Preface

This case book is a result of a project in science education funded by the Australian Learning and Teaching Council. The project, “A cross-disciplinary approach to language support for first year students in the physical sciences,” commenced in October 2007. It addressed the language needs of a diverse student body by investigating and testing language oriented strategic approaches to learning and teaching in first year sciences. This project was concerned with the acquisition of language specific to science in addition to the implicit teaching of meta-cognitive skills required in doing science. The disciplines covered by the project were biology, chemistry, and physics. Around 3400 students were involved in the project from the University of Canberra, the University of Technology, Sydney, the University of Sydney, the University of Tasmania, and the University of Newcastle in Australia.

BACKGROUND

Student retention and progression rates are a matter of concern for most institutions in the higher education sector (Burton & Dowling, 2005; Simpson, 2006; Tinto & Pusser, 2006). There is also substantial literature concentrating on the first year experience at university (Kerri-Lee Krause, Hartley, James, McInnis, & Centre for the Study of Higher Education, University of Melbourne, 2005).

Currently, there are two broad approaches to providing extra academic (rather than language) support to help students succeed during their first semester at university: targeting all students who wish to participate in extra learning opportunities or targeting only those students deemed to be at risk.

For example, the peer assisted study support schemes at the University of Wollongong, University of Queensland (Miller, Gregg, & Kelly, 2000), and now at the University of Technology, Sydney and a number of other universities, offered academic support to all interested students. Students usually self-select to participate in these schemes. While there are considerable resource implications associated with such broad-based schemes, they are widely reported to be effective (O’Byrne, Britton, George, Franklin, & Frey, 2009).

However, the problem with both of the approaches above is that students either have to self-select or be selected for such extra academic support. This works on the assumption that students who are not selected are all coping with their first year science study. This project questions this assumption and offers proof that as far as language in science is concerned, all students need support. Thus, we aimed to offer language support to all students who attended lectures and tutorials thereby developing an approach of academic support that supports all students.
PROJECT AIMS

Specifically this project aimed to:

1. Target the issue of language in science and suggest ways of solving some of the language issues by importing techniques and strategies frequently used in the teaching of foreign languages;
2. Create innovative online teaching modules that directly address the language difficulties in the targeted disciplines in science;
3. Expand and reshape the current teaching approach to include a language focus in the teaching of science in the face to face mode;
4. Increase student awareness of the language used in the targeted disciplines by presenting student and staff insights of the particular types of language used in that context;
5. Rigorously evaluate the implementation of these learning strategies on student learning to enable their transportability to other teaching contexts in higher education in Australia.

SCIENCE BACKGROUND OF STUDENTS

Students undertaking tertiary studies in the physical and biological sciences are a highly diverse group, and that diversity is increasing (Harris, et al., 2007). For instance, at the University of Sydney, Australia there are usually around 2000 students from various faculties in the first year chemistry cohort. Some of these students had little or no Higher School Certificate studies in chemistry (especially students in Sports Sciences). However, others have very high Universities Admissions Index chemistry scores (>98 for Veterinary Science students). With such a diverse group there is also, naturally, a wide range of interest in and aptitude for the subject. Such diversity is typical for classes in biology, chemistry, and physics at a number of Australian universities (see Table 1).

THE PROJECT METHODOLOGY

The project protocols were developed through collaboration among all stakeholders. These included a specialist in language learning and science subject specialists who were also e-learning developers and students. Designs built on the team members’ knowledge of research into online learning (Schulte, 2006), computer-assisted language learning (Zhang & Barber, 2008), linguistics (Zhang, 2006), empirical research in science (Ellem & McLaughlin, 2005), and pedagogical practice. A student-centered approach was emphasized in the design process and in the design itself.

The subjects in this project were taught by lecturers who hold broadly constructivist views of learning as described by Bruner (1986). In this view of learning, learners are considered to bring different conceptualizations, intentions, styles, and approaches to the learning situation (Kolb, 1984; Marton, Hounsell, & Entwistle, 1984; W. G. Perry, 1988). Students’ active engagement in learning activities was also an essential ingredient.

Furthermore, these activities should be based on direct experience as far as possible (Boud, 1993) and reflection was seen as important in building understanding (Schon, 1987). Finally, the project was also informed by Lave and Wenger’s ideas of situated learning (Lave & Wenger, 1991). Students and
staff were participating in academic communities of practice. Therefore, the classroom was no longer a site for the transmission of knowledge but rather a site for social practice. To be included in such a social practice environment, the language of that environment must be learnt.

In this process, the roles of teaching and lecturers were changing too. Science lecturers worked alongside an educationalist and contributed to educational research and scholarship. Just as experiencing change in how they learned took place over two years for the students involved in this study, academics teaching also experienced changes. The science academics involved in this project were extremely accomplished and knowledgeable individuals in their own disciplines. By participating in this project, they were positively recognizing the possible contribution education theories and practices could make to their teaching. The involvement of the educationalist was a way of establishing a mutually beneficial learning relationship so that science academics and the educationalist could gain new knowledge from each other. The educationalist involved in the project had very little scientific background or knowledge in the targeted disciplines. She, in a sense, was like a student who chooses to do science without the necessary pre-requisites.

In this model, changes in teaching approaches were explored through a co-teaching or peer coaching approach (Ladyshewsky, 2006; Roth, 1998; Roth, Tobin, Zimmermann, Bryant, & Davis, 2002) in which the education/language expert shared with the science academic techniques and strategies used in teaching in a constructivist model. The science academics taught the education expert the content and pedagogy used in a particular science discipline. This coaching practice before lectures and tutorials in private between the educationalist and the lecturers was an essential element in successfully implementing the change in science academics’ lecturing styles in the face to face context. During the coaching practice in private, the educationalist and the lecturers worked together to anticipate areas that students might not understand. This preparedness enhanced the delivery of the content using the new face to face protocol.

The staff project participants were instrumental in ensuring the sustainability of the project processes and findings. At each participating university, the staff project participants involved were instrumental in disseminating the outcome and findings of this project in higher education to colleagues within their own disciplines in their own universities and across the sector. Teaching project staff participants consulted

### Table 1. Summary of discipline areas studied through a language focus, host universities for each discipline and features of large student cohorts and learning environments

<table>
<thead>
<tr>
<th>Name of University</th>
<th>Discipline</th>
<th>Average UAI</th>
<th>No. of students in subject/unit</th>
<th>Web support</th>
<th>Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Technology, Sydney</td>
<td>Physics (1st year)</td>
<td>77</td>
<td>410</td>
<td>Yes</td>
<td>None</td>
</tr>
<tr>
<td>University of Sydney</td>
<td>Chemistry (1st year)</td>
<td>83</td>
<td>2000; 200 per class</td>
<td>Yes</td>
<td>High School Certificate (HSC) in Chemistry and no HSC Chemistry.</td>
</tr>
<tr>
<td>University of Newcastle</td>
<td>Biology (1st year)</td>
<td>N/A</td>
<td>450</td>
<td>Yes</td>
<td>None</td>
</tr>
<tr>
<td>University of Tasmania</td>
<td>Chemistry (1st year)</td>
<td>82.5</td>
<td>250</td>
<td>Yes</td>
<td>Year 12 Chemistry</td>
</tr>
<tr>
<td>University of Canberra</td>
<td>Genetics (2nd year)*</td>
<td>82.9</td>
<td>85 - 90</td>
<td>Yes</td>
<td>1st year Biology or Chemistry</td>
</tr>
</tbody>
</table>

*Second year Genetics at the University of Canberra was the target unit for the first language-based study in university science education performed by Drs. Zhang and Lidbury in 2006
with staff in units for the promotion of teaching and scholarship in higher education such as the Teaching and Learning Centre at the University of Canberra. Teaching staff project participants also conducted workshops to train lecturers in their disciplines in using the online and face to face protocols. Project participants were also involved in a peer-mentoring program organized at each individual institution. During the peer mentoring program, project participants mentored colleagues who intended to adapt and implement the strategies tested in this project, and they also conducted workshops and seminars to showcase the processes and outcomes of this project at their own institutions.

In the project, we undertook to do the following:

- Conduct an online language difficulty survey to ascertain the problems students might have with scientific language;
- Implement the following two protocols in teaching in all five universities

We also implemented the following protocols:

1. During each lecture, the lecturer built into the lecture materials short survey questions made available on VotApedia <http://www.urvoting.com> or audience response devices such as clickers <www.keepadinteractive.com> to offer feedback on lecture content;
2. During tutorials, interactive activities were introduced. Such interactive activities could include small group discussions involving the linking of concepts learned.

Ethics approval for surveying and communicating with participants was given and monitored by the University of Canberra Ethics Committee; approval number: 01-119. Each participating institution also obtained ethics approval for their participation in this project.

**TARGET AUDIENCE**

This casebook will be of interests to educators, science educators, both education and science lecturers themselves, as well as staff in teaching and development units. Researchers in higher education might also be interested as this cross-disciplinary approach to science education can be a sustainable model for the professional development of the staff.

**DESCRIPTION OF EACH CHAPTER**

The chapter submissions in this volume include nine chapters detailing successful collaboration in science education.

Chapter 1 documents the results of language difficulty surveys distributed in the participating institutions to ascertain the extent of the language difficulties encountered by first year science students.

Chapter 2 documents the successful implementation of various Chemistry language strategies in the first year Chemistry curriculum at the University of Sydney, Australia.

Chapter 3 is another instance of successful implementation in Chemistry at the University of Tasmania, in Hobart, Australia.
Chapter 4 documents the longitudinal implementation of language strategies in the curricula of Genetics and Molecular Biology at the University of Canberra, Canberra, Australia.

Chapter 5 details the verification of the Genetic Concept Inventory (GenCI) (Elrod, 2007) which was used extensively at the University of Canberra in the Genetics unit.

Chapter 6 of this book documents a successful transfer of the strategies to the subject of Human Physiology at the University of Newcastle, Australia.

Chapter 7 contains a description of the implementation of language strategies in the first year Physics curriculum at the University of Technology, Sydney, Australia.

Chapter 8 describes another example of successful transfer of knowledge to the discipline of first year Statistics teaching.

Chapter 9 is a concluding chapter which summarizes findings from the project for science education starting with the issue of language difficulties.

CONCLUSION

One of the key achievements of this project was that it succeeded in changing the teaching practices of science lecturers, not by imposing a set of “best practices” onto them, but by directly involving them in designing, testing, and implementing practices that they would use in their own teaching. With the idea of disseminating sustainable strategies in mind, the guiding principle of selecting suitable strategies was that the strategy must be easy to use and flexible enough to be modified to suit different institutional contexts.

As a result of the cross-disciplinary collaboration between the science lecturers and the educationalist (the project leader, Dr. Felicia Zhang), some twenty-five language oriented exercises created using the freeware Hot Potato software (http://hotpot.uvic.ca/), over forty critical thinking activities, and over forty five multiple choice questions and a large number of VotApedia questions (http://www.urvoting.com) in the disciplines of chemistry, biology, and physics have been created. These teaching materials can be used either online or in face-to-face contexts, in lectures or tutorials, and are not constrained by institutional computer infrastructure such as the Learning Management System (LMS). This case book contains many of the teaching materials used in different project sites and is intended to be a one stop shop for science language activities used in the project.

Finally, this book contains a wealth of ideas, practical exercise sheets, and technological advice targeted at a number of specific topics in the Physics, Chemistry and Biology curricular. In some disciplines such as Chemistry, materials concerning all the usual topics have been included. Though coverage in other disciplinary areas has been isolated to a few topics, the model of creating language oriented exercises, creating exercises that integrate the use of technology can be readily transferable to other areas of science and other disciplines such as the discipline of business and health. What distinguishes the materials in this book from other curriculum advice is that our learning materials are not like those in any science textbooks, are produced by the disciplinary science academics themselves rather than by the educationalist, can be easily implemented with or without technology, and most importantly, have proven to produce significant improvement in first year science students’ achievement.

Felicia Zhang
University of Canberra, Australia
REFERENCES


