

## Chapter 11

### **An integrated approach to teaching writing in the sciences**

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First year biology courses at the University of Sydney have traditionally incorporated assessment activities requiring students to write reports. Despite increases in the size of the student cohort during the past 10 years (n=1000 – 1600), we have maintained the philosophy that writing is integral to learning biology (Moore, 1993) and to the development of generic skills. The curriculum therefore needs to reflect a sense of the importance of ‘writing as learning’ rather than just being seen as a tool for assessment, or a task for formative assessment (Keys, 1999; Lea & Street, 1998). In this way the concept of communicating meaning is seen as the main role of writing, and students can be helped to move away from a surface approach of ‘how long does it have to be?’ (Nightingale, 1988). Integration with the discipline material and structure is an essential component of the learning process such that writing also helps to develop analytical abilities, scientific knowledge construction and retention (Dorfman & Taylor, 1998).

The aim of this chapter is to describe the creation of a collaborative program, involving language and learning specialists and biology staff, focusing on the significance of writing within the scientific discipline and practice, and emphasising the development of student independence and autonomy in the learning process. We used a research approach to develop the teaching program, which has been sustained and enhanced by the application of new insights from our ongoing research into student learning, as shown in Table 11.1.

### **Research informing the teaching of writing in the sciences**

#### *Insights from research in applied linguistics*

There is a rich tradition of ethnographic and linguistic research into the social construction of knowledge in the sciences. Although early research tended to focus on the more prestigious sites of discovery and publication (Latour & Woolgar, 1979; Gilbert & Mulkay, 1984; Latour, 1987; Bazerman, 1989; Myers, 1990), later research has been concerned with pedagogical environments where students are being apprenticed into scientific disciplines, discourses and communities (Swales, 1990; Bhatia, 1993; Halliday & Martin, 1993; Martin & Veel, 1998; Candlin & Plum, 1998; Hewings, 2001). One of the most influential research approaches in this area is genre analysis which involves both ethnographic and linguistic perspectives. Genres are ‘staged, goal-oriented social processes’ (Martin, Christie & Rothery, 1987); ‘staged’ because they move through structured stages ‘oriented’ towards a ‘goal’ or social purpose. Genres are ‘communicative events’ which share ‘communicative purposes’ taking place within a discourse community (Swales, 1990, p. 58). A key advantage of analysing genres is that analysis not only serves research purposes but can be used for developing academic writing pedagogy. Studies in the different traditions of genre analysis over the last 25 years have provided a rich resource for the researching and teaching of written texts in their context (Hyon, 1996; Jones, 2004). In Australia, genre analysis has been shaped by the influential theory of systemic functional linguistics (SFL) pioneered by Halliday (1985), a comprehensive description of how language choices make meaning in their context of use. This theory provides a systematic

description of the interrelationships between language and the contexts of situation and culture ‘how the linguistic features of a text relate systematically to the features of its environment’ (Halliday 1985). In addition, this theory has been the basis for much ground-breaking research into the language of science (Halliday, 1988; Halliday & Martin, 1993; Halliday, 2004).

Table 11.1. An overview of the integration of research and teaching in writing in the first year biology curriculum at the University of Sydney

Date	Research and Teaching Activities	Outcomes
1994 - 1996	Educational research informing the teaching of writing.	
	Use of literature on academic writing and genre analysis to address problems with undergraduate writing in science.	Application for funding and proposal development.
	Implementing <i>Writing in Biology</i> program, and training staff.	Implemented, with CAUT funding, and evaluated .
1996 - 2000	Evaluating <i>Writing in Biology</i> program to improve learning environment.	
	Ongoing evaluations by staff (n=60) and students (n=1000-1500), through quantitative and qualitative surveys, and focus group interviews.	Most evaluations positive, changes implemented, particularly in the area of feedback, and further evaluated.
	Publishing descriptions of the innovation and outcomes of initial evaluations.	See References: e.g., HERDSA and Communications Conference, ESA.
2000 - 2006	Research into student learning within the program	
	Collaborative projects on: <ul style="list-style-type: none"> <li>▪ Effects of attitudes to writing and prior experiences</li> <li>▪ Writing to learn in science</li> <li>▪ Using feedback on writing</li> </ul> Using methodologies based on approaches to study and phenomenography.	Publications in International Journals and presentations at International Conferences, University Teaching Showcases. Outcomes of projects fed back into the teaching program through seminars and further training for staff, and information online for students.

Genre analysis and pedagogy within the SFL tradition (often referred to as the ‘Sydney School’ (Jones, 2004)) is largely associated with the seminal research of Martin and colleagues working in primary and secondary school contexts and workplace contexts (see for example Veel (1997) in the area of school science and

Rose, McInnes and Korner (1992) in the area of workplace science). Genre analysis in this tradition provides descriptive resources which enable connections to be made between the micro language choices made at text level with the macro level, sociocultural influences driving those choices.

For example, a student's choice of the modal auxiliary 'must' in their discussion of the causes of dwarfism in pea plants 'The absence of gibberellic acid in dwarf plants *must* be responsible for their dwarfism' would be inappropriate in the context of how scientists make claims based on their results, whereas the use of 'may' would be acceptable 'The absence of gibberellic acid in dwarf plants *may* be responsible for their dwarfism'.

Although both usages are grammatically correct, clearly one choice is more appropriate. Making students aware of the range of appropriate choices, such as 'might' or 'could' and their variation in meaning helps them understand that language choices are not determined by a set of rigid grammatical rules but are part of a system for choosing meaning within a particular sociocultural context for a particular purpose. Such text examples can become part of a bank of resources for designing curricula for apprenticing students into discipline writing practices.

One such curriculum approach, genre-based literacy pedagogy, a literacy teaching and learning cycle model, has developed from genre analysis in the SFL tradition (see Figure 11.1).

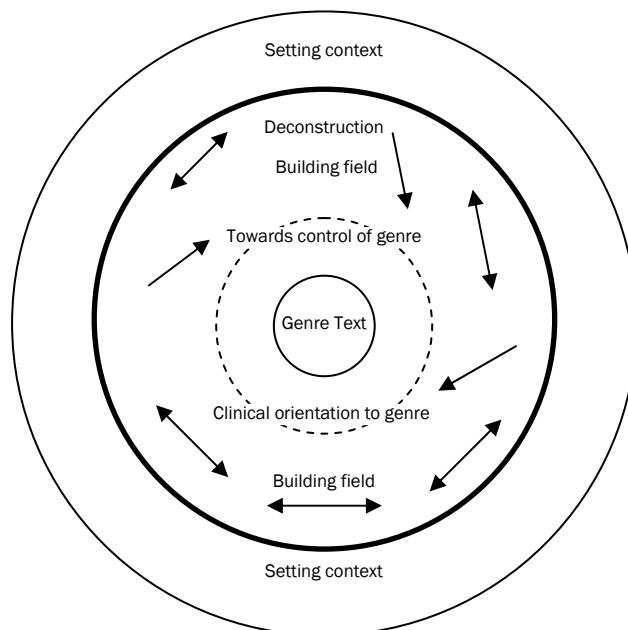


Figure 11.1. A genre-based teaching and learning model (Martin, 1999, p. 131)

This curriculum model (Martin, 1999) engages students in an interactive teaching and learning cycle where they acquire knowledge and understanding of the target genre and how to apply this in producing their own text. The cycle is typically divided into 3 phases, modelling or deconstruction, joint construction and independent construction. The cycle can be entered at any point according to students' needs and teachers can

move back and forth between phases as appropriate. The modelling phase makes explicit all aspects of the genre from social context to vocabulary or grammatical features, joint construction engages students in the process of writing an example genre with the teacher as guide, individual construction moves students on to writing a draft text for peer and teacher feedback before writing the final version. After this stage, students and teacher can critically examine the target genre, questioning the cultural values behind its structure and purpose and re-writing it as a different genre. See Martin (1999) or Cope and Kalantzis (1993) for more information on the genre-based teaching and learning cycle. The success of this model for literacy teaching in pre-tertiary contexts has meant that it has now been widely adapted to teach spoken, written and visual academic genres at tertiary level in both classroom and online contexts (Drury, 2004).

*Research processes and applications to teaching*

Our research into academic writing aimed to make explicit both the products and processes of writing required for success in first year biology (Prosser & Webb, 1994). Using genre analysis in the SFL tradition, we identified and analysed the pedagogical and assessment genres of first year, examples of which, together with their genre classification (or macro genre - a larger text comprising a number of genres) are shown in Table 11.2.

Table 11.2. Examples of writing tasks in first year biology

Text type	Question/Topic/Purpose	Genre with specific type in brackets
1) Factual description: practice writing exercise	To describe the characteristics of a seedling.	report (composition)
2) Laboratory report: assessed assignment	To determine the respiration rate of germinating mung beans using a respirometer.	macro genre: report, procedural recount, discussion
3) Field report: visit to the Botanic Gardens: assessed assignment	Write a brief description of the field characteristics which you would use to distinguish the Cactaceae from species of Euphorbia.	discussion

Authentic examples of each genre, namely student texts and staff models, were collected and analysis of a representative sample was undertaken to create a more generalised description of the genre (Drury, 2002). Analysis involves describing, firstly, the typical stages (schematic structure) the genre moves through to fulfill its purpose (thesis statement, argument etc.); secondly, the choice of cohesive features which link together these stages in a meaningful way and lastly, choices in vocabulary and grammar which are motivated by the more macro level features of the genre but which in turn influence these macro levels. An example of a partial genre analysis of a student response to the field report task in Table 11.2 is shown in Table 11.3.

Table 11.3. A partial genre analysis of a highly valued student response to the field report task

Schematic Structure	Text: Discussion Genre
(Paragraph 1) Thesis 1	1) <u>On close examination of the tables</u> , there do not appear to be any characteristics that enable the family Cactaceae to be distinguished from the genus <i>Euphorbia</i> .
Argument 1.1	2) <b>Both succulents</b> have spines and fleshy stems for water storage,
Argument 1.2	3) may grow as either trees or shrubs,
Argument 1.3	4) <u>and both</u> may or may not flower at the same time.
Argument 1.4	5) Despite the fact that the Cactaceae do not have leaves, the <i>Euphorbias</i> only sometimes have leaves,
Re-state Thesis 1	6) thus the presence or absence of <b>these</b> is not a distinguishing feature either.
Counter Thesis 2	7) <u>Textual sources</u> reveal (Curtis, 1983, p. 921) however that the two have quite different flowers which allow them to be distinguished.
Argument 2.1	
Argument 1.5	8) As not all of the succulents selected for examination in <u>the field</u> were in flower,
Re-state Thesis 1	9) <b>this</b> distinguishing characteristic does not appear in the table.

Comment: The text is divided into clauses for analysis. Themes or sentence beginnings are underlined and reference words are shown in **bold italics**. Both of these textual features are important in developing this text as a series of stages, arguments and counter arguments, before making a conclusion. Further analysis could provide a richer account, for example, the varying use of tense to distinguish between the author's observations in the field and his/her generalisations from these.

While genre analysis was taking place, ethnographic data was collected from interviews with students and staff. Staff provided information on the curriculum context including any guidelines, support materials and activities for writing, the learning goals for writing and the staging and composition of assessment tasks. Staff also identified typical student problem areas and their criteria for successful writing. These collaborative meetings allowed biology staff to build up a metalanguage for talking about language use and provide important discipline knowledge for language and learning staff. At the same time, student interviews provided insights into their problem areas in writing, their writing processes, their perceptions of staff expectations and what they thought would help them to write more successfully.

The detailed genre analysis of student and staff texts provided a rich corpus of resources for teaching materials and activities within the curriculum framework of genre-based literacy pedagogy. This curriculum model was adapted as a teaching and learning cycle for writing in first year biology as shown in Figure 11.2. As can be seen, there is an emphasis on preparation activities such as modelling and assessing which allow students to build their knowledge of the target genre and its context before they

engage in writing. By evaluating examples of the target genre, students can develop a metalanguage to talk about strengths and weaknesses in the writing and suggest their own criteria for assessment. They then use these criteria, complemented by those of staff, to assess their own practice and give feedback on peer and group writing. In this way, students are better prepared for the individual writing tasks which are part of the later assessment and feedback process.



Figure 11.2. The teaching and learning cycle in first year biology at the University of Sydney (Taylor & Drury, 2002)

### Evaluation to improve the teaching of writing

A cycle of evaluation, during 1995 to 2000, surveyed staff and students to provide quantitative and qualitative data on perceptions of the writing program. These data demonstrated increasingly positive perceptions of all aspects of the program and provided information on where changes should be made. Due to increasing student numbers some cuts were affected early in the program, specifically the introductory diagnostic tests used to establish written literacy levels in incoming students. However, the overall structure, including extensions in the area of feedback, has remained an integral part of the first year biology course for the past 12 years (Peat, Taylor & Franklin, 2005b). The accumulating evaluation data about the program raised questions

about the diversity of kinds of student conceptions and prior experiences, and prompted us to use more formal approaches to investigate the efficacy of the program. We therefore designed research projects to determine the extent to which prior experiences, confidence and attitudes to writing affected the way in which students used the resources. With this knowledge we could create profiles of incoming students and thus more effectively direct them in use of the program components. We also needed to better understand students' perceptions of writing in the program and the extent to which they learnt biology while writing.

### **Research into student learning**

We used two main methodological approaches to answer these questions, based in theories associated with approaches to learning (Biggs, 1987) and phenomenography (Marton, 1981).

#### *Methodologies*

*Approaches to learning.* We based our research on methodologies adapted from previous studies on student approaches to learning (Entwistle & Ramsden, 1983; Biggs, 1987; Biggs, 1989; Prosser & Trigwell, 1999; Ramsden, 2002). One project focused on determining the prior experiences of our student cohort with reference to academic writing and establishing any relationship to their subsequent approaches and outcomes in the writing program. We adapted the Study Process Questionnaire (Biggs, 1987) to provide quantitative measures of prior experience of writing, attitudes to the experiences of writing, approaches to writing and performance indicators prior to, and after, participation in the writing program (Taylor & Drury, 2004). We further refined our writing questionnaire for a quantitative study to determine the extent to which scientific knowledge and use of an appropriate writing style is developed through the writing process (Ellis, Taylor & Drury, in press). A cluster analysis was used to identify groups within our sample which showed similarities in the variables used in the questionnaires, such as common approaches and conceptions. We used the theoretical 3P model (Trigwell & Prosser, 1997) to describe the way in which students develop their understanding during the stages of the writing program, and identify the relationship between students' experience of writing and the quality of their learning.

*Phenomenography.* Phenomenography provides a structure for examining the variation in understanding of a concept, as experienced by individuals (Marton, 1981), through the creation of a list of critically different hierarchical categories which reflect all perceptions of the phenomenon to be categorised (Trigwell, 2000). A series of iterations of analysis allow the categories to be confirmed and quantitative data developed. Our studies used qualitative data about students' conceptions of writing and learning biology from open ended questionnaires. These data were analysed, using a phenomenographical approach, to characterise the process of writing and its outcomes, and the scientific understanding developed by students through writing.

#### *Research outcomes*

Using the approaches to learning methodology, we were able to create a profile of students with respect to their prior experiences of writing, their subsequent attitudes to writing, their approach to writing and their performance outcomes in writing during the program. We found significant correlations between the extent of prior experiences of

writing, positive attitudes to writing and approaches to writing. This study therefore confirmed that prior experience had a significant effect on students' engagement with the activities in the writing program but incoming achievement levels at the Higher School Certificate (HSC), as measured by University Admission Index (UAI), were not good indicators in terms of students' writing. This enabled us to identify characteristics of incoming students who may be embarking on the program with a clear disadvantage.

A cluster analysis allowed us to understand whether students had established a link between the process of writing and understanding biology. Unless there is a link established, the writing process remains a technical exercise with no relation to the biological information being studied, as had been demonstrated for many students during our previous research (Ellis, Taylor & Drury, 2006). We identified two groups of students within the sample. One group experienced writing as a way of understanding and employed deep approaches to writing. A second group employed a surface approach to writing and had no clear conception of writing in biology. These research outcomes showed a broad range of approaches to writing, and conceptions of writing, which were also reflected in the overall performance of students in the writing program and in their engagement with biology during the writing process.

Outcomes of the phenomenographical analysis identified categories of conceptions of learning through writing and student approaches to learning through writing as shown in Table 11.4. These have clear implications for the way in which staff approach their teaching in the program, since being aware of the types of students we are working with changes our approaches to teaching and makes the interaction more effective.

Table 11.4. Phenomenographic categories showing the variation in the experience of learning through writing (Ellis et al., 2006)

Categories of conceptions of learning through writing	% of student responses (n=165)
Writing as a way of learning about the writing process and science information	55
Writing as a way of understanding biology and its applications	45
Categories of approaches to learning through writing	
Writing to create a report by following a process	71
Writing to understand and explore biology	29

Using these research outcomes, we considered more carefully the links between areas where students lacked experience or confidence in writing, and the points in the learning cycle where we could provide extra help. We then made more explicit, in the student manual, our explanations of ways in which students could engage with the learning cycle to help with building confidence and developing writing experiences they may have missed at school. Integral to all these outcomes is the central role of feedback in developing students' writing. We enhanced the provision of feedback and created a range of online resources and self assessment materials for use during the writing process (Peat, Taylor & Franklin, 2005a). This included creating sheets for



students and staff detailing the criteria for feedback and marking. Students now have access to one-to-one discussion on a draft of their written report and can access, and participate in, online discussion and question sessions on their report writing (Taylor, 2002). We have also initiated further studies into the way in which students understand and use feedback on their writing (Taylor, 2006; Drury & Muir, 2006) which are allowing us to further refine our feedback procedures.

The significance of the student profiles, and categories of conceptions and approaches, identified in our research is now explored through discussion with staff, to help them relate to the way students work with the program and to help in understanding student patterns of learning. We have also designed training and marking sessions for tutors and report markers, and have enhanced the marking process through double marking sessions.

Our research has confirmed that students need a structured and explicit approach to the teaching of writing, focusing on modelling the criteria for good writing, and on giving, and working with, feedback. These outcomes become part of an iterative development cycle in our teaching, whereby students and staff become aware of the ways in which perceptions and approaches relate to their performance in writing, and emphasising the aims of the activities and making the assessment more explicit (Peat et al. 2005b).

### **Issues**

Overall, the program has undergone constant evaluation and change over the twelve years of its inclusion in the biology course. We still cannot measure explicitly whether student writing has improved as a result of our program, since successive cohorts show different profiles and therefore cannot be compared. In addition our expectations of the level of student performance have increased quite dramatically over the past 10 years. Students have, however, risen to these challenges and have a much better awareness of the importance of writing as evidenced by their asking for more opportunities to practice. A key requirement for initial writing preparation activities in the program, namely the provision of diagnostic exercises early in the course (Ellis et al., 2005; Ellis et al., in press), still proves too difficult a hurdle to surmount with such large cohorts and in a teaching environment where face to face class time is being further reduced. To address this issue, we are therefore currently exploring online initiatives for student self diagnosis and reflection, based on the model of the learning cycle.

### **Conclusions**

The outcomes of research into student learning in the writing program have allowed us to further reflect on the significance of academic writing in the science curriculum. Specific requests by students have caused aspects of the program to be incorporated into other first year biology courses. We have also built up considerable support from teachers in higher year courses, across a range of degrees, to incorporate the messages, and extend the activities, from the first year writing program into their curriculum. Genre analysis and pedagogy have proved to be a robust approach for the development of teaching resources for different discipline areas. A significant body of resources has been created which has extended our knowledge of writing in the sciences at tertiary level. Thus we are steadily consolidating a focused and motivating writing experience, for students in the undergraduate science degree programs, which is supported by our ongoing research program in student learning.