THE ROLE OF STUDENT WRITING IN LEARNING IN ZOOLOGY

THESIS
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by

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ABSTRACT

In this study I attempt to develop a rationale for the role of student writing in advancing learning in Zoology. To this end, I use the informed and insightful voices of five academics from the University of Cape Town's Department of Zoology to present a picture of the goals of the discipline, how they view the role that student writing plays in advancing these goals, a sense of the tensions they face in dealing with student diversity, and the promise and challenges of innovative approaches.

My interest in how staff view student writing stems from a belief that staff make use of student writing in different ways, depending on their assumptions about writing. I explore these assumptions by means of interviews with members of staff, in which I ask about how they understand the pursuit of science, the qualities a scientist needs to develop, the best ways to develop these qualities in students, and the part that student writing plays in this development.

What emerges in this study is the understanding that the kinds of writing we ask students to do reflect the forms of educational practice that we sustain. On the one hand, certain forms of writing may support forms of transmission pedagogy that are viewed as being at odds with progressive science education. On the other hand, if we are to develop alternative teaching approaches which are in keeping with contemporary views of science and learning, then we need to develop new genres of student writing that give expression to these goals and methods.

The study concludes with suggested avenues into curriculum review that would operationalise the insights developed by this study.

CONTENTS

CHAPTER ONE: INTRODUCTION

> *Academic writing has received relatively little attention until recently because it has been taken for granted, assumed to be transparent. If not seen as transparent, writing has long been seen as an all-purpose skill, an ability to translate thought with correctness and grace, but a skill unaffected by particular disciplinary problems or knowledge-making processes within specific disciplines.* (MacDonald 1994: 5)

Background

The broad context of this study is that of academic development (AD) at the University of Cape Town (UCT). This AD work originally started fifteen-odd years ago as an initiative to offer support to a small number of under-prepared black students who had gained entry to an overwhelmingly white institution. As black enrolments have grown over the years, however, with a majority black enrolment projected shortly, and as the institution has begun to realise that catering to the needs of underprepared students cannot be forever left to "support" structures, the institution has accepted new proposals to meet this challenge. These proposals envision a shift from conceiving of the need as *"support" for a minority* of black students, to realising that the institution needs to develop *systematic and system-wide provision that caters for all* of UCT's student population. The shift in thinking has involved replacing a "deficit" notion of under-preparedness with a developmental notion of the varying and legitimate needs of a "diverse" student body. This involves a shift of some responsibility for developing provision for diversity towards the mainstream departments of the University. It is acknowledged that departments will need to carry a part of this responsibility, but that the Academic Development Programme (ADP) will contribute with expertise and resources in various ways.

As one of a range of measures to this end, the ADP proposed the formation of a Writing Centre "to investigate the language needs of UCT's diverse student body, and make recommendations to the university about approaches to meet these needs." This was in response to "a widespread concern with students' writing and related skills ... and a recognition that writing skills are required in all disciplines, although the types of writing task may vary according to academic level and/or field" (Yeld 1992).

Two people were appointed jointly to co-ordinate the new Writing Centre, myself and my colleague Suellen Shay, and we opened our doors for business in February 1994. Our

approach to fulfilling our mandate was to have the project work in two ways:

- **Student Consultancy:** Any student - at any level - can ask for assistance with any academic writing task from one of our "consultants". This assistance is given through one-to-one conferencing over the task itself, but in ways designed to develop the student's ability to work increasingly independently. Each consultation is written up by the consultant in some detail, and stored on a data base for research purposes.

- **Departmental Consultancy:** We offer a service to departments whereby we collaborate with departmental staff in (as far as possible) curriculum review processes to develop student academic writing as an integral part of the course curriculum.

The Writing Centre is seen by the university executive as a "gearing agency", that is a small unit that will help to mobilise change in larger organisational units like departments and faculties. Our experience has been that the best (and perhaps the only) way to effect sustained change is through the combined processes of (explicit) curriculum development and (implicit) staff development. It is only through working collaboratively with staff on their own curricula that we are able to develop fresh insight in staff thinking and have these new perspectives reflected and entrenched in changed course curricula. Our developmental space, then, lies between the consciousness of staff and their curricular practices.

Our experience has taught us that staff have widely differing assumptions and understandings about a whole range of issues connected with their teaching practice. These assumptions and views are largely tacit, and it is only by uncovering these in unthreatening ways, and negotiating acceptable alternatives, that we are able to achieve the kinds of movement we seek.

Quine (1970) has called these collections of assumptions and perceptions "webs of belief". Different webs are invoked in different situations and work to regulate our behaviour in those situations. Conversely, our experience of different situations may work to modify the webs associated with them. Various studies have been done (see for example Carneson 1995, and Ensor 1995) to investigate how belief systems work to regulate teachers' practice, and

especially how they work to frustrate efforts to transform such teaching practice.

We in the Writing Centre have come quickly to realise that the contributions of personal belief systems and institutional value systems impact greatly on our ability to advance our work. This study, then, was designed partly to investigate something about the "webs of belief" regulating the practice of staff in departments we were working with.

The process of the study was informed by another agenda as well. This involves another "web of belief", as it were, but one that underlies *our* practice as academic development practitioners. Foundational to much of our work is an argument that, in order to make "epistemological access" available to a diverse student body, it is necessary for disciplines to uncover the varying assumptions and ways of knowing inherent in both their discipline and their teaching practice, reach some consensus in the department about what these are, and then make these available to students as an explicit component of the curriculum.

Thus, in selecting which strands of belief to investigate in the department under study, I was inserting structures of my own professional belief system. Their perceptions would emerge, but at least partly structured and defined by my perceptions and agenda. This agenda is often articulated in this study as *"developing a rationale for the role of student writing in advancing learning in the discipline."* But behind this agenda is a more generalised academic development one of wanting to see the curricula, teaching practices and organisational arrangements of the department working together to better equip students to succeed inside and beyond the university. Writing is foregrounded because it is (we have come to understand) a very useful port-of-entry into the concerns of academics. It is in dealing with student writing that academics are dramatically confronted with the problems that academic development wishes to address. By giving our project a "writing" label, we are able to gain access to a host of educational concerns that lie behind writing. We doubt we would attract as much interest as we have if we had used a "language" or "curriculum" label.

Context of the Study

In choosing the Zoology Department at UCT as my focus of interest, I was informed by a combination of practical and fortuitous factors. On the one hand, at the time of submitting this research proposal, the Zoology department was one that had formally asked the Writing Centre to assist them. This held the promise that sustained access might be possible. What was fortuitous was that the department is committed to requiring writing of students, and was prepared to commit resources to developing students' ability to write. It was only when I was well into considering my interview data that I realised my good fortune in working with staff who were so articulate and thoughtful about the issues I was exploring.

The insightfulness of the members of staff I interviewed has enabled a most important feature of this study: I have been able to develop "a rationale for the role of student writing in the discipline" *almost entirely by means of their voices*. From a developmental perspective, it is infinitely better to present a community with something that has, in some measure, "come from them", rather than trying to introduce a formula which may be seen as quite foreign.

In this study, I have used material from interviews I conducted with five members of staff from the Zoology department. They are:

Three Professors: One of these is currently Head of Department, another is a past Head of Department. All three are acknowledged as international leaders in their fields. All three are recipients of UCT's prestigious "Distinguished Teacher Award".

One Senior Lecturer: Also an acknowledged leader in his field, and someone with a proven track record of involvement in development activities in the university.

One Temporary Teaching Assistant: Also currently a PhD student, this young man has undertaken his undergraduate and postgraduate studies through UCT's department of Zoology, and thus has a detailed, recent experience of studenthood there, as well as some experience as a lecturer. A colleague remarked that he received "remarkably positive

evaluations from students for his teaching". In addition, he recently won an international award for one of his papers.

Summary

In this study, then, I attempt to develop a rationale for the role of student writing in advancing learning in Zoology. To this end, I try to use the informed and insightful voices of these five academics to present a picture of the goals of the discipline, a sense of the tensions they face in dealing with student diversity, and the promise and challenges of innovative approaches.

CHAPTER TWO: THEORY INFORMING THIS STUDY

> *Any discipline worthy of its name must offer its reasons for saying and doing what it does, reasons which will be deemed valid or invalid, embraced or rejected, only according to the norms of the historical community within which they are offered, and not according to those of some utopian order of ultimate rationality or imminent socialism.* (Felperin, 1985: 222)

This study aims to explore a particular curricular practice in an academic department: the way student writing is used to advance the learning goals of the discipline. To do this, the practice has to be disembedded from its disciplinary context, so that the practice itself, as well as its constitutive environment, may be rendered open to scrutiny. The practice of requiring students to write is not neutral or value-free (although it may often be perceived to be so), but forms part of the wider social practice of a university department. If this study is to uncover some of the "webs of belief" that inform the particular practice of student writing, then it must explore some wider features of the discipline and the department, including its academic and educational goals.

In this chapter I will briefly establish the theoretical bases for such a line of enquiry. I begin by referring to some elements of social theory that inform the interest behind this study, namely social constructivist arguments about how the explicit and tacit ideologies inherent in beliefs work to shape the discursive and social practice of individuals.

Secondly, I review arguments about the philosophy of Science that trace the shift from positivist paradigms to more constructivist ones, and I briefly explore some of the consequences of such a shift for the ways in which knowledge is understood.

Thirdly, I review discussions of approaches to teaching Science that take the constructivist paradigm into account.

Fourthly, I summarise key arguments in the literature on developing academic literacy, with a particular interest in developing science literacy, and an interest in the particular challenges facing English Second Language speakers.

In short, I try in this chapter to place the practice of student writing within the broader academic and educational context of the discipline. I argue that contemporary perspectives in the philosophy of science, and in current theories of learning, set up a particular set of challenges for the way in which science literacy is to be developed.

Discourse and Social Theory

Following Cherryholmes (1988), Gee (1990), Fairclough (1988 and 1992) and Giroux (1992), I subscribe to the view that the educational practice of any individual is informed by a set of values, interests and theories that, together, may be said to constitute an *ideology*. This term is not used here in the sense in which it is used when discussing a coherent formal ideology (like Marxism or Catholicism), but rather as the collection of theories about the world held by an individual in forms varying from what might be labelled as everyday "commonsense" knowledge, through to consciously-held, complex, abstract theories. These theories may well be inconsistent, contradictory and may be invoked differently in different settings. In spite of this, an ideology works to govern the choices that the individual educator makes in all that s/he says and does in her professional (or, indeed, any other) capacity. This ideology may be more or less consciously-held by an individual. The more consciously-held and explicit this ideology is, the more an individual is able to consider her or his practice to be ideologically-laden, and therefore able to consider alternative forms of practice when presented with alternative guiding ideologies. The less consciously-held this ideology is, the more powerfully the ideology may work to legitimate certain practices as "natural" or "commonsense." Ideologies are thus essentially social in that they work to order human behaviour in (more or less) productive or systematic patterns. These ideologies are constituted, and conveyed, by language: speech, text or performance. As Gee puts it: "Language is inextricably bound up with ideology, and cannot be analyzed or understood apart from it." (1990: *xx*) Awareness of the constitutive nature of language, "the place where actual and possible forms of social organisation and their likely social and political outcomes are defined and contested" (Weeden, 1987: 21) has given rise to a range of theoretical accounts (from the theorists mentioned above, for example) of the operation of "discourse." Here, discourse is understood as language that constitutes and conveys ideology and meaning in ways that crucially shape forms of social practice. Indeed some theorists

would argue that often discourse *is* social practice (Cherryholmes 1988; Fairclough 1992, for example). My interest, then, is in the way discourse structures, and is structured by, larger social practices and interests - in this case, the way one group of academics understand and reproduce their discipline.

The distinction drawn by Gee (1990) between discourses (small "d") and Discourses (capital "D") is useful here. The former are "connected stretches of language that make sense" while the latter are "ways of being in the world, or forms of life which integrate words, acts, values, beliefs, attitudes, (and) social identities." Clearly, no sharply defined border can be drawn between "discourse" and "Discourse:" each helps to constitute the other in a reciprocal dialectic. But what this distinction does do is to illuminate two important features of discourse theory. The first feature is that discourses are historical and inherited, and therefore are powerfully constitutive in that they establish almost the full range of ideologies and language available to society. The second feature is that since discourses are enacted and reproduced by individuals (albeit within social settings), there exists the potential for infinite innovation and contestation.

My goal in this study is to explore some of the ideological structures revealed in the discourse of my individual respondents. I assume a dynamic and changing disciplinary Discourse, and that the dynamism is in large measure to do with implicit ideological differences between individuals, as well as explicit contestation.

> *The ideologies embedded in discursive practices are most effective when they become naturalized, and achieve the status of "common sense;" but this stable and established property of ideologies should not be overstated, because my reference to "transformation" points to ideological struggle as a dimension of discursive practice, a struggle to reshape discursive practices and the ideologies built into them....Where contrasting discursive practices are in use in (an) institution, the likelihood is that part of that contrast is ideological.* (Fairclough, 1992: 87-8)

In some respects, my study explores conscious meaning, where ideology is explicitly articulated in response to my questions, and I have attempted to confirm my readings with the respondents. In other respects, I am construing tacit ideologies that I believe inform some of the responses. Some of these are less easily confirmed within the developmental context

of my larger professional goals, and the processes that I must follow for these insights to be mediated constructively might not allow them to be reported within the scope of this half-thesis.

This study, then, will explore one dimension of curricular practice (ie. student writing in one Science Faculty department) so as to reveal the ideological underpinnings that inform it.

> *In order to exert control over practice and not simply react to it, we must be explicit not only about what we do but also about what it is that structures what we do.* (Cherryholmes, 1988: 6)

To do this, I look at several ideological avenues that seem to me to be important. I look at elements of the philosophy of Science that inform current thinking in the discipline; I explore pedagogic approaches current in the discipline, and I explore assumptions about language and writing. I believe these various avenues yield fruitful insight which may be used to develop teaching and learning practices in the discipline, but I am also aware that these are only a few strands of the complex ideological matrix at work.

> *Inherited discourses come into contact with each other, sometimes reinforcing, sometimes conflicting. A first step in a poststructural, critical, pragmatic strategy is to describe relationships between historical developments and political practices and curriculum theory and practice.* (Cherryholmes, 1988: 145)

Philosophies of Science

This discussion begins with the landmark work by Thomas Kuhn, *The Structure of Scientific Revolutions* (1974), which posits a theory of "paradigm shifts" in the history of Science. His "paradigms" are the conceptual frameworks that are foundational to the academic practice of disciplines. These frameworks will guide the mainstream of knowledge construction in the discipline, and will also be necessarily evident in its curricula. But, Kuhn argues, these paradigms are not permanent. As increasing numbers of scientists find that the existing paradigm is insufficient to account for some key problems in the discipline, a period of instability may ensue within the discipline, culminating in the development of a new conceptual framework that is thought to be more adequate for the needs of the discipline. As

increasing numbers of scientists begin to subscribe to the new framework, it becomes entrenched as the new orthodoxy, and a paradigm shift can be said to have taken place.

One such paradigm shift in modern Science has been a move away from positivism and its reliance on rationality and method. Product of the European enlightenment tradition which sought through reason to liberate human thought from the confines of (often church-dominated) dogma, the thrust of the rational (or "Cartesian") project is best summed up by the thinker most closely associated with this tradition:

> *Whenever two persons make opposite judgements about the same thing, it is certain that at least one of them is mistaken, and neither, it seems, has knowledge. For if the reasoning of one of them were certain and evident, he would be able to lay it before the other in such a way as eventually to convince his intellect as well.* (Descartes 1628, in Cottingham, J *et al*, 1985)

This rationality assumed that human perception of the natural world was accurate and reliable, and was founded on a set of absolute and universal laws of reasoning (Bak 1994). These universal laws allowed a detached and objective consideration of sensory experience by means of the disinterested laws of logic.

Even as the trustworthiness of human perceptions was called into question as a result of the development of non-Euclidian geometry, and relativity and quantum theories (Pera 1994), the reliance on method was still considered to be the avenue by which the closest approximations to truth could be achieved. Contributing to this emphasis on method are theorists like Popper and Lakatos. Popper expected that method would offer a "clear line of demarcation between science and metaphysical ideas" (1959: 39), and Lakatos looked to establish "universal conditions under which a theory is scientific" (1976: 168). Although Popper subsequently softened his position in this regard (Pera 1994: 191), the image of science as fundamentally rational, or at least rooted in the logic of empirical method, was so strongly established that any weakening of the trust in rationality and method would be seen as a descent into *irrationality*. The dichotomy between the two was seen as absolute, with the only alternative to the one being the other.

The ascendancy of rational method, however, was undermined by arguments that historical

research had demonstrated that the greatest scientific leaps had been achieved precisely because "some thinkers either decided not to be bound by certain 'obvious' methodological rules, or because they unwittingly broke them" (Feyerabend 1975: 23).

This disavowal of method, taken together with the Cartesian dichotomy above, ushers in an epistemic crisis for science. Here theorists argue that if rationality and method do not exist, then science can only be explained in psychological or sociological terms (ie. "irrational" from a "pure" scientific point of view). The only alternative to rationality is "mob psychology" (Lakatos 1970: 91) or Feyerabend's equally unsettling vision:

> *It is clear that allegiance to the new ideas will have to be brought about by irrational means such as propaganda, emotion, ad hoc hypotheses, and appeal to prejudices of all kinds. (1975: 153-54)*

Various attempts have been made by theorists to rescue science (both natural and human) from this position on the horns of the Cartesian dilemma. I would like to look at the work of some contemporary theorists who, I believe, offer useful ways forward. Taylor, Nussbaum and Pera each separately tackle the dilemma through arguments that contest the definitions of rationality. They argue that the error committed by those who documented the collapse of method was to accept the concept of rationality as defined by traditional positivism. This was a definition that assumed "that rational argument requires neutrality, and deduction from premises that are external to all historical perspectives" (Nussbaum 1993: 235). Those who do this, argues Pera, are in fact subscribing to the Cartesian dichotomy which asserts that the only alternative to rationality and method is unredeemed irrationality. Instead, he continues, the challenge is to develop an altogether *new* point of view, in which "new meanings must be found for old concepts." Pera's proposal for the replacement of method is a *dialectical* model.

To illustrate this, he constructs three schema:

> *The **methodological** model views science as a game between two players: the researcher proposes, and nature - with its ringingly clear "yes" or "no" - disposes. In the **counter-methodological** model, the situation is the same, the only difference being that nature's voice is so weak that it is drowned out by the researcher's, who ultimately becomes nature's ventriloquist, providing the*

> *desired answers. The **dialectical** model is different; it requires three players: a proposer who asks questions, nature that answers, and a community of competent interlocutors which, after a debate hinging on various factors, comes to an agreement upon what is to be taken as nature's official voice. In this model, nature does not speak out alone. It only speaks **within** the debate and **through** the debate.* (1994: 21)

The reader will, by now, have begun to realise the attraction and potential usefulness of this theorist for a study like this. Pera himself acknowledges that his model occupies an "uncomfortable and demanding position" between the "vulnerable" methodological model and the "fashionable" counter-methodological one, but trusts that it will help to put science "in a more human light" and help us to understand its place "between culture and nature, and appreciate it for what it can give, without blaming it for what it cannot offer" (1994: 12). The value of his theory for my purposes can only be assessed, however, by examining it in a little more detail, especially in the ways that it understands the role of dialectics and dialogue in constructing knowledge, and in the crucial ways it re-defines key terms in the scientific lexicon. I cannot begin to do justice to Pera's detailed discussion, which covers a wide spectrum of issues central to the debate in the Philosophy of Science between the normative and descriptive schools. For the purposes of this study, I can only point to those features that are immediately useful to my present purposes.

As is implied in the name of the *dialectical model,* a key constitutive role is played by the interlocutors, and the dialectical techniques of "confutation and persuasion." The goal of the dialogue is to find the view or cognitive claim "that best holds out against criticism" (1994: 134). In this process, science is always seen as "the *transformation* of previous knowledge." A hypothesis is accepted as a result of "a selective competition with other hypotheses advanced by the community." In this debate in the community of scientists, the role of rhetoric becomes a key issue. Pera poses the question "What is the relationship between rhetoric and truth?" He responds by taking the view that, in his model, "the strength of an argument is relative to its premises, and the quality of a theory is relative to the state of its discussion" (1994: 136).

Denying that this is a hopeless descent into relativism, Pera posits a dialogic process between two interlocutors who are in disagreement. Since they are members of the same scientific

tradition, they share, Pera argues, a great deal more than they differ. "If they have the will and desire to converse, they will begin to build an overlapping area between their respective configurations ... where they can look each other in the eye and say *"we both"*. Thus they will set aside their reasons (for disagreeing) and look around for different ones. For example they will cite other factors, adduce other values, invoke other assumptions, etc. ... The moment one interlocutor loses the debate, the other theory automatically becomes the better one, supported by winning arguments" (1994: 140). In this fashion, argues Pera, a choice is made on the basis of "objective arguments."

Here Pera defends himself against a possible accusation that he has lapsed into method-speak by re-defining "objective" not to mean "impersonal" or "from the perspective of God's eye," but rather, "establishing a dialogical contact between the two sides so that a shift in consensus takes place through a debate between them at the end of which one gives in to the other" (1994: 141). Essential for this to happen is for the two interlocutors to *explicitly share the critical frameworks* and assumptions that will enable the dialogue to transcend the disagreement in the pursuit of a common scientific project.

Implied in this dialogue is a *rationality,* but not that of the methodological model which is tied to fixed rules; rather this is a rationality linked to the "*quality of arguments* which support the theories." This dialectical rationality, Pera maintains, "is ethically more tolerant because it is not linked to a single property or to a set of previously established requisites, but rather to a free debate over different properties and requisites." This, he says, "reflects actual scientific practice" (1994: 144).

Pera then tackles the relationship between rhetoric and truth, noting that "rhetoric has a biblical (if Plato is a Bible for philosophers) condemnation hanging over its head: what has it to do with truth?" The acceptance of claims as "true" depends on a *debate* along the lines of the dialectical model, and so truth has to be connected to rhetoric in some way or another. Pera argues against *substantive* notions of truth (that try to answer the question "What does it mean?"), noting that these have been widely discredited, and argues rather for *ascriptive* notions of truth (that ask, instead, "How do we know it?"). The goal is not to define "truth," but to *ascribe* or *presume* truth. An outcome of such an ascriptive process might be: "if a

theory is rationally acceptable because it is *supported* by arguments stronger than those *against* it, then that theory is persuasive for the community."

This is a softer, more contingent notion of truth. He offers it as an alternative to throwing out the idea of "truth" altogether, arguing that it is a useful concept. A better course of action, he suggests, is to make "the problem of the definition of truth less dramatic." But the role of rhetoric (in the contemporary, neutral sense of the word) is central:

> *Here rhetoric clearly has a constitutive role and persuasion is essential because our ascription of truth depends on the outcome of a debate conducted according to the factors of scientific dialectics. Since, as we know, facts are among these factors and are not the only ones, experience cannot be taken as the tribunal of (our ascriptions of) truth, but as one of the witnesses that are cross-examined by the participants in the debate. In the dialectical model of science there is no tribunal apart from discussion.* (1994: 150-151)

Pera acknowledges that the circumstances of scientific discussion vary widely, and that different theoretical systems need to be brought to bear in individual cases. Each of these cases - and the attendant theoretical systems - require different argumentative techniques to achieve the persuasive ends of the interlocutors. Pera calls the organisation of such argumentative techniques a "rhetorical strategy." There are no fixed strategies, he argues, but there are more-or-less recurrent ones. These are "moulded to the circumstances and invented," and he illustrates how some of these strategies owe their success not to any inherent values but to shrewd reference to dominant ideologies prevalent at the time. This raises the further problem, central to the philosophy of science, of the notion of scientific progress: if the choice and acceptance of one theory over another "depends on mastering rhetoric," in what sense can one say that the chosen theory is superior to the other? (1994: 172-176)

Pera argues that "the determination of progress (is) desubjectified" (ie. not rendered subject to individual arbitrary judgement) not because of any appeals to "rules working as algorithms or yardsticks" but because they depend on the arguments used in dialectical debate between a community of individual scientists. The multiplicity of individual, subjective points of scrutiny, all of which have access to the same common factors of the case (including the epistemic values, their interpretation and hierarchy), mean that when an argument has

achieved consensual recognition, its validity comes, not from an independent arbiter, but because the determination has been *intersubjectified* (1994: 189).

Taylor (1993) and Nussbaum (1993) would be in broad agreement with some of the theoretical positions held by Pera. For example, Taylor emphasizes the way in which our current modes of thought should be seen as rooted in - and as responses to - modes from the past. To abandon the past would be to abandon the path by which our current ways of understanding have evolved, and thus to abandon a crucial avenue of rational inquiry into our existing ways of knowing. In another parallel to Pera, Taylor describes the purpose of the exercise of rational judgement as an "error reducing move" (1993: 224) which works to progressively refine contradiction and confusion from thought, not so as to arrive at an ultimate truth, but to be able to judge one position as "less false" than another (Bak 1994: 8).

However, because of their concern with human science, rather than natural science, Nussbaum and Taylor foreground moral commitments (or "strong evaluations") in their pursuit of an alternative understanding of rationality. They believe that positivism's ostensible uncoupling of values from rationality in its drive for objectivity is misguided. They would argue that any attempt to articulate ideas in language necessarily involves a set of choices about what is articulated and how, and that these choices can only be made by referenee to sets of guiding values. A new rationality needs to acknowledge - and engage with - the value-laden nature of any science. This position, in my view, does not conflict with Pera's arguments; rather this simply foregrounds the ethical considerations that would be included in the shared "critical frameworks" that Pera contends needs to be part of any rational dialogue.

In summary, then, science is essentially a *communicative* endeavour. Meaning is constructed through rhetoric, and refined and validated in an ongoing dialogue conducted by a community of scientists. This is a community that needs to be aware of the historical roots of the conceptual frameworks that guide their practice, as well as their value-ladenness. The assumptions and values inherent in these frameworks need to be as explicit as the argumentation that constitutes the particular subject at hand.

Given this description of the nature of science, I will move on to explore theories of how such an understanding reproduces itself in the teaching of science.

Constructivist Approaches to Knowledge and Learning

The previous section has outlined constructivist approaches to the philosophy of science, and this section will discuss constructivist approaches to knowledge. It is worth briefly establishing at this point the distinction between these two constructivisms, as I use them here for the purposes of this study.

The preceding discussion recounts a *theory of science* which is broadly *social* and *discursive*. It concerns the construction of scientific meaning as a social discursive practice which takes place within and across scientific communities. The following discussion develops a *theory of learning* which is *experiential*, and to do with the *individual*. Although these two theories overlap in important and necessary respects, it is nevertheless useful to treat them separately for the purposes of this study, since they each illuminate separate bodies of data. The ways in which they overlap are, however, important for the coherence of my final argument, and I will draw attention to these in the concluding chapter of this study.

Although constructivist theories of learning have become current chiefly in the latter half of this century, the roots of this theory have been traced back as far as Socrates (see for example Hawkins 1994: 9). However most accounts (for example Von Glasersfeld 1984, Hawkins 1994) of the emergence of constructivism begin with Giambattista Vico (1710) and Emmanuel Kant (1783) and proceed through to Piaget (1937) and Dewey (1938 and 1963), demonstrating that this line of thought has been substantially represented in mainstream theory for some time. Modern proponents of constructivism are at pains to demonstrate the pedigree of this philosophical tradition precisely because it undermines the powerful and entrenched traditions of realism. It is in contrast to the assumptions of realism that the character of constructivism is best understood.

The central tenet of realism at issue here is the notion that the pursuit of science is the methodical and progressive accumulation of verifiable knowledge about the nature of a reality

that exists independent of the knower (Selley 1989: 85). There is an assumption of a reasonably close correspondence between this knowledge and this independent reality.

Constructivism would differ from realism in asserting that we cannot establish a clear correspondence between our knowledge and an independent reality because the only channel we have for apprehending the "real world" is the sensory data that we have used to assemble our knowledge in the first place. We do not have a separate way of knowing the real world that can somehow be used to evaluate the "correctness" of our knowledge. Instead, constructivists would argue, any workable theory we form is merely "*one* viable way to a goal that we have chosen" and should not be seen as the *only* one. "It tells us nothing - and cannot tell us anything - about how many other ways there might be" (Von Glasersfeld 1984: 24). For the theory to be workable (or "viable" to use Von Glasersfeld's term), it simply means that the theory "fits" with whatever external reality there is. This "fit" may only be partial, and the scientific endeavour is forever to adapt theory in the search for better "fit" and "viability." In this way, the focus of the constructivist is on *the way the human mind constructs its account of its own experience*, rather than the realist's focus on a supposed external and independent reality. Piaget has summed up this idea very succinctly: "Intelligence organises the world by organising itself" (1937: 311).

This organising process is a constant "adaptation" (Piaget's term) of knowledge towards increasing viability. This happens as a result of "a necessary interaction between conscious intelligence and environment" (Von Glasersfeld 1984: 24), which is our experience. Von Glasersfeld follows Kant in arguing that "experience as well as all objects of experience are under all circumstances the result of *our* ways and means of experiencing" (1984: 29). He continues (drawing on Vico) by saying "the world we experience is, and must be, as it is because *we* have put it together in that way." Further, it is important that our ways of "putting together" our experience be understood historically, that whatever constraints exist on how we construct our experience "spring from the history of our construction, because at any moment, whatever has been done limits what can be done now" (1984: 30).

Von Glasersfeld continues by arguing that the process of constructing knowledge cannot be a "passive receiving" but must come about as a result of "an active subject's activity" (1984:

31) which he calls (after Piaget) "operating." This is the activity of a goal-directed consciousness which seeks to evaluate experience so as to repeat positive experience and avoid negative experience. To distinguish between classes of experience presupposes some classificatory activity, which is essentially an effort to "establish regularities in the experiential world" (1984:32). In order to establish regularities, a basic comparison must be made between one experience and another, resulting in a judgement of either "equivalence" or of "individual identity" (1984: 33). Thus any notion of continuity or of change in experience is the result of active "operations carried out by the cognizing subject and can never be explained as a given fact of objective reality" (1984: 34). A further argument is that the criteria used by the "cognizing subject" to compare two experiences must be chosen by the individual, since these are not inherent in any external "reality." Thus, we choose the experiences we wish to consider, and we choose the criteria by which we compare them. These choices imply goal-driven behaviour, and thus our individual goals are a key factor in determining how we construct our experience.

> *What we experience, cognize, and come to know is necessarily built up of our own building blocks and can be explained in no other way than in terms of our ways and means of building. (1984: 39)*

An interesting further implication of this theory (Von Glasersfeld continues in his avowedly *radical* theory) is that if we regard knowledge as an attempt to order our experience, it is where our constructions *break down* (ie. fail to "fit" or fail to prove themselves "viable") that the "real world" makes itself felt. The failure of a construction points *more certainly* to a facet of whatever external reality might exist than a viable construction, since all we know about the viable one is that it doesn't *conflict* with the external world. We do not know how close or how remote the fit is. Von Glasersfeld quotes Warren McCullogh: "To have proved a hypothesis false is indeed the peak of knowledge" (Von Glasersfeld 1984: 24).

Other theorists have emphasised the particular *social* nature of constructivism. Ernest (1993), for example, has critiqued Von Glasersfeld by arguing that his radical constructivism places unwarranted emphasis on the individual subject and neglects the broader social context that equips the individual with the linguistic, procedural and conceptual materials for the construction of knowledge. Ernest argues that it is important for educators to conceive of

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learners as participating in an educational "conversation" which builds "socially negotiated understandings." This educational context is "a complex, organised social form of life" (1993: 6), and as such reflects the assumptions and social and power relationships of the social milieu. An excessive focus on the individual (which is how Ernest reads Von Glasersfeld) runs the risk of being "a distraction from the social and political goals in education" (1993: 7). In his emphasis on how issues of social practice inform learning, Ernest's argument anticipates, in my view, the role of genre theory in helping us to understand - and transform - educational practice. I deal with this in a later section of this chapter.

Other additions to constructivist theory help to make clear the complexities involved in the progressive construction of knowledge over time. Fensham *et al* argue that it is not helpful to conceive learning as always a decisive replacement of primitive constructions with more sophisticated ones. They argue instead for "an accretion of information and instances" (1994: 6) which build knowledge that is often context-dependent. For example, they point out that scientists

> *accept that in the day-to-day world things stop moving if no force is applied to them, whatever Galileo and Newton said. They have learned which meaning and which principle is appropriate in a particular context.* (1994: 7)

Related to this is the notion of situated cognition (Brown *et al* 1989, Birkenkotter & Huckin 1993) which argues that all learning is situated in the context of the environment and activities that generated that learning.

> *The activity in which knowledge is developed and deployed ... is not separable from or ancillary to learning and cognition. Nor is it neutral. Rather it is an integral part of what is learned. Situations might be said to co-produce knowledge through activity.* (Brown, *et al* 1989: 32)

Given these understandings of the contextual nature of learning (and its application), it is persuasive to believe that an individual may simultaneously hold multiple conceptions about the same idea, but apply these differentially in different situations. These different conceptions are, however, "related and can be shown to have a form of hierarchy of inclusiveness" (Fensham, *et al* 1994: 8).

In summary, a constructivist theory of cognition focuses on the experiential learning of the individual. This theory rejects the realist notion of knowledge as a set of universal and unchanging truths which exist independent of a knower, and which it is the task of science to discover. Rather, constructivism argues that knowledge can only be understood as a construction of the human mind, using the resources available to that mind. These resources include our sensory data, our prior experience and understanding, the ways of knowing made available to us through social and educational practice, and the matrix of motivations, contingencies and contexts that intersect to comprise our experience. The theory holds that learning is essentially an active process which classifies experience in certain ways, and that learning is highly context-dependent, possibly resulting in multiple, complex, and even contradictory conceptions.

Implications for Pedagogy

This account of the construction of knowledge has considerable implications for pedagogy. This section will firstly consider these implications for the construction of learning opportunities, and then will discuss some professional considerations that emerge for the educator.

Firstly, and uncontroversially, learning needs to be essentially an active process of goal-driven engagement with experience, rather than a passive receiving of ready-made constructions.

Secondly, the *existing* cognitive resources of the learner are crucial to the kinds of constructions s/he can subsequently build. These resources may include the range of theories s/he already holds as "viable," and the criteria and goals which play such a major role in the selection, ordering and evaluation of experience. A foundational set of theories to be considered here would be the way the individual learner understands knowing and knowledge. If we are to expect a learner to engage in the risky business of formulating and evaluating theory, then s/he must understand knowledge as a partial, tentative and changing human construct. If s/he understands knowledge in any more positivist way, then her potential to evaluate existing constructions, and theorise in significant and viable ways, is

severely restricted. Similarly, if the learner understands that s/he constructs meaning for herself, then s/he is empowered to do this autonomously. If, however, the learner understands knowledge as something remote and existing independent of the knower, then *knowledge* is separated from *experience*, and the primary resource for knowledge making is devalued. In addition, the learner's *belief* in her own ability to construct knowledge is compromised, undermining a foundational part of her motivation.

Thirdly, the more abstract forms of learning (typically found in academic thought) are increasingly dependent upon language to be constituted, sustained and communicated. With language come the conceptual frameworks that order knowing, and both language and concepts are entirely mediated by social practice. As such, these cannot be seen as separate from human interest on the one hand, and the contingencies of context on the other. Thus learning cannot be divorced from human concerns and the dynamics of context without contributing to an abstraction of knowledge that is at odds with constructivist understanding. This view has led to approaches which aim to develop "concepts-in-contexts," where activity, application, and motivation are considered as carefully as the content goals of the learning. These aim to illustrate the "reflexive and iterative nature of the relationships between knowledge and actions. One feeds on the other" (Fensham *et al* 1994: 4-5). This is an advance on the 1960's 'discovery approaches' which were critiqued as offering insufficient direction for learners towards important concepts - "what we want students to think about" (Prawat 1992: 378). These approaches assumed learners would naturally chance upon key ideas, but since these key ideas were often culturally-specific, these assumptions worked to further disadvantage the already marginalised.

This "concepts-in-context" view is also an advance on 'process approaches' which, its critics (for example Millar 1989, Kirkham 1989) have argued, resulted in a subtle shift in emphasis from "science as reliable knowledge, towards scientists as reliable knowers" (Millar 1989: 58). This ignores the 'interestedness' of data and method, and the need for these to be open to scrutiny by the scientific community before being accepted. It also suggests "a set of rules or standard procedures" which constitute scientific method and which can be generically applied to produce reliable knowledge. Whilst science does have

> *characteristic ways of working, and characteristic standards of judgement, ... these can never be fully encapsulated in a set of rules. They contain many tacit elements which can be communicated only through the interaction between the learner and a more experienced practitioner. Doing science is more like the skilful exercise of a repertoire of 'craft skills' (Polanyi 1958) than the following of an algorithm. The training of scientists involves the process of coming to internalise these tacit canons of procedure and judgement.* (Millar 1989: 59-60)

This implies a necessary provision of opportunities during which learners can "internalise these tacit canons" in close proximity to more experienced scientists: almost a kind of apprenticeship.

In summary, a constructivist pedagogy would look for the design of learning situations to be learner-centred, concept-driven and context-specific; learners need to be asked to draw on their prior knowledge and on meaningful goals and motivation in their attempts to frame and solve problems, and to grapple with selected "big ideas"; explicit assumptions about the constructedness of knowing should infuse the processes, and the language of speculation should be made available to this end. Above all, the learning process is intensely communicative, as meaning is constructed and conveyed entirely in *language*, and knowledge is negotiated in an inherently *social* process.

A constructivist theory of learning also holds implications for the way educators view their practice. As mediators of a discipline, educators must have at their command particularly well-developed conceptual frameworks that offer accounts not only of the 'content' of a discipline, but also of some of the layers of social practice that form the context in which learning happens. In a university, these practices include the construction of disciplinary knowledge, and the reproduction of the discipline through succeeding cohorts of learners.

In considering some of the challenges facing university educators, Zietsman draws on Von Glasersfeld's theory to distinguish between the viability of a *practical* action (viability is fairly simply determined by whether the action is successful or not) and the viability of a *conceptual* operation. For the latter to be viable depends not only on the success of immediate purposes, but also with the much more complex requirement that the conceptual operation *not be in conflict* with other conceptual operations simultaneously held.

> *Philosophically speaking: what you are requiring is coherence in the conceptual world. Here the interaction between adaptation and viability becomes clear: one does not want to have a conceptual world in which one has multiple conceptual models for similar problems and then find that the models are mutually contradictory. That is a disequillibration, and requires an adaptation of knowledge - because it is not viable anymore.* (Zietsman 1994: 562)

Implied in this view is an obligation on educators to consider the theoretical models informing their practice so as to forge a reasonable conceptual coherence. In the academic world, this is a responsibility inherent in the profession of knowledge construction, *and* a responsibility inherent in the goal of promoting successful learning. These responsibilities are intricately linked: the nature of knowledge constructed through academic research should not, according to this argument, differ in fundamental ways from knowledge offered for students to consider. This is different from Fensham's (1994) earlier point (see above) which argued that it is natural that an individual may hold different conceptions for use in different contexts. In the academic context, the enquiry of a discipline, and the way the discipline seeks to reproduce itself, should surely be consistent. Constructivist learning theory, with its emphasis on making explicit the ways of knowing, insists on this consistency.

This has further implications. If ways of knowing are human constructs, rather than "natural," then these deserve the same critical scrutiny as the products of these ways. Academic practitioners need to be as scrupulous and reflective about the ways of knowing enacted in their teaching methods as they are about the ways of knowing reflected in their research methods.

Russell and Munby (1989) use Schon's (1987) notion of 'reflection-in-action' to explore the relationship between an educator's intellectual orientation to science, the way the educator presents an image of science to learners, and the capacity of the educator for reflection-in-action. Schon's concept of reflection-in-action is a key idea underlying a theory of how practitioners advance their professional knowledge, especially in how that knowledge is reflected in professional practice. Reflection-in-action is the way an experience of an otherwise familiar moment of practice results in the practitioner 'seeing' the moment differently and hence naming or describing it differently, and thus construing the

phenomenon in language in a fresh way. Schon calls this shift of understanding 'reframing.' This essentially experiential insight is, according to Schon, central to the way practitioners evolve their practice. And central to practitioners' *capacity* to experience such 'reframing' is the nature of the metaphors employed by individual educators to conceive of their practice. Some metaphors are stable or 'stale' and restrict opportunities for reframing, whilst others are more generative.

Russell and Munby illustrate these ideas in a series of case studies of science teachers they have worked with. One teacher clearly viewed science as a body of established knowledge to be transmitted to learners, generally conducted teacher-centred learning, and the dominant metaphor of the language by which she described her practice was "covering the curriculum." In analysing her development over a period of two years, Russell and Munby could find little evidence of 'reframing' or evolving professional understanding as Schon would define it. On the other hand, another teacher viewed science in more constructivist terms, usually provided problem-solving approaches to learning, and generally employed a metaphor of "making sense" when talking about his practice. Russell and Munby claimed to detect frequent 'reframings' in the practice of this teacher, and they suggest that this correspondence between one's intellectual orientation to science and one's capacity for reflection-in-action is "intriguing," (1989: 124) and warrants further research.

Studies of the role played by the way professionals conceptualise their practice through metaphoric images (for example Munby 1987) have pointed to the power such metaphors have to constrain or open up possibilities within such practice. The next section of this chapter begins with a consideration of how educators view the nature of language and writing, and its role in the curriculum.

Writing and the Curriculum

Assumptions about what is *entailed* in student writing is foundational to how staff *see the role* of writing in student learning. For example, if writing is understood to be merely *a technical process of transmitting finished thought from mind to paper* according to a fixed set of grammatical rules, then the role of writing in the curriculum may be seen as a simple conduit

by which students prove they have learned what is required of them. This is an instrumental view of writing as a set of discrete skills which, once learned, may be applied in any context. Language, here, exists as a semiotic system independent of context and particularities of meaning, rather as Saussure (1983) conceived of *langue* as distinct from *parole*. In this view, writing is incidental to the production of knowledge.

As my data will show, this view is widely held, perhaps as a result of education systems that focused on grammar and syntax to the exclusion of many other dimensions of writing. The schooling system has usually not equipped us with the conceptual tools to discuss writing in any other way. But amongst the consequences of this instrumental, 'conduit' notion of writing are firstly, the idea that student writing problems are defined in terms of errors of grammar and syntax, which can be solved by closer attention to the relevant rules. The second consequence is that the language and writing skills needed by students are properly developed at school. The failure of students to write adequately when they reach university is therefore a failure of the schooling system, and is not a legitimate concern of the academe. Thirdly, the lamentable inability of students to write clearly is a result of a passing crisis of illiteracy in the education system which will doubtless be resolved in due course. In the meantime, if the university feels compelled to do anything about the problem, it need only see such measures in terms of temporary remediation. Rose (1985) has documented such a view in some detail, and shows the effects of these notions in, firstly, stigmatising students with various labels of 'deficiency' and, secondly, constraining any systematic planning to address the issue as university decision-makers subscribe to "the myth of transience." (1985: 355)

But if language is differently understood as "*constitutive* of knowledge itself" (Ward 1994: 51) - and this is central to constructivist theory - then writing may be seen as *a much more complex business which consolidates - and even advances - thought and learning in unique ways*. Writing then may be seen as much more integral to achieving the goals of the curriculum.

This second view of writing - a view that understands writing as a component in the acquisition of *literacy*, and therefore involving a complex of social, cultural and

psychological factors - is one that has been cogently argued. (See for example Ballard and Clanchy 1989, Street 1994) Such a view of writing is especially significant for the academic world, where the challenge is the acquisition of *academic literacy*. This is a form of literacy that is integrally bound up with the systematic (but abstract) ways of thinking of each discipline. As such, a student is only able to articulate the discourse of a discipline once s/he has a conceptual grip of the material under discussion, and a sense of how language is used to express ideas in that discipline. (Taylor 1989)

Because academic work is necessarily abstract and complex, each discipline has developed linguistic short-cuts which it uses to refer to various theories and sets of assumptions that have been commonly established by the disciplinary insiders. One is therefore able to refer to wide and complex bodies of thought by means of the briefest verbal cues. Although this is sometimes pejoratively referred to as "jargon," it is an essential means by which the academic conversation happens.

The challenge for the newcomer is to acquire not only the linguistic cues, but to acquire also the succeeding layers of sedimented meaning that have accumulated behind those terms in that discipline. Very often, this also involves understanding complex relationships *between* bodies of knowledge (eg. that this set of theories emerged as a critique of a prior set of theories, and was made possible by a changing set of assumptions), as well as certain foundational understandings about the nature of knowledge (Universal Truths or tentative constructions?) and the Western critical tradition.

In short, successful academic writing relies on the successful acquisition of systems of disciplinary thought. *Writing* cannot be understood separately from *what is being written.* The first consequence of such an understanding is to give greater prominence to the role of writing in reflecting and advancing the conceptual learning goals of a discipline. Writing is therefore a curricular responsibility which must be addressed by all disciplines. The school system cannot teach students how to write for academic purposes; it can only teach students how to write for schooling purposes. Occasionally (but not often), some schooled writing abilities are helpful in the academe, but generally, the kinds of literacies involved are substantially different.

The second consequence of an "academic literacy" approach to writing is a realisation that the curriculum needs to pay greater attention to the opportunities it provides for students to explicitly grapple with the language of the discipline. This includes active approaches to reading, listening and discussion of concepts, an apprenticeship to both the concepts *and the language by which they are constituted.* Students then need opportunities to present concepts in oral and written dialogues, where they expect responses, and where they will take greater ownership for what they say. This stands in contrast to the normal practice by which a student hands in a piece of writing in the knowledge that it will be *graded*, rather than *responded to* in any more naturally communicative way. (Ward 1994: 144) The various forms of writing (or genres) common to a discipline need to modelled and understood for how they convey meaning to different audiences for different purposes. (Moore 1994) For example, an article in a refereed journal demands a substantially different approach from an article intended for a more "popular" audience, and yet they may concern similar subject matter.

A third consequence is an appreciation of the complexity of the process of "enculturation," encompassing as it does the acquisition of the values, norms and practices of a discipline. Whilst it is essential for as many of these as possible to be explicitly taught as the ways of knowing of the discipline, there must always remain a vast but vital range of subtleties that cannot be expressed in terms of planned-for learning outcomes. One such dimension of these subtleties is summed up by Millar (after Polanyi) as a "repertoire of (tacit) craft skills" (1989a: 60) which are internalised, at least partially, as a result of a close working contact with a more experienced practitioner. Another dimension lies in the evolving identity of the student as s/he develops a sense of self defined dialectically through communicative relationships with others in the discipline (Bruffee 1986). This is a learning that comes about through the enactment of the role of apprentice, and it is upon this learning that the forces of the 'hidden curriculum' work most powerfully (See Caprio 1993 for a discussion of the concept of 'learned helplessness,' for example).

A fourth consequence of such an approach is a recognition that students who are learning through the medium of a second or third language will face greater challenges in coming to terms with the linguistic (and therefore conceptual) processes of learning. They may require

additional, enrichened opportunities to absorb and produce the language and meaning of the discipline. As they take new risks, they may make "errors", and educators may need to increasingly try to distinguish between, on the one hand, instances of student text which demonstrate conceptual achievements in spite of language problems, and, on the other hand, student texts which are instances of manipulations of chunks of language unsupported by clear conceptual grasp. Increasingly, also, educators will need to develop a repertoire of developmental responses that cater to the varying needs exposed in student texts.

In summary, then, the "academic literacy" view of writing sees the abstract forms of knowledge and learning typical of academic study as inseparable from the language by which they are constituted. Successful learning is therefore only evident if it can be articulated in the language(s) of the discipline (ie. writing, speech or performance).

Writing as Social Practice

This final section concerns the role of writing as it reflects or enacts the social practices of the discipline - both in the construction of knowledge and in structuring student learning. My point-of-entry for this discussion is a consideration of contemporary genre theory. In contrast to earlier notions of genre as a concern with textual form, recent approaches consider texts rather through the relationships between producers and consumers of these texts, the respective identities of these participants, and the social forces that intersect in that situation. In this view, genres are "typical ways of engaging rhetorically with recurring situations," and reflect "social motives in response to social contexts" (Freedman and Medway 1994: 2-3). Rather than seeing textual forms as stable and persistent, genres are understood to "evolve, develop and decay" (1994: 3), and are often "blurred" (Geertz 1983) or "bleed into one another" (Freedman and Medway 1994: 3). Underlying this conception of genre is an understanding of language (and therefore writing also) as being inherently *social.* A genre perspective, then, understands texts not as "autonomous" entities (Geisler 1994), but as *reflecting* and *constituting* social practices.

Following Bakhtin, writing is understood as essentially *dialogic:* Any utterance (to use the term in Bakhtin's sense so as to include texts) is made in response to previous utterances, and

is made in anticipation of forthcoming responses (Hunt 1994: 244). Seen in this way, utterances (or texts) constitute interventions in social situations, and are therefore of the same order as actions (see Austin 1962 for an account of "speech-act theory"). Like the activities of individuals, their utterances are also prompted and constrained by the *role* that the individual assumes in that particular situation, the rules that she assumes to operate there, and the complex intersection of motives, contingencies, and power arrangements enacted there. Dialogues and their contexts (rhetorical and social) cannot be understood apart from each other. The explorations of genre theory are attempts to understand this mutually constitutive relationship.

Bazerman (1988) has documented the evolution of a repertoire of scientific genres, especially the science journal article, and the "social, empirical, and epistemological consequences" (1988: 318) of the emerging genres. In his explorations, he finds how individual scientists "use, transform, and invent tools and tricks of the symbolic trade." He shows how some of these "have proven so useful and forceful as to become regularised and even institutionalised mandatory features of particular types of scientific communication" (1988: 318-9). For example, tracing Newton's "search for the most persuasive, compelling form to create shared appreciation" of his work with prisms, Bazerman argues that Newton developed "a model for the form of scientific argument that influenced all of scientific practice," and as a result

> *he dominated the history of science not just because he discovered a few major laws, but because in finding the way to articulate those laws he found a powerful, long-lasting (though ultimately and necessarily temporary) solution to the problem of how one should talk about the subject.* (Bazerman 1988: 317)

Newton's form of representation became institutionalised, and in so doing, shaped not only the form of future such utterances, but also "all the activity leading up to, surrounding, and following after" such utterances. In other words, genres have implicit within them the cultural and epistemic assumptions of the social practices they sustain. In attempting to conform to an institutionalised genre, then, one must conform to the host of tacit values and expectations constituting that genre. In this way, genres act to reproduce social practice in compelling ways.

This understanding of the evolution of genres helps to "de-naturalise" them and identify them as historical, human constructs. As such they then become liable to critical scrutiny, deconstruction, contestation and change.

My concern here is in how genre theory may assist in developing an understanding of the role of writing in science, and in science education. Given Kuhn's theory of evolving paradigms of thought, and the shifting sets of assumptions underlying those paradigms, it seems important to understand the assumptions implicit in the common genres of science that have survived these paradigm shifts and which currently confront learners. It is clear that these tacit values will play a role in shaping learners' responses.

Three key critiques of the predominant use of (for example) the genre of the experimental article in the science classroom are relevant here. The first critique is that the form and function of the experimental article reflects a positivist paradigm that is no longer consistent with contemporary constructivist understandings of science. Lewontin (1991) has argued that the four-part structure of the experimental report (and the form for grant requests from governmental funding agencies) in effect constitute the "experimental or observational protocol that constructs facts out of an undifferentiated nature" (1991: 147). The effect of the "daily reinforcement" of this implicit view of science through their reading and writing the literature of science has ensured that "most natural scientists, and especially biologists, are really positivists" (1991: 141).

In an interesting account of studies which compare the practices of scientists when *writing* journal articles with their practices when *reading* such articles, Geisler (1994) showed that scientists tend to write so as to *strip* their findings of contextual detail, and thus strive to 'objectify' their science, whilst scientists tend to read their colleagues' work in ways that *search out*, or insert, exactly that contextual detail, in an effort to evaluate the work. This is a process of "rhetorical recovery" that seeks the "temporal and human aspects of (the) indigenous culture" of the scientific processes that gave rise to what has been represented as formal, relatively decontextualised knowledge. This 'indigenous culture' consists in the "details of the lived experience, in the lab, in the conference room, in the funding agencies" - exactly the details that students are taught to leave behind, and which scientists also leave

out of their more public, formal identities (1994: 92).

What enables this separation of "the formal domain content of the academy" from "the indigenous rhetorical processes that give it life," argues Geisler, is "the cultural myth of the autonomous text" (1994: 93). This is a belief that "a text can stand independent of its context of production or interpretation, and that a text can mean the same thing to all readers in all ages" (1994: 4).

Geisler argues that the "separation of expertise into the distinct problem-spaces of domain content and rhetorical process is an important mechanism by which our society delivers expertise to some but withholds it from others." She argues that the growth of professionalising middle classes in the late nineteenth century resulted in the division of expertise into two: "a formally explicit knowledge of domain content that became the mainstay of general education aimed at producing laypersons, and the more informal and tacit knowledge of rhetorical process that remained the more-or-less hidden component of advanced training aimed at producing a new class of professional experts" (1994: 89). In this way, a "naive understanding" of expertise, stripped of its rhetorical context-markers, is provided for novice learners through the medium of "autonomous" textbooks. In this way a "great divide" is created - not between orality and literacy - but between expert and layperson. This great divide is maintained until students have survived the filtering of undergraduate curricula and have passed though the eye of the graduate needle into postgraduate studies. Geisler argues that it is only at this level that learners are granted access to the real rhetorical spaces of the expert content domain, with all its contingencies, uncertainties and ill-defined problems. At this level, she continues, the field has achieved a level of abstraction that "practically guarantees that experts will be the only ones able to use a field's texts in any kind of sophisticated manner, will be the only ones who can sustain serious interaction or invite serious response on specialised content:"

> *In this way, the processes of cognitive development have become heavily intertwined with the sociological dynamics legitimizing professional privilege.* (1994: 94)

Millar (1989b) and Sutton (1989) have both illustrated the pedagogic pitfalls of allowing such

generic practices to hold unchallenged sway over science education. Millar argues that the danger lies in the retention of the idea of science as "infallible, received knowledge" and the pedagogic consequence of teaching becoming "an arid business of rote learning of standard facts, theories, and methods." (1989b: 54) Sutton argues that the genres of the experimental report and the science textbook "too readily give an impression of science as depersonalised information, rather than ideas open to debate," and as a consequence "are now proving inadequate to the task of developing scientific awareness" for learners and also "to the task of projecting an adequate image of scientific thought" (Sutton 1989).

This first critique, then, is one which holds that the traditional genres of science are inconsistent with social constructivist *philosophies* of science. The second critique is one that argues that the typical genres of science education are inconsistent with constructivist theories of *learning*. This is manifested in "a lack of fit between the processes the writing demands and those in which students need to engage in order to gain some cognitive hold" over knowledge (Freedman and Medway 1994: 15-16). The genres assume that learners have already overcome any discontinuities between their own prior knowledge and the forms of knowledge displayed in the educational genre. This is in large measure a result of the fact that the educational practice enacted by such genres tend to be *displays of already-acquired knowledge,* rather than opportunities to *structure new learning* through problem-solving approaches. The conflict is thus between, on the one hand, a tacit requirement of educational practice for reproductive strategies from the student and, on the other hand, the student's need for experiential learning processes if s/he is to develop the competencies needed to cope with rapidly evolving scientific practice.

For example, if the learning goals of a course include developing the ability of learners to frame problems, think laterally and speculatively about approaches to investigating the problems, and be critical and open-minded about the outcome of such approaches, then asking students to follow the traditional rhetoric of the experimental write-up may be counter-productive. Equally, an implicit expectation (enacted in assessment practices) that student writing should respect the authority of source texts above possibly contradictory experimental outcomes may also cut across the experiential and critical processes that experiment-based learning hopes to achieve. Millar (1989b) documents repeated instances of *teachers* who

reproduce experiments on plant tropism from textbooks with anomalous results, but who continue to uphold the authority of the textbook.

This mismatch between learning goals and literacy practices is further illustrated in Geisler's account of various studies done to test claims made by (for example) Langer and Applebee (1987), which asserted the value of analytic writing in developing higher-order cognition in learners. The outcome of various studies suggest that analytic writing does indeed help to develop higher-order cognition in learners, but that such forms of learning are inconsistent with the "standard knowledge transmission purposes" inherent in many curricula (Geisler 1994: 48). The results of the studies suggest that when learning is conceived as transmission of established knowledge, writing appears to be "not only superfluous to student learning, but actually detrimental to the process. In other words, on the simple task of knowledge getting, writing is at best a crippled practice" (1994: 51).

The third critique of the traditional genres of science is that they may be reproducing unsatisfactory relations of gender, class or culture. It is not within the scope of this study to consider these important issues in any detail, except in the instance most immediately urgent to South African educators: the extent to which the existing genres of science education may work to further marginalise English Second Language (ESL) learners who already carry the burden of educational underpreparedness. In discussing the problems of ESL learners, Inglis (nd) asks us to consider that the apparent lack of proficiency in English on a particular task may be indicative of one or more of the following:

a) poor ability in English that prevents adequate achievement of the task;
b) poor understanding of the demands of the task;
c) misconceptions about the concepts that the task is designed to test;
d) misunderstanding or lack of knowledge of underlying concepts that the task concepts are based upon.

If we accept that the host of implicit assumptions and expectations that populate a given task (and its anticipated outcome) are socio-culturally determined, and may be invoked by the subtlest of linguistic cues, then each of Inglis's levels of concern above may represent

succeedingly difficult challenges to some ESL learners.

Ballard and Clanchy (1991), following a similar tack, argue that different cultural traditions may emphasise substantially different assumptions and expectations in their teaching and learning processes (see Table 1).

For students who may have been immersed in one intellectual tradition to make the transition to another is complicated by the generally tacit nature of these traditions. It is easy for confusions resulting from (for example) differences in foundational assumptions about the nature of knowledge to be ascribed to language problems, or even levels of innate ability, unless educators are aware of such differences. This suggests that alternative learning styles (and their respective sets of assumptions and expectations) need to be consciously addressed, and opportunities for 'enculturation' into the alternative literacy practices be provided.

ATTITUDES TO KNOWLEDGE	conserving	<--------->	extending
LEARNING APPROACHES	reproductive	analytical	speculative
LEARNING STRATEGIES Type	memorisation and imitation	critical thinking	deliberate search for new possibilities and explanations
Activities	summarising describing identifying and applying formulae and information	questioning, judging and recombining ideas and information into an argument	speculating hypothesizing
Characteristic Questions	what?	why? how? how valid? how important?	what if?
Aim	'correctness'	'simple' originality, reshaping material into a different pattern	'creative' originality, totally new approach or new knowledge

TABLE 1: Learning Styles (from Ballard and Clanchy 1991: 22)

In historically white South African universities, this probably implies that the Western intellectual tradition still holds unquestioned sway, and that learners from alternative traditions must be the ones to make this difficult transition. This is likely to be a reality for a while yet, and recognition is needed for the substantial inequities that this sustains.

These three critiques of the traditional genres of science and science education seem to suggest some central avenues to be considered by curriculum developers who look to including literacy practices that are consistent with the various theoretical perspectives informing science education. Firstly, our insight into the processes of experiential learning insists that one can only learn to participate in the dialogues of the discipline through reasonably "authentic" participation in the discourse. For example, any writer makes assumptions about the knowledge levels of their audience, knowing "when to assert and when to assume" (Giltrow and Valiquette 1994: 49). But this knowledge-of-knowledge is largely tacit, and is not easily rendered explicit.

A problem with the experiential approach here is that educational genres cannot be the same as professional genres. They are instances of different social practices: the apprenticeship to a discipline on the one hand, and the generation of disciplinary knowledge on the other. In addition, normal educational practice works to strip student genres of the kind of dialogic character that Bakhtin had in mind when he described "utterances." Student genres certainly respond to what has gone before (a task statement), and they anticipate a subsequent response (a mark), but these bracketing phenomena are generally exclusive to the learning milieu and are dialogic only in the limited sense that educators will respond by grading the student texts, rather than entering into the sustained dialogues typical of the construction of negotiated meaning.

I believe that a threefold response is available: firstly, students need to be exposed to *a wider range* of operational genres, including ones that increasingly approximate the literacy practices of the professional world outside the academy. This would involve two inter-related developments: on the one hand, the construction of more open-ended, problem-solving tasks that address the needs of some interested community; on the other hand, the construction of a more empowered student identity that would find expression in a growing professional and communicative role for the student vis-a-vis the task and the target community. The nature of the task and the identity constructed for the student are reciprocal facets of the same instance of educational practice.

The second response involves the development of fresh educational genres that provide

enhanced opportunities for dialogic rhetorical relationships between learners and educators, and between learners themselves. This development might need to include a shift in the identity of the educator away from that of authoritative disciplinary gate-keeper to a more facilitative one that admits of the tentativeness of knowledge - indeed places this tentativeness at centre-stage - and sincerely enrols in the educational project as a learner-educator. This is not to be naive about the real power in the hands of educators; it is a reconstruction of how that power is played out.

The third response involves the development of a conscious and critical strand to any curriculum which considers the typical (and powerful) genres of the discipline, their form and function, how they constitute - and are constituted by - social practice, and the role they play in reproducing social practice. The goal would be two-fold: students should be able to better appropriate the genres that offer access to social goods, and they should be better equipped to contribute (from a position of expertise) to the evolution of genres towards more progressive social practices.

All three of these responses involve an alteration of educational practice. This is consistent with our (earlier) understanding that educational genres must reflect and constitute forms of educational practice. To use Geisler's words, we cannot change "the crippled literacy practices of students ... without also altering the relationships out of which these texts arise" (1994: 52).

Conclusion

The practice of requiring students to write, thus, cannot adequately be understood without reference to the wider educational context in which such practice is situated. This study aims to explore the educational context of one science department at the University of Cape Town, and thus to construct a platform from which to consider the practice of promoting science literacy in that department. Or, to use another metaphor, the goal is to disembed the literacy practices of the department from the disciplinary relationships that construct them, so as to better understand both. The following chapter discusses how this aim is operationalised in this study.

CHAPTER THREE: METHODOLOGY

> To adopt any intellectual tradition is to adopt a way to challenge social arrangements. Each 'rationality' provides a logic to frame problems *and* their solutions. To select and organize schemes for analysis and interpretation has consequences beyond 'descriptive' reporting. (Popkewitz 1984: 185)

> I know of no "method" for the conduct of qualitative inquiry in general or for educational criticism in particular. There is no codified body of procedures that will tell someone how to produce a perceptive, insightful, or illuminating study of the educational world. (Eisner 1991: 169)

Paradigms and Approaches

In order to identify the methodological direction of this study, I have chosen Guba's (1990) model of four intellectual traditions or "paradigms". These are what he terms the *positivist,* the *post-positivist,* the *critical theory* and the *constructivist* paradigms. (see Table 2)

	ONTOLOGY	EPISTEMOLOGY	METHODOLOGY
POSITIVISM	*Realist* - reality exists "out there" and is driven by immutable natural laws and mechanisms. Knowledge of these entities, laws and mechanisms is conventionally summarised in the form of time- and context-free generalisations.	*Dualist/Objectivist* - it is both possible and essential for the enquirer to adopt a distant, noninteractive posture. Values and other biasing and confounding factors are thereby automatically excluded from influencing the outcomes.	*Experimental* - questions and/or hypotheses are stated in advance in propositional form and subjected to empirical tests (falsification) under carefully controlled conditions.
POST-POSITIVISM	*Critical Realist* - reality exists but can never be fully apprehended. It is driven by natural laws that can only be incompletely understood.	*Modified objectivist* - objectivity remains a regulatory ideal, but it can only be approximated, with special emphasis placed on external guardians such as the critical tradition and the critical community.	*Modified experimental* - emphasise critical multiplism. Redress imbalances by doing inquiry in more natural settings, using more qualitative methods, depending more on grounded theory, and reintroducing discovery into the inquiry process.
CRITICAL THEORY	*Critical Realist* - as in the case of post-positivism.	*Subjectivist* - in the sense that values mediate inquiry.	*Dialogic, transformative* - eliminate false consciousness and energise and facilitate transformation.
CONSTRUCTIVISM	*Relativist* - realities exist in the form of multiple mental constructions, socially and experientially based, local and specific, dependant for their form and content on the persons who hold them.	*Subjectivist* - inquirer and enquired into are fused into a single (monistic) entity. Findings are literally the creation of the process of interaction between the two.	*Hermeneutic, dialectic* - individual constructions are elicited and refined hermeneutically, and compared and contrasted dialectically, with the aim of generating one (or a few) constructions on which there is substantial consensus.

TABLE 2: Intellectual Traditions (Adapted from Guba 1990)

I locate myself in the constructivist camp, both because I am personally persuaded that this is currently the most useful frame, and because it offers me a theoretical basis to support my work, which may require me to engage with members of various disciplines and negotiate how knowledge-making is mediated to students there.

Although acknowledging one's position in one broad paradigm has fundamental implications for one's world view and the forms and goals of enquiry one pursues, I am persuaded by the arguments of (amongst others) Guba (1990), Strauss and Corbin (1990) and Smaling (1992) that the subsequent choices of research approaches and methods need not be closely circumscribed by such a paradigmatic location. Smaling demonstrates that a "fruitful combination of paradigmatic approaches or between-paradigms triangulation" is possible (1990: 6), and warns that "it is not at all clear what sort of and how many distinct and monolithic social scientific paradigms really do exist" (1990: 5). He argues on the one hand that a choice of (for example) an empirical analytical paradigm, does not preclude the adoption of (perhaps) qualitative research methods and, on the other hand, that choices of particular research methods do not imply particular paradigms. Instead, he concludes, choices of research method are more likely to be influenced by a range of *pragmatic* factors. He identifies eight "dimensions" [which "may be paradigmatically impregnated, but certainly not in their entirety" (1990: 10)]: the researcher, the object of study, its context, the research question, the research goal, the audiences, the conditions set for the study, and the time-span available.

The next section will discuss some of the pragmatic constraints shaping this study, and how some of these factors have played out in the course of the research process.

Methodological Issues in the Field

The issues under study in this research exercise have currently yet to be documented in any explicit manner in the context of UCT's Department of Zoology. There is no formal departmental policy document on student writing which offers a rationale for the use of writing to advance curricular ends. Although many of the senior academics are passionate

about the role and value of writing in student learning, the assumptions and logic informing these perceptions have not been made explicit in any systematic or public way. In this regard, I subscribe to the notion that, firstly, these implicit theories held by staff operate to influence their practice in powerful ways and, secondly, that many of these assumptions may be shared amongst staff in the course of their routine interactions and may - through a "commonsense" consensus - have assumed the proportions of a kind of established (but partly unarticulated) orthodoxy. Further, staff may have invested in these assumptions to varying degrees, and the process of unearthing these assumptions - and their attendant normative baggage - may require delicacy and tact.

The methods adopted for this study, then, would need to allow the assumptions and implicit theories held by the respondents to emerge, and to be assembled in useful ways. The "usefulness" of the emerging stories would need to include their value in informing, firstly, the Writing-Across-the-Curriculum (WAC) work pursued by practitioners like myself; secondly, the pedagogical decisions made by staff in this particular department; and, thirdly, if more generalisable insights emerge, the approaches taken by staff in other cognate disciplines.

It is with this context, and these purposes and audiences in mind that I designed the research process assuming a broadly interpretative tradition. This approach seemed indicated since the purpose of the study - an exploration of the understandings and perceptions of a handful of academics about abstract educational theories - does not lend itself to more quantitative approaches. Such quantitative approaches are usually informed by the empirical-analytical tradition which assumes an extant hypothesis and seeks to *prove* or *measure* in ways that will confirm or refute the hypothesis. The goal of this study is rather to "uncover and understand" (Strauss and Corbin 1990) attitudes and beliefs and, by engaging with these attitudes and beliefs, to attempt to construct a rationale for writing in the discipline. The goal of this exercise is, in this way, rather to *generate* theory, or - at least - *coherence* of theory.

A further decision was whether I would draw on the perspectives of critical theory, with the explicitly ideological and liberatory discourse of that approach. Given the recent political transitions in South Africa, it would seem at first glance that such a line of enquiry would

be timely and appropriate. Such a choice would have indeed resulted in very different questions, or at least different analytic interests. However, more immediate pragmatic considerations militated against this. The project (under whose umbrella I gained access to the department) is a relatively new and unproven one, and as a WAC practitioner, I am barely an apprentice. Our identity (and hence our power) in the institution is thus relatively unformed and fragile. It seemed wiser to use this opportunity to establish a personal expertise, and an institutional identity for the project that would enable further access more widely in the institution, so that we could subsequently tackle important political issues from a position of greater strength. Also, issues of institutional transformation are slow to make meaningful impact in the day-to-day business of departments, and it seems strategic to initiate educational debate in terms that departmental staff are relatively comfortable with. Indeed, my experience of the last two years suggests that very little grassroots educational development can be carried on without the involvement and commitment of such disciplinary insiders. Thus to attempt to initiate a debate with a department which foregrounds the politics of race, gender and class in the educational practice of the department seems at this stage to be self-defeating. These issues are real, and infuse all that we do, but must await a moment when they can be tackled as a joint project invested with the commitment of all parties.

A further dimension of the context of this study is the developmental agenda that informs it. My work at the University of Cape Town is for the Academic Development Programme, and key amongst its objectives is staff development and curriculum development so as to serve the needs of "a diverse student body." Originally conceived as "support" activities for a minority of "underprepared" black students, the ADP has re-defined its identity and role so as to embrace the rapidly changing demographics of the institution, and to re-position itself so as to achieve institution-wide and programmatic impact.

Thus, even though the dialogue I establish with my respondents seldom invokes the critical discourse of race, class and transformation, the goal of promoting more *meaningful* access for learners is inherent in this study. This is a concern that access is not simply an issue of admission, but of curricular provision that enables reasonable chances of success. It is understood that without provision that addresses the needs of a diversity of learners, the institution will, by default, continue to privilege an economic elite, and continue to

marginalise the disadvantaged. It is anticipated that provision that "caters to diversity" will be of primary benefit to underprepared learners. This study, then, is informed by an underlying transformatory agenda.

I chose to locate this study in the Zoology Department at UCT because the department had invited my project (The Writing Centre) to assist in developing student writing in the context of their second-year curricula. Part of my motivation was that the research would help to inform my development activities, particularly in helping to promote a more informed conversation in the department about writing. It is significant, I feel, that while my initial proposals for development activities in the second-year courses were accepted, my proposal for this study was at first rejected as irrelevant. I had to argue forcefully for this exercise to be retained as part of the package. This was an early hint that staff may have conceived student writing as, perhaps, a problem for students, rather than a more integrated curricular problem.

My research method, then, would need to be *hermeneutic* (so that it would provide an opportunity to explore the ways my respondents understand their practices) and *dialectic* (in that my engagement with my respondents should, in various ways, constitute a dialogue between my theories and theirs).

Given these goals, and the constraints of time and space involved in a half-thesis study, I chose the interview as my central data-generating method. This method would give me immediate access to the explicit views of Zoology staff. An alternative (or additional) approach might have been to embark on a discourse analysis of various departmental texts - handbooks, course outlines, marking guidelines, assignment instructions, the way staff mark student texts, etc - and I retained this as a back-up possibility, but mindful of possible difficulties this approach might present if I was to maintain the trusting relationship with Zoology staff that I would need to sustain my developmental work with them outside the confines of this particular study. I was concerned that such a discourse analysis approach - unless carefully handled - may result in staff feeling in some way "exposed", with the result that they may be less willing to admit me to their personal and curricular spaces.

In the event, my interviews seemed to be yielding fruitful data, and I decided not to pursue the discourse analysis option. Such an approach, however, would almost certainly be most generative, and may well be essential for a larger study (especially for "triangulation" purposes), but in the AD context would need to be skilfully handled so as to serve developmental purposes, be ethically respectful towards the participants, and still maintain the rigour of the study.

The Interview as Method

McCracken (1988) argues that no instrument of inquiry is more revealing than the interview: it is a means to take us "into the mental world of the individual, to glimpse the categories and logic by which he or she sees the world," and thus to assist us to obtain " a qualitative understanding of how culture mediates human action" (1988:9).

I have chosen an *unstructured* (Cohen & Manion 1980) or *focused* (Yin 1984) interview format, which would allow me the leeway to explore and digress in spite of a pre-arranged schedule of questions that I would endeavour to cover in each interview. I felt this was essential since, although I had some preconceived ideas, I needed to provide an opportunity for alternative and additional insight to develop. I felt that it would be possible, even desirable, to allow the progress of the interviews to be at least partially shaped by the logic of the responses, since this might point to alternative systems of logic to the one I had constructed in my interview schedule (see Appendix 1).

This logic is one that progressed from an interest in the epistemic foundations of the discipline, to the qualities of a good Zoologist, to how those qualities are developed in students, and finally to the role of writing in developing those qualities. My agenda - that of "disembedding" an aspect of educational practice so as to develop an explicit rationale for the use of writing in advancing student learning - is constituted in these questions.

In approaching the issue of the validity of the interview as a method for what it is that this study is trying to "do", I must explore for a moment how the interview process is conceived. Kitwood (in Cohen & Manion 1980) identifies three conceptions of the research interview:

i) *a potential means of pure information transfer:* a skilled interviewer and a sincere and well-motivated respondent can generate accurate and detailed data. The interviewer would need to be alert for (and eliminate) instances of bias and "socially-desirable response." In this account, "accurate" data can be distinguished and separated from "bias."

ii) *a transaction which inevitably has bias, which is to be recognised and controlled:* Each participant will define the situation in individual ways and will respond according to complex motivational matrices operating at that time. It is the job of the researcher to control for these biases by, for example, "having a range of interviewers with different biases."(311) This account sees methodological ways of dealing with endemic biases "which are potential obstacles to sound research."

iii) *an encounter necessarily sharing the features of everyday life:* Rather than having to deal with bias, the researcher needs to develop a "theory of everyday life" that takes into account the features of interviews. Cohen and Manion refer to Cicourel's (1964) five "unavoidable" features of an interview:

1. Factors such as mutual trust, social distance and the interviewer's control, which will vary in each situation;
2. The discomfort (and resultant avoidance) a respondent may feel at penetrating questioning;
3. Both parties will hold back part of what is in their power to state;
4. Many meanings - clear to one - will be opaque to the other, even with the best of intentions; and
5. It is impossible, just as in everyday life, to bring every aspect of the encounter within rational control. (1980: 311-312)

In this last conception, interviews are seen to be fundamentally rooted in their own contexts, and the role of the researcher is to identify - as far as possible - the characteristics of that encounter so as to account for the features of the transaction. This is a conception of an interview that will not allow of "data" that can be separated from the context in which it is generated, that can be "cleansed" of bias and subjectivity so that it attains some degree of

objectivity. Consonant with this view is the research conducted by Potter and Wetherell (1987) which suggests that views expressed by individuals vary according to context.

A consequence of subscribing to this third conception of interviews is that notions of reliability and validity (in their positivist, empirical sense) become "redundant," since "every interpersonal situation may be said to be valid" (Kitwood in Cohen & Manion, 1980: 319). There is, however, another more postpositivist concern about "validity" - that of the relationship between the research and the researched - which I discuss towards the end of this chapter.

A further factor which has a bearing on issue of the validity of the interview as method for this study, is the nature of the questions I directed to the respondents. These were almost always (with one exception) phrased in general terms, rather than referring to specific instances of practice. This phrasing resulted in equally generalised responses that discussed the issues in more-or-less *abstract or idealised* terms. This is in keeping with my goal, that of developing a rationale for writing-to-learn in the discipline. That these idealised and abstracted views will eventually need to confront pragmatic conditions on the ground is a given: the ultimate goal (beyond what can be reported in this study) is to set up a systematic conversation that explicitly explores the tension between the two, acknowledges the limitations of the department, and makes public decisions about approaches to be taken. Such a process will doubtless involve compromise, but will hopefully result in more conscious and consistent planning and reflection.

Although I interviewed eleven members of staff, I have used data from only five of these interviews, for reasons I discuss below. I am therefore not claiming that the account I have constructed is in any way "representative" of the collective views of the department. I am merely constructing one account which will have some (limited) claims to be legitimately introduced into a departmental debate about teaching and learning issues. My account is representative only in that it claims to represent limited fragments of individual views offered at one point in time, and in a particular context. The account is "valid" only insofar as a few members of the discipline consider it a worthwhile contribution to the disciplinary conversation.

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Even as I offer this disclaimer, I must also acknowledge that this limited study has constituted some sort of intervention in the department. The very fact of embarking on this exercise, and drawing some individuals into it, will inevitably have - indeed, already has had - consequences. Some respondents have already acknowledged that they think of some issues differently, and in one instance, an interview had the direct result of an invitation to participate in the design of a new third-year course. So in trying to theorise the nature of an interview (and the account that issues from it), I need, on the one hand, to be modest about what the account represents yet, on the other, still acknowledge that it is an instance of practice that carries consequences.

A detailed exploration of the dynamics of each interview, with an account of how the roles and investments of the participants played themselves out in the ensuing dialogue would be an interesting study in itself, but is beyond the scope of this thesis.

The Interviewing Process

I approached the Head of Department for his advice about who to interview. He offered me a list of eleven names, and my impression is that he chose individuals who were most senior, who had proven track-records as effective teachers, or who were most closely involved in formulating innovative teaching approaches. He included himself amongst the eleven.

I sent a letter of request to the other ten members outlining my project, indicating (on his advice) that the HoD had suggested they may be valuable contributors, and estimating the total time commitment that might be involved, should they agree to participate. All agreed to participate. In retrospect, I believe that one or two may have been reluctant participants. One said that he considered it a valuable exercise, but made it clear that he resented the time he had had to dedicate to the interview. I wondered whether, in this instance, mention of the HoD in the letter had been seen not simply as approval for the project, but as subtly coercive. The majority of my other respondents, however, I judged to be very willing participants, and many cheerfully allowed the interview to continue beyond the agreed time, often necessary because of their detailed and thoughtful responses to my questions.

Because of year-end pressures of time, I ended up having to schedule the eleven interviews very close to one another. On the first day, I conducted four of the interviews, and conducted two a day on each of two further days. All the significant interviews were conducted in the space of a week when my own schedule allowed me no time to process what I had gathered before the next interview.

The consequence of such a rushed data-collection process is that I was unable to consider interesting issues that were emerging and warranted closer attention, or to evaluate how effective my questions were in eliciting the kind of data I was pursuing, and hence to modify my schedule of questions. I am aware that some unplanned issues registered in my mind through the progress of the interviews, and that I included these in subsequent interviews. But I am certain that if I had planned my process so as to allow some detailed consideration of one interview before embarking on another, I might have generated different data. An additional point, though, might be that the rushed process resulted in my asking similar kinds of questions across most respondents in a way that enabled me to develop a sense of commonalities and divergences that I was later able to explore in my data analysis.

I asked some of my respondents at the close of the interview how they had experienced the process. The most negative of the responses began with an admission that "It's been interesting," and "the goals are so important," then developed into a upwelling of frustration over wasted time, ending with:

> *Sorry for telling you how annoying it is, but I think one must also be honest about these things. Any waste of time is annoying. But it is not a waste - any usage of time that doesn't directly effect or benefit one is sometimes a frustration. But I'm glad I did this.*

Although, in the end, I did not use this respondent's interview in my study, I include this comment because it reflects the pressured working context of my respondents, a pressure that (I believe) works against the educational (as opposed to the research) dimensions of academic practice, and which constrained the opportunities in which I could take the emerging constructions of the study back to the host community.

Another respondent ended on a curious note, raising an issue I'll consider in more depth in

the final chapter of this study:

> *It was very useful - it made me think about things. But it won't make me change the way I teach.* (Z3)

The rest of the feedback was positive. Of particular interest for me in the light of my AD agenda, were the following responses which hinted at how an interview might help to open up developmental possibilities:

> *Quite interesting. You took a very different approach from what I thought you were going to do. I thought you'd be more formally oriented towards the question of writing, but in reality it's been the bigger concepts, and perhaps the most interesting thing is that its stimulated me to think about perhaps some of the challenges I should be putting to the staff.* (Z1)

> *It's two-and-a-half hours well spent. I didn't anticipate two-and-a-half hours, but it's going to be very exciting. I find it interesting talking to someone totally outside my discipline. And the way you think. Because some of your questions are actually quite difficult to answer. I'm not sure that I satisfactorily answered them. ... It's certainly made me think about my subject again, and it's made me feel good about it.* (Z4)

> *No it has been interesting Rob, because you've tried to pull out for me - you've made me think myself why I do Zoology, and you've made me look at the way I try to teach.* (Interview not used in study)

This last comment I include because the response was quite unexpected and, had I more time, would send me on another study to try to unpack the workings of my interviewing discourse:

> *Worthwhile, but that's because of your style. You have a unique ability to make someone feel that what they are saying is actually relevant and worthwhile listening to, which is brilliant. So yes, I'm feeling good about it.* (Z5)

Analysing the Data

Given the goal of this study, that is to develop a coherent rationale for the use of student writing to advance learning, the object of this analytic process is to search for commonalities between the various accounts presented by my respondents, for textured detail to enrich these common threads, and for a line of reasoning that may be offered as a starting point for the departmental debate. In searching for theories to guide practice, it is necessary to assume that

there may be competing theories available. Where these are crucial to the debate, they must also be uncovered.

I have followed (approximately) the analytic procedures outlined in Manion and Cohen for "phenomenological analysis" (1980: 327-333), in McCracken for "discovery of analytic categories" (1988: 41-46), and in Eisner for "qualitative enquiry" (1991: 189-192).

In each case, the analytic process involves identifying individual utterances from a transcript that fit into (either pre-established or emerging) categories and recoding these into class statements. These class statements from the range of respondents are then compared for patterns of consistency or contradiction.

In my case, the chief categories were reasonably clearly established at the outset, and these form the major subdivisions of the analysis chapter. Within each subdivision, however, the account I have developed has varied with the intent of the subdivision, and the data available. For example, in the first subdivision ("What is Zoology?"), I go to some lengths to establish individual coherence for each of the five respondents. I believe that five distinct voices are heard, each presenting an individually-textured view of the discipline, but yet also offering an important commonality that I have interpreted as a broadly constructivist approach to science. It was important for this commonality to be established and confirmed if I was to proceed with any confidence upon the subsequent stages of my analysis, since these later stages depend crucially on this commonly-held constructivism. Having performed this analytic move, I took my write-up of each respondent's views to the individual concerned for their inspection and approval. Somewhat to my surprise and pleasure, they all approved my selection and interpretation.

This approval gave me confidence to proceed to subsequent analytic moves. But here I began to blend the voices of my respondents, calling on their evidence to construct an argument. In some subdivisions (eg. Nos 2 and 3), the argument is only briefly established so as to allow greater space for the later subdivisions which come closer to addressing the goal of this study.

Throughout the data analysis chapter, I have presented the account simply, assuming that the reader has read the theory chapter, and that much of what the respondents say will invoke resonances from this theoretical frame. Often, the considered quality of my respondents' comments is such that their points stand alone, and need little interpretation. In the selection of excerpts (itself an interpretive move), and the development of my commentary, I am looking for an interplay between the "best practice" suggested by the theorists, and the views offered by my respondents. In my selection, I am looking for evidence that in some way reflects on one broad theoretical path that I believe may positively inform the way teaching and learning happens in the department. This path is mine (woven from theoretical threads appropriated from other authorities), and I do not claim to discover it from the views of my respondents. I am, however, seeking sufficient validation from their insights to be able to present the path as a contribution to the disciplinary debate. This on-going debate (started long ago) will doubtless chart many other paths in the future.

Taking the Study back to the Department

Lather argues that an important part of any research that has a transformatory agenda is "the extent that the research process enables people to change by encouraging self-reflection and a deeper understanding of their particular situations" (1986: 263). She argues for two ways of discussing this process, and calls them *face validity* and *catalytic validity*. Face validity is "operationalised by recycling description, emerging analysis, and conclusions back through at least a subsample of respondents," while catalytic validity is "the extent to which the research process re-orients ... participants" in a transformatory way (1986: 271-2).

The final section of this chapter reports on ways in which have tried to take components of the research back to my respondents, and speculates about emerging "re-orientations".

My *first* move for feedback I have already mentioned earlier: I needed to ensure that my respondents generally agreed that they saw their discipline from a broadly postpositivist or constructivist perspective. I did this by taking to each respondent a copy of how I had selected and interpreted their comments on this issue (see sections 1.1 to 1.5 in Chapter Four, and Appendix 2: "Letter to Respondents"). All were content with my selections and

my interpretation.

The *second* opportunity came as an invitation from the Head of Department (one of the respondents). He asked me to write a brief report on my study to inform a two-day planning meeting that the department had scheduled for a weekend in August, and suggested I should come to part of the meeting. I drafted the report (an earlier version of the one contained in Appendix 3) and ensured copies were circulated to all staff in the department in good time. I attended the meeting as requested, was formally welcomed by the Head of Department, but discovered that no slot existed in the agenda for discussion of my report. I sat through the meeting, and contributed to discussion (sometimes quite usefully, I thought) whenever I could, but at no time did the subject of my report or its focus of interest enter the conversation. I left somewhat bewildered.

A few days later, I received an e-mail message from one staff member, saying he had read the report, found it "interesting" and would like to discuss these problems in 1996 in the context of the Masters Coursework programme he convenes. This remains the only acknowledgement I ever received of this first report.

I actively negotiated my *third* opportunity by requesting a slot in the department's end-of-year meeting for a discussion of an updated version of the report (see Appendix 3: "Report to Zoology Department"). This happened as I requested, and I have summarised the outcome of that session in Appendix 5 ("Responses from Staff").

My *fourth* move was to invite my respondents to read to read my theory and analysis chapters (see Appendix 6: "E-mail to Respondents"). Three responded, saying they would like to read my analysis chapter. One (the Head of Department) cautioned that he was unlikely to have the time to read and respond in the time frame I had indicated. Another (Z4) returned the chapter and the "Report to Zoology Department" with many responses noted on the documents themselves. I include portions of these in Appendix 7 ("Response from Z4").

These were my attempts at establishing some "face validity" or "recycling" my study back to my respondents within the time frame of this half-thesis report. I believe, however, that

these four moves described above have in themselves had little transformatory effect (in the sense that Lather intends) on either the views of the respondents or on the content of the main body of this study. The impact of the study (Lather's "catalytic validity") is more likely to be reflected in the work I have done outside the strict confines of what is reported in this half-thesis, principally in the Writing-across-the-Curriculum project I have worked on in conjunction with Z4 (course convenor) and other staff. I believe that the extended discussion (two-and-a-half-hours) that happened during my interview with Z4 laid the foundations for our subsequent work together. I enclose (with permission) in Appendix 8 ("Excerpts from Post-Mortem") some fragments from the minutes of a meeting attended by my colleague Moragh Paxton and I, in which it is possible to see the kinds of movement that this study advocates.

CHAPTER FOUR: DATA ANALYSIS

I begin this chapter with a detailed construct of how each of my five respondents views his discipline. This may seem at first a disproportionate allocation of space in this chapter to a question somewhat remote from the central concern of this study, which is the role of student writing in the discipline. I believe, however, that this is space well used, since the accounts of the discipline given by my respondents offer (in my view) a richly textured set of requirements and possibilities for Zoology teaching and, therefore, for the role of writing in learning. I believe, also, that this treatment allows something of the identity of each respondent to emerge from the start, and that some of their later utterances may then carry resonances of their individuality, rather than simply being disembodied voices stripped of all context. I hope, in this way, to compensate for the necessary anonymity of a research study by sketching something of an ideological "personality" for each of my respondents.

ANALYSIS 1: "WHAT IS ZOOLOGY?"

For each respondent, I have attempted to pull together the dominant motifs which emerge for me from the discussions, and to sum these up in some sort of categorical statement (which I have inserted as the heading for the selection from each respondent). The intent was to identify trends, or the broad thrust of the various viewpoints, which could operate as "handles" to facilitate discussion of the data.

I am aware that, in making selections, I have been looking for specific kinds of responses to the question. Generally, these seem to have been responses that, either directly or indirectly, shed light on the epistemic assumptions of the respondent. I am aware that I have had difficulty separating *"What is Science?"* from *"What do scientists do?"* and, in retrospect, this may be because of the epistemic ambiguity that my discussion addresses.

Predictably, I find no *fundamental* discrepancies between the respondents, merely differences of emphasis which I believe present opportunities for valuable insights into ways of thinking about the discipline.

I list below a selection of excerpts from each of the respondents. I have selected and arranged these in a way that I hope best "tells a story" about the scientist and his science, without distorting the original account beyond recognition. I then offer a brief summary of the "trend" of each respondent, as I have constructed it, in a way that I hope will justify the title I have chosen for each. I have shown each of the relevant selections and subsequent construct to the respondent concerned, and all five have approved both selection and construct.

1.1 Z1: "Zoology as social construct"

a) *We've also lost out in not communicating to the broader world - this is true of science in general. It's resulted in Science becoming very exclusive and either being treated as something incredibly powerful and magical and problem-solving, or to complete rejection because people don't understand what it's all about.*

b) *I think what has changed is the realisation that it's stupid to try and hide the personal opinion or something one person has done behind what was essentially jargon. To try and disguise it as being something objective when in reality some things never are objective.*

c) *All science is tentative. ... An appreciation that concepts change is terribly important.*

d) *(A) huge advance has been development of quantitative Zoology. Instead of just being descriptive, people are trying to put numbers to things, and to be able to develop from these numbers to general principles. (This involves) modelling a situation using numbers ... (Another) major advance is molecular development ... (which) relies on the development of techniques.*

e) *Any science is cast in the social setting that exists at the time you do the study. In fact this is a realisation that has powerfully influenced the whole philosophy of what science is. We've gone through the phase where science is seen as something incredibly objective and we're only concerned with the facts - but in reality one's whole attitude and response and interest is dictated by social mores of the time. I think we're now entering a phase where people are much more concerned about integrating their science into human needs and hence into ethics and sociology and so on.*

Z1 suggests (in extract a) that the identity of a discipline is constructed in the social domain, and that this identity has clear ramifications for the social purposes (or neglect) of the discipline. Both examples offered (in extract a) of possible public conceptions are negative ones, the result - in his view - of inadequate communication.

Contrary to these possible public perceptions, Z1 asserts the *subjective* and *tentative* nature of his discipline. This is illustrated when he points (in extract d) to the growing quantitative trend of the discipline, which relies on the development of *techniques* to generate numerical data for *modelling* or the derivation of *principles*. These are all consistent with a notion of Zoology as a human construct that changes as new ways of seeing are developed. He finally confirms that the discipline cannot be seen as remote from its social context and purposes.

1.2 Z2: "Biology as debate"

a) *(Logical thought) is something fundamental to all scientific disciplines. You can't ignore evidence. There may be a number of different ways of interpreting the evidence, and you must consider all those different ways of possible interpretation.*

b) *(The discipline) is highly speculative.*

c) *There are hardly any universal laws in Biology. If you try to give me a universal law in Biology, I can shoot it down immediately.*

d) *Darwin had no concept of contingency, which we now have.*

e) *For someone who's going to be a scientist, they must (have) the ability to think they may be wrong ... It's a certain humility of thought, which I think is essential to a biologist.*

f) *I say to them "Now here are the facts. It means this, doesn't it? Ah, but it could mean that." And they come up afterwards and they say "But which is right?" And I say "You think about it, and argue it." In fact nobody knows.*

g) *... So that they can debate different points of view on the same topic, and at the same time sort out their own ideas as they go along. This is part of what they have already discussed - a biological topic is a debate - it's not cut-and-dried.*

h) *One thing my students must have by the time they get to third year - whether they are going to be school-teachers or scientists, it doesn't matter - and that is the ability to communicate*

i) *And what I'm interested in at Honours level is not what they remember, but how they are going to be as Zoologists, when they get out of here.*

In extract a, Z2 holds *logical thought, evidence* and *interpretation* together as a foundational tripod for the discipline. Thereafter, with few *universal laws* to depend on, and the vagaries of *contingency* to contend with, the Biologist advances the discipline with *speculative*

thought. Central to such thought is an intellectual *humility* based on the assumption that "final truth" is unlikely. The pursuit of Biology, then, is fundamentally a *debate*, with *communication* an integral part of the conduct of the debate. Z2 seems to suggest that it is participating in the disciplinary debate (and the positions taken up) that construct the role and identity of the professional person that emerges: "How they are going *to be as Zoologists* when they get out of here."

1.3 Z3: "Logical and tidy thinking is what ends up being good Science."

a) *What we equip (the students) to do is to see animals within the context of these broad concepts that we teach them, and understand why they are there. Why animals are where they are and why they do what they do. "Why" in an evolutionary sense.*

b) *Our ethic is: As a scientist you have to accept the body of evidence.*

c) *The fundamental concept of being a scientist (is that) whatever principle we're talking about is a principle which can be measured and proven within a reasonable limit. Science depends on observation and laws, whereas Theologists will base their teaching on belief that can't be proven. We base our teaching on the scientific principle that it can be observed, measured and proven. Nothing can ever be proven 100% of course. A principle must incorporate variation.*

d) *Biology - unlike Physics - doesn't have laws. It's more a sense of fundamental trends. Physical laws don't have exceptions. All Biological laws have exceptions. There are no biological statements which don't have exceptions. Unlike classical Science, it doesn't have set laws, it has general tendencies of which there are always exceptions. ... You can go and measure them (trends and tendencies) in the real world.*

e) *There always is uncertainty in Biology. That's why statistics are so important to biologists - you can never say this particular thing happens 100% of the time. You say "What is the likelihood that this is true?" A likelihood falls within given tolerances. Variability is a fundamental necessity in Biology. If there were no variability, there would be no evolution.*

f) *These are just ways of thinking, they are not actually explanations. ... Trends set the general background, (but) variability is the interesting thing - biological systems differ from one-another because of that variability. ... But you still have to understand the basics (of the general trends). ... (These are) two levels of thinking - both are important. But variability is what makes biology different to other sciences.*

g) *I subscribe to this (the exclusion of personal pronouns). I always correct this. I don't know why. ... In science we strive for objectivity - impersonal language gives feeling*

of "objectivity" but doesn't really change what happened.

h) *Logical and tidy thinking is what ends up being good science.*

For Z3, Zoology (or at least the way it is presented to students) consists in *broad concepts* (extract a) and *ways of thinking* (extract f). Recurrent through his account are *two levels of thinking* (extract f): the first level he characterises as the *general background* or *the basics* (extract f), and this is where Scientists must consider *the body of evidence* (extract b), where principles *can be measured and proven within a reasonable limit* (extract c), where the task of the Zoologist is to discern *fundamental trends* (extract d) and *general tendencies* (extract f), where knowledge is constructed as *likelihoods* that occur within *given tolerances* (extract e).

The second level is *"interesting"* (extract f), indeed a *fundamental necessity,* and this is the *variability,* the *uncertainty* (extract e) and the *exceptions* (extract d) that are characteristic of complex biological systems and which give rise to differences between these systems, and thus to evolution.

In negotiating the tension between seeing the broad landscapes of "trends," and understanding the generative potential of "variability," it is *logical and tidy thinking that ends up being good science.*

1.4 Z4: "*My Science*: Zoology as communicative commitment"

a) *And yet that is what Science is. The construct is there, but sooner or later there will be a little bit shot off it. The whole edifice will collapse. ... What's actually occurring when you go out into the field, is you're taking a snapshot there, and there, and there.*

b) *Most Zoologists would erect a hypothesis about how something goes, and then try and tear it to pieces. Then your observations come in and then there is a deductive process. Then argument - another component of writing - argument to support the thought processes that led to that deduction.*

c) *(Ecologists work) directly at the interface between Science and politics.*

d) *I couldn't justify myself as a Zoologist or a scientist doing what I love if I didn't feel that it had a fundamental spin-off to my fellow human beings. ... And my science is directed at people. For their benefit, but also the organisms.*

e) *I believe that being applied is essential. If my science did not have a human and global perspective and spin-off, it's not worth doing. Many colleagues would argue Science is worth doing because it's there. I don't subscribe to that view.*

f) *Again ethics: I have a duty to report back, to say "I've found this, I'm worried about that." ... (Students should be able) to express their science in words of one syllable to the lay person.*

g) *And Science is very personally based.*

h) *When I say "intimacy," I mean that we are talking my science. We are not talking about (other scientist's) stuff, we're talking my Science. And in talking about that, all sorts of other issues come up. The politics, the ethics, the morality, the immorality, the ways in which one gets around those, or fights those, or takes a stance. A lot of my Science is taking a stand.*

i) *One of the really enjoyable things about Science is the argument. There are no two 100% agreeing views on any particular issue - and that is because we are all individuals.*

j) *One cannot allow that student to graduate with poor communication skills, or writing skills. Not just because it's standards, but because they are going into a market-place where they are not going to be able to fulfil their job-requirements and their role in the community. So it's not just a standards issue, it's again an ethical issue.*

k) *The way in which you measure a scientist is communication. Publication is not communication.*

Z4 asserts Science as a human *construct*, but points to the centrality of *argument* in sustaining and structuring the construct. Science is constituted through the public exposition, and contestation, of argument. This essentially public nature of scientific argument situates it in the domain of social practices, and therefore of *political* and *ethical* issues. If Zoology is essentially an *applied* discipline, then *human* and *global* consequences are inherent in its pursuit. Part of the responsibility of the Zoologist must be to *communicate* science and its spin-off to the wider community. In doing so, the Zoologist cannot lose sight of her own "situatedness" and subjectivity, and her conscious choices, that together constitute her *stance.* In these ways, Science is essentially a *communicative* endeavour.

1.5 Z5: "Looking for the best knife to cut the edge with."

a) *Zoologists are attempting to get an understanding of biological processes, and they use animals as the vehicle to look at that...versus the botanists, who use plants.*

b) *Zoology is largely dictated to by funding and the funding is dictated by what you are looking at. And (my area of research) has become hot. It has become one of the cutting edges of Science today. ... I suppose because (this area of research is) providing a way of testing certain of the fundamental theories. ... And what you keep looking for is the best knife to cut the edge with, and (this area of research) seems to be moving forward theory, for example faster than life history studies. ... You know life history is just a mass of data, whereas something like (this) will cut right through and start challenging a major tenet of, maybe, Darwinian theory.*

c) *But when you're doing your PhD you suddenly realise that the thing to do is to look at what has been accepted for years, get an experiment which will hopefully show that perhaps that's not the case. ... Then you got to go out and look for the best model - what animal is your best model for testing that.*

d) *You want to get to the hot things that ultimately will sell your science and you'll get into a good journal for it. ... You have to get something hot in order to get good publications, and publications is how you are gauged - you know the expression: "Publish or Perish."*

e) *(My area of research is) an example in my field of something which is recently rated in a journal which addresses these sort of things as the hottest topic. ... its threatening to turn something over. So if you can do that then you've moved forward. It's kinda like breaking down - breaking out of a paradigm. You've got these paradigms which get set up, accepted, it becomes doctrine, and everyone learns it, and suddenly someone comes up with the next frame which says "Hold on, what have we got here?" ... and suddenly someone shows this piece of research which shines - which really suggests that the whole thing is poppycock. And then things get moving really fast. ... And if you are working on it, your papers flew into top journals. That was good Science. Presumably it is.*

f) *You can see the norm but you gotta look lateral to really see everything in perspective, and to get unique insight into something. ... Its one thing to be lateral, its another thing to be able to do it all on your own.*

g) *We are subjective individuals attempting to do objective work. ... We are trying to impose something rigid on something out there which is quite random.*

h) *I think honesty is more the issue here than the truth. I think if you are honest with what you have done, it is by default as close as you can come to the truth. As close as your brain will let you get to the truth.*

i) *If you are looking for the truth anywhere, you have to do a series of experiments*

which will be as objective as we can possibly make them, and take into account everything that you possibly can, and then be honest with your results. That's all you can do. Whether you get to the truth or not -

j) *(I've been reading a) brilliant debate (about definitions) which opened my mind about how free-flowing the whole thing is - how malleable it is. ... Depending on how you define it, is depending on what you take. ... Last night I was writing a paper and I was choosing: Am I gonna go strict, or am I gonna go soft? And what does it mean, once I've chosen that? I've got to align myself with a very dynamic field.*

For Z5, the activity of Zoology is about *testing*, or *challenging*, or *moving forward* fundamental theories; it is about *turning something over*, *breaking out of a paradigm*, or coming up with *the next frame*. To do this, one needs *vehicles*, the *best knife to cut the edge*, the best *model for testing*. In selecting these, a career Zoologist needs to be alive to the dictates of *funding*, and the topics defined by *journals* as "hot". Together, these add up ("presumably") to *good Science*.

He describes the tension between the *subjectivity* of individual scientists and the supposed *objectivity* of scientific enquiry; he contrasts the *rigidity* of scientific theory with the *randomness* of "out there"; *honesty* needs to distinguished from *truth*. In the end, Science is a matter of *definitions* and shrewd *alignment*.

In my selections and constructions above, I have been explicitly looking for *commonalities* of understanding and perception as they emerge for me in the utterances of each individual. I have been looking for complementary detail that would help to construct a coherent account of the ontological and epistemic vision of each individual. In short, I have been looking for *consonance*. I believe that I can discern a reasonable commonality of vision *across* the individual scientists as well, in that the discourse is reasonably consistent with post-positivist and non-positivist paradigms generally. In broad terms, it seems that each of the respondents have stated fairly explicitly that they understand the constructedness of their discipline, and the implications of that for what they are trying to do.

But an analysis of their discussions can also be made in a way that looks for contradictions and incompatibilities, an analysis that looks for *dissonance*. Although each of the respondents clearly asserts a constructivist epistemology for Zoology (or "Biology" or "Science"), there

also seems to intrude references to more positivist notions of scientific enquiry. There are references to "logical thought," "evidence" and "facts"; the processes of empirical enquiry and experimental processes are invoked, "logical and tidy thinking," and the search for "truth" and "objectivity" are goals that occur in discourse that is otherwise not at odds with constructivist understandings.

From here on, I select data *across* my respondents, rather than trying to present individual accounts. In effect, I shift from representing the discourse of individuals to representing the discourse of a department through the voices of a sample of authoritative individuals. This necessarily involves a reduction in the nuance and complexity that emerged in the interviews, but this is consequent on the purposes and limitations of this study.

ANALYSIS TWO: "WHAT SHOULD A ZOOLOGY STUDENT BE ABLE TO DO?"

The responses to this question can be selected in pedagogically reassuring ways, and I present below just such a collection of quotes:

a) *Its a training in research - involves writing skills, communication skills, literature skills, ability to read and interpret and think critically, integrate concepts. (Z1)*

b) *(Students must learn) the ability to exchange ideas and to incorporate ideas into your own thinking and to compare concepts and ideas, and express and communicate in different ways. (Z1)*

c) *The first thing I'm asking a student to do in my second-year course is read, think and assimilate a body of information, and then convert it into yourself, and give your view of what is really important in that information body. ... So many students are taught at school to regurgitate. They are spoon-fed a set of facts, and they are actually awarded - re-enforced - awarded high marks - "Good boy" "Good girl" - for regurgitation of - often in an unintegrated splat. I don't want a student to trot out stuff that he or she thinks I'm going to like. I want students to convert the information into them, and use their own ethics, their own moral standpoints and their own background knowledge and aspirations and feelings to convert that information into a story that is them. OK, albeit using facts; do they actually accept those facts? Do they accept some of them? Do they reject some of them? If so, why do they do it? How would they do it better? ... And in doing so they are communicating with me an individual standpoint, an argument. ... the development of critical thinking. (Z4)*

d) *I would look there for the ability to think they may be wrong. ... It's a certain humility of thought, which I think is essential to a biologist. (Z2)*

e) *I think a good essay requires a student to draw information from a number of sources - And then he's got to integrate the information. ... Partly so that they can debate different points of view on the same topic, and at the same time sort out their own ideas as they go along. ... A biological topic is a debate - it's not cut-and-dried. And that has to get through. (Z2)*

f) *I think first and foremost would be an ability to think laterally. Which means they've broken out of the school paradigm in my opinion. As soon as you can go onto lateral thought you can see the norm but you gotta look lateral to really see everything in perspective, and to get unique insight into something. (Z5)*

g) *But perhaps more importantly what we want to do is produce ... free-thinking individuals, who can challenge, you know, most of what we say, who'll feel free to challenge most of what we say. (Z5)*

In these accounts, students can look forward to a training in research, which equips them to think critically, integrate concepts, and take personal and distinctive ownership of ideas. Students will be encouraged to develop a humility of thought, a scepticism and a willingness to view issues from multiple perspectives. Ultimately, students will learn to think laterally and independently, and will have the confidence and freedom to challenge authoritative knowledge.

But there are also explicit and implicit expressions that these ideals are not always achieved.

a) *Most undergraduate courses require you to sit down and learn certain facts, (like) the names of major groups of organisms. Much more important is that students know <u>how</u> to do their studies, rather than having absorbed facts. But we only really practice this fully at Honours level. (Z1)*

b) *At undergraduate level we are not yet fully training people to be scientists - its only when they enter the Honours year that we start to accomplish that. So I feel for the undergraduate level we're teaching people to think, to absorb the literature and interpret it, to do the practical things that are related to that discipline. We are also teaching them a basic body of information. (Z1)*

c) *At a first year level, I'm looking for a series of facts. (Z1)*

d) *(I'm concerned about the fact that we) don't train our students in critical thinking and the ability and confidence to communicate. (Z1)*

e) *Because the prac write-up normally - they are asked specific questions for which the answer is often only one sentence, or even just a couple of words, so that it doesn't really test their skill in communicating an idea. ... They may be asked "To which phylum does this animal belong? And why?" But they are not expected to be able to write a very complex report on why: "Because the thing has got four legs and five toes." (Z2)*

f) *The fundamental concept of being a scientist (is that) whatever principle we're talking about is a principle which can be measured and proven within a reasonable limit. Science depends on observation and laws ... We base our teaching on the scientific principle that it can be observed, measured and proven. (Z3)*

g) *(At undergraduate level) you just get dumped on. Facts come raining down on you and you accept it. (Z5)*

h) *Because I had not learned how to think really. I was no different from school. At the end of my three years of undergrad teaching, until I went into Honours, and then I learned to think and the learning curve in Honours was phenomenal. I mean I really struggled. ... I suddenly had new insight because I'd learned how to think*

independently. (Z5)

In most interviews (with one notable exception), the respondents were clear that the training in critical approaches, even the foundational view that knowledge in the discipline is tentative, partial and changing, was not offered in any systematic way until the start of postgraduate programmes. If these approaches are offered at undergraduate level, some respondents say, they tend to be the exception, and are out of keeping with the tenor of the rest of the programme.

> *And this last couple of years I have come under flack on occasion from some students for saying things like - for taking students through that sort of process and then shooting it down. They don't like it. And yet that is what Science is. ... At the end of the lecture I said "OK What do you think of that?" (The students replied) "Oh It works for us." and I said "Well, it's bullshit." Jeez, did they create. "What have you done, Prof? You've wasted our time." (Z4)*

Explicit, too, is an admission from a senior staff member that foundational goals in this respect have not been established for the whole department:

> *I think we could get a general policy that would say: "As far as our students are concerned, we're aiming to accomplish the following..." It's never been done. We've never sat down and asked ourselves that question. (Z1)*

My impression is that although there is reasonably wide (but unspoken) consensus about what kinds of critical qualities students *should* be demonstrating, there is uneven understanding about *how* and *when* these qualities should be developed, and who is responsible for doing so.

ANALYSIS THREE: "WHAT DO WE DO WITH STUDENTS IN ORDER TO DEVELOP THESE QUALITIES?"

Some respondents provided clear examples of approaches intended to develop critical thought in students. Here one contrasts approaches that might typically result in reproductive strategies from students with approaches calculated to develop higher-order cognition:

> *You can run a practical by standing up at the beginning and saying "Do this." and you talk for half-an-hour and they do it and at the end they take it away and write a*

report and you mark it. Or you can say half way through the prac you can stop the prac and you can break the class into groups of four or five and you get a demonstrator with each and you ask: "OK, What have you learned? What's the significance of this and where's it taking you?" Not only interactive, but make them think about the bigger concepts. "What's the significance of all this? Why are you trying to learn this anyway? Why do this dissection?" (Z1)

Another respondent offers an example which also seeks to develop evaluative skills, but with an ethical slant:

Because Zoologists ironically kill organisms in order to study them, we very clearly make statements to the students, we give them a set of scenarios: "In this instance, an experiment is designed to do that, and in that one it is designed to do that. What do you feel about the number of organisms they are proposing to kill? Why are they doing it? What would you do to modify that?" That's what we do in that first practical, and it goes down very, very well. It wakes them up. (Z4)

Some respondents offered examples of activities aimed to foster the notion of uncertainty so foundational to the discipline:

They get a shock - my first-year students - the first time I say to them "I don't know." ... And the second shock they get is when I say to them "Now here are the facts. It means this, doesn't it? Ah, but it could mean that." And they come up afterwards and they say "But which is right?" And I say "You think about it, and argue it." In fact nobody knows. (Z2)

(Z1) is an example of a lecturer who continually suggested that this is what Zoology about, he continually in his lectures asked questions - he'd set something up and you'd buy it because he is the lecturer and you've gobbled it - and then as he works his way through the lecture, he'd set about destroying it. He'd chip, chip, chip away and eventually you'd be left with nothing. So what you thought you were going to learn about that day he'd just disproved. He was very good at setting things up and then showing you how you can destroy them. (Z5)

Respondents repeatedly emphasised the importance of interactive approaches that maximised opportunities for staff and students to communicate intensively with each other outside of the formal lecture situation. But again it seems these are confined to the postgraduate years:

But it's amazing, as you hit Honours, probably one of the key things is discussion groups. For the first time you get a whole evenings - you go to their places, informal - you get a whole evening's education on an informal basis where you have a single subject ... and you have one of your permanent members of staff who runs this thing, who just directs this - like a chairman - and you squabble and you argue and you

discuss and only then is that information yours, once you've digested it and argued it - then its yours. In an Honours, if you don't argue - even if you're wrong - then you are losing all the way. Because that's what they're looking for. (Z5)

One respondent gives a glimpse into what the effect of close interaction might be, even as he regrets the lack of it:

What is missing for me as a teacher is intimacy. ... (As a student) we had very intimate sessions on a regular basis, at least once a week. ... It achieves a number of things. For me as a student, and subsequently in my career, it first of all developed an ability for one-on-one communication. Secondly it developed very serious critical thinking, because you were working with a brain that was in that field. ... Thirdly, it demanded of each individual student to communicate with other students. ... And that is missing. When I say "intimacy," I mean that we are talking my science. ... And in talking about that, all sorts of other issues come up. The politics, the ethics, the morality, the immorality, the ways in which one gets around those, or fights those, or takes a stance. A lot of my science is taking a stand. (Z4)

Another staff member recalls a rare moment in an undergraduate course:

We shifted from the fact-dumping scenario to "Okay Let's stop the prac early" - the fact dumping side of the prac: "Learn nerves one to ten" - "and let's get them to think about something that even we don't know the answer to," because theory hasn't really satisfactorily answered it. We'd get them to think about that. And they'd take pot-shots and the thing is that when they know that they can't be wrong, because its not proven as yet, then suddenly they are off the leash and then they come galloping out with the ideas. No-one can turn around to them and say "You're wrong!" Some one can only turn around and say "But is that logical?"

I remember the first time I was given something which wasn't known. You could not be an idiot, because - you are always scared of being an idiot - you couldn't be an idiot because there was no absolute answer for it. (Z5)

Far from intimidating students with uncertainty (as was hinted in some earlier excerpts) the potential of open-ended issues and tasks is suggested here.

ANALYSIS FOUR: "WHAT IS THE ROLE OF WRITING IN DEVELOPING THESE QUALITIES?"

I want to approach this question in three parts: I ask, firstly, how staff understand the notion

of "writing." I find two broad patterns of understanding emerging, and these I label respectively as "instrumental" and "communicative" notions. In the second part, I explore briefly some of the consequences of the instrumental notion that are suggested in my data, and in the third part I show how communicative approaches to writing are beginning to emerge in the thinking of some respondents.

i) How do Staff Understand the Notion of "Writing"?

Across all my respondents, I have found a dichotomous response to my questions around this issue; this dichotomy is clearly represented in the following assertion:

> *I don't think its my job to teach undergraduate students to write English. I don't mind teaching individual Hons students to do it - I don't see how anybody else can do it. ... Only professional scientists can teach people the subtleties of writing in a scientifically acceptable way. (Z3)*

The distinction made here is that undergraduates write "English," but that postgraduates write "in a scientifically acceptable way." Since the respondent has attached a crucial pedagogic responsibility to these distinctions, I asked him to explain further how he saw the differences:

> *At undergrad level I would teach them "precise" writing which isn't necessarily scientific - teach them to say what they actually want to say. You don't have to be able to understand basic scientific principles to be able to say what you want to say. I don't think at under-grad level they're capable of writing in a very scientific way because they haven't got to the stage of really understanding scientific principles that determine why you can't say this. The student needs to understand the basis on which one is correcting him - they haven't enough development to really write scientifically. But you can train them to write English precisely. I don't consider it to be my job to teach them how to write precise English, but I do consider it to be my job to teach them how to write precise science. These are not the same. (Z3)*

"Writing science," here, is explicitly linked with the development of a conceptual understanding of the discipline. There is another form of writing, though, which is writing "English," or even "precise English," which does not seem to be linked with conceptual understanding in the same way: "You don't have to be able to understand basic scientific principles to be able to say what you want to say." This latter ability he shortly afterwards describes as "basic English."

I looked for evidence of a similar distinction amongst my other respondents, and found it: "Simple English" consists of

> *vocabulary - written and spoken, the basics like spelling. ... grammar and sequencing (Z1).*

Implied here (and in the previous quote) is that the business of writing this "simple English" (Z1) involves learning straightforward rules. This notion is echoed in this comment about ESL undergraduates:

> *If they won't make the effort to brush up in the medium they are being taught in, there is nothing we can do, and they have to fail if they can't communicate. (Z4)*

Language, here, is an instrumental thing, something you can "brush up". Hinted at here is an attitudinal sanction, which suggests that a failure to "brush up" is reprehensible because learning these rules is an elementary process. This attitudinal strain (and its linkage to a suggestion that the rules are straightforward: "the basics") is glimpsed again in the following:

> *But once you've mastered the basics, I think everybody should be striving for good writing so that they are communicative. Bad writing is an insult to the reader. (Z1)*

This perception of "writing-as-simple English" is clearly present in all respondents (as further evidence below will show) and, for the purposes of this study, I want to call this the "instrumental" notion of writing. In summary, this is a view of writing as simply involving a set of elementary rules of grammar, spelling and punctuation that can be fairly easily learned.

This "instrumental" notion is further clarified when it stands in contrast to another notion of writing that emerges from the interview data. This is a more complex understanding of writing, involving more complex forms of learning. This respondent tried to describe it in the following way:

> *There is a tiered arrangement of what you're trying to do. I do think we need to teach the fundamentals: the spelling and grammar, but once you've gone beyond that, learning to communicate in an accurate, concise, lucid way, that's where the osmosis comes in. (Z1)*

As a follow-up to this comment, I asked this respondent how important a conceptual clarity of the subject matter was for the writer:

> *It's vital. That's not learning to write, that's learning how to communicate a particular topic. Very difficult for someone to write about something without having a conceptual grip. (Z1)*

Here the distinction is clearly drawn between "writing" and "communicating." The latter seems to be to "write *about something*," as if simply "writing" is something different. The suggestion is, perhaps, that "writing" (as opposed to "communicating") is some sort of discrete, generic skill that has an independent existence, something instrumental, context-free and unconnected to "content". "Communicating," on the other hand, is intimately linked to *what is being conveyed.* This seems to echo the earlier assertion by Z3 that there is something called "writing science" which is similarly content-dependent, and which is distinct from writing "English." I will call this more complex perception the "communicative" notion of writing, to distinguish it from the earlier "instrumental" notion that I have identified.

A further implication of the term "communicating" is the assumption of an *audience*, that a reader is receiving the message, and even possibly that a dynamic professional dialogue is underway:

> *The way in which you measure a scientist is communication. Publication is not communication. (Z4)*

The respondent means "publication" in the sense of formal writing for journals. "Communication" for this scientist involves a much more immediate sense of an audience in whom he can envision a *response*. Moments later, the same respondent says that learning to write is

> *learning to use words in such a way that they have impact as well as accuracy. And I think we concentrate too much on the accuracy side of things. We need to have accuracy, but we also need to have that passion. (Z4)*

Both "impact" and "passion" suggest a *clearly* human identity for his audience, rather than the more remote and abstract rationality of journal discussion.

An important point to note is that while both the instrumental and the communicative conceptions of writing seem to co-exist side-by-side in most of my respondents, the order in which they emerged in my discussions with some of them is, I believe, significant. The instrumental notion surfaces first, and the communicative notion emerges only as a result of further prompting from myself. This is aptly illustrated in a passage from an interview with a staffmember who was drawing on his own experience of learning to write as a postgraduate student. I asked him what it was he was learning, and his response was emphatic:

> *Grammar. A big thing grammar. Punctuation, commas, semi-colons, colons, all being used incorrectly. (Z5)*

I pressed him by asking if it was simply a matter of improving mechanical things like syntax:

> *No it's not only that, It depends on - if it's your supervisor - when they get hold of it, they will question your argument and your logic. In many instances, often you know exactly what you want to say, but you haven't managed to put it down correctly. And they will take one of your paragraphs, put a line through it, tell you to turn over, and they will have written out exactly what you wanted to say very succinctly. And you say "Well that's what I wanted to say" and then you start getting a feel for how to say it. That takes, of course, the longest. I mean the grammar I picked up quite quickly. (Z5)*

The notion of writing-as-grammar (for which the respondents all employ similar terms) gives way to more complex understandings, but here conveyed in less articulate ways. The discourse of grammar is easily available, but the complex notion of learning to communicate is "getting a feel for how to say it". Each respondent articulates the notion in different ways. This communicative notion of writing is understood and valued, but there is, beyond variants of the term "communication," no common set of terms shared by these respondents for this notion.

The existence of these two contrasting notions of writing, the order in which they occur in discussion, and the availability or otherwise of shared terms to describe these notions are, I suggest, fairly easily explained. The instrumental notion is simply a residue of an educational system that has only ever explicitly spoken about "language" in terms of "grammar" but in so doing has established a belief in the primacy of such an approach, a common syntactical lexicon, and a valuing of a certain kind of "correctness." The

communicative notion is less clearly articulated by these respondents, but it is very personally (if not passionately) understood. This is an understanding that has developed through their own growth as writers in an exacting professional domain, and is intimately linked to their personal and academic success. Yet this crucial ability is itself probably seldom the subject of explicit discussion, in formal or informal terms. If writing is discussed at all, it is probably in the context of what is perceived to be the wilful failure of students to present reasonable prose.

Having identified these contrasting notions of writing, the concern that must follow is how these notions are operationalised in the practice of these staff. In other words, how do these differential perceptions influence the decisions and attitudes of staff? The next section will explore some possible consequences of a reliance on a instrumental view of writing.

ii) Consequences of the Instrumental Notion of Writing.

The first consequence of a distinction between "writing simple English" and "communicating science" is a clear delineation of responsibility. The former is "the responsibility of schools" (Z3), or - beyond school - it is the responsibility of the individual student to "brush up" on "the basics." Respondent Z3 is explicit that it is not his responsibility to teach "English," although he readily asserts that no one outside the discipline can teach a student how to write in that discipline. He absolves himself from the responsibility of dealing with writing at undergraduate level by defining writing at this level as being in some way below a threshold of "basic scientific principles:"

> *You don't have to be able to understand basic scientific principles to be able to say what you want to say. I don't think at under-grad level they're capable of writing in a very scientific way because they haven't got to the stage of really understanding scientific principles that determine why you can't say this. The student needs to understand the basis on which one is correcting him - they haven't enough development to really write scientifically. But you can train them to write English precisely. I don't consider it to be my job to teach them how to write precise English, but I do consider it to be my job to teach them how to write precise science. These are not the same. (Z3)*

In the absence of any more explicit alternative theories about how undergraduates learn to

write in a discipline, this respondent is able to define for himself an exclusive and privileged role.

This claim to an exclusive domain of intellectual pursuit - one that stands above the prosaic business of "training" undergraduates to "write English precisely" - is doubtless a seductive one, and one not unknown in the "Oxbridge" tradition which assumed an elite, linguistically homogeneous student body. But in South Africa's context of rapidly changing university demographies, it has the potential to take on political ramifications.

> *When I lecture now to first-years, my black students tend to sit in the first two or three rows - and half the time they're trying to pay attention - they're very well-behaved - and a lot of them are very nice people - but half the time I can see that they do not understand what I am saying. Now if one tries to come down to a lower level, which is dangerous, and I try to define every word they may not know about, then the rest of the class is just so thoroughly bored. I don't know what the answer is. Not only do they not comprehend me very well, I don't comprehend them very well when they come and ask me questions. (Z2)*

Here, making the curriculum accessible to first-year ESL students is equated with a drop in standards (coming "down to a lower level, which is dangerous"). Another respondent, referring to his experience with some ESL students who, he asserts, couldn't write as well as his "brother in standard seven," is more explicit:

> *I would have thought that by definition that a university as a centre of excellence would exclude people who were so disadvantaged. Now it's unfortunate - I really feel terribly sorry for all disadvantaged people, I really do - but I don't know how (the university authorities) can contradict themselves so openly and say "We are a centre of excellence," and "We are the elite education-wise in the country," and yet we have people of the calibre of perhaps a standard seven. ... The problem is out there, and I don't think the university should be having to handle that. (Z5)*

Firstly, a language deficit is conflated here with "calibre," or what I interpret to mean academic potential. This elision between language and intelligence translates into an exclusionary response, a location of responsibility for dealing with "disadvantage" elsewhere. The distance (in the account of Z3) between undergraduate and postgraduate responsibilities has the potential to widen (if we follow the consequence of the views of Z5) to a distance between those who are admitted to a "centre of excellence" and those who are not.

"Excellence" is not defined in terms of the institution's record of enabling teaching, but in its capacity to be exclusionary to all but educational (here read "linguistic") elites.

This is an admittedly severe reading of these data, a "worst-case-scenario" as it were. *It is also important to read these extracts as expressions of the concern and frustration of unquestionably committed teachers who are having to cope with a situation they are ill-equipped to understand or deal with.* But I offer the "severe" reading because of a fear that as staff encounter greater pressure from increasingly underprepared cohorts, and are offered little or no support in their struggle, the exclusionary response may well become their understandable resort. It is part of the role of a study such as this to develop both awareness and approaches for dealing with this problem. A key strategy of academic development work is to inform the understanding of academic staff so that they are increasingly equipped to respond to the needs of student diversity. Of great value to this endeavour will be our ability to draw on *existing insight* of staff to develop approaches to cater to student needs. Constructivist theory would endorse the idea that working to strengthen beliefs that are already partially in place is better than trying to introduce a ready-made formula from the outside. To this end, this analysis of my interview data continues in an effort to show how my respondents' insights point the way to more communicative approaches to the development of student writing and learning.

iii) The Challenge of a Communicative View of Writing.

I asked my respondents how students learn to write, and the responses that seem to draw on more communicative notions of writing suggest the importance of reading and modelling:

> *Essential for good writing is a passion for reading good books and enjoying how people write - you learn by instinct. (Z1)*
>
> *(Writing develops) also through reading of original literature, and they see how first-class scientists write things. ... Can also pick up from reading a bad paper how things should not be done. (Z2)*
>
> *Essays are derived from proper scientific literature, and students copy that style. (Z3)*
>
> *(I learned that) my own style was not acceptable ... so I learned someone else's style. ... I'll copy the style from journals. (Z5)*

But foundational is the need for conceptual clarity that has been internalised, or become "owned," by the writer:

> *I find it tremendously difficult to write. I knew what was right, what was correct. I mean I could look at something and say "Well that's what I should be aiming for," but I just couldn't seem to get there. Because it was very important to put your own thoughts in as well. And as soon as I put my own thoughts in, it came out a big jumbled mess. The reason for it - primarily - was that I didn't really understand it yet. ... I didn't really understand the topic at hand. The best essay that I ever wrote was the one I understood the best. (Z5)*

Two interesting instances of the murky relationship between language proficiency on the one hand, and conceptual grip on the other, emerge from the data. Both concern second-language students. The first fragment of transcript concerns an African-language speaker:

> *Z5: ... I had a terrible case of plagiarism - she knew what was the right way to write, but she didn't know how to do it, so she plagiarised something horrific ... She presented something I would have dreamed of writing ... She knew what was good but she couldn't do it. She was so far away from it that she was resorting to a really blatant form of cheating.*
> *RM: She didn't have the conceptual stuff?*
> *Z5: Not at all.*
> *RM: But she was able to identify the right readings - ?*
> *Z5: - yes, brilliantly -*
> *RM: - and to cut and paste together - ?*
> *Z5: - yes so that it was a lovely coherent story.*
> *RM: But she didn't understand it?*
> *Z5: She had not the f - She might have lifted it from one article to get the coherence. I could never find the source article.*

In this excerpt, the possibility is denied that the student may have had some conceptual grip but at the same time lacked the linguistic resources to articulate it. An informed reader, however, may wonder whether the selection of a reading unknown to the lecturer, followed by such a successful "cut-and-paste" (a common strategy for students struggling to acquire new discourses) was possible without some understanding of the subject at hand. (This ignores the possibility that the essay might have been the product of the essays-for-cash industry reportedly growing around universities)

The next excerpt is more encouraging, since it reveals a respondent grappling with the relationship between language and cognition. It is worth quoting at some length because, like

the previous excerpt, it poses the conundrum of how learners develop complex, abstract concepts with limited linguistic resources in the medium of instruction. This extract (concerning an Afrikaans speaker) also offers, in its final sentence, an intriguing glimpse of a possible way-in to tackling her problem:

> *She's classic in that she can trot out rote stuff. When it comes to a practical, she's so meticulous. She will produce the most magnificent specimens and she passes her subjects on that basis. Not on her writing. She cannot write. She writes gobbledygook. I cannot make head-or-tail of it. ... She does not have the basic English background - basic background in the language - to understand and subsequently convert it into herself and put it back. It's a straight language problem - do you follow me? ... I suspect that she has the conceptual grasp because in terms of practical - we don't just say "Dissect this" - an example - this last exam she got a top mark in that component - students had to dissect an animal in a certain way and then compare it to another that they didn't dissect. The question was "What are the adaptations for in this one and how does this one differ, and what are it's adaptations designed to do?" And she was absolutely spot-on. She got the concept of comparison, the evolutionary background to it was there, and that's a hugely difficult, abstract concept, set of concepts. She's got the intellectual nous to get that - it gives the idea that it's probably a language problem. But I can't prove it. ... I offered extra essays - she was the only one who took me up. And every time she didn't know who her audience was, who she was writing for and why she was writing it. (Z4)*

Coming from a "coloured" Afrikaans-medium school when apartheid curricula still held sway, this student is almost certain not to have encountered the concept of evolution in her mother-tongue. Yet she achieves "top-mark" in a practical requiring her to apply this "hugely difficult ... set of concepts." We are confronted here with one dimension of the complex set of problems facing English second-language students (and their lecturers) at university, which (in my view) warrant further investigation. For example, I would want to explore further (as I conspicuously failed to do in this interview) by which means this student communicated her clear conceptual grasp to staff, and whether it was the *absence* of issues referred to in the final sentence of this extract that enabled her successful performance.

Central to this emerging communicative view of writing (and perhaps the only certain claim that can safely be made) is an understanding of the *complexity* of what is involved in successful student academic writing. The ability to write well involves an intricate matrix of (amongst others) language proficiency, conceptual clarity and an array of contextual factors that cannot easily be encompassed in simple curricular terms. Another respondent sums it up

(as I understand his words) as a matter of enculturation:

> *Biology is quite a complex subject. It's not just the way second language people write it at the end, it's the amount of their ability to understand it in the first place. Now you're talking about difficult scientific concepts and using words which are second language to them which they haven't heard before. I think there is a lot necessary that they need to be cultured to understand in the first place and express it themselves. But this is different to concessions at exit level. Special provision must be made to get them to be able to understand and express things in the same way as if they had been English first language.*

A consequence of recognising the "cultural" nature of this learning is an acknowledgement of the need for the "special provision" of a communicative environment that will afford the linguistic and conceptual access referred to here.

The rest of this section will explore some of the dimensions of this communicative environment, not for ESL students alone, but for *all* learners. For example, the role of critical feedback is frequently stressed:

> *It is also important when marking to detail every error and every way in which the thing can be improved. I think they learn from that. (Z2)*

> *(One can assist a poor writer with) the amount of constructive criticism that you give back. ... And it's extremely time-consuming, but essential. (Z4)*

However, critical feedback alone is insufficient:

> *No, (the role of writing in developing critical thinking is) not a unique role, because direct discussion obviously is also part and parcel of that ... We give a student back the essay, and what's it got on it? It's got writing: "Rubbish." "Spelling." "Don't like this." "Why did you say that?" You know what happens afterwards? Nothing. There is no follow-up discussion of that essay. I believe we should have a special tutorial that actually brings the student in - that's what happened to me as a student - they were gruelling experiences, but my God they taught me to write. My prof called me in and said "OK engage me on that issue: Why did you say that?" And then we'd have a bloody good argument about it, and he'd go away enriched, and I'd go away enriched, because we had written to each other the thing we had discussed subsequently. It has to be linked. (Z4)*

Two crucial observations emerge here: the act of writing needs to be part of a meaningful communicative exchange, and it needs to be located in a context of broader accountability.

If the staff response to the writing is one of closure (ie. simply awarding a grade without further engagement or obligation), then the student can *write to that closure* by submitting a dummy effort. An example of such a desultory approach is offered by another respondent, recollecting his own undergraduate experience:

> *I had to write essay about trilobites (but) I had no feel for it. ... It was never mine. From books to brain to paper - it never became a thought. It never was crystallised in any way. I never thought about it, I just processed it. I couldn't understand it. (Z5)*

The difference came for this respondent at postgraduate level:

> *And so I think the bottom line is for the first time you are forced to address your corrections. In a hundred-percent way - you can't just say "Oh yes, look there's a spelling mistake." You're actually forced ... you actually have to correct it. So it's the fact that you have to do it, and then it's iteration. You do it again and again and again. ... I think the most important thing is having to face it. (Z5)*

The difference, I believe, is a shift in the relationship between student and lecturer. It seems that at postgraduate level, the student is required to be more accountable, is positioned in an *on-going, interactive relationship* with disciplinary experts, and is invested with a more meaningful responsibility for learning and communicating. The undergraduate ritual of writing is essentially closed-ended: the student writes a response to a task that s/he views as a pro-forma exercise, and the response is "marked" by the lecturer; the communicative episode is hollow and one-way.

Another staff member gives us glimpse of a further way of understanding this shift in relationship:

> *At Honours level, is when we start to teach them to write. (They learn) from peer-review. ... We treat them as peers at post-graduate level. I see a big difference happening at post-graduate level - I think we achieve a lot in teaching them the difference between scientific and unscientific writing. (Z3)*

The shift in relationship has to do with a change in the *identity* of the student. An identity that is included in the disciplinary community of scientists is one which can call on fundamentally different levels of motivation, investment and accountability. It also implies a more interactive and authentic dialogue between interlocutors, with substantially less of a

hierarchical distance between them than is evident in an undergraduate relationship.

A further dimension of this change in identity involves a shift in the *audience* for student writing:

> *We are going to be in for the high-jump in a big way unless we do a number of things. One, Become more articulate out there ... out in the community and the schools, at the political interface, working with the Dept. of Water Affairs and Forestry Engineers, educating them as to why they should listen to us, and they educating us as to what their problems are, and then we negotiate. ... This has writing implications. One of the things we don't do in this department is teach students to write for the general public. That's a major gap. (Z4)*

For this respondent, the role of a scientist crucially involves linkages with the broader community, and this involves an interactive dialogue. His *task* as a scientist includes a keen sense of accountability:

> *Again ethics: I have a duty to report back, to say "I've found this." "I'm worried about that." (Z4)*

This is a vision of a scientist as informant, monitor, lobbyist, agitator, agent: someone inextricably embedded in the ebb and flow of social practices. This has implications for the kinds of writing a scientist needs to be able to do. If one wishes to intervene effectively in the business of the community, the *form* of writing that is used is crucial:

> *And when they get out and they are trying to attract the attention of Minister Kader Asmal or De Villiers, they are going to have to do that sort of writing. They can't write an abstract, introduction, methods - it won't wash. (Z4)*

The social practices of scientists, then, find expression in a variety of textual forms:

> *There are several different types of writing that need compartmentalising. One is the observational, deductive experimental writing: "I did this. I thought this. I wondered that. I designed that. I observed this and these are my interpretations. Take it or leave it. Argue with me." That's one compartment. The other is: "You have given me this money. I have done this with it. These are the management recommendations. Thank You and Good Luck." We completely ignore it but it's the most common form of writing. Then there is: "I've really enjoyed my life as a Zoologist. I appreciate being paid my salary to do this. This is what I've been doing with it, and this where it counts for you, the person out there in the street." That's another one. That's a*

> *general overview. And the fourth is: "I have a major problem with the way in which your attitude as the person in the street, your attitude as the politician, your attitude as the decision-maker, is having on this particular set of problems. And my science says that this is what has happened." That's a fourth component. And then the fifth is the really rigid "I have a piece of science to communicate to a fellow scientist." (Z4)*

For this respondent, the *role* of a scientist, the *audience* to be considered and the *textual forms* to be employed are indivisible. The implications for university science teaching are compelling. I will summarise some of these in the next chapter, and will also point to possible difficulties that may be encountered in attempts to implement these insights.

CHAPTER FIVE: SUMMARY AND CONCLUSION

> *Users of a genre share not only knowledge of the genre but also a particular configuration of knowledge-of-the-world.* (Giltrow and Valiquette 1994: 48)

What has been achieved by trying to disembed the practice of student writing from its disciplinary context? It is that the kinds of writing we ask students to do reflect the forms of educational practice we sustain.

If we were to combine the darkest moments of the theory and analysis chapters of this study, it is possible to construct a bleakly exclusionary potential for science education. To start with, it seems that it is possible for the novices of undergraduate years to be restricted to an objectified, positivist notion of science. This is the science of closed authoritative knowledge, a *commodity* to be transmitted and memorised. It seems that this science-for-novices may stand at quite a distance from the complex, messy processes and contingencies of expert science, which is fundamentally about *inquiry*.

The problem lies not in acknowledging the novice identity of the learner (indeed this is necessary) but in the way that the novice identity is constructed and sustained over time. Crucial to this construction is how the pursuit of science is understood, how a scientist should be characterised, and what the path of development from novice to expert should consist of. If the movement towards expertise is not charted in explicitly qualitative terms, then the learner may inadvertently be locked into a novice identity that is at odds with the growth of expertise. Further, through the closed-ended tasks and texts of passive studenthood, the undergraduate learner may be denied even the identity of *agent*, which is transitional to that of *expert*.

Central to this path of development are the language and texts of science education.

> *An attempt has been made to make science more accessible by downplaying science literacy. But diluting scientific discourse necessarily involves diluting the science that is taught. As we have seen, science is unthinkable without the technical language science has developed to construct its alternative world view. ... The linguistic technology is the key - not just to science literacy but*

> *to understanding and practising science itself.* (Halliday and Martin 1993: 202)

The identity of novices is constructed in the language of science-for-novices: a decontextualised, diluted rhetoric that masks the real constructive processes of expert science.

If, in addition, the novice arrives with the handicaps of educational under-preparedness and having to learn through the medium of a language other than her mother-tongue, then the novice may find (as was suggested in my data) that her particular learning needs have been defined as lying outside the responsibility of the discipline. In this way the ESL learner may be denied sufficient opportunities to acquire even the diluted discourse of science-for-novices. She is expected to seek the language of access from other outsiders, other novices or laypersons.

But what also emerges from the disembedding exercise is the promise of alternative educational practices, quite consistent with the most contemporary perspectives on science and learning, but which seek new educational genres through which to find fullest expression. Some of my respondents point to the generative potential of a student text that configures the learner as a responsible agent in a community, solving real problems and communicating in increasingly authentic ways. If student performance becomes increasingly exposed to the evaluative scrutiny of wider audiences, then the washback effect of such genres on curriculum could be considerable. Not only would the competencies of expertise need to be prioritised, but the learning needs of underprepared and ESL learners would be highlighted in dramatic ways.

This (somewhat idealised) latter vision will always come up against the constraints of large class sizes and diminishing resources, but my experience with at least one second-year course in this department has shown that, given insight and determination, a radically different educational environment, necessarily supported by changed educational genres, is practically possible (see Jacobs and Moore, forthcoming).

For the Zoology department at UCT, this adds up to the question ***"What is it that we want the undergraduate curriculum to do?"*** I believe that this study offers some of the terms

through which this debate may be conducted.

The remainder of this chapter is in two parts: the first sums up the curricular implications of what has emerged from the data reviewed in the previous chapter, and the second raises some possible problems involved in implementing such a curricular vision.

1. IMPLICATIONS FOR CURRICULUM PLANNING

What emerges from the previous chapter are two foundational sets of understandings that, I believe, need to inform curriculum planning. The first set of understandings concern the way we view language and writing, and the second set concern the way we view the curriculum and the learner.

i) Notions of language and writing

Part of my interest in how staff view student writing arises from a belief that staff make use of student writing in different ways, depending on their assumptions about writing. For example, if writing is understood to be merely a technical process of *transmitting finished thought* from mind to paper according to a fixed set of grammatical rules, then the role of writing in the curriculum may be seen as a simple conduit by which students prove they have learned what is required of them. But if writing is seen as a much more complex business *which consolidates - and even advances - thought and learning* in unique ways, then it may be seen as much more integral to achieving the goals of the curriculum.

It is clear from my interview data that both conceptions of writing mentioned above are embedded in the thinking of my staff respondents in the host department. This often takes the form of respondents distinguishing between students being able to "write simple English" as opposed to "writing Science." The former is a matter of following the straightforward rules of syntax (something that should have been learned at school), whilst the latter is dependant on understanding the concepts and conventions of the Zoological communities, and can only really be taught by Zoologists themselves. Some feel that "writing English" was what happened during undergraduate years, and that students only began to learn to "write

Science" when they began postgraduate study.

But the general consensus amongst respondents is that "it is very difficult for someone to write about something without having a conceptual grip" of the subject matter. In addition to this conceptual clarity, students also need to be exposed to models of scientific writing, both in terms of the formats used and the linguistic and argumentational conventions. But form alone is insufficient: "Good writers are not simply using a rote-learned formula, they are learning good writing within the formula. This you learn by osmosis."

It seems, then, that learning to write in Zoology involves, on the one hand, *explicit teaching* of forms and conventions, *modelling* of various forms of writing, and *practice* with meaningful tasks followed by meaningful *feedback* from disciplinary experts. This is an induction to the discipline through immersion in the *language* of the discipline. On the other hand it also involves developing a clear grasp of the *concepts* at hand, and being able to articulate the *problems, processes* and *analyses* of the discipline within the accepted written formulas. Successful writing, therefore, seems to be one of the most important outcomes of the *entire* curricular process.

This is a highly significant understanding. It suggests that the demonstrable success of a course curriculum and the development of student writing are, in large measure, dependent upon each other. This has three important implications: ***Firstly,*** *the process of writing must engage the student in marshalling all the intellectual qualities and skills fostered by the course.* Student writing can only benefit from explicit development of these qualities in practical and written components of the curriculum. Successful writing - in the words of one respondent - "is a critical process" and thus reflects the success of students in developing the critical abilities that are the goals of the curriculum. ***Secondly,*** *the development of student writing becomes a crucial objective for courses that value communicative abilities,* because it is at once a vehicle for advancing learning, the means by which students are assessed, and the principle medium by which the discipline is constituted. Student communicative skills thus take their place beside course concepts as goals of the curriculum. ***Thirdly,*** *a survey across the written responses of a group of students on a course can yield valuable information about which competencies have been successfully promoted amongst reasonable*

numbers of the group. This could assist staff in critically evaluating the success of their own course.

ii) Notions of curriculum and the learner

Attached to this understanding of the role of writing must be a complementary understanding of curriculum and the learner. Some of my respondents have made it clear that the curriculum should not be viewed as a mass of established fact to be "covered", nor should the learner be viewed as a passive receiver of such "fact", who is later required (in the memorable words of one respondent) to regurgitate the learning "in an unintegrated splat." How one conceives of a learner and how one understands the curriculum are two sides of the same coin. The "coverage" view of curriculum can only hold if the learner is seen in passive terms.

The alternative to this is a view of curriculum as "a network of important ideas to be explored." This is an "open systems view of curriculum," much more consistent with the contemporary views of science as complex, uncertain and changing (Prawat 1992: 382). Connected to this view of curriculum is an alternative notion of the learner. In this view, the learner is understood as being at the centre of the learning process, an active agent who must construct learning by engaging with new concepts in ways that extend and change what they already know.

This view of the curriculum and the learner, argues Prawat, has consequences for the role of the educator. Educators need to divide their curricular attention roughly equally between the selection of "the networks of important ideas" (ie. "content"), and consideration of the ability of learners to engage with those ideas. This involves careful prioritisation of concepts deemed "important" for a discipline, the design of processes by which learners can most successfully explore those ideas, and monitoring of how individual learners are constructing their varied paths through these ideas. Further, the more thoroughly these ideas are explored, and the more explicitly connected and integrated the learning is with possible contexts of application, the greater the likelihood that learners will make connections across different contexts, and thus achieve some measure of "transfer". This argument returns us to the

communicative needs of the curriculum: for students to plot their paths through these ideas, and to demonstrate what they have made of them, involves the development of their communicative abilities as an integral goal of the learning process.

In summary, the challenge facing educators as they consider their curricula may be summed up by the following considerations:

1. Which are the important ideas and abilities (intellectual, practical and communicative) that the course aims to develop?

2. Given the range of learners on this course, what processes could be designed to *best enable exploration* of these core concepts in a way that meets (especially the linguistic) needs of this diversity of students?

3. How does the course plan to *systematically support* the exploration of these concepts and the development of these abilities through readings, lectures, practicals and assignments? How can these activities be designed to promote critical approaches in students, rather than rote-learning?

4. What *communicative processes* would enable this exploration? How will language (spoken, written, read) be used (by all those involved) to *establish and apply* these ideas and abilities in the course of learning?

5. How will learners demonstrate their learning, or how will we *assess* individual progress? Moreover, how will we *evaluate* the success of our course in equipping students with these important concepts and abilities in ways that are *consistent with our contemporary conceptions of science and learning?*

2. PROBLEMS OF IMPLEMENTATION

In this final section, I will sum up some of the issues and difficulties that have arisen in the

course of this study. Popkewitz offers an important caution, especially given the way I have concluded this section just ended:

> *The call for prescription is both to limit the debate (about what is an appropriate world) and to alter the character of the struggle (of our society). Further, those who offer prescriptions seem to offer only new (or old) banalities and introduce glibness. (1984: 199)*

I am very conscious that prescriptions are the underlying currency of this study, and the warning sounded by one of my respondents at the end of his interview is worth re-iterating:

> *It was very useful - it made me think about things. But it won't make me change the way I teach.* (Z4)

This points to an important area of further study: Why is it that some teachers adhere to traditional forms of practice in spite of being exposed to theory that suggests "better" forms of practice? This crucial question does not fall centrally within the scope of this present study, but is one that warrants careful consideration over time. This may be usefully done in this host department, since one committed and innovative group of staff in Zoology (with some assistance from UCT's Writing Centre) has completely reviewed a second year semester course so as to incorporate some of the "prescriptions" mentioned earlier in this chapter. While the initial results of this work (see Jacobs and Moore, forthcoming) appear most encouraging, it will be important to monitor whether wider attempts to reform (especially undergraduate) curricula are undertaken, and whether they are successful and sustained in the face of growing student numbers and shrinking resources, and increasing proportions of underprepared students.

These concerns are important for the goals of this study, one of which is to attempt to forge some coherence between the webs of belief that guide the production of knowledge and those that guide teaching and learning. What emerges from this last discussion is that "coherence" should be seen here as having two distinct dimensions: a *horizontal coherence* between abstract systems of thought (eg. between philosophies of science and theories of learning), and a *vertical coherence* between a web of belief and the context or circumstance in which it is invoked. In seeking to establish a horizontal coherence (as this study does), we need to be alert for powerful contesting webs of belief attached to particular situations that subvert

this coherence. Beliefs about, for example, the problematic nature of large class sizes, underprepared students, or institutional systems of reward are instances of beliefs (founded or otherwise) that will operate against the best of intentions.

The concerns raised by some of my respondents about the challenges presented by underprepared and English second language learners are very real. The nature of the difficulties such students face are, I believe, still only partially understood, and there is a limit to what we can expect departmental staff to undertake in catering to these needs. This limit, however, is crucially dependant on a range of influences that operate on the willingness of staff to embark on time-consuming innovation. Apart from the personal "webs of belief" held by individuals (the concern of much of this study), these influences will include the prevailing ethos in the department, faculty and institution regarding work of this nature, and the reward systems at every level that serve to value some forms of academic practice above others. Without conscious attention to the development of appropriate "webs of belief", and the institutional ethos, value systems and resources *to support these*, the work necessary to cater sincerely and effectively to the full diversity of our student body will not happen.

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APPENDIX ONE

SCHEDULE OF INTERVIEW QUESTIONS

In the interviews I will seek to explore perceptions of Zoology staff about

1. the nature of the discipline of Zoology
2. the nature of academic writing generally
3. the *role* of writing in advancing or reflecting learning in Zoology, and the *forms* of writing best suited to this purpose
4. the implications of the above for the way the discipline is mediated to a diverse student body.

QUESTIONS

1. When someone is "doing" Zoology, what are they doing?

(This is an interest in the epistemic foundations of the discipline. The discipline is attempting to give an account of what? To whom? By which rules? To what ends?

What is the theoretical basis of the discipline? What are some of the fundamental assumptions of the discipline? What kinds of enquiry can Zoology "legitimately" embark on, and which kinds not?

Is there a single, coherent orthodoxy at the centre of the discipline which lays down the rules for acceptable evidence and argument? Or are there *contending* ideologies that need to be reflected in curricular concerns? Or is it better to see the discipline as *evolving* in a particular way? In other words, if Zoology is not to be seen as a static discipline, then what is the best way of understanding how it is changing?)

2. Are there some fundamental qualities of
- **an academic**
- **a scientist**
- **a Zoologist**

that the Zoology curricula attempts to develop?

(Is the undergraduate programme essentially an introduction to:
- a bank of knowledge?
- a centre of enquiry?)

3. When a student writes, what is happening? Or: ...what is s/he doing? Or: What

is the process of writing?

(Is writing simply a process of transcribing completed thought from mind to paper? Or does it involve unique forms of processing? *Can there ever be such a neat dichotomy?*

Do different kinds of writing happen under different circumstances? (eg: Transmission vs. Writing-to-learn) If so, what shapes these circumstances, and how are the respective products/processes qualitatively different? Are these different forms of writing *purposely* set? What educational implications might these understandings have? Is there a legitimate place for "transmission" types of writing - eg. tests or exams - and if so, what is being assessed? Is there room for alternative kinds of assessment based on other modes of writing?)

4. What are the typical forms of writing in Zoology?

(Both student genres (lab reports, essays, exams) and professional ones (Journal articles, reports, presentations). Do these differ, and if so, why? Why are these particular forms used? What is different about an essay, compared to a lab report? What does each of these forms "do" - both ostensibly (in the fictive context established for the student) and in reality? What educational or disciplinary purposes are served by setting students to do these forms of writing?

Are these forms fixed, or are they evolving over time? Are they adequate for the professional purposes of the discipline (given the way the discipline is evolving), and for the educational purposes of the department?)

5. Is "scientific" writing aiming to represent accurately some external, factual reality?

(This may have been dealt with under questions 1 or 2. Is the paradigm of positivist, empirical enquiry predominant, or is there some place for social constructivist approaches - either *alongside* empiricism, or in *opposition* to it?)

6. Are some forms of writing more "objective" than others? Should a Zoologist aim for "depersonalised" language that omits pronouns and makes wide use of the passive voice?

(Is there *ever* room for the use of "I" - if so, under what circumstances? Or: Should a Zoologist *ever* obscure agency?)

7. Where do students learn how to write?

(Does this happen "at school," or does it never stop happening?)

What is it they are learning?

(Are they learning the rules of grammar, appropriacy and form? Static or dynamic rhetorical traditions? Are they learning the culture and politics of a particular context? Are they learning a socio-disciplinary identity?)

How do they learn these things?

(Do students learn to write - or learn anything else for that matter - by an osmotic process of acquisition or do they learn consciously through explicit tuition? I would want to explore the role of a range of possible mediation activities including lectures and tutorials, readings and modelled texts, style guides and feedback. If "cultural" issues emerge here, I would want to explore the advisability of special curricular provision for students from more culturally "distant" backgrounds.)

8. What happens when a staff member assesses a piece of student writing?

Would different staff members arrive independently at the same assessment of that piece of writing? Why?/Why not?

9. When assessing student writing, can we (and if so, should we?) separate "content" from "language"?

Is it possible to have a situation in which it is clear that a student has a firm conceptual grip, but has expressed this clumsily, *or* a situation where it is not possible to be sure whether the student does in fact really understand because of obscure expression?

10. Should concessions be made for second language speakers when assessing the linguistic dimensions of writing?

Do we acknowledge on the one hand that second-language speakers face a greater cognitive burden because they have to learn through a medium that is not their mother-tongue, and yet on the other hand rightfully demand the same standards of all students?

11. What is the difference between "writing" and "presentation"?

Are written records used in different ways from spoken presentations? Are the *content* and social/educational *purposes* of these two modes different? If so, in what ways and why? For example: Is there a distinction between "record-keeping" or "writing-to-learn" or "assessment" on the one hand, and dissemination or broadcast on the other? How is the student Zoologist constructed in each case? Or: In which of these modes is the student most closely approximating the practice of a professional Zoologist?

APPENDIX TWO

The Writing Centre
27 July 1995

Dr. XXXXXXXXXXXXXX
Zoology Department
UCT

Dear XXXXXXXX

Thank you very much for agreeing to look at this brief extract. It is part of a "verification" process in the qualitative research I'm doing as a follow-up to the series of interviews I was granted with Zoology staff late last year.

This extract is from quite early in my study in which I am looking at how various respondents think about their discipline (Science/Zoology/Biology). I have chosen extracts from the interview that I think contribute towards a reasonably coherent account, and I have listed these extracts in italics. Below that, I have attempted a brief summary of what I think the extracts are saying.

This is clearly a construction *I* have developed, but to enhance its "validity," I'd like you to look at it (particularly the summary), to see whether you think it is a *reasonable* reflection of the views in the quotes. Whilst this can never reflect the full complexity of your understanding of your own discipline, it should nevertheless not be a *distortion* of your views.

If you would like to re-word the summary, or make any comments, please jot these on the sheet, and I will happily reflect these in my study. These extracts (by the way) will be inserted completely anonymously - even your initials "XX" in the summary will be replaced by "Z3," an arbitrary numbering.

On the last page is a summary of four philosophical paradigms drawn up by Guba (1990): Positivism, Post-Positivism, Critical Theory, and Constructivism. Could you briefly look at the four, reading across the table, and say (perhaps by ticking against one or more of them) in which you would place yourself. If more than one helps to describe your position, that's fine, or if you wish to mention another tradition that is not there, that's also fine. Please pop the sheets back to me (c/o ADP) in the internal mail.

Many thanks for your help

Regards

Rob Moore

APPENDIX THREE

THE WRITING CENTRE

REPORT TO ZOOLOGY DEPT. ON RESEARCH STUDY

Context

I have been conducting a study into how Zoology staff understand the role of writing in advancing learning in this discipline. In order to do this, I have interviewed a number of staff members, and I have almost completed my final write-up of this study. I have been afforded the opportunity to present a summary of this study to the department, both to inform the department and to obtain any responses or suggestions that staff may have.

I have been granted a brief slot in the Zoology staff meeting planned for Monday 27 November, and would be grateful for any feedback you are able to offer then. However, I would be happy to discuss the report, or issues related to it, at any other time.

Thank you for taking the trouble to look at this report.

Line of Thought

Using the interview data, my study attempts to construct a rationale for the role of writing in advancing student learning. My line of inquiry proceeds as follows:

1. What is the nature of the discipline of Zoology?

2. Given the nature of the discipline, what qualities or competencies do we want to develop in our students, the Zoologists of the future?

3. What educational processes would best develop these qualities or competencies?

4. What role should student writing play in assisting these processes to develop these qualities and competencies?

In other words, my study attempts to identify an understanding of the role, and forms, of student writing that would best advance the interests of the discipline as it replicates itself through succeeding generations of student Zoologists.

Naturally, my exploration of staff perceptions reveals both commonalities and diversities of approach. I will briefly summarise the issues as they have arisen from the interviews, indicating, where possible, the divergent views that might be fruitful areas of debate.

"What is the nature of the discipline of Zoology?"

Since the business of education is to do with the fostering of knowledge in learners, it is necessary to understand something of the nature of that knowledge, and of Zoological ways

of knowing, if we are to create optimal conditions for learning. I asked my respondents how they understood their discipline as a science.

My analysis of the interview data revealed a broad consensus that the discipline must be understood as *a human construct*, that knowledge becomes "science" when it achieves a degree of *public consensus in the scientific community,* and that this knowledge is to be understood not as final, universal and immutable, but simply as *the best theory currently available.* Theories are changeable, and what is accepted today may be overthrown tomorrow by quite different ways of thinking. Scientific knowledge, therefore, is constructed by human, social processes in social settings and is thus subject to human purposes and interests.

A consequence of this understanding of knowledge is the recognition of the essentially *subjective* nature of scientific pursuit: The preconceived theories and purposes in the mind of an individual scientist work to shape the goals and methods of his/her enquiry. A failure to recognise the constraints of preconceived theories - and therefore a possible failure to be receptive to unanticipated alternatives - may have the result of limiting the analytic vision of the scientist and thus lessening the possibility of fresh discoveries that help to move forward the scientific endeavour.

The nature of scientific enquiry seems to necessarily involve a dialectic between stable and unstable knowledge. It is necessary for a scientist to assume an instability of knowledge - to *doubt* a theory - if s/he is to test it and arrive at a conclusion. Yet the conclusion s/he finally asserts is an attempt to again stabilise knowledge.

The scientist is continually testing subjective theories against the external world. Subjectivity is acknowledged, but objectivity remains an ideal to be striven for. One theory may be judged better than another when evidence suggests it offers a better "fit" when tested against the external world. The job of the scientist is to propose theory, to design experiments to test these theories, to generate data, and to critically judge the data for "fit."

This critical faculty - a determination to take no explanation for granted, a readiness to think laterally, a willingness to consider multiple interpretations - is foundational to the discipline. Since no final, objective knowledge is possible, the pursuit of the discipline is essentially participation in a rigorous public *debate* that establishes (by broad consensus of the scientific community) which theories are currently most persuasive. Since science is so rooted in debate, the way in which scientific arguments are constructed by means of method, evidence, reasoning and (some would assert) value-judgements is crucial. *Scientific meaning is constituted and conveyed by communication.*

Some (but not all) of those interviewed argued that social responsibility is also inherent in the role of the scientist. A prominent component of this responsibility is the obligation to communicate with wider constituencies than the scientific one alone.

In summary, scientific knowledge is tentative, partial and changing. The process of scientific enquiry involves acknowledging the subjectivity of the enquirer, but always striving for objectivity. The scientist needs to be alive to new ways of seeing and the possibility of alternative explanations. Science only really has meaning and value when it is communicated clearly to appropriate audiences.

"What qualities or competencies do we want to develop in our students?"

In general my respondents agree broadly that students need to acquire the following range of concepts and competencies. Respondents placed different emphases on some competencies, and argued that some needed to be developed before others, but broad consensus was evident in the following.

Firstly, *students need to understand the essential nature of scientific enquiry, as outlined in the discussion above.* Unless they are equipped with this foundational perspective, both what they learn from the courses, and their approach to their studies, may be undermined by misapprehension. Students often carry inappropriate ideas of science from their schooling, residues of which may persist throughout their undergraduate years, hampering the intent of the department's curricula.

Secondly, *students need to be provided with opportunities to develop the mental competencies to be logical, critical, sceptical, innovative and rigorous in their approach to scientific work.* They need to be able to demonstrate these qualities in their classroom interactions, in their reading (both guided and independent) and in their practical work. Several respondents spoke of students needing to incorporate these qualities into their own ways of thinking, of developing a personal and individual ownership of ideas and perspectives. The best way for students to develop and demonstrate these qualities is through opportunities in which they can *apply concepts in open-ended problem-solving situations.*

Thirdly, *students need to be equipped with an understanding of current trends in theory, certain foundational concepts, and a training in current methods, techniques and technology.* Students need to learn something about current "ways of knowing" in the discipline, some of the dominant conceptual systems in currency, as well as the practical and technical skills needed to pursue Zoology.

Fourthly, *students need to be developing their learning, and communicating this learning, through a variety of communicative modes.* These include the ability to interact confidently in classroom situations, the ability to make oral presentations, and competence in various forms of writing, including educational, academic, professional and popular forms.

For the purposes of this discussion, I will refer to the development of these abilities as broadly "critical approaches" to teaching Zoology. These stand in contrast to more traditional approaches which involved rote-learning of large bodies of material presented as authoritative "fact", and the setting of practicals which had predetermined and predictable outcomes. These traditional approaches were widely criticised by my respondents. One senior staffmember argued that the department needed to move closer towards an understanding of learning as "playing with concepts, and communicating those concepts."

"What educational processes best develop these qualities and competencies?"

It was in response to this question that I sensed the greatest diversity in thinking. Generally the tension was between what staff felt *ought* to be done, and what they felt was often the *practice in reality.* Usually expressed in discussions about undergraduate curricula, the tension was (in some cases) between, on the one hand, knowing that student learning should

involve the development of critical competencies through broadly "problem-solving" approaches and, on the other hand, feeling the pressure of having to deliver heavily "content-laden" curricula to large numbers of students. Others felt that the development of critical capacities had little place at undergraduate level, and were (justifiably) only dealt with at post-graduate level. Some argued that students had little capacity for critical approaches at undergraduate level, while others felt that it was the weight of numbers that precluded such approaches. At least one respondent felt that critical approaches were only really worthwhile at postgraduate level, since only these students were likely to become practising Zoologists. Undergraduate students were more likely to become teachers.

In spite of a range of opinion about when, and with whom, critical approaches should be undertaken, I was presented with almost unanimous opinion on what kinds of activities would best inculcate those qualities and competencies that characterise excellence in the discipline. These included, ***firstly,*** *presenting students with meaningful opportunities to grapple with real (or open-ended) problems.* Respondents often spoke about the highly motivating effect of presenting students with issues that are unresolved, and inviting them to tackle these issues. As far as possible (some of my respondents argued), students should be involved in formulating specific problems associated with an issue, and in developing approaches to investigating these problems. Such an approach best mirrors the real processes undertaken by scientists in the field.

Secondly, *staff felt that it was important to ensure an interactive learning environment that fostered maximum communication between staff and students, and between students themselves.* It is essential to involve students in on-going debates, both to underline the nature of the discipline, and to develop students' abilities to participate in the debate.

Thirdly, *staff felt that, ideally, curricula should be "concept-driven" rather than "content-driven."* It is better to equip students with foundational concepts, and the knowledge of how to access more detailed information, than to try to ensure that students absorb the vast bodies of knowledge generated by the diverse arms of the discipline. If students are equipped with key concepts currently in use in the discipline (and how to apply and critique such concepts), and know how to critically approach the relevant literature, then they are on the way to becoming independent learners and Zoologists.

But Zoology is a complex and diverse discipline, and many respondents felt that *a crucial* ***fourth*** *part of apprenticeship to the discipline is close and sustained contact with mature scientific minds.* Although scientific processes and knowledge are often presented as neat and rational products in journals, the reality is often much more complex and intuitive, and learners will best absorb the approaches used by top scientists through close contact with them in a working environment. Several respondents spoke of the learning process as one of "osmosis" or "enculturation."

"What role should student writing play in developing these qualities and competencies?"

Part of my interest in how staff view student writing is a belief that staff make use of student writing in different ways, depending on their assumptions about writing. For example, if writing is understood to be merely a technical process of *transmitting finished thought* from mind to paper according to a fixed set of grammatical rules, then the role of writing in the

curriculum may be seen as a simple conduit by which students prove they have learned what is required of them. But if writing is seen as a much more complex business which *consolidates - and even advances - thought* and learning in unique ways, then it may be seen as much more integral to achieving the goals of the curriculum.

It is clear from my interview data that both conceptions of writing mentioned above are current in staff thinking. This often took the form of staff distinguishing between students being able to "write simple English" as opposed to "writing Science." The former is a matter of following the straightforward rules of syntax (something that should have been learned at school), whilst the latter is dependant on understanding the concepts and conventions of the Zoological communities, and can only really be taught by Zoologists themselves. Some felt that "writing English" was what happened during undergraduate years, and that students only began to learn to "write Science" when they began postgraduate study.

But the general consensus amongst staff (and in this they echoed the international literature) was that "it is very difficult for someone to write about something without having a conceptual grip" of the subject matter. In addition to this conceptual clarity, students also need to be exposed to models of scientific writing, both in terms of the formats used and the linguistic and argumentational conventions. But form alone is insufficient: "Good writers are not simply using a rote-learned formula, they are learning good writing within the formula. This you learn by osmosis."

It seems, then, that learning to write in Zoology involves, on the one hand, *explicit teaching* of forms and conventions, *modelling* of various forms of writing, and *practice* with meaningful tasks followed by *feedback* from disciplinary experts. On the other hand it also involves developing a clear grasp of the *concepts* at hand, and being able to articulate the *problems, processes* and *analyses* of the discipline within the accepted written formulas. Successful writing, therefore, seems to be the end-product of the *entire* curricular process.

This is a highly significant understanding. It suggests that the success of a course curriculum and the development of student writing are, in large measure, dependant upon each other. This has three important implications: ***Firstly,*** *the process of writing must engage the student in marshalling all the intellectual qualities and skills fostered by the course.* Student writing can only benefit from explicit development of these qualities in practical and written components of the curriculum. Successful writing - in the words of one respondent - "is a critical process" and thus reflects the success of students in developing the critical abilities that are the goals of the curriculum. ***Secondly,*** *the development of student writing becomes a crucial objective for courses that value communicative abilities*, because it is at once a vehicle for advancing learning, the means by which students are assessed, and the principle medium by which the discipline is constituted. Student communicative skills thus take their place beside course concepts as goals of the curriculum. ***Thirdly,*** *a survey across the written responses of a group of students on a course can yield valuable information about which competencies have been successfully promoted amongst reasonable numbers of the group.* This could assist staff in critically evaluating the success of their own courses.

In common with various other departments at UCT, some Zoology staff are reviewing the form and role of writing tasks in their courses, and are proposing some innovative approaches to the use of writing. This often involves a move away from total reliance on

traditional written forms such as essays and lab reports (although the value of these is not diminished) and the inclusion of other forms of writing commonly required of practitioners in the field. These innovations also acknowledge that the techniques involved in answering examinations need to be as explicitly developed as any other form of writing, or conversely, that exam formats may need to be reviewed to see if they may better approximate the written forms developed in the course.

Conclusion

In summary, I offer the following questions as possible avenues for reviewing the content and method of courses:

1. Which are the core concepts and abilities (intellectual, practical and communicative) that the course aims to develop?

2. Given the range of learners on this course, what processes could be designed to *best enable exploration* of these core concepts in a way that meets the needs of this diversity of students?

3. How does the course plan to *systematically support* the exploration of these concepts and the development of these abilities through readings, lectures, practicals and assignments? How can these activities be designed to promote critical approaches in students, rather than rote-learning?

4. What *communicative processes* would enable this exploration? How will language (spoken, written, read) be used (by all those involved) to *establish and apply* these ideas and abilities in the course of learning?

5. Firstly, how will learners demonstrate their learning, or how will we *assess* individual progress? Secondly, how will we *evaluate* the success of our course in equipping students with these important concepts and abilities in ways that are consistent with our contemporary conception of science?

The role of writing in advancing learning is being seriously reviewed in faculties across the university. Such review processes are, in most cases, generating useful debate about the goals and methods of courses, illustrating again the unique role of writing in the academic learning process. It seems appropriate, then, that the innovations currently underway in the Zoology department are reported on both within the department and more widely.

Thank you for the opportunity of presenting this discussion.

Rob Moore
20 November 1995

APPENDIX 4

RESPONSE FROM Z9

To: George Branch,
Head, Zoology
22.11.95

Dear George,

WRITING CENTRE REPORT BY ROB MOORE

I read the above report with interest. I did not know the exercise was taking place and was not interviewed, but having read the report I thought you may be interested in my comments.

Whilst I enjoyed reading Rob's discussion on the role of student writing in Zoology, his entire thesis hinges on one *sine qua non*, which is almost dismissed in parentheses on P77 (para 2) - "....rules of syntax (something that should have been learned at school)".

Unless this level of achievement can be assumed, the remainder of Rob's dialogue becomes more theoretical than the precepts on which the science of Zoology are based!

Students who enter undergraduate curricula without having mastered basic communication skills in written English are unlikely to flourish in the intellectual environment envisioned by Rob Moore. Given the ostensibly high standards which UCT strives for and claims to maintain, the polarization ofcommunication abilities within undergraduate classes is already worrying. The introduction of curricular changes based on some form of intellectual accelerator principle could result in this polarization becoming even more extreme. Whilst the intellectual elite of most classes could undoubtedly blossom under such a system, many (perhaps most) could fall even further behind because they do not understand basic linguistic principles.

The pursuit of idealism is unlikely to succeed unless it is based on a stable foundation; it is critical to identify the key components of such a foundation. In recent years it has been mandatory for Zoology majors to pass a first year maths course. In instituting this requirement, the department has acknowledged the importance of numeracy to the modern scientist. Only very recently, however, has the importance of literacy been highlighted. It is possible to be a scientist without being numerate; it is impossible without being literate.

I suggest that, at this stage, the literary shortcomings of many students will not be resolved by attempting to change the ways in which they think - the root of the problem is much more fundamental. If a certain level of numeracy is mandatory for a Zoology major, an acceptable and proven level of literacy should also be <u>mandatory</u>.

As Rob rightly points out, training students in the basics of literacy is not the task of the Zoology department. But, for the Zoology department to be able to hone these skills they have a right to expect a certain level of proficiency as a starting point. Quite clearly, for many

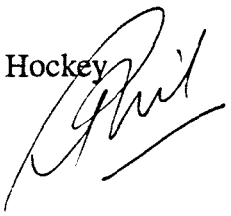
students this proficiency level is not reached at school. I would suggest, therefore that the formal literacy requirements for a Zoology major be raised to the same status as the formal numeracy requirements but with the possibility of exemption based on English matric results.

(Perhaps an assessment of competency in English could be made by setting a comprehension test based on Rob's report!).

You may consider that the limited amount of undergraduate teaching I undertake does not fully qualify me to hold an opinion on these matters. However, I have griped about illiterate undergraduates for years and Rob's essay has prompted me to put some of these gripes and suggestions in writing. As updated evidence of my contentions, but more for your amusement, I enclose a series of quotes from essays I recently marked from first year Zoology students. These were chosen more to illustrate conceptual shortcomings than literary ones, but serve to illustrate the point! As you will doubtless recognise, these scientific eggs were laid in response to a question which you set!

Best glitches,

Phil Hockey



APPENDIX FIVE

REPORT TO ZOOLOGY DEPARTMENT: RESPONSES FROM STAFF

I circulated my report to the Zoology department (see Appendix 3) a week in advance of the meeting planned for 27 November 1995. A copy was placed in each staff member's pigeonhole, and the agenda of the meeting circulated to staff included a paragraph outlining the goal of this item of the agenda.

The meeting comprised about 18 staff members. Of these, three were respondents I have used in this study. These were Z1, Z2 and Z3. Unfortunately Z4 was ill, and Z5 is no longer teaching in the department. In addition, three others were staff members with whom I have worked on a Writing Across the Curriculum project for two Zoology second year courses. In the report below, I call these staff members Z6 (A professor and course convenor), Z7 (a senior lecturer) and Z8 (an assistant lecturer). Although I had interviewed Z6 and Z8 as part of my original data gathering for this study, I did not use their data, simply because of the need to keep the study within manageable proportions. Three other staff members whose contributions are mentioned below are Z9 (a senior lecturer), Z10 (a professor) and Z11 (a professor). I have had no other previous dealings with these last three.

After I briefly summarised the report, I presented the meeting with two broad questions:

1. Does this report "speak to" the educational concerns of the department?

2. Are there any constraints on implementation of ideas like these?

The following account of the meeting is constructed from notes made by myself and a colleague during the meeting.

The overwhelming focus of the discussion concerned the challenge of dealing with underprepared, ESL learners. No-one questioned any of the earlier premises of the report, with the exception of Z10, who commented that he could not understand why I was singling out the Zoology department, since what I had included was applicable to all departments in Science.

The challenge of catering for underprepared and ESL learners was introduced first by the Head of Department (Z1), when he summarised parts of a letter from another member of staff (Z9) (see Appendix 4) not present at the meeting. In essence, Z9 argues that "literacy" is essential in order to become a scientist. He suggests that the implication of this understanding is that "the formal literacy requirements for a Zoology major be raised to the same status as the formal numeracy requirements" (ie. a first year Maths course), "but with the possibility of exemption based on Matric English results." In other words, Z9 seems to be arguing that a first year English course should be a requirement for Zoology majors. In this he was supported by Z11, who argued that a year of English Literature should be a requirement.

These views were contested by Z8, who argued that it was a mistake to try to separate grammar and content, since breakdown in language was often the result of lack of conceptual

clarity. Z7 agreed, and reminded the meeting that the Science Faculty had tried an English for Academic Purposes (EAP) in Science course, but that this course had been resented and resisted by students who felt that such a course was not integral to Science. Instead, she argued, the Zoology department needed to do as much as possible itself to promote students' linguistic and conceptual growth. She argued that being able to express ideas in simple language came as a result of a very clear grasp of those ideas. She was supported in this by Z6. She continued by arguing that the problems of "ADP" students were not those of language, but a host of other needs. Z8 argued that, rather than seeing the solution in courses in English Literature, students should instead be immersed in Zoological literature.

Z1 commented that plans to put in place in 1995 an intensive drafting and feedback process for first year students had been thwarted by a shortage of resources. Without sufficient members of staff (particularly tutors), the growing numbers of ESL students would "fall through the cracks" because of their language and educational background.

Towards the end of the time available to me, I commented that almost the entire conversation had centred around the challenge of ESL students. Z1 responded by saying that first language speakers also had problems, but that the ESL challenge was a very current one for the department.

On several occasions during the session, both Z1 and Z6 volunteered the view that my contact with the department had fundamentally shaped the way the department thought about writing, and had particularly influenced the way writing and communication was taught at first and second year level.

Comment

In spite of the views mentioned in this last paragraph, it is my impression that the shifts in perspective and practice had happened not department-wide, but only with the staff I have worked most closely with in curriculum review initiatives (ie Z4, Z6, Z7, & Z8). I would be interested to know whether Z1 (the HoD) was articulating his own shifts in perceptions and practice, or whether he is reflecting reports from other staff.

APPENDIX 6

E-MAIL TO RESPONDENTS

From: Self <SOCSCI/MOORE>
To: COOK PA. PETE,BRANCH GM. GEORGE,DAVIES BR. BRIAN
Subject: Research on Writing
Cc: paxton
Date: Tue, 14 Nov 1995 17:18:15

Dear Colleagues

You will remember last year kindly agreeing to be interviewed by me as part of a research study I'm doing for an M.Ed. My special thanks go to you for your help, since I drew quite substantially on your comments for my final write-up, nearing completion now.

Feedback to the department has happened/is happening in various ways:

1. I asked you to look at an early analytic move I made which selected some of your comments which shed light on how you viewed "science." Your very reassuring comments at that point gave me an important foundation to continue my write-up.

2. George asked me to circulate an interim report on my research around the time of the week-end planning meeting held by the department in August this year.

3. I will be circulating a final version of this report (about six pages) next week to all teaching staff in the department, and Charlie Griffiths has kindly afforded me a slot in the staffmeeting on 27 Nov so that staff can comment on the report. I will try to include the central thrust of these comments in my final write-up for the thesis.

4. In addition, however, I would like to offer to the staff whose views I have relied on most the opportunity to read chapters from my thesis, in the unlikely event that they have the time to do so. In particular, I would be happy to make available:

i) my analysis chapter - about 20 pages single-spaced - but probably quite readable. This chapter draws on the comments of my interviewees, and tries to construct a rationale for the use of student writing in learning Zoology.

ii) my theory chapter - about 20 pages single-spaced - but probably a somewhat denser read than the analysis chapter. This chapter reviews current debates in the philosophy of science, theories of learning and science education, and theories about the role of writing in education. Whilst the analysis chapter can probably stand on its own, the excerpts I have included in it will probably "resonate" more if the theory chapter has also been looked at.

If you are interested (and have the time!), I would need to get your feedback by about the beginning of December if I am to include your responses in the thesis itself (which I would like to do!). But I also entirely understand the pressures you are under from your work both inside UCT and beyond.

Perhaps you could respond by e-mailing me one of the following options:

Option A: Sorry, can't fit it in before December!

Option B: Please send me the Analysis Chapter!

Option C: Please send me the Analysis AND Theory chapters!

Option D: I'll look at the report you write for the staff meeting, and try to comment then!

Once again, many thanks for your very valuable help in this project!

Warm regards

Rob

APPENDIX 7

RESPONSE FROM Z4

I include (on the next two pages) a sample of the responses made by Respondent Z4 to an extract from the "Report to the Zoology Department". He responded similarly throughout my Analysis chapter as well. I have chosen this extract because this is where he is most critical, in that he offers a suggestion for improvement, namely that my study has neglected to mention the role of hypothesis in science.

I reproduce some of his comments below, in the interests of readability:

> (Top para:) *hypothesis and theories*
>
> (Indicating "Theories are changeable":) *and by new knowledge - "shooting down" the NUL hypothesis!*
>
> (Having circled *"subjective"*:) *many would scream NO! Science is objective by definition (I do not subscribe to this view!)*
>
> (Indicating fourth para:) *Rob - we need to discuss the role (VITAL) of hypothesis vis a vis theory. I haven't seen the word hypothesis yet.*
>
> (Indicating second-last sentence of para five:) *It is also <u>THE</u> source of confusion, doubt and criticism of science as a pursuit (as opposed to the pseudo math of engineers) <u>by the layperson.</u> In which the seeds of political destruction of real science will always be sown for ever! Sad to say. = THE CONUNDRUM.*

The rest of his responses throughout the report and the chapter were, in one way or another, affirming what the study has done. He concluded by saying: *Fascinating! Can I read more please?* and then: *Can I take 10% of the profits please?*

My analysis of the interview data revealed a broad consensus that the discipline must be understood as *a human construct*, that knowledge becomes "science" when it achieves a degree of *public consensus in the scientific community,* and that this knowledge is to be understood not as final, universal and immutable, but simply as *the best theory currently available.* Theories are changeable, and what is accepted today may be overthrown tomorrow by quite different ways of thinking. Scientific knowledge, therefore, is constructed by human, social processes in social settings and is thus subject to human purposes and interests.

A consequence of this understanding of knowledge is the recognition of the essentially *subjective* nature of scientific pursuit: The preconceived theories and purposes in the mind of an individual scientist work to shape the goals and methods of his/her enquiry. A failure to recognise the constraints of preconceived theories - and therefore a possible failure to be receptive to unanticipated alternatives - may have the result of limiting the analytic vision of the scientist and thus lessening the possibility of fresh discoveries that help to move forward the scientific endeavour.

The nature of scientific enquiry seems to necessarily involve a dialectic between stable and unstable knowledge. It is necessary for a scientist to assume an instability of knowledge - to *doubt* a theory - if s/he is to test it and arrive at a conclusion. Yet the conclusion s/he finally asserts is an attempt to again stabilise knowledge.

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Fourthly, students need to be developing their learning, and communicating this learning, through a variety of communicative modes. These include the ability to interact confidently in classroom situations, the ability to make oral presentations, and competence in various forms of writing, including educational, academic, professional and popular forms.

For the purposes of this discussion, I will refer to the development of these abilities as broadly "critical approaches" to teaching Zoology. These stand in contrast to more traditional approaches which involved rote-learning of large bodies of material presented as authoritative "fact", and the setting of pracs which had predetermined and predictable outcomes. These traditional approaches were widely criticised by my respondents. One senior staffmember argued that the department needed to move closer towards an understanding of learning as "playing with concepts, and communicating those concepts."

"What educational processes best develop these qualities and competencies?"

It was in response to this question that I sensed the greatest diversity in thinking. Generally the tension was between what staff felt *ought* to be done, and what they felt was often the *practice in reality*. Usually expressed in discussions about undergraduate curricula, the tension was (in some cases) between, on the one hand, knowing that student learning should

APPENDIX 8

EXCERPTS FROM "POST-MORTEM"

I include in this appendix (with permission from Z4) excerpts from a course review meeting held at the end of the first piloting of an innovative second-year course in Invertibrate Zoology. The Writing Centre (represented by Moragh Paxton and myself) contributed in various ways to the new approaches developed for this course, especially in terms of task design, genre, assessment practices, etc. The excerpts represent, I believe, evidence of changing literacy practices that are broadly in keeping with the spirit of this study, and that were partially prompted by the involvement of Z4 in the study itself.

POST-MORTEM: ZOOLOGY 201S, 1995,
AND NEW DIRECTIONS, 1996
Discussion Document prepared by Z4

Participants:

MORAGH (Writing Centre)
Z4
Z6
ROB (Writing Centre)
Z7
Z8

1. The involvment of the Writing Centre in this course was a RESOUNDING SUCCESS, forcing teaching staff to rethink "how, what, and why" and for whom", and added significantly to the objectives of the course - *to give the students an understanding of the concepts embodied within the science of Zoology through both a variety of written and oral forms of communication.*

This involvement also led to the demise of "the essay" as a form of assessment, simply because of the fact that Zoology 201S teaching staff (after challenge from Writing Centre staff) awoke to the lack of purpose enshrined in the essay format.

The following extract (going over the page) reflects, I believe, a growing sensitivity to ways of inducting students to the genres and assessment practices of the discipline:

ASSIGNMENTS AND TESTS

1. The practical test at the end of the semester was successful (a full practical period was used for the test).

2. Students requested more (sigh!) testing and it was unanimously agreed that a formal written test would be incorporated into the timetable.

Discussion of this issue led to some exciting innovations:

(i). The course co-ordinator will arrange for three essays from the ZOO201S exam (November 1995) to be transcribed VERBATIM into a handout.

The essays will constitute the "best", a randomly selected "third-class-to-lower-second-class pass" and a "fail" at *circa* 30%, answers to the same question. Each student will be provided with the transcriptions *without any commentary* (or assigned mark), together with a transcription of the question that elicited the answers. This information will be provided during a standard Thursday lecture slot and students will be requested to read the handout before the next day.

(ii). Prior to supply of transcriptions, each student will be informed as to which lecture block will be targetted for the written test: approximately two weeks notice will be furnished.

(iii). Twenty four hours after provision of the "real-answer-handouts" students will attend the Friday lecture and will be given 15 minutes to re-read the handout AND TO GRADE EACH ANSWER. Students will then be organised into groups and asked both to announce their individual grades for each answer to their peers and to argue the criteria upon which they based those grades. The staff will then gather the grades, their ranges and the criteria used, and the remainder of the Tutorial will comprise a discussion of staff/student assessments. This will allow students to gain an insight into the methods of examiners and to learn what constitues a "good" answer within the context of Zoology 201S. The learning curves will be high on both sides!

(iv). Students will be tested the following Friday. They have the topic and the "model"-answers as well as an insight into the marking methods of examiners. Staff will (unknown to the students) slightly alter the thrust of the question that was used in the first tutorial and will present this slightly modified version for examination. The student answers will be graded and will form part of the class assessment: detailed written commentary for each student will be furnished by staff.

(v). As a follow through (after they have received the results of the written test) we intend to present them with a Friday "Tutorial" in which each student will be given the same "block" of lectures that they were tested on (*de novo*) and ***asked to design a suitable examination question.*** Each student will be provided with an OHP transparency and pen and will be required to write their question for general view and criticism. We are not sure how this can safely be handled in 45 minutes, but the insights gained by the students into the examination process will be an invaluable "life experience". Eacg student will be allowed to get "inside the heads of examiners" and to understand concepts from the points of view of both recipient and messenger!

(vi). Finally, each student will be provided with a selection of past theory examination questions in order to drive home the course approach towards concepts rather than content.

3. Although assignments were very effective, their sequence and timing was inadequate: the students reacted very favourably to the second assignment in which they were asked to write an article for "*African Wildlife*" describing the biological significance of a newly discovered "living" specimen of the Burgiss Shale Fauna (rather as though it were a "coelocanth-like" modern discovery).

10. The best posters will be taken by the Department for use as teaching tools in disadvantaged schools and may also be used for displays both within the Department as well as at the 2-Oceans Aquarium for the general public. These innovations, we feel, will provide an enormous incentive for students in terms of developing excellence and a sense of public involvement, relevance and worth to the wider community: ***it makes enormous sense within the framework of the outreach policy of the University (and as such should be advertised as part of this departments activities(!)).***