Needs to be less environmentally impactful. (*environment*)
Environmental Law			
Jeremy	Five negative evaluations	Four appreciations & one judgement about public nuisance laws.	The law does not adequately protect the right to sunshine for installation of solar panels. (*environment*) The law is not equitable. (*social*) The best outcome may be payment of damages. (*economic*)
Jasper	Seven negative & one positive evaluations	Five appreciation evaluations and three judgements about standing to sue in environmental litigation.	Laws need to be liberalized. (*social*) Need for laws to allow important conservation organisations the right to sue the government in order to protect the environment . (*environment*).

6.3 Summary of findings from student assignments.

The purpose of the preliminary discourse analysis used in this section was to explore whether there were any differences between the three major discipline areas within environmental studies with regard to the expression of critical thinking in student assignments. The findings indicate that the object of critique in each assignment was specific to that subject and field of study, requiring considerable background knowledge of the topic and which was different in each case. However, the Applied Environmental Science texts could be said to be broadly critically analysing the theory and practice of environmental health/management. The Environmental Engineering assignments focused their critique on technical processes, and the Environmental Law assignments critiqued the inadequacies of the law. Ultimately most of the assignments were also offering some critique of government and/or organisations that were assumed to be responsible for the environmental/social/economic impacts of what was being evaluated. The Environmental Engineering assignments also indicated that the individual and researchers are responsible. Apart from one Environmental Engineering assignment which had gained a Pass, all of these sample texts were from HD assignments.

In terms of the genre of the assignments, it should be noted that the Applied Environmental Science assignments were representative of the different stages of research reports. Mikaela's assignment was focused on the literature review she would later use in her project report. Maeve's assignment was a project proposal which included a pilot study. While both are closely linked to a report structure, they are each different. The genre of report writing is also common for engineering subjects, however academic essays are more common in law subjects. One of the main differences relates to the structure required for different genres and this is well documented elsewhere (Lindsay, 1995; Ravelli and Ellis, 2004; Swales and Feak, 1994).

In terms of critical thinking it was found that the conclusions of each assignment were representative of the expression of evaluation of the object of critique, apart from Roberto's which had somewhat different evaluations in earlier parts of his report. For example, earlier in his assignment he had mentioned the fact that there are some serious

potential problems and environmental risks with STPs, such as cracking of pipes. He also made a strong point about the close proximity of the plant to South Creek, which flows into the Hawkesbury Nepean River system, and stated that: *"if the region was subjected to flood, the environmental damage <u>would be horrendous….</u>"* Yet his overall conclusion about the environmental impact of the STP was positive. He reflected on aspects of the plant, for example the size of the plant was much greater than he had expected and the processes were more complex than he had expected. This was expressed in less formal language such as: *"but this filtration process was <u>much more complex than I thought</u>…."* This type of reflection was valued by the lecturer.

All of the assignments used the more formal technical language of their field, apart from Roberto's which sometimes reverted to more everyday expressions. For example, in the reflection indicated in the previous paragraph and the statement in his Conclusion that *"we have to consider wastewater treatment as water use…"* less formal language can be found. His recommendations generally were addressed to the individual layperson rather than the responsible organisation, or the government. For example, *"it is recommended to avoid flushing possible toxic or hazardous material down the drain."*

The most noticeable difference between the 'content' of the sample Conclusions was that the Environmental Engineering texts presented more positive evaluative expressions than did either of the other two discipline areas. While Mikaela provided positive evaluation of the *"adoption of a systematic approach"* to OHS and that Risk Management is a *"uniform approach"* her six other evaluations were negative. Most of Maeve's evaluative expressions were also negative, though she provided positive comments about how her research study could assist in preventing an epidemic of HIV/AIDS. Jeremy offered a completely negative evaluation of the law, while Jasper's only positive comment seemed to be that the *"courts seem willing to stretch the flexibility of the rules"*. Both of the Environmental Engineering texts, on the other hand, were much more positive in their evaluations but raised cautious negative comments in regard to the environmental impacts.

In terms of Attitude, or type of evaluation, it could be said that there were some differences, though these were reflected as much within discipline areas as between

them. In the Environmental Science texts it depended on the object of critique. For example, Mikaela's conclusion focused on the approach of Risk Management to manual handling. This was predominantly dealing with a policy, so most of the evaluative expressions were appreciations. On the other hand, Maeve's Conclusion mostly dealt with people related issues so more of her evaluations were judgements. She also included an emotional evaluation (affect) when she wrote that the need for *"research...is urgent."*

The Environmental Engineering texts again revealed differences, though perhaps this was more attributable to the level of language control of each student. Roberto was writing in a second or another language which may have influenced his English expression and grade for his assignment. His Conclusion only had four evaluative expressions, two judgements and two appreciations. The latter referred to the processes of the STP. Stuart placed more emphasis on the processes of solvent extraction in his conclusion and thus used more evaluative appreciation expressions. His two judgements evaluations referred to people, one being directed at researchers.

Both of the Environmental Law conclusions used more evaluative appreciation expressions because they were primarily critiquing the law. However, Jasper also applied several judgements to human behaviour when referring to the *"arguments against loosening the rules of locus standi [which] do not stand up to the evidence from other common law countries"* and that *"courts seem willing to stretch the flexibility of the rules."*

Finally, in order to determine whether the student texts reflected elements of the discourse of sustainability they were analysed in terms of reference to environmental issues, social issues and economic issues (see Table 6.6). Although broadly speaking the Applied Environmental Science conclusions were evaluating environmental health/management approaches, the focus appeared to be mostly on the social benefits and to some extent on the economic implications. The Environmental Engineering conclusions both placed a balanced approach on environmental, social and economic issues, though each emphasised a different aspect. Roberto implied that the environmental advantages, and following from these the social advantages, of the STP

justified the economic cost and he placed some of the responsibility for the economic and environmental disadvantages on society. Stuart concluded that the social advantages of the extraction process outweighed the environmental and economic disadvantages, but recommended that research could be done to overcome these. While environmental issues may have been somewhat in the background of the two Environmental Law Conclusions this was still a focus within each assignment. For example, access to sunlight in terms of solar energy and standing to sue regulations in terms of enabling conservation groups to better challenge the government, were the essence of their critique though they were not emphasised. Social comments were made and Jeremy clearly incorporated an economic issue in terms of payment of damages. Thus it would seem that the Environmental Engineering conclusions more consciously addressed the key concepts of sustainability, the triple bottom line, in the two assignment Conclusions.

The next chapter discusses an overview of the findings from Chapter 4, the analysis of questionnaires, Chapter 5, the analysis of interviews with lecturers and students, and the findings from this chapter. The next chapter will also discuss the significance of these findings for teaching and learning critical thinking within the context of specific subjects and courses of environmental studies.

CHAPTER 7: DISCUSSION AND INTERPRETATION OF DATA

7.0. Introduction

In this chapter I have synthesised the findings from the three previous chapters to discuss the research questions:

How is critical thinking expressed in university environmental subjects?

*How is student critical thinking encouraged in these subjects?*

The chapter is divided into three main sections including: expressions of critical thinking in environmental subjects; discussion of strategies that encourage student critical thinking; and discussion of strategies that hinder student critical thinking.

The complexity of perceptions of critical thinking is evident in this study, where it was found that critical thinking was often defined as a variety of different abilities and skills. These abilities and skills included analysing and evaluating information, questioning the information and its underlying assumptions, coming to conclusions based on evidence, and reflection. Different lecturers emphasised different skills and some definitions were outside this range. Despite the complex nature of the concept of critical thinking, both lecturers and students perceived that students' critical thinking improved over the duration of a degree course. This appears to support McPeck's (1990) subject specific argument that emphasises the development of student critical thinking through learning the content and the language of a subject. Pithers and Soden (2000) also refer to literature that "supports the notion that critical thinking can be developed more effectively in the course of teaching subject-matter content" (p.243) as opposed to generic thinking courses.

Because environmental studies is an interdisciplinary field it is considered important that students understand different disciplinary approaches to critical thinking and writing (Jones et al, 1999). This will in turn increase students' understanding of the different approaches to assessment of critical thinking in their assignments. It was found that there were several different approaches to critical thinking among this group of lecturers that varied according to the philosophical and ideological paradigms of subjects. The paradigms and consequent perceptions of critical thinking reflected the

division between the positivist approach to environmental education and the humanitarian/social justice approach of education for sustainability as described by Sterling (in Huckle and Sterling, 1996; Tilbury and Cooke, 2005). The latter represents a more holistic view including ideas such as social equity, interdisciplinary and transdisciplinary understanding of environmental issues, an awareness of bringing about change and a learner centred approach to education. The former is based on the objective scientific paradigm. I have labelled these perceptions of critical thinking Scientific/Technical and Paradigmatic approaches (see Section 7.1). The third aspect of critical thinking that emerged from the interviews with both lecturers and students was Reflection. This was found to be present in the Scientific/Technical and Paradigmatic approaches to critical thinking to a greater or lesser extent, though appeared to be more highly valued in the Paradigmatic approach (see Figure 1). These broad approaches varied according to the disciplines of environmental science, engineering and law and according to the focus of the subjects themselves.

A number of strategies for encouraging student critical thinking have been used by environmental educators, some of which are more beneficial to students than others. These can be grouped into in-class activities, types of assignments and the attitudes to assessment of these, as well as written support materials. The strategies could be seen to represent good teaching practice (Biggs, 1999), including providing an effective "classroom climate" (p. 62-65). Student perceptions of these strategies revealed that it was often the written strategies which were of benefit, in conjunction with a number of other strategies, while a number of the lecturers perceived that in-class discussion and debate alone fostered student critical thinking.
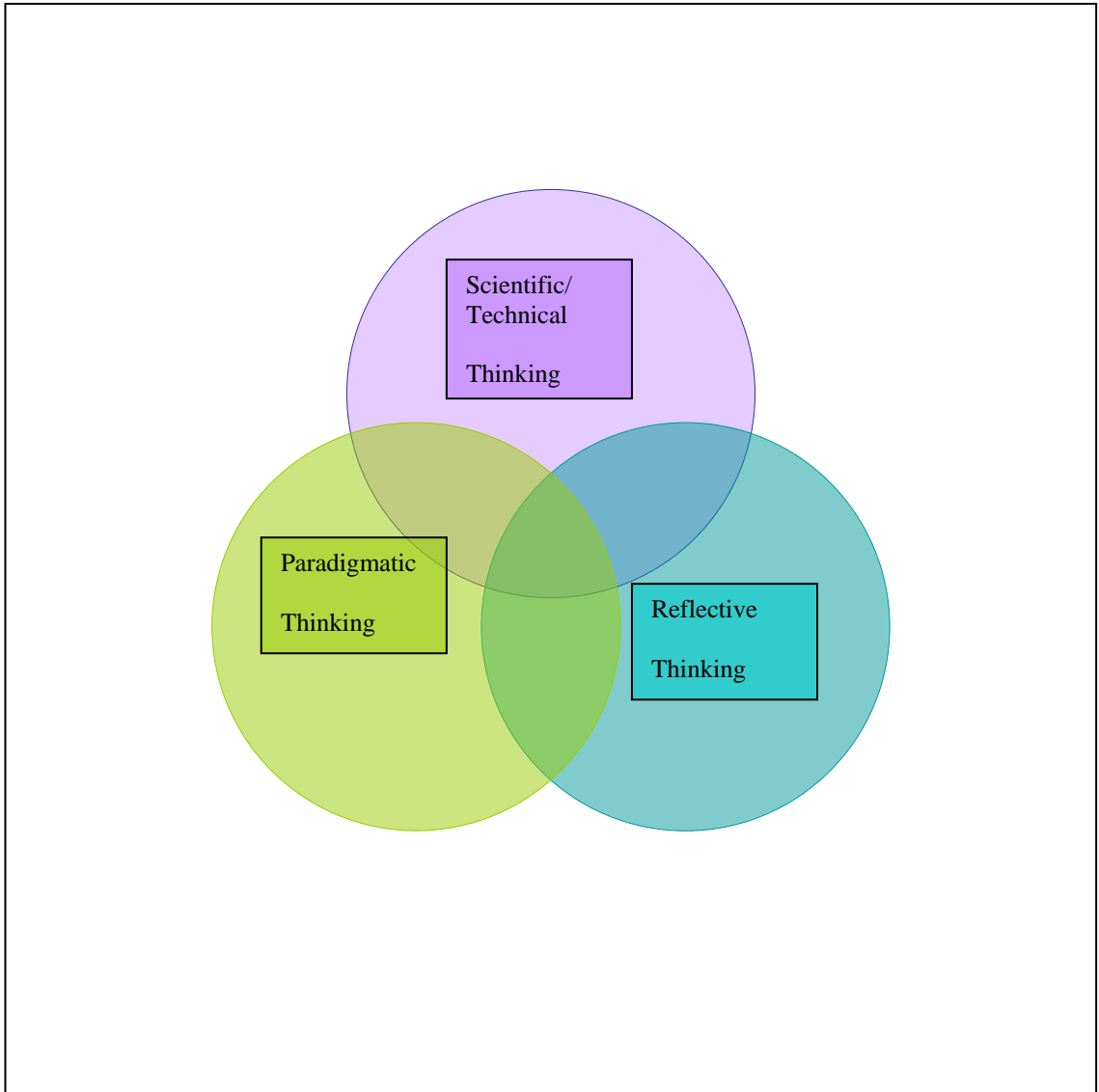
Figure 1: Three approaches to critical thinking in environmental subjects.

7.1 Expressions of critical thinking

7.1.1 Scientific/Technical approach to critical thinking

It was found in these case studies that a number of environmental subject lecturers defined critical thinking in terms of abilities such as logical reasoning, from an objective or scientific/technical point of view. Stables (2001) would describe this perspective as "scientific realism" where "facts about ecology [are] to be discovered, understood, transmitted and acted on" (p. 124). Typically, students were expected to assess the value of information for the benefit of scientific inquiry, for effective technical achievement or for applicability in practice. This often meant placing emphasis on the evaluation of the statistics and design of research studies or experiments. Such an approach could also focus on the analysis of the technical details of a problem, with the aim of basically solving the problem. The solution of the problem was often presented as an end in itself, without any reference to the influence of the paradigm or power relations involved. Such an approach in engineering is explained and critiqued, for example, by Beder (1996) who is particularly concerned about decisions being made by engineers and scientists without reference to the context of the community affected by a proposal. Jones et al (1999) use the term "crude realism" to describe the same approach and assert that this is something that "prevents students from thinking critically about the production and justification of scientific knowledge claims" (p. 353). The expression of this approach varied according to discipline and subject area.

For example, one such Environmental Science subject based on a framework of objective scientific method provided students with a number of guidelines including a set of questions to assist them in evaluating the literature. The lecturer emphasised that students could not practice critical thinking without first acquiring knowledge and this knowledge, gained from reading the literature, invariably included quantitative and statistical information. He expected students to evaluate research studies from the

perspective of assessing whether they had sound scientific design and valid results. The definition of critical thinking given to students in a subject outline was as follows: *"**Critically** implies investigating if this article answers the questions who, what, where, when, how and why, and assessing if it represents a thorough piece of reporting or recording of information. Ask yourself if the message comes across clearly (could the writer have used a graph in preference to a table to clarify the data being presented?), and question whether the scientific quality of the work is sound (is it well-supported by references?). Remember that before you can constructively criticise others, you must have developed adequate knowledge to measure their endeavours against, and in this regard it is essential that you carry out enough reading…."* This explanation provides a prescriptive definition of critical thinking that is useful for students and a guide to better literature search practices, however it does not include the concept of challenging dominant paradigms or ideological assumptions.

On the other hand, it is in keeping with some of the definitions of critical thinking in the literature where assumptions of skills such as logical reasoning are paramount (Halpern, 1996; Norris and Ennis, 1990; Paul, 1994). This is especially noticeable in the definition of critical thinking espoused by Freeley (1996), which is "the ability to analyse, criticise, and advocate ideas, to reason inductively and deductively, and to reach factual or judgemental conclusions based on sound inferences…" (p.1). This approach to critical analysis fits within a positivist framework and with assessing the validity of research design, results and arguments. It reflects a finding by Hyland (2005) who, after examining the evaluative language used in various academic texts, concluded that a "more linear and problem-orientated approach to knowledge construction…allows arguments to be formulated in a highly standardised code" (p. 189). This is indicative of the objective style of writing traditionally employed by scientists and engineers.

Examples from each of the target disciplines illustrate that it is possible for a scientific/technical approach to critical thinking to be put into practice in different subject areas within environmental studies. In Environmental Science, as mentioned above, a positivist approach to the discovery of information lends itself to the critique of the reliability and validity of studies in the literature and of students' own experiments. In Environmental Engineering this approach appears to be more concerned with

problem solving, particularly in relation to the processes involved in engineering solutions. For example, quantitative measurements of environmental impacts are used as a basis for critical analysis, and the focus of the critique is technical. It does not necessarily include a broader socio-political critique. Critical analysis at a technical level in Environmental Law is concerned with the effectiveness of the law in practice, its applicability and especially with the precision of language. For law students, expression of critical analysis within this approach is possible without introducing arguments about ideology, paradigms or philosophy, as was indicated by one of the law students (see Section 5.3.1).

In environmental subjects generally this approach to critical thinking is perhaps easier for students to engage with because it can be presented as an objective, quantitative form of comparison and evaluation. This may explain why several of the Environmental Science lecturers estimated that most of their students' assignments demonstrated critical thinking. One of these lecturers specified that *"contrasting three or four views"* was indicative of critical thinking in first year, whereas by third year students were expected to take more of a *"literature review"* approach. However, this perception of critical thinking does not appear to take into account the ideological, theoretical or paradigmatic level of understanding required in other subjects and implies that there is an acceptance of the dominant paradigm/s.

7.1.2 Paradigmatic approach to critical thinking

Other lecturers took a more paradigmatic approach. The concept of paradigm is based on "basic belief systems" (Guba 1990) and how this determines what will be researched and how the research will be carried out (p. 18). Guba refers to differences between paradigms as being reflected in the answers given to basic questions concerning ontology, epistemology and methodology and identifies four possibilities: Positivism, Postpositivism, Critical Theory and Constructivism (pp. 19 – 27). In my research this approach demonstrated a broader, holistic critical analysis of the paradigms, ideologies and power relations embedded in subject content. While those who took this approach did not necessarily exclude the scientific/technical approach to critical thinking,

particularly in relation to evaluating literature and research, their definitions extended to the realm of the socio-political contexts of a situation. For example, they valued the questioning of assumptions, questioning dominant paradigms, and emphasised social justice and reflective thinking. The approach is not dissimilar to "critical realism" where "the quest for sustainability is inextricably related to the quest for social justice" (Stables, 2001, p. 124). Jones et al (1999) also use the term critical realism to mean accepting that "knowledge contains both subjective and objective elements" (p.352).

For instance, an Environmental Science subject that was presented from an action learning framework placed emphasis on critical thinking as questioning, particularly the questioning of organisations, governments and social institutions with regard to how effectively they put their principles into practice. Critical thinking was perceived of as a process that students needed to engage in, and students were encouraged to critique the framework and approach presented in the subject. The definition given in the lecturer's interview was: *"along the lines of exposing dominant practices, dominant meanings and unravelling what is taken for granted...putting the spotlight on an organisation and the way it works, how it operates. How, for the government especially, [do] productivities match its aims?...as a professional – what decisions would I make if I worked here?"* This lecturer expected students to critically analyse the literature for their projects, though his expectations went beyond this to encouraging critique of paradigms. Students were encouraged to think in terms of becoming a *'change agent'* in their professional practice, and readings about this concept were provided for them to reflect on and discuss. The concept of a change agent is similar to Barnett's (1997) explanation of a "critical being," or someone who acts on their critical thinking. This more holistic approach to environmental studies is supported in the literature where there is an emphasis on the need for greater awareness of the political and ideological influences on environmental decision-making (Carvalho, 2001; Chapman, 2004; Gough, 2002; Harding, 2002; Orr, 1996; Trainer, 1994).

In the discipline area of Environmental Engineering, the paradigmatic approach to critical thinking was concerned with students learning how to find information, evaluate it, and make decisions within a broader socio-political context, rather than remaining focused on the technicalities. The process of effective and sustainable decision making

was considered to be of equal importance to technical expertise in Environmental Engineering, with circular thinking and reflection favoured over the dominant paradigm of linear thinking. The former was described by an engineering lecturer (see Section 5.2.3) as a *"female way of thinking"* as opposed to linear thinking, which was seen to be a male way of thinking. Critical thinking was perceived of as closely interconnected with informed decision making and skepticism. It was acknowledged that this approach could be criticised, especially in civil engineering, which places so much importance on students learning large amounts of technical information. Raising awareness of the influences of different values and interpretations of environmental issues in the discipline of engineering is a focus of authors such as Beder (1996) and Harding (2002), and this particular lecturer used these authors as a stimulus for classroom discussions and exercises.

In the discipline area of Environmental Law the paradigmatic approach was demonstrated through critique of the dominant anthropocentric paradigm underlying the current environmental laws. Ultimately the effectiveness of the law, regarding protection of the environment, was perceived to be limited by the anthropocentric paradigm of Environmental Law and the corresponding choices of language which value the rights of the individual rather than those of the environment. For example, the expression in law that planners must simply *"consider"* environmental impacts and not *"adopt"* greater protection was considered to be a serious flaw, because it is open to a variety of interpretations. The main critique of the dominant paradigm was oppositional to this and viewed the law from an ecocentric perspective, in which protection of the sensitivity of the environment takes precedence over human progress. Unfortunately, many students do not reach this level of critical analysis but focus on when and how to apply the law as it stands, according to one of the student interviewees. A lecturer who took this approach clearly identified it in his subject outline: *"I take the view that Law must be considered in the political, social and economic contexts in which it operates."* Thus, although there was encouragement for students to extend their critical thinking this far it was not necessarily evident in the assignments that were analysed in this study.

These different approaches to critical thinking are reminiscent of the above mentioned debate between the approach of scientifically based environmental subjects and those which use a broader sustainability framework with an emphasis on empowerment of the learner (Huckle and Sterling, 1996; Hutchison, 1996). The former is portrayed as more objective with an emphasis on a one way transference of information, where the educator is the expert. The latter is participatory and learner centred, where the educator has the role of a learning facilitator. However, there is often a need for students of environmental studies to participate in subjects that take either framework. They need to be aware of the differences between them and of the influence this may have on the approach to critical thinking.

McPeck (1990) stated that "different definitions of 'critical thinking' will require different criteria of measurement" (p. 58), which was demonstrated in these case studies (see Section 7.2.5). In the applied Environmental Science subjects that were more closely explored in this study there was an interdisciplinary approach to environmental sciences and this was evident in the two different subjects. This theme emerged in the interviews, subject outlines and student assignments. For example, the students were aware of the different paradigms underlying the two subjects, one having a scientific framework and the other an action learning framework. In these two subjects there was some conscious explanation of the epistemological and philosophical concepts of the relevant framework. This is referred to in the literature as important for student understanding of critical thinking (Jones et al, 1999; McPeck, 1990). This was also evident to some extent in both Environmental Engineering and Environmental Law, though it was not clearly written about in subject outlines.

7.1.3 Reflective approach to critical thinking

The role of reflection in the critical thinking process was clarified in the interviews with lecturers and students. Reflective thinking was understood to mean thinking about one's own practice, experiences and learning. This more common understanding is a very subjective approach aimed at stimulating improvement in learning. Students may be asked to examine their own practice or understanding of theory in order to discover how

they could improve. Reflective thinking was also viewed as expressing independent thought where students demonstrated reflection in assignments and class discussions, such as questioning their own lifestyle regarding environmental issues. Another interpretation of reflection was of a more objective ability that could only be practised when a student had first gained adequate knowledge about a topic. This appeared to be a more objective view of reflection that did not necessarily relate to the student assessing his/her own learning as such. Although critical thinking and reflection were not seen to be the same thing by many interviewees in this study, there was a perception among those who favoured reflection that it was a necessary part of the process of critical thinking.

As was noted in the literature, reflection was a theme related to developing student learning and thinking (Boud et al, 1985; Boud, 1999; Biggs, 1999). Reflexivity, which includes interaction with issues and people as well as reflection, was perceived to be vital to successful environmental education by Janse van Rensburg (1994) and essential to social change or "social transformation" (p. 3). Critical reflection as part of environmental studies differentiates this style of learning from the more information heavy, passive learning approach of the positivist sciences (Gough, 1997) where students are mostly required to rote learn and apply facts. As was found for the concept of critical thinking, the literature revealed different perspectives on reflective thinking and similarly differences were also found in this study.

In an Environmental Science subject reflection was considered to be of sufficient importance for one entire assignment to be devoted to a reflective document. This assignment required students to reflect on what they had learned from their major research project, and from the subject, in relation to their own development of professional competencies. In another subject reflection appeared to be a more objective review of the literature. Both of the Environmental Engineering lecturers who were interviewed referred to reflection as part of the critical thinking process. One spoke about the classroom situation where students reflected on a field trip, and incorporated this into their report. She saw this as evidence that they were thinking independently and thus critically. She commented about one of her recommended student assignments, *"I expected analysis that was both at a technical level and also a personal level…at a*

reflection level." Though she did not specify marks for reflection she appeared to regard reflective statements positively, noting that they were often written in the first person and that this was quite acceptable. The other engineering lecturer asked students to write a reflective section at the end of their assignment, which was worth ten percent of the assignment marks. She asked the students*: "Who does it affect and how does it affect the economic and social environment?"* She also wanted them to reflect on their process of researching information for their report. Reflection was a topic that was not mentioned by the Environmental Law lecturers who were interviewed, though one of the students considered it to be an important skill (see below).

A number of the interviewed students referred to reflection as part of the process of critical thinking. Reflection was included in a definition of critical thinking and positive comments were made about the benefits of the reflective document by Environmental Science students in terms of developing critical thinking, particularly for final year students. An Environmental Engineering student mentioned reflection because he felt he could have written much more in the reflective paragraph of his report. He appeared to appreciate the importance of writing the paragraph. A law student referred to reflection as a requirement in the course, relating it to his work experience in a law practice and the practical operation of the law. He also commented that personal reflection is something that may be a *"higher order function of the brain"* that not many students engage with. This was not specifically linked to critical thinking. It would appear that reflection and reflective thinking was considered to be a more important aspect of critical thinking in applied Environmental Science, by the lecturers and the students, particularly in the subjects with a paradigmatic approach. The Environmental Engineering lecturers who were interviewed also placed importance on reflective thinking. Reflection appears to play a far less significant role in Environmental Law subjects.

Confirmation that personal reflection is an additional aspect of the process of critical thinking is interesting. In some environmental subjects it appears that reflection is quite interconnected with critical thinking. This implies that the accepted generic approach to teaching critical thinking, which focuses on the philosophical methodology of logical reasoning, analysis and deconstruction of arguments and their premises, may not be

adequate (ACER, 1999; Ennis and Millman, 1989; Norris and Ennis, 1990). Reflection on learning and practice, which usually requires prior content material and knowledge, is an aspect of critical thinking that tends to be content specific and is often subjective, requiring students to think independently.

Thus, the inclusion of reflection appears to provide further support for the specifist argument in the debate about critical thinking (McPeck, 1990). However, while McPeck rejects the suggestion that critical thinking is a "process of reasoning" (p. 34), the perceptions of many of the lecturers and students in this study were that critical thinking is a process of learning. It was perceived to be a process that developed over a period of time from first to third/fourth year. Despite this most of the students agreed that critical thinking developed during their undergraduate degree, yet they had as many diverse definitions of critical thinking as had the lecturers, such as: deductive reasoning, problem solving, evaluation of the law or evaluation of the literature, and developing an argument. One engineering student simply described critical thinking in terms of the *"processes"* he had undertaken to produce his assignment, such as brainstorming and structuring his answer.

Others had a more holistic/ideological approach emphasising socio-political issues or subjective reflection and were aware that it was necessary to question assumptions and to *"think outside the box"*. They acknowledged that it was important to evaluate what they were reading in terms of ideological bias. One such student was considered to be a critical thinker most of the time by her lecturer, and in her assignment she questioned everything in relation to the program she was investigating, including the paradigm of action research that was emphasised in that subject.

7.2 Teaching and learning strategies that encourage student critical thinking

The majority of participating environmental studies lecturers estimated that most of their students demonstrated critical analysis in their assignments by third or fourth year. However, some lecturers had very low expectations of students' performance even by their final year of study, especially in the discipline area of Environmental Engineering. Despite this most participating lecturers believed that they encouraged their students to think critically and were willing to share the teaching strategies they used.

7.2.1 Discussion and debate

Half of the lecturers who responded to questionnaires in this study felt they encouraged the development of student critical thinking by providing an opportunity for discussion and debate in class. Sometimes they mentioned discussion in small groups as being particularly successful, which is similar to Hager et al (2003) and Tomlinson (1997). In the disciplines of Environmental Engineering and Environmental Law discussion in class was the dominant strategy used. Others provided activities that guided or challenged student thinking, such as brainstorming answers to controversial questions. Half of the lecturers in the study consciously encouraged students to critique the framework or paradigm of the subject, either through student initiated questioning or guided discussion in class. This indicates a reasonable awareness of a paradigmatic approach to critical thinking. While this study is not able to verify these lecturers' interpretation that classroom activities provide most encouragement of student critical thinking, further research involving observations may provide this information.

7.2.2 Linking sustainability and critical thinking

Subjects where critical thinking and sustainability principles were an important focus, especially where students were challenged to ask questions, were found to be very helpful in developing critical thinking. This is in keeping with some of the literature on

the empowerment of students of education for sustainability, for example, Huckle and Sterling (1996) and Hutchison (1996). Another Environmental Science subject provided students with a set of questions to apply to readings. A questioning approach to teaching is considered important for developing student critical thinking by Duron et al (2006).

Several lecturers and students observed that environmental and sustainability subjects were conducive to critical thinking. This could be because many environmental problems often do not have definite answers and there is a need to challenge existing paradigms and political decisions (Harding, 2002; Orr, 1996; Trainer, 1996). For example, at one university both the students and the lecturer spoke of the benefits of an engineering course where a compulsory first year subject based on sustainability had an emphasis on critical thinking. Whilst this may have been difficult for many first year students in their first semester, the expectation of critical thinking had raised their awareness. One of the final year Environmental Science subjects expected students to engage in critical thinking and reflective thinking through assessment tasks, the subject outline and readings, guided tasks and discussion. This subject also emphasised questioning the "status quo" and the concept of sustainability.

7.2.3 Teaching style

A lecturer's definition of critical thinking will relate to how it is taught, as has been noted by authors of different persuasions (McPeck, 1990; Moore, 2004; Norris & Ennis, 1990). Those lecturers who aim to empower students often believe it is necessary to provide space for discussion and debate in class. Many of the lecturers in this study focused on this strategy and some used only this strategy. However, the success of this strategy depends on teaching style and those who are more learner focused, who provide an egalitarian classroom, group work and opportunities for reflection were more likely to engage students at a deeper level (Biggs, 1999) and thus encourage their critical thinking. Several of the lecturers involved in this study made comments about the egalitarian situation they had established in class and their students acknowledged the advantages of this. According to Johnson et al (1996), teaching style affects learning. Moreover, they differentiated between teachers who simply answer questions and those

who create questions and thus create discussion. Several of the lecturers in this study paid particular attention to questioning, including writing a challenging question on the board for discussion or providing challenging resources for discussion.

7.2.4   Types of assignments

Although the students involved in this study felt they had benefited from discussion in class, especially when the lecturer was obviously guiding debate or students were discussing issues in small groups, they placed more emphasis on other strategies. For instance, most of them felt they had developed their critical thinking by engaging in researching the literature. This supports McPeck's (1990) contention that critical thinking is best developed through increasingly gaining knowledge of a subject. Those who had been involved in their own research proposals or projects had become more critical through the process of completing the project, including the challenges of writing it as a report. For example, the student who had written a report on the manual handling practices of the SRA had become critical of the organisation because of its attempt to prevent her from releasing the information, despite assurances that it would only be seen by the marker. She also critiqued the presentation of the subject, which had focused on action learning and qualitative research, yet did not provide students with guidance in the methodology for writing up such research.

7.2.5   Attitudes to assessment of critical thinking

Attitudes to assessment can greatly influence the outcome in student work. In an attempt to gain a more practical demonstration of the perceptions of lecturers I explored their attitudes to the assessment of critical thinking. However, only half of the participants provided information about what they do, which is indicative of a lack of clarity about this process.

While it appears that most effort regarding the assessment of critical thinking in the literature has concentrated on generic thinking tests such as the Cornell Critical

Thinking test (Ennis and Millman, 1989), there has not been much written regarding a more subject specific approach to assessment. In support of this point, Pithers & Soden (2000) refer to the difficulty lecturers have in assessing critical thinking and state that "assessment and evaluation of critical thinking has been sorely neglected world wide" (p. 239). In this study lecturers who did respond to the question about assessment of critical thinking focussed on the quality of the argument presented by a student, and the provision of evidence to support it. Others mentioned expressions of students' own ideas and acknowledgement of a range of viewpoints. Such criteria are consistent with a theme in this study that many lecturers expected students to demonstrate wide and in-depth reading. Evaluation and appraisal of information in the literature was considered an important aspect of the development of critical thinking. The lecturers who had marked the sample assignments for this study were able to provide more detail of how they assessed critical thinking.

Those lecturers who were interviewed had different criteria for assessing critical thinking. This varied according to the content of the subjects and courses, the framework and assumptions underlying each of them and the way in which the subjects were taught. Lecturers often identified certain parts of an assignment where they were more likely to expect critical thinking to be demonstrated such as in the Discussion and Conclusion sections of a report. A few lecturers identified the literature review as a section for finding a student's argument, and some indicated that the student's choice of topic for an assignment could also demonstrate critical thinking. Others indicated that critical thinking could be found throughout an assignment. These two attitudes to assessment of critical analysis in assignments can be viewed similarly to that of assessment generally, as "analytic" or "holistic" (Biggs, 1999, p. 152). Biggs favoured holistic assessment and allowed that this may include subjective judgement.

A holistic attitude to assessment of critical thinking was exemplified by one of the interviewed engineering lecturers who explained that she wanted to find evidence of students' thinking processes in assignments and examination papers, and to find the influence of this on their decision-making and problem solving. There was also an identified reflective section of their major assignment worth ten percent of the marks (see Section 5.2.3). She believed that the student assignments she had recommended

had demonstrated critical analysis of the engineering techniques they had investigated, and she admitted that her assessment was intuitive. A holistic approach to assessment of critical analysis in Environmental Science expected students to develop a strong argument, to critique the dominant paradigm and to reflect on their own learning. One of the student assignments in particular had achieved this holistic level of critical analysis in its critique of the practices of an international health program, government responsibility and the client organisation. Similarly, a law lecturer clearly identified that critical thinking required students to think beyond a descriptive approach to the law, to consider its purpose and whether the purpose is achieved. The Environmental Law assignments that were analysed were very critical of existing environmental legislation and its limited effectiveness (Section 6.3), though neither of them appeared to critique the dominant anthropocentric paradigm.

In comparison an analytic attitude to assessment of critical thinking was more likely to identify certain sections or aspects of an assignment, rather than the whole, as containing argument and critical thinking. For example, the assessment practices of the two interviewed Environmental Law lecturers were noticeably different from each other. In contrast to the lecturer mentioned in the paragraph above, the other law lecturer was interested in the conclusions students reached and made quite an issue of the quality of their written expression. He claimed that law is a field of study where control of language is essential and explained that it was at the sentence level that critical analysis was evident. He placed emphasis on correct grammar, spelling and sentence structure as an indicator of critical analysis, yet in the subject outline for this subject there was an obvious expectation that students should evaluate the effectiveness of the environmental laws.

Although findings revealed the role of reflective writing to be important in several of these environmental subjects, specific details of how this was assessed were not explored in this study. As Boud (1999) indicated, there are a number of different approaches to reflective thinking and writing and the current study found demonstration of this. For example, in an Environmental Science subject one written assignment was completely devoted to reflection on learning and the provision of evidence by the student that they had met the required six competencies. However, no examples of such

documents were provided for analysis. In Environmental Engineering a reflective paragraph in an assignment focused on how the student had found the information for the whole assignment, however it was indicated in the lecturer's interview that she was looking for comments on learning in the process of writing the assignment. In the other subject reflection was expressed as comments throughout the report written in the first person, thus indicative of the student's own thinking. Further research could investigate the expression and assessment of reflective writing in this field.

In terms of their recommended assignments, the interviewed students felt they had demonstrated critical analysis in a variety of ways. For example, several students identified particular parts of their assignment that contained critical analysis, such as their choice of topic, assignment structure, literature review, discussion and conclusion. Others mentioned that the whole assignment contained critical analysis and referred to the argument they had presented and supported with primary and/or secondary evidence. Since the assignments from Environmental Science were based on the students' own research, or preparation for primary research, they critically analysed the relationship between theory and practice in their field taking into account those responsible for identified problems. Such experiential and active learning is acknowledged to be important for the development of critical thinking by Duron et al (2006).

The Environmental Engineering assignments were based on secondary evidence of varying amounts and quality, as students were not writing about their own research projects. On the other hand, the assignment in one subject was based on a field trip. The assignments were noticeably more positive in the conclusions they reached than those from the other disciplines (see Section 6.3), however they were sometimes evaluating situations that posed serious environmental threats if left without intervention. Both engineering lecturers expected students to address the triple bottom line of sustainablility regarding impacts on the environment, society and economics (Beder, 1996; Pezzoli, 1997). The engineering students and lecturers felt these assignments had satisfied that criterion.

The Environmental Law assignments used cases as primary evidence with one student explaining in his interview how he had developed his critical thinking by recognising that he had to interpret judgements for himself, rather than base his arguments on the interpretations of others. These assignments were more negatively critical than those in the other discipline areas, due to the perceived inadequacies of the current legislation. The expression of critical analysis in both of the Environmental Law essays was dependent on the development of an argument with evidence from cases to demonstrate the limitations of the relevant law. Both student authors had recommendations for improvements to the legislation.

7.2.6 Written feedback from lecturers

The interviewed students believed that the lecturers' comments on returned assignments were very helpful for developing critical thinking. The Environmental Science students greatly appreciated the lecturers' feedback. In some instances this was during the process of preparing their assignments. It is acknowledged that good teaching practice calls for regular feedback on students' work (Biggs, 1999; Duron et al, 2006) and several of the lecturers indicated that they did this. However, as indicated by Lea and Street (1998) the type of written feedback can either reinforce the power relationship between student and lecturer, when the student is seen to lack skills, or encourage a positive interaction resulting in learning.

7.2.7 Supplementary written information about critical thinking

Other written material, for example readings about critical thinking and information in the subject outline, helped students to better understand their lecturer's expectations. This is in keeping with the idea that the epistemological basis for individual subjects should be made explicit to students (Jones et al, 1999), and attitudes to critical thinking should also be explained to students as part of understanding the discourse of a subject (Fairclough, 1995; Gee, 1990). Many lecturers included critical thinking in the aims and objectives of their subject outlines and some included it in assignment instructions and

marking criteria. Written instructions for assignments which include the terms "critical thinking, critically analyse or critically evaluate" appeared to have a positive effect on student assignments, as was found by one of the engineering lecturers (see Section 5.2.1). Several students also commented on the value of having critical thinking as part of the marking criteria and, as mentioned above, this could give students the impression that all of them are capable of demonstrating critical thinking in their assignment.

Lecturers and students perceived that the provision of written material about the meaning of critical thinking was helpful. Some lecturers used a number of these strategies. Environmental Science subjects, especially those in the applied sciences, more consistently supplied written resources with explanations of the meaning of critical thinking. Several lecturers in various disciplines regarded the concept of interdisciplinarity as assisting with the development of student critical thinking, which supports the assertions of Jones et al (1999). It was found in this study that students of applied Environmental Science who had experienced an interdisciplinary approach to environmental issues appeared to have a clearer understanding of the different expectations regarding critical thinking.

Interestingly, although it was mentioned in the literature review that "model" assignments can be useful for students (Lukeman, 1992; Farrell et al, 1997) only one Environmental Science lecturer appeared to use this strategy for encouraging student critical thinking. This is something that could be researched further, in terms of the evaluation of benefits to students of using this strategy. From my experience in the field of teaching tertiary literacy this appears to be a useful resource for students, though none of the students in this study mentioned such benefits.

7.2.8 The student perspective

Several of the students who were interviewed attributed their improvement in critical thinking to maturation and external experiences, such as workplace experience and political activism, as well as to the teaching strategies employed by their lecturers. For example, one mature aged Environmental Science student believed that her critical

thinking had increased through working in an organisation connected with the medical profession through which she had read and learned about information not easily accessible to the public. On the other hand, one of the Environmental Law students reflected on his earlier years of study and identified his own lack of primary research as a problem for critical thinking. Other students acknowledged the value of applying extra effort, especially through researching and reading and practising critical thinking. Importantly, it appears that students need to discuss and think reflectively about the processes they engage with to develop their critical thinking, and then relate this to written critical analysis.

The previous project conducted by the Critical Thinking and Writing Network at UWS concluded that there were some common processes that successful students might engage in when writing an assignment, which developed their critical thinking. These processes included:

- thorough analysis of the question;
- immersion in the field through reading and experiential learning;
- asking questions;
- making links to the other topics in the subject, other subjects and to work situations;
- viewing the topic from different perspectives;
- awareness of relevant concepts and frameworks of subjects;
- developing a position with arguments to support it (James et al, 1999).

Students in the current study identified most of the learning processes listed above, as well as other processes such as discussion in class, groupwork, brainstorming, experiential learning, deductive reasoning, practice and reflection.

7.2.9 The significance of this study

There are some notable differences between the previous CTWN study (see Section 2.1.4) and this study regarding the teaching and learning of critical thinking. For example, reflection on learning was a significant aspect of the process of critical thinking in environmental subjects, with the exception of Environmental Law subjects.

Students in this study also appreciated being involved in experiential learning situations and doing their own research in order to develop their critical thinking abilities.

The three approaches to critical thinking: scientific/technical, paradigmatic and reflective, were found to be present to differing degrees in the various subjects in this interdisciplinary field. They were also expressed differently according to discipline. The identification of these approaches to critical thinking in environmental subjects at university level contributes to the understanding of the expression of critical thinking. A more detailed account of the strategies used by lecturers to encourage student critical thinking was also revealed, suggesting possible guidelines that could be useful for other practitioners. This level of detail is one of the benefits of having undertaken qualitative research (Freebody, 2003; Higgs, 1997).

7.3 Teaching strategies that hinder student critical thinking

7.3.1 Information overload

Subjects that overload students with information were identified in several student interviews as a hindrance to the development of critical thinking. Students observed that such subjects did not allow time for critical thinking, a point Biggs (1999) would agree with. There are subjects that require students to memorise certain information, as was acknowledged by McPeck (1990) to be appropriate in earlier stages of acquiring knowledge and developing critical thinking, however to do this successfully university students need time to think through the issues. A one way teacher orientated approach with the emphasis on transmission of knowledge is less likely to involve students in interactive learning and reflection (Biggs, 1999; Boud et al, 1985; Janse van Rensburg, 1994) and thus potentially discourages student critical thinking.

7.3.2 Assumptions made by lecturers

Based on student and lecturer interviews, I contend that another factor that appears to hinder the development of student critical thinking is a lecturer's assumption that students know what critical thinking is and that they already practise it. For example, a law lecturer expressed the view that law students should not need encouragement in furthering their critical analysis because most of them were higher level students, entering university with a high tertiary entrance score. This does not account for the additional difficulties students from other language backgrounds and other discipline areas they may encounter. In addition, students from other discipline areas may not have such high tertiary entrance scores and the assumption that they know what critical thinking is may be unjustified. These students would no doubt benefit from being provided with written information about critical thinking. I agree with authors such as Fairclough (1995) and Gee (1990) that this attitude is leaving the understanding of discourse to chance rather than being explicit for the benefit of students. It is important

that lecturers clarify their expectations regarding critical thinking, especially in terms of assessment, considering the diversity of the student population today (Haggis, 2003).

7.3.3 Attitudes to assessment

A noticeable difference in attitudes to assessment was illustrated by the ways in which marks were allocated to critical analysis in assignments. While many lecturers did not specifically allocate marks for critical analysis, those who included critical analysis as a criterion in the marking schedule more obviously perceived that all students were capable of demonstrating it. Unfortunately, they did not always provide a definition of critical thinking in their subject outline or a reading to explain the concept. Others specified descriptions for each grade in their marking criteria indicating that it was only in the assignments of High Distinction (HD) or Distinction (D) level that critical analysis was expected. This latter approach presents a practical problem for the concept of critical thinking as a graduate attribute, because it is only a small percentage of students who gain the higher grades.

Students interviewed in this study agreed that most students are capable of demonstrating critical thinking at some level and revealed that for them it was the result of hard work, researching a wide range of readings, and practice. However, several of them made the point that some students do not want to put the extra time and effort into developing their critical thinking because they can gain a "Pass" without it. Thus some students view critical thinking as an optional extra which they can engage with or ignore. This has negative connotations for the concept of critical thinking as a graduate attribute.

Furthermore, from my analysis of subject outlines and written materials, if the lecturer provides a marking schedule which only anticipates that HD and D assignments will demonstrate critical thinking, it could be that many students may assume they cannot reach this level. The students who were interviewed supported this understanding when they spoke about students who only wanted to pass the subject. They understood that critical thinking took more time and effort and improved with practice. While it may not

be a hindrance, it could be said that marking criteria which indicate that only high grade assignments demonstrate critical thinking could limit the potential for many students to develop their critical thinking. Several students and lecturers who were interviewed appeared to value the inclusion of critical thinking as one of the criteria in a marking schedule and thus expected of every student.

7.3.4 Lack of clarity

Based on the findings of this study an encompassing definition of critical thinking for students could be expressed as follows: *critical thinking in environmental subjects involves a number of processes, such as analysing and evaluating information, in context, in order to make informed decisions and take a position on issues. More effective critical thinking includes scientific/technological, paradigmatic and reflective approaches, according to the framework of each subject.* However, ultimately the definition students also need to be aware of is the one held by the lecturers of their different subjects. Because these definitions and expectations vary between subjects it is difficult to assess critical thinking as a generic skill in a "content free" skills test, such as the ACER (1999) test. This study has provided further evidence that this is an inappropriate method for testing graduating university students, as has already been stated by Moore and Hough (2005).

Finally, I would suggest that not being explicit about the paradigm/s in a subject and the subsequent lack of critique of these is a hindrance. This has repercussions for the interdisciplinary field of environmental studies (Carvalho, 2001; Chapman, 2004; Gough, 2002; Harding, 2002).

The next chapter will provide some conclusions based on the analysis and triangulation of findings. It will explore the implications of this study for the enhancement of student critical thinking in environmental and sustainability subjects, for other disciplines and for the future. It will also offer suggested areas of further research and recommendations.

CHAPTER 8: CONCLUSIONS AND IMPLICATIONS OF THIS STUDY

8.0 Introduction

The previous chapter discussed the findings from the different phases of the research with reference to the relevant literature. This final chapter will draw conclusions and implications from the findings for the teaching and learning of critical thinking in university environmental and sustainability subjects. While the critical practices revealed by these case studies cannot be generalised, they do provide insight into some of the ways in which critical thinking is expressed and encouraged in this field. This should be useful for practitioners in the university setting (Stake, in Denzin and Lincoln, 2003).

Three different yet complementary approaches to critical thinking were apparent in varying forms across all cases. The *paradigmatic approach* to critical thinking involved political and philosophical understanding and was not evident in every subject, though it could be found to a greater or lesser extent in each of the targeted discipline areas. Most subjects included a *scientific/technical approach* to critical thinking which involved analysing and evaluating readings and research studies, solving problems particularly in engineering, and scrutinising language, particularly in law. The *reflective approach* allowed for students to self-critique and evaluate their own experiences, practice and/or learning. This latter approach was more evident in some of the science and engineering subjects than in law subjects in the environmental and sustainability field.

The findings also revealed a range of pedagogical strategies that appeared to successfully encourage student critical thinking, depending on the approach taken by each subject lecturer. The most noticeable difference between the three cases was the narrower range of strategies used in Environmental Law subjects and the broad range of strategies evident in Environmental Science subjects. On the other hand, although many of the participants emphasised the importance of discussion and debate in class it was in the Environmental Law subjects that debating was most developed. Assessment strategies that encouraged students to express critical analysis also played an important

role and these were most noticeable in the science and engineering subjects, though the assessment of critical thinking within subjects generally remains an ongoing issue. Finally, a significant finding in this study is that the majority of lecturers and students participating in the research considered critical thinking to be very important for the field of environmental studies.

8.1 Differences in approaches and strategies between cases.

8.1.1 Case 1: Environmental Science

The case of Environmental Science demonstrated well the interplay of the scientific/technical, paradigmatic and reflective approaches to critical thinking. Within those applied science subjects most closely explored, it was recognised by the participating students that there were three different approaches involved and that lecturers had different expectations regarding critical thinking. The implication of this is that an interdisciplinary approach to environmental science and making explicit these different approaches to critical thinking contributes to a greater awareness of critical thinking for students, through exposure to different paradigms and perspectives.

It was in Environmental Science (applied) subjects at one particular university that students appeared to receive the greatest level of support in terms of identified strategies for developing critical thinking. This included having the opportunity to undertake their own primary research, and provision of clearly articulated expectations that critical thinking was a requirement in assessment tasks. Subject outlines included written explanations of critical thinking, though they were distinctly different approaches, and readings on critical thinking and related topics were part of the course materials. There appeared to be adequate opportunity for discussion and debate about the issues and content of subjects with an emphasis on open communication between lecturers and students. A reflective document as an assessment item raised student awareness of the relevance of this approach to the development of their critical thinking. Lecturer feedback regarding assignments was described as generous by students.

The implications of these findings are that, through exposure to many varied strategies for developing critical thinking and the interdisciplinary nature of their courses, these students were familiar with what was expected and were confident to express their views. Analysis of student assignments revealed a level of critique which encompassed the three approaches to critical thinking and demonstrated awareness of sustainability and socio-political issues.

8.1.2 Case 2: Environmental Engineering

The expression of critical thinking in the case of Environmental Engineering subjects differed between lecturers, with most of them emphasising the scientific/technical approach of problem solving in practical situations and evaluation of the literature. Only one lecturer expressed critique of a dominant paradigm. Students expressed critical evaluation of current environmental engineering practice in their assignments. A scientific/technical approach to critical thinking was evident in their reports, with the inclusion of reflection most obvious in a subject where it was a requirement for assessment. Critique of paradigms was not obvious in these assignments though evaluation of information addressed the triple bottom line often referred to in education of sustainability (Beder, 1996; Pezzoli, 1997).

Since a number of the participating Environmental Engineering lecturers appeared to have low expectations with regard to the expression of student critical thinking in assignments, it is worthwhile considering what might improve this situation. One possibility is that most of the questionnaire participants did not include paradigmatic or reflective elements in their approach to critical thinking, mainly emphasising technical problem solving. On the other hand, when paradigms and reflection were specifically included, the students appeared to be challenged to think critically within a broader context.

Other strategies that were found to encourage student critical thinking could be seen to be good teaching practice (Biggs, 1999; Duron et al, 2006). Classroom discussion was a common strategy employed in most subjects and the benefits of this were acknowledged

by participants. Another successful strategy used in this discipline was the inclusion of the terminology "critical thinking" in assignment instructions. This appeared to have a positive effect on students' expression of critical analysis, however students also need to understand what is expected. Without clear instructions and an understanding of expectations students may not consider it necessary to include critical thinking or evaluation in their assignments and may resort to descriptive writing.

Also this study indicates that there was a positive effect on the expression of student critical thinking in assignments when critical thinking was included as a criterion in a marking schedule. However, the topic of assessment of critical thinking in assignments is open to debate and requires further research. The implications of the findings are that expectations regarding critical thinking should be both discussed in class and written into subject outlines and marking criteria.

The success of a first year subject based on sustainability and critical thinking in engineering courses at one university indicated that this is a strategy to consider at other universities. Interviews with Civil Engineering students who had studied the subject revealed a clear commitment to the concept of ESD, and there was evidence of critical thinking about environmental impacts in their assignments. Findings suggest that the particular faculty's attitude to sustainability, to critical thinking and to student learning may be the most pertinent factor involved here (Byrne et al, 2004). When there is a positive attitude to these concepts, student assignments are more likely to demonstrate critical analysis.

8.1.3 Case 3: Environmental Law

This study indicates that two approaches to critical thinking are dominant in the discipline of Environmental Law, with the paradigmatic approach especially helpful and the technical approach to critical thinking a necessary complement. Because the reform of environmental legislation offers significant opportunity for the prevention of further environmental destruction, students' ability to critique the anthropocentric nature of current legislation was seen to be important. This latter approach is seemingly best

developed in class especially in the form of debating. The requirement to critique the language of legislation, at a more technical level was considered to be a necessary skill for demonstrating critical analysis in law. The implication for teaching practice of the significance of the role of language in Environmental Law is that this needs to be explicit in both oral and written instructions for assignments, especially if students have some difficulties in this area.

The strategies for encouraging critical analysis were not as obvious in this case, apart from that of debating in class. An emphasis on the requirement of critical thinking was found in the objectives of most subject outlines, and in one subject the essay questions had a focus on "critical evaluation". This appeared to be considered to be sufficient. Environmental Law subjects in this study did not offer written explanations, resources or references about critical analysis, which in the case of Environmental Science had been of assistance to students. The assumption in one subject that all law students are able to practise critical analysis without any specific encouragement, seemingly based on the high entrance score needed to study law, does not take account of NESB students and students from other faculties studying environmental law subjects. The findings in the case of Environmental Science indicate that it could be very valuable for the development of critical thinking to provide written material to support what students learn from debating in class, particularly for non-traditional law students. It could also be beneficial to all environmental law students to increase their awareness of critical analysis.

Although there was no reference to reflective thinking as an aspect of critical analysis by the Law lecturers involved in this study, the value placed on the role of reflection in the other discipline areas indicates that the inclusion of reflective thinking may be beneficial to the development of a broader understanding of critical thinking for their students.

8.2   *General conclusions and implications resulting from the case studies*

The findings from this study suggest the following guidelines for lecturers of environmental subjects when planning their subject outlines, assignment instructions, marking criteria and learning activities. Many of these guidelines are similar to the teaching practices recommended by authors such as Biggs (1999) and Duron et al (2006). However, this study indicates something more specific about the teaching and learning of critical analysis. For instance, there are specific implications regarding generic testing of critical thinking skills and regarding critical thinking in the field of environmental and sustainability studies. The findings of this research suggest that there could be benefits to the development of student critical thinking as a subject specific ability if content lecturers were to collaborate with staff from academic literacy and learning units within the university, whose role is increasingly being recognised as complementary to the content lecturer in relation to development of students' academic literacy skills (Haggis, 2003; Jacobs, 2005).

8.2.1 The issue of testing critical thinking as a generic graduate attribute

The findings of this research suggest that the graduate attribute of critical thinking is not generic nor independent of context, but tied to the learning of subject content. This implies that it is not appropriate to test critical thinking in a generic skills test such as that proposed by ACER (1999). This issue has been raised by other authors (Biggs, 1999; Haggis, 2003; McPeck, 1990; Moore, 2004; Moore & Hough, 2005). Rather it is preferable to assess critical thinking through subject assignments. If all students were expected to demonstrate some level of critical thinking to gain a pass in their assignments, then universities could more confidently claim critical thinking as a graduate attribute. However, this does raise the issue of whether critical thinking should be expected in every assignment and in every type of examination. This study has not attempted to answer this question, which could be an area for further research.

8.2.2 The link between critical thinking and environmental/sustainability subjects

As was indicated by several participants, environmental/sustainability subjects often contain information that is open to debate, thus providing more opportunity for discussion of different points of view and encouraging students to make decisions about issues. This suggests that the sustainability subject in first year engineering that was found to be a successful background for the development of student critical thinking could be an initiative worth repeating in engineering courses in other universities. It also suggests that a sustainability subject could be included in a number of other relevant disciplines, but especially in the sciences, engineering and law. This could provide an introduction to critical thinking in an interdisciplinary setting and meet government objectives regarding sustainability (Commonwealth of Australia, 1999; NSW Government, 2002).

8.2.3 Interdisciplinary learning

One of the underlying issues of this study is related to student confusion about what critical thinking means, which is understandable considering the diversity of definitions of the term. Where lecturers were explicit about their expectations, though they might be different in each subject, this was enhanced by an interdisciplinary context. For example, when students were exposed to a paradigmatic, theoretical or political level of critique in certain subjects, and had an opportunity to think reflectively and develop critique at a scientific or technical level in other subjects they had more opportunity to expand their understanding of critical thinking.

This study suggests that there could be benefits from an exchange of information in regard to student understanding and learning about critical thinking. For example, students in the disciplines of Environmental Science and Environmental Engineering could benefit from the finding in the case of Environmental Law that an emphasis on debate in class is very important for developing argument and critical thinking abilities. Students in Environmental Law could benefit from the findings in the case of Environmental Engineering that suggest a sustainability subject, inclusion of reflection and the terminology of critical thinking in assignment instructions and marking criteria can be beneficial. Both of the Environmental Law and Environmental Engineering

disciplines could benefit from the Environmental Applied Science findings that demonstrate the benefits of an interdisciplinary approach and a wide range of explicit teaching and learning strategies. These include, written explanation about critical thinking and conducting more primary research to develop students' understanding of sustainability and critical thinking.

8.2.4   Advantages of certain teaching strategies

The implications of this study are that students benefit from experiencing a variety of teaching and learning situations that aim to develop critical thinking. These include discussion and debate in class, written explanations of the meaning of critical thinking and graded written exercises which focus on critical thinking, such as summarising and evaluating readings. Experiential learning, such as field trips were found to stimulate critical thinking. The benefits of wide reading to prepare for assignments was also emphasised by both lecturers and students. Environmental Science students indicated that generous written feedback on their returned assignments was helpful for developing critical thinking. Issues related to assessment require closer consideration. Implications of this study are that action research projects involving collaboration with academic literacy lecturers could be a successful strategy for providing contextualised exercises and activities to develop student critical thinking (Jacobs, 2005). This could also include an interdisciplinary perspective.

8.2.5   Issues related to marking criteria

If only HD and D students are identified on marking schedules as critical thinkers the implication is that other students are unable to think critically or that it is not necessary to put in this extra effort. Students can comfortably gain a pass without it. Therefore, the findings of this study suggest that marking schedules need to include a mark for critical thinking, so that it is obvious that all students are expected to demonstrate this ability. Student achievement of a higher or lower grade will then depend on other qualities of their work. Overall, critical thinking could be identified as a requirement to pass an assignment, and this study suggests that it is more likely to engage students when

critical thinking is included as a requirement in assignment instructions or marking criteria. It would need to be clearly explained to students. Other methods of assessment such as peer assessment (Boud, 1999) could also enhance critical thinking skills, however, this requires further research.

8.2.6   Time for thinking

Overloading information in subjects is not conducive to the development of student critical thinking, according to student interviews in this study and the literature (Biggs, 1999; Duron et al, 2006; Gough, 1997). This implies that for subjects embedded within the positivist framework it is important to allow time for reflection and thinking at a paradigmatic as well as a technical level. There is some support for this implication in the literature, for example, McPeck (1990) suggests that all subjects should have a philosophical element to set them in a broader context and Jones et al (1999) suggest the inclusion of epistemological concepts for each subject. This is especially important for environmental and sustainability subjects.

8.3.   Further research

The exploration of critical thinking in the subject areas of Environmental Science, Environmental Engineering and Environmental Law suggest a need for further research. For example:

- comparison of results with exploration of critical practices in other discipline areas using a similar research design;
- comparison of approaches to critical thinking in other countries within the environmental and sustainability field;
- further research to improve assessment practices of critical thinking within subjects, possibly involving action research;
- exploration of the relationship between critical thinking at university and critical thinking in the professional situation, including the question of adequate preparation;

- research into reflective writing practices and their assessment;
- the findings of this study could be complemented by observations of classroom interactions.

The implications of this study have resulted in a number of recommendations or guidelines for practitioners in the environmental and sustainability field. For example:

- that lecturers provide explicit explanations for students of their expectations regarding critical thinking;
- that this include a definition or description of critical thinking which is mindful of the three approaches found in this study;
- that written explanations be included in subject outlines;
- that critical thinking/critical analysis be included as a criterion on a marking schedule whenever appropriate;
- that readings about critical thinking be considered as supplementary reading in a reference or resource list in subject outlines.

There are also broader implications resulting from this study for the teaching and learning of critical thinking which could be considered on a university wide basis. For example:

- that generic critical thinking skills tests be replaced with a more concerted effort to encourage and assess student critical thinking within each subject;
- that professional in-service courses be developed for subject lecturers to raise awareness of the need for specific strategies, as have been identified in this and other studies, to be included in teaching practices;
- that these be tailored to discipline areas with some attention paid to interdisciplinary fields such as environmental studies;
- that subject lecturers work collaboratively with academic literacy staff in universities in order to develop the most effective approaches to teaching and learning about critical thinking for students in that subject.

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APPENDICES

Appendix A: Questionnaire for lecturers

Appendix B: Summary of responses to lecturer questionnaire

Appendix C: Interview questions

Appendix D: Sample theme analysis of transcript of interview

Appendix E: Sample discourse analysis of Conclusion of student assignment

APPENDIX A

Questionnaire for lecturers and tutors

The following survey is part of a research project *Exploration of critical thinking in environmental subjects*. The survey will be kept confidential and will contribute to an analysis of responses according to three broad discipline areas: Environmental Sciences, Environmental Engineering and Environmental Law. Your response to the survey is voluntary and will be taken as your consent to participate in this section of the project. Your participation is greatly appreciated.

1. In which of the following undergraduate areas of environmental/sustainability studies do you teach? Please tick and indicate year of study.

Environmental Science   ☐

Environmental Engineering ☐

Environmental Law   ☐

2. How important is critical thinking in your subject? Please explain.

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3. Do you expect to see evidence of critical analysis in student assignments? How does this vary according to year of study? Please explain.

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4. Estimate the percentage of assignments you mark which contain critical thinking:

1st year………….   2nd year……….   3rd year ……….. 4th year ……….

5. How do you define critical thinking? Could you provide an example?

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6. What do you do to encourage critical thinking in student assignments and in the classroom situation?

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7. To what extent is protection of the environment, and other broader social issues, a key concept in your subject?

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8. How do you assess critical thinking in student assignments? Do you expect a wide range of sources to be consulted?

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9. Is there a specific framework, or underlying set of assumptions in your subject/s? Could you explain this?

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………

10. How do you encourage critique of such a framework/s or assumptions?

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………
………

11. Do you make your expectations about critical thinking explicit to students? How?

………
………
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………

Could you please enclose a copy of your subject outline, assessment tasks and criteria for marking assessments? These will be coded and analysed separately from the survey.

Thank you for your time and effort in responding,

Erst Carmichael.

APPENDIX B

Summary of responses to lecturer questionnaire

The following are summaries of responses to the questionnaire from Question 2 - 11, according to the discipline areas of environmental science, environmental engineering, environmental law and environmental economics. The three lecturers who indicated that they taught in more than one environmental discipline are entered in a separate section called Interdisciplinary. The lecturers' own words are used, with minor editing due to limited space. Each table represents responses to one of the questions, in the order they were presented on the questionnaire, and each number corresponds to one lecturer's response per question. The same number is used for that lecturer's response for every question. The table for responses to questions 3 and 4 are presented together because of the close relationship between the two questions. The responses are coded according to themes (see Chapter 4).

QUESTION 2. How important is critical thinking in your subject? Please explain.

Subject area	Comments
Environmental Science	1. Very important. I am trying to encourage more critical thinking in my own classes, and in the other classes where I am the Director of the Environmental Science Program. **(B)**
	2. Needs to be progressively introduced from 1st yr, emphasised in 3rd yr. **(C)**
	3. One of the core objectives of course (1st year subject) **(B)**
	4. Very - students are expected to analyse field data and make recommendations, draw conclusions, evaluate journal articles for adequacy and correctness. **(B)**
	5. Extremely - because knowledge in the area in "state of flux" - variety of conflicting explanations for some phenomenon; Ss need to develop skills to decide about these explanations, both as students and future environmental scientists. **(A)**
	6. Very important in tutorials, though not well attended (tutorial attendance only worth 5%). **(B)**
	7. Essential – in postgraduate program, thesis must be based around hypothesis. **(A)**
	8. Very – necessity in any science subject. **(B)**
	9. While first year of necessity involves some rote learning to bring students to a common level for dialogue, still a requirement to introduce critical thinking/analysis. (**C**)
	10. Very - Ss need to engage in and critically analyse work based project **(B)**
	11. Moderately important. It is possible to be awarded a Pass or Credit grade based on recall of information and general technical competence, but highest marks are reserved for those whose work (especially lab and assignments) gives evidence of cr. Thinking **(C)**
	12. Essential part of problem based learning and highly relevant as virtually all students are in practice shortly after graduating, if not before. **(A)**
	13. Most important **(A)**
	14. Central: focus is on analysis of data and presenting arguments to support conclusions. **(A)**
	15. Essential – critical thinking drives effective professionalism. The ability to think critically, strategically & creatively will serve students throughout their lifecourse. **(A)**
	16. Some subjects make direct reference to it in both lectures and

Environmental/Sustaina ble Engineering	1. Significant, as the environment does not remain constant. Ss are expected to analyse a situation critically first before any application. **(B)** 2. Quite. I want Ss to think about the implications of their water and wastewater solutions in terms of sustainability etc. Not much luck! **(C)** 3. Evaluating environmental issues **(B)** 4. Very important. All the units I teach contain critiquing available/published literature. **(B)** **5.** Whilst the subject is instructional, I would like students to think critically about urban infrastructure. **(C)** 6. Very - basic aim of tertiary education **(B)**
Environmental Law	1. Very important to adopt a critical in depth analysis of current law and policy. **(B)** 2. It is essential that students look behind the law – both statutes and court judgements, as well as relevant government policy. For instance, are the objectives of a particular statute expressed or implied? How are they achieved? Is achievement likely? Why/why not? Can any improvements be suggested? **(A)**
Environmental Economics	1. Extremely important. The core paradigm of my lecture course is that environmental problems are not the result of human indifference and greed, but the result of identifiable, analysable and correctable instances of resource misallocation due to management failure. **(A)**
Interdisciplinary	1. The units I teach involve Ss working on projects. Critical thinking is an essential component in all aspects of project work – from proposal to writing a completed report. (Science & Engineering) **(A)** 2. Extremely important – I teach issues-based units and policy type units – critical thinking is part of interdisciplinary study and is needed for problem solving. (Science & Law) **(A)** 3. Very important. Critical thinking is needed to solve complex environmental problems. (Science & Law) **(B)**

QUESTION 3. Do you expect to see evidence of critical analysis in student assignments? How does this vary according to year of study? Please explain.
QUESTION 4. Estimate the percentage of assignments you mark which contain critical thinking.

(NOTE: These two questions will be viewed together because they are closely related. "N/A's" were entered by respondents, not by the researcher.)

Subject area	Q.3: Expect to see critical analysis?	Q.4: Estimate percentage seen				
		1st yr	2nd yr	3rd yr	4th yr	
Environmental Science	1. Yes, but understand it will not always be there. Expect more in higher levels of study. **(C)**	1. N/A	30%	50%	80%	**(C)**

#	Response	#	Percentages	Code
2.	Yes, by year 3 expect critical thinking in assignments graded HD. Still possible to get Pass without. **(D)**	2.	5% 10% 50% 75% (Hons)	**(B)**
3.	Only teach 1st year. Expect to see evidence of critical thinking in all assignments. **(A)**	3.	100% (1st year only)	**(A)**
4.	Limited in Yr 1 subjects - mostly reporting what is. Yr 2 - development of analytical skills - critically evaluating data & inputs. Yr 3 - careful critical review of data, analysis and references. **(B)**	4.	10% 40-60 80-100 100	**(B)**
5.	Yes, I set a level 3 assignment where students have to constructively critique a published scientific paper. First they have to find their own paper in the library! The paper has to have a serious flaw in experimental design and the students have to suggest improvements. I would not demand such high level skill of level 1 students, but would expect level 2 to be able to critique a paper supplied to them. **(B)**	5.	20% 30% 60% 100%	**(B)**
6.	Yes, but generally only in high quality students. **(D)**	6.	N/A (only teach 1st yr)	**(E)**
7.	Yes, undergraduate work must be technically correct and logical, postgrad must be critical. *(This is a postgraduate subject).* **(C)**	7.	- - 10% 50%	**(C)**
8.	Yes, a good scientist has to think critically. **(B)**	8.	- 30% 60% 80%	**(C)**
9.	Yes, in the two "literature" assignments (the second more than the first) and in the two practical write ups (second moreso). **(B)**	9.	50% (only teaches first year)	**(B)**
10.	Yes, absolutely. I only teach final year undergrads & expect critical analysis skills. **(D)**	10.	- - 20 – 40% -	**(C)**
11.	Expect to see evidence in all years, but this depends on the unit (subject). 1st yr forensic science (with case studies) requires more critical analysis than 2nd yr physical chemistry, which emphasises familiarity with technical concepts and various types of technical competence. **(D)**	11.	60% N/A 50% 80%	**(B)**
12.	Yes. Expectation does not vary, but level of critical thinking achievement does. PBL takes at least 3 years of study to fully potentiate, and probably influences ..lifelong learning mode. Requirement in all assignments. **(A)**	12.	100 100 100 -	**(A)**
13.	Yes, 1st - 3rd (medium - high) **(B)**	13.	90% 100 100 -	**(A)**
14.	- **(F)**	14.	30% - - -	**(D)**
15.	Yes. Any sign of reflexivity - stepping outside assumptions and expectations. Students, regardless of year do this at different levels. **(D)**	15.	30% (1st year only)	**(D)**
16.	Yes I do! But some students don't like to think, let alone think critically. All too often they just want answers - too focussed on assessment. **(D)**	16.	10% 30% 30% -	**(D)**
17.	Yes. Some students show moving levels of thinking, others are good to start with,	17.	- - - -	**(E)**

Subject	Response					
	others never really make it. **(D)**					
	18. With first year first semester students our expectation is limited. All subjects as all levels have components either in assignments or Web CT discussions to allow development of critical thinking. So our expectation of a 3rd year student is more. However, this is not always delivered… **(B)**	18. 10%	25%	N/A	33%	**(D)**
Environmental Engineering	1. Yes. We expect high levels of critical thinking in early subjects as opposed to the norm. This expectation is set early on so that they follow that in other following years. **(B)**	1. 35%	35%	30%	30%	**(D)**
	2. I only teach 4th yr and postgrads and yes, I would like to see some aspect of critical assessment. Not much luck. **(D)**	2. -	-	-	appr10%	**(D)**
	3. Yes greater depth **(B)**	3. 50%	60%	70%	80%	**(B)**
	4. Making inferences based on statistical analysis & critique of published literature detailing limitations and possible extensions **(D)**	4. N/A	10-20	20-30	60-70	**(B)**
	5. I try to encourage critical analysis **(D)**	5. -	-	3%	-	**(D)**
	6. Yes, more sophisticated with each successive year (4 year course) **(B)**	6. 20	20	40	80	**(B)**
Environmental Law	1. Yes, this is essential for every student since the topic is assessed by assignments. Descriptive writing is not permitted. Does not vary except for international students who are less critical. **(A)**	1. -	-	-	150	**(B)**
	2. This relies on the subject. In Env Law for LLB students, critical analysis is expected in research essays but not in take home assignments with hypothetical fact scenarios. **(D)**	2. -	-	-	-	**(E)**
Environmental Economics	1. I expect students to understand the paradigms of Env. Economics and to be able to analyse environmental issues from this approach. **(A)**	1. -	70%	80%	-	**(B)**
Inter-disciplinary	2. Yes. The depth of critical analysis is relatively low for a first year unit compared with a final year unit. The depth varies in terms of literature accessed and the analysis & interpretation of data. (Science & Engineering) **(B)**	1. -	-	-	-	**(E)**
	3. Yes, definitely. I expect a greater range of viewpoints to be evident as students prosper, eg. in 1st yr 2 - 3 fairly contrasting views may be OK. In 3 - 4th yr I expect a fairly involved 'literature review' approach. (Science & Law)**(B)**	2. 100	100	100	100	**(A)**
	3. Yes. This is very difficult for younger environmental science students, but less so for graduate students. (Science & Law)**(C)**	3. -	-	100	100	**(C)**

QUESTION 5. How do you define critical thinking? Could you provide an example?

Subject area	Comments
Environmental Science	1. Ability to question a concept, piece of information etc in depth - present a well argued personal perspective, draws on the original material (lectures, readings etc). There are numerous examples…Sydney's population …present a perspective on what is a desirable population for Sydney in 20 years from now, and …argue why this is the case. **(A)** 2. Ability to analyse a situation from various viewpoints and critique accepted dogma, eg. biological control critique presented to yr 3. **(B)** 3. Ability to assess validity of information, discuss implications of actions on environment. **(B)** 4. Informed evaluation of a set of data, facts, situation, image or reference. **(B)** 5. Ability to identify faults and flaws in a piece of work and suggest a way to remedy this, eg. where class members present experimental designs for proposed project and these are critiqued. **(E)** 6. I equate c.t. with analysis, being able to identify salient points and judge evidence. **(B)** 7. Not simply accepting a "standard" outcome, any good research includes critical thinking. **(A)** 8. Not to accept everything, be able to evaluate, analyse and synthesise information. **(B)** 9. Think through the issues to arrive at a conclusion, eg. Given a published paper, students can critique the materials and methods; in an experimental exercise students measure water use by a plant under different conditions, then discuss… **(C)** 10. Seeing through and challenging dominant meanings and practices – in projects need to objectively consider existing approaches to professional work. **(A)** 11. Capacity to integrate knowledge and ideas from different sources, which need not all be from the same area of knowledge, eg Ss analysis of water sample can be in terms of inorganic ions but then interpreted in terms of water flows, chemical and biological processes, landuse, legislation… **(E)** 12. An ability to identify, study, evaluate, analyse, draw conclusions, and make recommendations within an objective framework. **(B+C)** 13. Thinking systematically, logically, strategically with "gap analysis" in mindset. **(E)** 14. Making judgement about some event or thing based on criteria, plus being open minded about the criteria used to make judgement, eg spraying of crop in upper catchment; frog numbers in lower catchment declining; conclusion – may be connection – more evidence needed. **(B)** 15. The ability to acknowledge and think outside epistemological assumptions, eg seeing divorce as a societal answer to the problem of marriage, rather than as the social problem itself. **(D)** 16. Thinking via analysis. Examining the situation more fully from a number of angles may produce more complex, helpful answers. **(B)**

| | 17. Questioning information. Looking for sources. Thinking comparatively. Seeking context of ideas. Awareness and engagement. **(A)** |
| | 18. Analysis of events/features/statements/data in the light of existing theories/philosophies/values in the literature, then identifying your own stand or interpretation. **(B+C)** |

Subject area	Comments
Environmental/Sustaina ble Engineering	1. Students are required to critique a present scenario using the data available along with the knowledge and experience they have acquired. A thought/viewpoint is analysed fully before it is accepted or rejected eg. Students look at a particular theory and analyse it while applying it to a case study. **(B)** 2. I want students to question what they do, question their results especially when way out of a realistic range, assess environmental implications (basic). **(A)** 3. Ability to evaluate options within defined guidelines **(B)** 4. "Thinking" independently (on your own) based upon the facts (data) available - to draw meaningful conclusions, clearly realising the limitations of conclusions. **(D)** 5. Analysing urban facilities, both existing and proposed eg M5 extension, sewage disposal, recycling. **(B)** 6. Ability to examine an issue from several view points and logically arrive at a conclusion. **(C)**
Environmental Law	1. Crititical thinking involves taking an existing fact/situation and making suggestions for improvement at a law reform level. On a theoretical level it could require a critique of the current paradigms or suggestions for a new one. **(A+C)** 2. Not accepting knowledge for its own sake. Eg a section of a statute contains certain words. What is the objective behind them? Does the remainder of the statute support it? What is the likely outcome?eg Salinisation of the Murray-Darling basin being the result of failures in information, markets, property rights, policies and paradigms. **(A)**
Environmental Economics	1. Ability to analyse an issue and prescribe appropriate policy correction. **(B)**
Interdisciplinary	1. Ability to see clearly, see big picture as well as details, balance arguments etc. (Science & Engineering). **(E)** 2. Seeing a situation from alternative points of view, in particular it relates to problem solving and challenging assumptions. **(A)** 3. Ability to take a problem and devise a solution based upon individual analytical abilities. **(B+C)**

QUESTION 6. What do you do to encourage critical thinking in student assignments and in the classroom situation? (Note: some answers were coded according to more than one theme).

Subject area	Comments
Environmental Science	1. In lectures pose questions, different perspectives. In tutorials debate different perspectives. Field trips include different people and ideas. I structure essays, reports etc. to encourage critical thinking. **(B+C)** 2. Students are set assignments where critical thinking is explicitly a criteria for <u>HD grade.</u> **(E)** 3. First tutorial of term is devoted to critical thinking. Students are

		required to discuss statements and evidence for claims made. This is required in student presentations and field trip reports. Have debates so students have to argue their case and rebut other team's arguments. **(B)**
	4.	Direct it in assignments, present alternate viewpoints to interpretations; explain process of arriving at analyses and interpretations; specific reading assignments. **(B+C)**
	5.	I emphasise that there is more than one explanation/model/hypothesis that fits available facts. I go through published papers and discuss faults with class. I encourage students to do original research (level 3) & present designs and conclusions to wider audience. I set assignment topics require evaluation of the question, not regurgitation. **(D)**
	6.	Not a lot - try to set essay topics, tutorial topics that are more than just a description of a subject. **(C)**
	7.	Emphasis is on logic and information gathering (UG level). At PG level critical thinking comes through the one on one supervision approach. **(F)**
	8.	Various approaches - not enough time to list them all. **(F)**
	9.	Work up to it; first assignment guided (series of tasks), second much less so. **(C)**
	10.	In the classroom we show and discuss videos such as "Rats in the Ranks". We explore methods and approaches to analyse their workplace eg. political mapping, understanding context. **(B)**
	11.	Asking students to relate what they are learning in environmental chemistry to what they hear in the media and to identify popular misconceptions; ask students to interpret chemical data in a wider context : photochemical pollution, landuse patterns etc. **(D)**
	12.	(I) Teach basic natural scientific method (ii) Expand this teaching through application to problems in PBL framework (iii) Group working solutions minimises personal bias (iv) Presenting solutions with peer reviewed evaluation (v) Put these ideas and skills into practice through industrial placements. **(C)**
	13.	Written feedback, analysis matrix tool. **(E)**
	14.	Present theory of cognitive processes and pattern recognition - extrapolate this into processes of critical reading and writing… Encourage students to question everything. Show how traditional schooling does not encourage critical thought. **(A+B)**
	15.	To approach knowledge as a "construct" that can be deconstructed and ask students to do the same. **(B)**
	16.	Explanation, plus extra marks for greater depth of thinking. **(B+E)**
	17.	Generally try questioning assumptions, present various points of view and play devil's advocate. **(B)**
	18.	Asking students to read relevant literature, showing videos, encouraging open discussion in class, introducing theories in class through lectures, including critical thinking as an assessment item. **(B+E)**
Environmental/Sustainable Engineering	1.	Critical thinking is spelled out explicitly as a requirement in assignments. In the classroom students are challenged with different scenarios for a particular problem and asked to think which is appropriate, considering all factors. **(B+E)**
	2.	Explain what I expect, provoke the students with questions, explain controversial issues. Hand out critical readings which go beyond traditional engineering aspects. **(B+D)**
	3.	Peer evaluation, classroom discussion/presentations. **(B)**
	4.	Classroom interaction, class participation, provocative questions. Assignments - heavy weighting on analysis and originality. **(B+E)**
	5.	Ask them to be critical and award extra marks for their opinions and analysis. **(E)**

	6. Lecture format, assignments, tutorials **(F)**
Environmental Law	1. We provide students with readings (articles) which they are required to analyse and discuss. **(D)** 2. Stress that merely descriptive texts will no attract high marks. I expect critical analysis of topics chosen, based on a core argument with recognition of counterargument. **(B+F)**
Environmental Economics	1. Present coherent and logical exposition of paradigms, analyses and policies of environmental economics. **(F)**
Interdisciplinary	1. Compare and contrast issues, raise points that see both sides of the "coin", present a different and new point of view on a situation. (Science & Engineering) **(B)** 2. I set assignments and exams with open-ended questions. I tell students that in environmental issues there are no right or wrong answers- just good or bad arguments. (Science & Law) **(D)** 3. My entire unit focuses on critical thinking in science preparation (Science & Law). **(A)**

QUESTION 7.   To what extent is protection of the environment, and other broader social issues, a key concept in your subject?

Subject area	Comments
Environmental Science	1. Very important **(A)** 2. Sustainablilty rather than protection per se. Students do two core sociology courses. **(B)** 3. Understanding issues a main concept, from this follows on the need for protection. Broadly social issues are touched on but followed up more in other subjects. **(D)** 4. Always underlying - overt in 3rd year. **(A)** 5. A great extent. I emphasise that Homo Sapiens and their activities are a major threat to the environment. We discuss the cost to the planet per head in the developed/undeveloped world. I attempt to foster idea of the value of habitat other than in terms of commercial gain. **(A)** 6. Major theme in semester 2 ("Environment and Society"). **(A)** 7. My teaching is based around sustainable development - it is the core outcome (postgraduate subject). **(B)** 8. To a very high extent - that's what Ss are interested in. **(A)** 9. Not key concept per se. The "key concept" is to impart understanding of the diversity of life, of how ecological systems function etc, and we have open discussions on topics such as genetic engineering and social acceptance. But the key is to ramp up student knowledge to allow them to participate meaningfully. **(D)** 10. Ss project topics vary but most have an element of environmental protection, fewer combine or focus directly on social issues and reasons for problems. **(B)** 11. The subject emphasises chemical processes, but the wider environmental consequences are also considered - air quality, ozone depletion, potential for global warming. **(B)** 12. Process knowledge is integrated in all subjects (in the program). In EH about 20% of units have a >90% focus; in EM 30% of units have >90% focus on this area. **(E)** 13. Most relevant to my subject in relation to the concept of Sustainable Development. **(A)** 14. Use ESD as criteria reference for helping students think critically about an environmental resource management issue. **(B)** 15. Comments on the question: "protection" not always a social issue; "other broader social issues" - "double barrelled" - broader social

Subject area	Comments
	issues - key concept in addition to generic thinking and communicating skills. **(C)** 16. ESD and such topics rate highly **(B)** 17. Prefer to think in terms of sustainable uses rather than blanket protection. **(B)** 18. See answer to question 2: Because sustainability encompasses not only the science of natural environment but philosophy, values of society, therefore argument for/against sustainability requires critically analysing all views. **(A)**
Environmental/Sustainable Engineering	1. No answer. **(E)** 2. Very strongly but gets complete rejection by civil engineers. They think it is the problem of the environmental engineers. **(A)** 3. Central to all courses. **(A)** 4. Less than 10 - 15% **(E)** 5. Part of this subject eg. alternative energy, recycling, waste disposal/treatment **(D)** 6. Important **(A)**
Environmental Law	1. To a great extent. I take the view that Law must be considered in the political, social and economic contexts in which it operates **(A)** 2. Protection of the biophysical environment is a key concept. But at the outset, the broad nature of "environment" is considered, including the social environment, eg. Merton case re LEP provision on public housing. **(A)**
Environmental Economics	1. Protection is important but more important are issues of environmental improvement and achievement of ESD. **(B)**
Interdisciplinary	1. "I do not understand this question" (Science & Engineering) **(E)** 2. 100% focus or underlying principle (Science & Law) **(A)** 3. Central (Science & Law) **(A)**

QUESTION 8. How do you assess critical thinking in student assignments? Do you expect a wide range of sources to be consulted?

(Note: Responses are broken up into a response to the first question (a) and to the second question (b).)

Subject area	Comments
Environmental Science	1. Yes - increasing with each year of study, but this is not enough - I expect key points from different sources to be understood, to be argued in depth. It is not a matter of summarising references, or "name dropping". **(E; B)** **2.** Comments in written work more important than sources (but latter can be indicative). **(E; B)** 3. Expect a number of key sources for assignments, a wider range for presentations and debates. Expect Ss to be able to rebut arguments in debates. **(A; A)** 4. Look for ideas beyond simple repetition of references; look for breadth in reviewed ideas/journals; look for variation in ways of analysing data. **(C; B)** 5. I assess critical thinking in terms of the logical evaluation of work known to have flaws, the logical assessment of conflicting points of view, logical merit of solutions proposed by the student. I don't necessarily rely on a wide variety of sources - may not be necessary. **(A; E)**

	6. Assess essay structure and argument. 6 - 8 sources (1st yr). Depends on topics as to whether mainly textbook based or also journal article & recent literature. **(A; D)** 7. If a student can challenge my understanding of an argument through logical argument this is a good sign. Yes, many sources should usually be consulted. **(A; A)** 8. Not quite clear what is meant. **(D; F)** 9. Yes to sources - again this is guided in 1st year. **(E; C)** 10. I dedicate one component of each assessment task to critical analysis. I look for evidence of student understanding of the dimensions of a workplace/professional problem and the depth of linking the problem to systemic or dominant culture. **(A; F)** 11. Currently I have no formal criteria. It is good to see a diverse reference list, but thoughtful analysis of a single source is preferable to snippets from several different sources. **(D; B)** 12. Yes - not always the case but an important factor in the assessment of work (wide reading). **(E; A)** 13. Yes books, articles, web-based data with a minimum number for each category (sometimes with a specified time, eg. post 1990) **(E; D)** 14. Expect 3 literature sources and 3 primary sources. Students keep a journal of observation and reflection. **(E; D)** 15. A) Originality, moving out of comfort zone. B) Yes, but C.T. does not always demand "sources". **(B; B)** 16. No but research is always good. I look for a good argument, complexity and depth of understanding. **(A; E)** 17. Yes. An ability to present views of stakeholders in an issue. Yes wide range. **(C; A)** 18. For assessment I look for ideas/theories of several authors, identification of agreement/disagreement, student's own view with a supporting statement. Referencing is very important. **(C; F)**
Environmental/Sustainable Engineering	1. No answer. **(E; F)** 2. In theory yes, in practice this does not really happen, though getting better. I want to see journals, conference and internet sources. I have not made it into more critical and less related resources yet. **(E; C)** 3. No specific mechanism - inherent in nature of assignments. **(D; F)** 4. Number of references not as big a factor as the inferences made and their justifications. **(E; B)** 5. I want them to express their ideas. **(B; F)** 6. Yes - a wide range. **(E; A)**
Environmental Law	1. By reading and assessing ideas in assignments. Yes wide range - but some personal input is also required. **(D; A)** 2. Range of sources relies on topic. Ss can choose their topic subject to my approval. Empirical research, including interviews with government officials etc is highly recommended. **(E; F)**
Environmental Economics	1. Understanding the paradigms and policy analysis rather than a broad survey of unconnected research. **(D; B)**
Interdisciplinary	1. A) Depth and breadth of argument. B) Yes. (Science & Engineering) **(A; A)** 2. A) I look at the argument development by students - whether a range of viewpoints or possibilities are considered. B) Yes I expect a wide range of references to be utilised. (Science & Law) **(A; A)** 2. No answer. (Science & Law) **(E; F)**

QUESTION 9. Is there a specific framework, or underlying set of assumptions in your subject/s?

Subject area	Comments
Environmental Science	1. The idea of sustainability - students come to their own perspective after being presented with the information and encouraged to develop the necessary analytical tools. **(A)** **2.** Question too broad to be answered simply. **(G)** 3. Not sure what you mean - maybe assumption that humans have an obligation to minimise environmental impacts and that humans are irreversibly damaging the environment. This environment is critical to our long term survival. **(A)** 4. Only in some do I expound them - mostly technically based. **(B)** 5. Not sure what you are asking here – probably the most common framework I teach is that "science proceeds by disproof, not proof, so we can never, ever be sure whether our paradigm of the world is correct". **(C)** 6. Examination of condition of environment based on evidence (2 lectures per week = 26 lectures), plus the importance of value judgements (1lecture per week = 3 lectures). **(C)** 7. Environmental problem solving requires an interdisciplinary/transdisciplinary approach. **(E)** 8. Not sure what is meant. **(E)** 9. Yes. Aims/objectives are specified for each week. Re "overall assumptions" – no. Theory of evolution is accepted as a solid working rule. **(C)** 10. There are a few - some about learning, some about thinking and acting strategically and some frameworks on project management. **(D)** 11. The subject is based on the assumptions and methodologies of science: the physical world is real and knowable and subject to physical laws that can be studied and progressively elucidated through experiment, testing of theories and intersubjective verification. **(C)** 12. Academic group have developed a set of core competencies, including communication & presentation skills, critical thinking, learning, group processes and project management which underpins course. Has resulted in "core competencies manual". **(D)** 13. Yes, eg. from Macro - Micro analysis contexts **(E)** 14. Learning is facilitated through research and research is a learning process (based on Kolb, Dewey & Lewin). Complexity of environmental problems can be managed using <u>systemic</u> methods of description and analysis. **(D)** 15. Professionalism is dependent on critical thinking **(D)** 16. Yes, as in all paradigms there are many assumptions. Society is built on metanarratives and absolutes, why should uni be any different? **(E)** 17. No. **(F)** 18. Most subjects have a standard framework: environment, social, economic values and the balance of all 3 in sustainable development. **(A)**
Environmental/Sustainable Engineering	1. No answer **(G)**

	2. No. **(F)**
	3. Sustainability **(A)**
	4. Meaningful inferences. **(E)**
	5. Set topics are covered **(E)**
	6. Varies according to unit objectives. **(E)**
Environmental Law	1. Yes, a contextual interdisciplinary approach. **(E)**
	2. Yes, subject outline addresses objectives of subject and weekly topics. **(E)**
Environmental Economics	1. Environmental problems are the result of management failure and resource misallocation. **(G)**
Interdisciplinary	1. Students must work with "real world" situation for their project. (Science & Engineering) **(E)**
	2. All of my units have a set of objectives defined for them. I suppose an underlying assumption is that environmental protection and sustainable management is a good thing to strive for. My unit objectives include – "develop critical thinking skills…" (Science & Law) **(A)**
	3. No answer. (Science & Law) **(G)**

QUESTION 10. How do you encourage critique of such a framework/s or assumptions?

Subject area	Comments
Environmental Science	1. There is no single definition of sustainability, and that students should develop and apply their own perspectives in light of the available research. **(A)**
	2. In many cases I don't. **(D)**
	3. Have tutorial discussions, look at issues, like Gia hypothesis. Textbook has critical thinking activities that question some of the basic assumptions. **(B)**
	4. In 3rd year subjects I tell students to make independent evaluations – reinterpret the facts, situation and data. **(B)**
	5. I encourage class debate on the way we do science. Often I will deliberately put an opposing view to the class and encourage questioning and criticism. **(B)**
	6. Encourage students to formulate their own position or to challenge (!) present position. **(B)**
	7. Through questioning the basis of the research. **(A)**
	8. I am not sure what is meant. **(E)**
	9. Rational logical questioning of any issue is welcomed. **(A)**
	10. Hard to say. Students are encouraged to use a broad framework to manage their project, as well as specific methods. They choose both and have the opportunity to evaluate how these served them at the end of semester in a final reflection document. **(A)**
	11. The assumptions are not challenged in this subject (other subjects exist for this purpose), but their applications are. The difficulties of analysing complex, dynamic systems are emphasised, and social & political dimensions are considered. **(D)**
	12. Student evaluation and feedback through the independent SEEQ system. **(C)**
	13. Giving Matrix Analysis tool for exercise in the workshops prior to assignments. **(B)**
	14. Facilitated discussion occurs on a weekly basis to encourage exploration of key ideas, their background and basics for use. **(B)**
	15. Open debate & discussion on all class topics. **(B)**
	16. I try and illuminate assumptions and get students to question them. Best are 3rd & 4th yr or PG as most school leavers are not ready.

	(B)
	17. Expect students to argue opinions **(A)**
	18. Question not given (pilot survey). **(D)**
Environmental/Sustainable Engineering	1. No answer. **(D)** 2. A bit of Sharon Beder on occasion. Hard to get beyond broad information content with undergraduates. They pretty much request spoon feeding. **(E)** 3. Peer review/discussion. **(B)** 4. No answer. **(D)** 5. The topics are pre-set. **(E)** 6. School and individual lecturer review within a QA/QC process. **(C)**
Environmental Law	1. Through discussion and hypothetical problems, role plays, etc. **(B)** 2. Evaluation by students by addressing forms prepared by Uni – filled out without my presence. **(C)**
Environmental Economics	1. Ability to analyse an issue and to prescribe the appropriate policy correction in terms of Environmental Economics, eg. Salinisation of the Murray-Darling Basin being the result of failures in information, markets, property rights, policies and paradigms. **(E)**
Interdisciplinary	1. No answer. (Science & Engineering) **(D)** 2. I often ask students fundamental questions like: Why are you studying environmental science? Or What are we trying to achieve with such and such technique or approach? (Science & Law) **(B)** 3. No answer. (Science & Law). **(B)**

QUESTION 11. Do you make your expectations about critical thinking explicit to students? How?

Subject area	Comments
Environmental Science	1. Yes. I tell them, put it in writing in expected outputs, and include in marking sheet. **(A+ B+C)** 2. Stated in course profile/assessment criteria. **(B+C)** 3. Tutorials, also feedback on presentations **(A)** 4. Direct it in assignments; present alternate viewpoints to interpretations; explain process of arriving at analyses and interpretations; specific reading assignments. **(B+A+D)** 5. Yes. I have a set of selection criteria linked to each assessment item. This is included in each subject profile, and explained at first contact session. **(C+A)** 6. No **(E)** 7. Yes, upfront in "educational aims" on handout. **(B)** 8. Yes. **(G)** 9. By provoking class debates on 'controversial' issues of the day, eg. genetic engineering, greenhouse effect. **(A)** 10. It is one of the 6 competencies outlined in the subject and throughout the course. It is discussed in Web CT discussions and forms part of marking schedules. **(B+A+C)** 11. Students are encouraged to think critically in lectures & some assessment tasks. The learning outcomes for the subject are being rewritten to make explicit references to critical thinking. **(A+C)** 12. Made explicit in the core subject (1st year) "Environment and Agriculture: Integrating Approaches". Contained as elements of process in all subjects. (Readings) **(A+D)** 13. Yes, by specifying assessment criteria that contain a high

	percentage of critical analysis. **(C)** 14. Students are expected to discuss their thoughts and feelings about their capability in doing research & in learning about the process of research. **(A)** 15. Yes, set and explained criteria in assignments. Content on the topic. (Readings) **(C+D)** 16. Yes, in a written explanation with worked examples, incorporating deconstruction, analysis modes of production & outcomes. This is then reconstructed producing a new picture & greater understanding of systems. **(D)** 17. No. **(E)** 18. I have not done this before but I think a prescriptive instruction is required. **(G)**
Environmental/Sustainable Engineering	1. No answer **(F)** 2. Not as much as I should. (Subject outline attached). **(G)** **3.** No, just inherent in dialogue. **(E+A)** 4. Yes, using progressive assignment/assessment tasks & regular feedback. **(G)** 5. Yes, I tell them I want <u>their</u> ideas. **(A)** 6. Clearly defined in handouts; lecturers in attitude to students' work. **(B)**
Environmental Law	1. I explain that Environmental Law is polycentric and that values, community, expectations, economics etc play a greater role than in many other traditional areas of law. **(A)** 2. Verbal advice. **(A)**
Environmental Economics	1. Yes, by encouragement and the analysis of real world issues (such as salination of the Murray-Darling). **(G)**
Interdisciplinary	1. Depth & breadth of argument, range of sources consulted. (Science & Engineering) **(G)** 2. Yes, stated in unit objectives. Plus notes on expectations for written work and what P, Cr, D & HD mean, plus marking guides. (Science & Law) **(B+C)** 3. No answer. (Science & Law) **(F)**

APPENDIX C

Interview questions

Lecturers

1.   Why did you recommend this assignment as a successful example of critical   analysis?
2.   Where in the assignment can critical analysis be found?
3.   How do you encourage student critical analysis in your lectures/tutorials?
4.   Are there particular frameworks/paradigms or assumptions underlying your subject? Could you please explain these?
5.   Do you encourage students to challenge these? How?
6.   Do you have different expectations for different years of study regarding critical analysis?
7.   Do you make your expectations regarding critical thinking explicit to students?
8.   To what extent are protection of the environment, sustainability, and other broader social issues, key concepts in your subject?
9.   What do you mean by these terms?
10.   How do you assess critical thinking in student assignments?
11.   To what extent does plagiarism interfere with student critical thinking?
12.   What is your definition of critical thinking?

Students

1.   Why do you think your assignment was recommended as a successful example of critical analysis?
2.   Where in the assignment can critical analysis be found?
3.   How are you encouraged by your lecturer/tutor in this subject to develop your critical thinking skills?
4.   Are there particular frameworks or assumptions in this subject? Could you explain these?
5.   Are you encouraged to challenge these frameworks/assumptions?
6.   Are the expectations regarding critical thinking different according to your year of study (ie. 1st - 4th year)?
7.   How can you develop your critical thinking skills yourself?
8.   How important are protection of the environment, sustainability, and other broader social issues, as key concepts in your subjects, particularly this one?
9.   What do you mean by the terms: Protection of the environment; sustainability; broader social issues?
10.   How would you define critical thinking?

APPENDIX D

Sample theme analysis of transcript of interview

Transcript Paul (Environmental Practice – Applied Science (EH/EM) **A) MB (final project report)** 1. Why did you recommend this assignment? P. Because what she does here is challenge a lot of what has been written and published through the eyes of the sponsoring agency, which in this case is WHO. What she's doing is …she's a student with a fairly enquiring mind. She's come in and she's looked at WHO publications that claim certain philosophies, approaches and they have quite a rhetoric that counts as quite important process work when you're dealing with community development, and communities, and consultation and all of those kind of things, empowerment. She's quite attracted to exploring how that happens on the ground, I think initially to get some experience at it. But what she's done here is uncover a bit of, and she's developed evidence for the fact that they tend to write about it in a …because they use the rhetoric therefore it happens. And …she needed only be there five minutes to discover that the words don't mean anything. What she's discovered is that the WHO organisation present a reasonable case for why things will happen that way then they tend to co-opt the language and probably not change their practice at all. Rather than saying …if there is some new language coming into the discourse around development and community, and WHO want to either drive that language, in this case "Healthy Islands". Healthy Islands is a concept and it's based around health promotion rhetoric, then the tendency, she found…was for the government in the country…to do what they normally did, not change their practices, but say that they fit that rhetoric. Int: So she could see the inconsistency between the rhetoric and the practice? P: Exactly…she was also in a position where she was able to observe and challenge the work of her own academic staff here at the university, who were involved in it and write about that. Int: Mmm? P: They'd actually asked her to go over and do this work. She'd gone over [to Fiji] and in the process critiqued not only the WHO approach, but also the approach of some of our academics who are working over there. So there's a good separation between me and that program and I was able to say…feel comfortable writing what you want to write. …It was brave of her to follow through in the way she did, and then somehow to negotiate that with her client, who was an academic on her campus. Int: Did she manage to do this without causing too much…Do you think that from her having been so challenging, I suppose, that she may bring about some change? P: It is hard to say…the involvement of the staff from here in that project hasn't been ongoing. She was essentially evaluating something that was finishing anyway. So what she did was give a report on some of the strengths of it, which is unlikely to go anywhere, at least in that project. It was kind of over anyway. Int: It's a shame it is not incorporated somehow. P: I'm not sure whether the client may have got a different report.	*challenges and critiques practice* *critiques rhetoric* *inconsistent theory and practice* *critiqued academics and government*

In this subject I warn people that the client may want something completely other than what I ask for…I felt my role in this was to help her write it in a way that was not "blaming", raise the issues and quite clearly…argue, have suitable evidence as to why something might not match the rhetoric and be able to present issues. …It's quite an art. …Her final report… has a lot of recommendations and a lot of issues for the client. She presented quite a straightforward report on what those issues were. She prefaced it with "this is all working towards …a good end but these are the kinds of things that are needed to improve it, as opposed to saying "you've got it totally wrong". Your message is not so harsh and…therefore more likely to be effective.	*argues (with evidence) *lots of recommendations
2. Where did you find critical analysis in this assignment? P: The practice or the outcome of it? Int: Good question. More where do you feel you saw evidence of critical analysis or critical thinking, either in the process or the outcome. When we say "process" are we talking about the process of her writing or … P: The process…of her generating the report. I think you have to …an example here is that M. in her earlier literature review outlines what the principles of the concept: accounting for health, are. …She outlines the principles and in her Discussion goes back to each of those principles and, using her own data (which is both qualitative and quantitative) explains the flaws in the practices of those principles, which are claimed as being fundamental. And the flaws are quite obvious. For example, one is where you reorient the health services so that people can get access…and her claim is that simply putting them in at three known buildings??????????… that's not reorienting, that's just locating. Then she goes through each of the …claims.	*critical thinking is a process *qualitative and quantitative data
B) SP (Manly Lake – project proposal) 1. Why did you recommend this assignment? P: I don't know if I recommended this assignment. Int: No, I think you recommended the student, so I asked them to bring an assignment which THEY thought showed critical thinking. If you don't agree with them that's fine… P: If I was going to say anything about this one – it kind of stands out from the other proposals is that S tries to get at some of the historical elements to her study. So she's kind of asking the question why? Why is this catchment run like it is? Whereas a lot of other students would say: what does this catchment look like?…Her design had elements of talking to locals that have been in the region for decades, wanting to get their views on how it's changed and why and that kind of thing. …And it struck me that she was taking on a historical dimension to the problem. Whether she knew it or not that was where she was more critical…so many students fail to look at the facts around… Int: Look beyond just the here and now? P: Yes. Well it seems to me critical analysis often amounts to asking the question why is it? "Why" can't be traced back six months or twelve months. People think twelve months, environmental issues…they don't look very, far enough back. …They may not be thinking about history overtly, about what has happened at that time being part of their analysis. 2. Anything you want to say about where critical analysis can be	*historical background

found [in the assignment]? This is a project proposal?
P: Well…her range of methods, talking about the stakeholders, input and values and historical content. …The other sort of element of critical analysis, I'm not sure if it's critical analysis, is that she provides a design of possible analysis formats for the types of data she gets.
Int: What do you mean?
P: She offers …a lot of people in the focal stage are trying to get data and analyse it. She's able to say she uses a particular regime to …"the value of the river". She's come up with a particular set of criteria she will use, whether it be a single response or multiple. For example, recreational, educational, set out some parameters of some possible responses, even before she's got the data…from the range of literature. So that's more of an analysis, structural thing than critical analysis. …Her report is more about the state of the catchment, but she's pushed it to have a look at some of the questions of historically why. It's a bit hard…she's got multiple forms of data, some to do with water quality, some to do with people's views, previous study material. Triangulation…six or seven elements.

C) MS – Lit review
1. Why did you recommend this assignment?

P: I did send them back and say these didn't get anywhere near the sort of feedback they normally get, so this…
Int: Do you normally give a of feedback? Obviously you think that's important. Do you think that helps in the process of critical thinking?
P: Depending on the question, important part of the process, teaching, restate the expectations – what's a professional piece of writing - it's about flagging issues that are important. The other level is getting them, once they've constructed something, to go away and have another look at it again. Depending on the topic, sometimes it's a lot easier to ask questions that will invoke some sort of reflection at a deeper level… ramifications for their own practice, those kind of questions…flagging that either I want them to go down that line or they have my permission to go down that line…
Int: Basically encouraging them to go further…
P: Yeah that's right.
Int: With MS's lit. review why did you see this as a successful example of critical analysis?
P: Really it only comes close to critical analysis through understanding and challenging of the literature, but not based on their own experiences and practices. That's where they miss out on the richness. For somebody like M who's methodical and can comprehend the literature and construct a very strong…pull out the main themes of the literature, and describe how various authors on that topic agree or disagree on the topic she does a pretty good job at that kind of integrating and doesn't mind taking a position here and there. I try and ask them to take a position, that shift is quite significant indeed. With a lit. review, because I expect them to reflect back to work, unless they have a section that deals with implications for practice throughout…Within the context of this assignment I do ask them to do a lit. review to frame up their, broaden out their reading around, open up and broaden their understanding of the topic. [I want them] to understand the project they are doing within the broader literature, Australian,

range of methods

own thinking > criteria

feedback important

asks questions

encourages further questions

understands and challenges literature

broader literature >

international. So I don't actually press them to critically review the literature, more to analyse the situation. I don't call it critical review of the literature…	*international context*
Int: There are definitely different versions of critical analysis, some that focus more on the actual nitty gritty of the subject, others which do take in a much broader context. So in that assignment did she reach a stage of [recognising] implications?	
P: No, she's put together a strong review of what the literature says.	
3. How do you encourage student critical thinking…?	
P: I don't have a lot of lectures, so the way I do it is to use questioning through Web CT. In essence this is, based on a reading, I'll be asking them some questions around, in the context of this subject, look[ing] at their practice in a number of different ways. So I give them some reading that they probably may not see as relevant …but I then ask them to focus on a bit of that reading and to relate it to their own project, Environmental Health or Occ. Health. So they get something like 6 weeks or so of discussion amongst themselves, private on Web CT.	*questioning technique*
	relate theory to practice
Int: You don't see it?	
P: I can but …there job is at the end of the semester to post back, in a section where everyone can see, a summary of their discussions – where it's gone, how broad it got, what it covered, but also maybe giving the rest of the group some agreed principles they might have about that issue in relation to their practice. So again it is making the implications in terms of maybe one topic, say we have had to look at in terms of everyone's work, ten key points. They would each get a summary…they would each have an opportunity to feed back. Internals do it as well. Because it's a project subject, the first few weeks we spend, as internals, together. Trying to support internals to get out there and find a client that they can take on. So we go through the process that they might need to follow and in some cases make the first phone call. Helping them share strategies around how you might get past the PA…who will say yes or no. Because it's timetabled a day a week they use most of those days …to clarify their assignments. By the end of second semester I might have these dates set but only half a dozen turn up…	
Int: It's up to them really to take advantage of coming in.	
P: That's a good way we can use those things…	
4. Frameworks? (one week later)	*student as researcher*
P: I can't remember what I wrote in the survey…but …the most important thing …the objective is really about seeing themselves involved in research as a professional. So on one end it is about researching substantive issues, the other element is perceiving themselves as researchers…	
5. Do you encourage students to challenge these frameworks?	*learn to think and challenge experientially*
P: I could probably add a few. I think the merging of a whole lot of frameworks comes from elements of professional practice. It's a professional area, ethics and so on, lifelong learning, project management and the way people realise that may be through a whole range of different activities. No two people doing the same kind of thing. When I look at what the assignments are asking them to do it's all about designing something that they conduct in the workplace, a negotiated something in the workplace. They kind of see that through, the project management element but they question/critique their own professional development around all of that. Be reflective in their practice. There's no kind of grander story	*critique own professional development*
	reflection

around environmental sustainability or anything like that, but it doesn't exclude people obviously involved…people's projects may be involved in something like that.	

APPENDIX E

Sample discourse analysis of Conclusions of student assignments

"Solvent extraction processes will serve a useful purpose until they are superseded by a new technology. The cost and short-term consequences of remediation may discourage its use, but it remains a non-destructive means of removing toxicity from soils and sediments. The process is well understood, unlike some other technologies, and can reliably remove contamination quickly and effectively. There is no reason to limit the use of this technology, as there appears to be no long-term consequences of its use. However, researchers should aim to develop a less disruptive and more environmentally benign means of remediation with the same flexibility." (Stuart – Environmental Engineering)	*+ve apprec'n* *-ve apprec'n* *+ve apprec'n* *+ve judgement* *+ve apprec'n* *+ve apprec'n* *-ve judgement*
"It is evident that public nuisance, despite having been chastised as possessing an excessively liberal ambit, is too narrow to afford any reasonable degree of protection to landowners concerned with ensuring that the sun's rays reach their property. The usefulness of this legal doctrine in this context is further weakened by the fact that even if	 *-ve apprec'n* *-ve apprec'n*

liability for public nuisance is established, the <u>vagaries of equity</u> render the <u>type of relief which will be awarded unpredictable</u>. For instance, a landowner who succeeds in holding his neighbour liable for public nuisance as a result of the shading of his PV array is <u>not assured of injunctive relief</u>, and may have to make do with damages." (Jeremy – Environmental Law)	*-ve apprec'n* *-ve judgement* *-ve apprec'n*