Forging New Directions in Physics Education in Australian Universities

Service Teaching

A report on the findings of the Service Teaching strand of the 2007-9 Physics Project, funded by the Australian Learning and Teaching Council

March 2009

Editors
Les Kirkup
Alberto Mendez

“In my opinion the project has done a splendid job of bringing key issues of science education to light in a way that physicists take seriously and will engage with. Through them, it has forged a national community of practice.”

Professor John Rice
Executive Director, Australian Council of Deans of Science
Forging New Directions in Physics Education in Australian Universities

Service Teaching Working Party Report

Report prepared by Les Kirkup and Alberto Mendez

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Project website which includes the report in electronic format at:

Support for this project has been provided by the Australian Learning and Teaching Council, an initiative of the Australian Government Department of Education, Employment and Workplace Relations. The views expressed in this report do not necessarily reflect the views of the Australian Learning and Teaching Council Ltd.

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2009
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In this report we present the findings of the Service Teaching strand of the ‘Forging New Directions in Physics Education in Australian Universities’ project funded by the Australian Learning and Teaching Council (ALTC). A version of this document appears as Appendix 4 of an extensive report sent to the ALTC, available for download on their website at www.altc.edu.au/. Alternatively, an electronic copy may be downloaded from the project website at www.physics.usyd.edu.au/auutc/.

1. Preamble

Our goal in the service teaching strand of this project is to reach consensus about what constitutes good practice in service teaching in physics. We intend to identify such practice in Australian universities and disseminate our findings through workshops involving physics academics and contact with discipline leaders, such as HODs and the Australian Council of Deans of Science (ACDS). We also intend to disseminate elements of this work through a website and papers presented at national conferences.

Through service teaching, the tertiary physics community in Australia connects with many thousands of students each year. Physics service subjects have a key role to play in the development of graduate capabilities such as the capacity to learn in, and from, a diversity of disciplines in order to enhance the application of scientific knowledge and science related skills in professional contexts1.

Students in service subjects carry with them their experiences of physics, which affects the esteem with which physics is held by an influential community of university-educated citizens. Other reasons for concentrating on physics service teaching include acknowledging the growing importance of contributions that physics makes to other disciplines and the fact that the financial well-being of most Australian physics departments is tied to their service teaching.

Our study brings an emphasis to the student voice, as we explore what is meant by good practice in service teaching, where such practice is occurring, and the factors that allow good practices to flourish within a physics department. In particular, we are keen to examine the question “what impact does a semester of physics have on students not intending to major in physics?” Through a consideration of students’ expectations and experiences of service subjects, we are intent on identifying and promoting indicators of good practice.

Much data were gathered through the surveys. We do not present an exhaustive analysis of the data gathered, but we do draw out some important issues that deserve further consideration.

We would like to thank our fellow academics and students from around Australia who gave generously of their time to support and actively engage with this project. They have done much to maintain physics service teaching in Australia on the teaching and learning agenda.

1.1 Summary of activities and achievements

Through the service teaching strand of this project, we have:

- Reviewed service subject teaching materials from twelve universities.
- Identified models of physics service teaching.
- Engaged the physics community in identifying and ranking indicators of good practice in service teaching.
- Devised, trialled and analysed students’ expectations/experiences surveys of service subject.
- Identified links to major and laboratory experiences as key issues emerging from the surveys.

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1 Graduate attribute adapted from UTS Science.
• Communicated findings of this strand of the project at four workshops in three state capitals.
• Published student surveys on the project website.
• Published three peer-reviewed conference papers on this work.
• Distributed to academics the findings from the expectations/experiences surveys, both for their own subjects as well as for all 35 subjects.
• Invited subject co-ordinators (or equivalent), of subjects in which high student expectations were matched by equally high student experiences, to describe their subjects for inclusion on the project website as well as through a presentation at a national workshop.
• Disseminated findings of the project to Australian HODs at the biennial national Australian Institute of Physics (AIP) Congress held in Adelaide in December 2008.
• Obtained feedback from academics on the merit of the surveys.

2. Background

Physics and physicists have an image problem, especially among those not majoring in physics, but who are nevertheless required to enrol in a semester of physics to fulfil course requirements. Physics is perceived by many students as being a collection of complex facts; dull, and with little connection to today’s world (Cheary et al, 1995; Fonseca and Conboy, 1999; Guisalsola et al, 2002). Physicists remain stereotyped as middle-aged bearded men, wearing white coats, surrounded by equipment and writing neatly in notebooks (McDonnell, 2005).

Dissatisfaction with physics subjects delivered to non-physics majors has a long history (Caswell, 1934; Lapp, 1940) and though many approaches aimed at addressing the situation have been proposed, fervently-held negative views affecting engagement with physics have withstood attempts at serious reformation. Clues as to why this might be expected can be found in a study carried out by Sheila Tobias almost two decades ago (Tobias, 1990). Tobias found that the absence of community, large class sizes, and lack of contagious enthusiasm, conspire to turn even extremely bright and intellectually hungry students away from physics.

Though there is generally a shared understanding of the term service teaching (at least within Australian universities), there are differences of opinion regarding which subjects should be classified as service subjects. For example, a service subject could be described as one delivered to majors drawn from another school or faculty (such as the Faculty of Engineering). Other descriptions would include physics subjects delivered to students within a school or faculty (for example, physics taught to medical science students in the Faculty of Science). A useful definition of service teaching was included in the 2004/5 AUTC study ‘Learning Outcomes and Curriculum Development in Physics’ (Mills et al, 2005).

A physics service subject is one delivered, maintained and assessed largely by a department of physics, specifically designed for non-physics majors....

In this report we make the distinction between subjects routinely enrolling both physics majors (PMs) and non-physics majors (NPMs), often referred to as mainstream subjects, and those enrolling only NPMs, which would normally be regarded as service subjects.

2.1 Impact and scope of physics service teaching

There are several reasons why the issue of provision of physics to NPMs, while far from being new, deserves to remain a matter that attracts serious and sustained attention by the physics community in Australia. Those reasons include:

2 Some of the material in this section may be found in published papers (Kirkup et al, 2007, Kirkup et al, 2008).
Those who were NPMs at university deliver a significant fraction of the teaching of physical principles in primary and secondary schools, both public and private, and will continue to do so for the foreseeable future. A recent study showed that one in four senior high school physics teachers in Australia had not studied physics beyond first year, and almost 43% of high school teachers lacked a physics major (Harris et al, 2006). These NPMs are emissaries for the physics discipline in schools, with the vital role of increasing the awareness of physics’ contribution to society. Their experiences of physics at university (which may be limited to a single semester of physics) will shape their attitudes towards physics and, by natural extension, those of the students that they teach.

As a physics community we have a precious (and in some cases a final) opportunity to promote physics to students who are destined to major in disciplines as diverse as physiotherapy, civil engineering and forensic science.

There is a growing awareness of the importance of physical thinking, for example in the biological sciences, and that recent developments in this area are urging greater reliance on quantitative approaches to science of the type promoted by physicists. As Bialek and Botstein expressed it (Bialek and Botstein, 2004):

...the fragmented teaching of science still leaves biology outside the quantitative and mathematical structure...this strikes us as particularly inopportune at a time when opportunities for quantitative thinking about biological systems are exploding...

In first year, where by far the greatest number of students encounter physics, their initial experiences are crucial and influence the extent to which they are prepared to persist with their studies (Pitkethly and Prosser, 2001). Science in the U.S., for example, has been shown to lose 40% to 60% of students with higher than average abilities within two years of entering college or university. The retention rate worsens when minority groups are considered. The educational experience and the culture of the discipline as communicated to students have a major influence on student retention (Seymour and Hewitt, 1997). First year physics service subjects, which reach many thousands of students annually in Australia, have a sizeable potential to affect (for the good or otherwise) retention rates in science and engineering.

The economic imperative cannot be ignored by Australian physics departments, as all teach a significant number of NPMs. Pollard et al (2006) reported that half of the physics departments in Australia rely on their service teaching for more than 50% of their income. Service teaching has become increasingly critical as the amount of money available to physics departments to support teaching has declined over the past decade, affecting, for example, staff numbers. Staff numbers have declined in Australia from in excess of 350 in 1994 to under 250 in 2002. Physics departments, for example those in the UK, who have ignored service teaching or never had such teaching to fall back on in lean times, have been downsized or closed altogether. To emphasise the seriousness of the situation: in 1994 there were 79 physics departments in the U.K. By 2005 that figure had fallen to 48 (Parliamentary Office of Science and Technology, 2007).

The number of NPMs taught in every Australian university physics department exceeds that of PMs. As an example, at a Sydney research-based university, around 1000 students enrol in first year physics subjects and of these only ~100 continue on to major in physics. The NPMs are ambassadors for physics. Those that take up leadership roles in business, industry and politics, have opportunities to influence strategic policies which have the potential to impact on physics as a discipline and science in general. Negative or disheartening experiences of physics can only prejudice the physics community when such leaders begin to exercise their authority and influence.
2.2 Recent drivers for change in service teaching

There are contemporary drivers for change in undergraduate teaching which form a backdrop to a review or revitalisation of physics service teaching. For example, the adoption and development of models which are outcomes of the Bologna Process, is fuelling the debate about generalist as opposed to specialist first degrees.

Impact of the Research Quality Framework (RQF) and the Excellence in Research for Australia (ERA)

The escalating focus on research carried out by universities in Australia which is partly a consequence of first the RQF, and more recently the ERA, has encouraged universities to divert or redistribute scarce resources to maximise support for research. For some time to come this cross-subsidisation of research will have an unquantifiable effect on teaching and learning at universities. Possible outcomes of the diversion of resources are: rationalisation of subjects resulting in increased class sizes, especially in the first year where service teaching dominates; reduced focus on curriculum reform and teaching developments; and increased teaching workloads for those designated as research inactive staff. There is evidence that a similar initiative in the U.K. called the Research Assessment Exercise (RAE), which has been carried out over the past 16 years, has been responsible for an unwelcome distortion of values in the U.K. higher education system, leading to reduced emphasis on teaching and learning matters (Jenkins, 1995; Banatvala et al, 2005).

The Bologna Process

In Europe, the Bologna Process is driving reforms to secure consistency and portability of qualifications (allowing, for example, credit transfer between higher degree institutions). It is recognised that this process will have a major influence on the development of higher education around the world (DEST, 2007). The Bologna Process favours the creation of general bachelor degrees (3 years, full time) followed by master degrees (2 years, full time), which are more specialised and professional in orientation. If higher education policy makers in Australia are convinced by the Bologna Process, it is not difficult to imagine general science degrees in Australia increasing in number. These degrees may be expected to have physics as a core component, which in turn would lead to many more NPMs studying the subject, at least in the first year. Already in Australia, the University of Melbourne has introduced major changes to its bachelor degrees which are now based on six broad undergraduate programs followed by a professional graduate degree (The University of Melbourne, 2007). These changes may be seen as congruent with some of the recommendations to emerge from the Bologna Process and provoke other higher education providers in Australia to re-evaluate their offerings at the bachelor level. It is timely to examine the extent to which serious ‘buy in’ to the Bologna Process and the models of provision of undergraduate courses that flow from the process, necessitate a rethink of the physics curriculum in general at the undergraduate level, and especially in the first year (though we do not attempt that examination here).

3. Methodology of characterising current models of teaching physics to NPMs

We began our consideration of physics service teaching by canvassing the members of the service teaching working party and heads of departments about the current state of service teaching within their universities. The purpose of this was to obtain an up-to-date snap-shot of current practices in a diversity of institutions, which would inform an analysis of the types of physics service subjects extant in Australian universities. We were also anticipating that since the AUTC study on ‘Learning Outcomes and Curriculum Development in Physics’ (Mills et al, 2005), changes might have occurred in some institutions as a consequence of staff reductions and the resulting consolidation of subjects. Indeed, one head of department reported that due to such pressures, large numbers of engineering students were enrolled in mainstream physics subjects for the first time in 2007.
Nine universities representing metropolitan and regional universities from New South Wales, South Australia, Western Australia and the Australian Capital Territory (ACT) responded to a short survey as follows (questions in bold):

*Where do your non-physics majors come from (i.e. are they mainly from another faculty, such as engineering, or are they within your faculty, e.g. physics taught to environmental science students)?*

Eight out of nine universities indicated that greater than 50% of their teaching to non-physics majors was taught to engineering students. Other significant contributors to the teaching load include students majoring in physiotherapy, general science and the biological sciences.

*Are non-physics majors taught together with physics majors?*

Of the universities surveyed, there were no first year (or first level) subjects which were populated solely by physics majors. Physics majors were either taught together with engineers (six universities) or with other science students (three universities).

*Is your service teaching mainly to first years?*

All nine universities canvassed indicated that service teaching was provided mainly to first years. Six universities indicated that a small amount of service teaching was provided beyond first year.

*Is there anything special that distinguishes your teaching of non-physics majors compared to your teaching of physics majors?*

Of the six universities that responded to this question, two indicated that there was no special distinction:

“We aim to do the best we can for all!”
“There are no differences where engineers and science students are co-taught.”

Four universities indicated that extra maths/physics tutorials were provided, usually on an optional basis:

“For those with poor maths/physics background, we run drop-in tutes and extra lectures on some topics (although these classes may be attended by ‘non service’ students).”
“Extra maths support is offered as optional tutorials.”
“Voluntary tutorials are available.”
“There is a support programme for weak students comprising one extra tutorial each week.”

*Is physics embedded within first year subjects not described as physics subjects? If so who teaches the physics component?*

Three out of nine universities indicated that a substantial amount of physics was embedded within first year (engineering) subjects taught by engineering schools/faculties and not by the physics department.

The findings of this snap-shot align with those of the AUTC study on ‘*Learning Outcomes and Curriculum Development in Physics*’ (Mills et al, 2005), which emphasised the importance of service teaching, and the regard it is held in by Australian physics departments who continue to be financially dependent on teaching to NPMs.
3.1 Reviewing subject/course materials

Subjects enrolling non-physics majors are diverse in content and mission. In order to reasonably assess that diversity, we collated material from 42 physics subjects in twelve universities representing universities from New South Wales (3), Queensland (3), Victoria (2), the ACT (2) and Western Australia (2). The materials reviewed included subject/unit outlines for all subjects, lab manuals for 21 subjects and assignments/exams for 20 subjects.

The diversity in both level and content of what is taught to NPMs is large. For those subjects which enrolled both PMs and NPMs there is clear evidence of rigor being maintained, with the role of mathematics being emphasised. This is nicely summed up by a quote from the subject outline of one mainstream physics subject which enrolls large numbers of NPMs.

This is not a course about physics (original emphasis) – it is physics. Students learn physics by doing it, by solving problems, whether on paper or in the lab. Concepts and principles are learned in context, by example and then by development. It is important to understand the limits of applicability. Mathematical skills ... are essential tools in much problem solving. However, the art of problem solving in physics is understanding the principles and where they apply, and how and when to use them and the relevant mathematics or other tools.

Extract from subject outline for subject enrolling both PM and NPMs at a metropolitan university

Service subjects enrolling NPMs only, exhibit a diversity of content and approaches. They include those offering a general introduction to physics, generally at a lower conceptual level than those subjects enrolling PMs, to those for which the curriculum is much more aligned to the areas in which the NPMs were majoring. The following excerpts taken from the learning outcomes/objectives of two subjects (from different universities) are an indication of the diversity found amongst subjects delivered solely to NPMs.

From the outline of a general subject for NPMs:

On completion of this unit you should be able to demonstrate your achievement in the following learning outcomes:

- Understand fundamental concepts and principles of mechanics, thermal properties of materials and wave motion and sound.
- Apply physics principles to understand the causes of problems, devise strategies to solve them and test possible solutions.
- Use a range of measurement and data analysis tools to collect data ... carry out analysis with due regard to uncertainties and communicate ideas and explanations.

From the outline of a customised subject for NPMs:

A student who successfully completes this unit will be able to:

- Explain and apply principles of forces, momentum and energy to the motion of objects in simple cases of relevance to the human body and applications.
- Use the concepts of physics to explain the operation of body systems such as those for breathing, circulation and metabolism.
- Determine the behaviour of simple electrical circuits, including storage and dissipation of energy in capacitor circuits, with applications such as nerve conduction and defibrillators.

3.2 Categorisation of subjects

As a result of considering the materials supplied, such as laboratory manuals and subject outlines, two models emerged which allow for the useful categorisation of physics subjects taught to NPMs.
The identification of subjects in universities across Australia that fit each model leads naturally to the consideration of benefits/limitations that may accrue from the adoption of each model. This in turn may allow us to explore the relationships between those models and student expectations, experiences and attitudes towards physics.

**Model 1**

In model 1 subjects, PMs and NPMs are taught together and the subjects are prerequisites for later stage physics subjects. In some institutions students are enrolled in first year science and other subjects without, at that stage, being classified as majoring in any particular area and it is not until the end of the first year that it becomes clearer who are the PMs and NPMs. In such cases it may be better to describe students as *intending* PMs or NPMs. The syllabuses of model 1 subjects generally include topics that would be regarded as quite traditional, such as mechanics, thermal physics and electricity.

**Model 2**

In model 2 subjects, only NPMs are taught. We propose two sub-classifications which reflect the extent to which the subject has been designed for a specific audience.

Model 2A subjects, like Model 1, are quite conventional first year physics subjects, but are predominantly algebra-based and so are populated by NPMs only, as such subjects are not suitable prerequisites for senior physics subjects. The syllabuses of these subjects are conventional in the sense that the topics and orientation reflect a general introduction to physics with no special orientation towards other disciplines, such as engineering or the biosciences. These may reasonably be categorised as *service* subjects as they support the learning of students destined to major in areas other than physics.

Model 2B subjects again contain only NPMs and would not normally act as prerequisites for senior physics subjects. However, they have an intentional or overt orientation towards a particular clientele, be they majors in engineering, bioscience, or physiotherapy.

In some situations, subject descriptions may show that the subject lies somewhere between model 2A and 2B. While clear links between the physics and the major area of study of students enrolled in a subject may be absent in the subject outline (suggesting that the subject be classified as 2A) the lecturer may make significant use of examples drawn from disciplines in which the students are majoring. We therefore accept that the categorisation is imperfect. When we surveyed students taking particular subjects, we contacted the relevant subject co-ordinator (or equivalent) for advice regarding categorisation of the subject where that could not clearly established from the subject outlines.

Through a review of subject outlines available in the public domain, we were able to identify which Australian universities offered subjects aligning broadly with models 1 and 2 (see Table 1).

<table>
<thead>
<tr>
<th>Offering only model 1 subjects</th>
<th>Offering only model 2 subjects</th>
<th>Offering both model 1 and 2 subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of universities</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

**Table 1: Prevalence of models 1 and 2 in Australian universities.**

**3.3 Considering the models**

We now discuss the usefulness of the models we have proposed to categorise subjects taught to NPMs. It is possible to consider approaches taken to physics teaching and learning, say at first year
level, without categorising subjects by the apparent extent to which NPMs are catered for. We anticipate, however, that there are several factors that will be important to, say, student engagement with physics subjects by the way subjects are actually, or apparently, aligned to a student’s degree and career intentions/aspirations. We conjecture that a NPM student enrolled in a subject fitting models 1 and 2A, where there may be no attempt to bring special attention to the relevance of the subject to their major or align the subject with preferred graduate attributes/capabilities of the NPMs, may respond less positively to the subject than an NPM student enrolled in a subject conforming to model 2B.

In particular, it would be valuable to examine and map the relationships between subjects fitting each model to the issues described in Table 2.

<table>
<thead>
<tr>
<th>Concerning the</th>
<th>Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student</td>
<td>Expectations, retention, self efficacy and self confidence, engagement</td>
</tr>
<tr>
<td>Subject</td>
<td>Design of laboratory experiences, assessment methods, teaching approaches, links with prior knowledge/experience</td>
</tr>
<tr>
<td>Curriculum</td>
<td>Alignment with graduate capabilities/attributes, frequency of update, extent of inter-disciplinary representation of curriculum development committees, frequency of updates of curricula</td>
</tr>
</tbody>
</table>

Table 2: Issues that may be mapped against models.

Some of these relationships are likely to be difficult to tease out (for example, the effect, if any, of any particular model on student retention) as part of a one year study. By contrast, student engagement or attitudes towards physics, for example, are likely to be easier to establish and we give this special attention in this study. As part of the project we used surveys to sample students in subjects aligning with models 1 and 2 which are representative of offerings of physics departments across a broad range of metropolitan, regional and rural universities in Australia.

Table 3 shows the categorisation of subjects (n=42) from twelve universities discussed in section 3.1 indicating the percentage of subjects falling into each category.

<table>
<thead>
<tr>
<th>Model</th>
<th>1</th>
<th>2A</th>
<th>2B</th>
<th>2A/2B?</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of subjects</td>
<td>43</td>
<td>33</td>
<td>12</td>
<td>12</td>
</tr>
</tbody>
</table>

Table 3: Categorisation of subjects conforming to models 1, 2A and 2B based on materials such as subject outlines. The column headed 2A/2B? indicates that 12% of subjects were difficult to categorise based on available subject materials.

4. What constitutes good service teaching? General

Good practice in university teaching and learning is the main concern of many texts, papers and online articles. The latter are often found on webpages allied to ‘Centres of Learning and Teaching’ (or equivalent). Some consider university teaching and learning in general whilst others focus on first year only (see Barefoot: www.herts.ac.uk/about-us/learning-and-teaching/learning-teaching-institute/home.cfm and Krause: www.griffith.edu.au/gihe). Well established standard texts on teaching and learning (Biggs, 1991; Marton et al, 1984; Laurillard, 1993) do not attempt to draw a distinction between teaching to non-majors and teaching to majors in terms of the purpose, challenges and pressures with respect to effecting good practice.

The lack of consideration of matters impacting particularly on service teaching may represent a gap in the literature. Are there issues regarding good teaching practice which require special emphasis with respect to service teaching, that distinguishes it from non-service teaching, or are there simply differences in nuance?
General propositions of good practice, for example in the area of learning from experience as expounded by Boud et al (1993), apply to students in service subjects:

- Experience is the foundation of, and stimulus for, learning.
- Learners actively construct their own experience.
- Learning is a holistic process.
- Learning is socially and culturally constructed.
- Learning is influenced by the socio-economic context in which it occurs.

Issues related to engagement face learners required to enrol in a subject which they may have steadfastly avoided in the past, or which they regard as peripheral to their immediate or future needs. As Rogers commented (1969):

“Nearly every student finds that large portions of his curriculum are, for him, meaningless. Thus education becomes the futile attempt to learn material which has no personal meaning.”

How well is the physics integrated into the curriculum of the major, for example to what extent do the majors a) advise on physics content/context and b) know what is being taught?

Many issues face a lecturer required to deliver a subject to students not majoring in their area of expertise. Some examples:

- Is the lecturer comfortable when linking physics to areas in which he/she has little or no direct experience?
- Is the lecturer sufficiently aware of existing and emerging relationships between the physics and the students’ major?
- Does the lecturer perceive pressure to ‘dumb down’ the physics, concerned that a poor pass rate or poor student feedback scores in a service subject may lead to its discontinuation?

Relevance and context are key issues for students. In a recent survey canvassing students drawn from many disciplines, student motivation to learn was affected most by:

“Showing how theory can be applied in practice, establishing relevance to local cases, relating material to everyday applications, or finding applications in current newsworthy issues.”

Kember et al, 2008

The extent to which relevance is, or should be, pursued in a service subject deserves to be a matter of debate. When relevance is regarded as essential, how prepared or qualified are academics in the servicing discipline to relate more than token examples of relevance?

Turning momentarily to the bigger picture: There is growing awareness that a science degree should:

“...relate as much to the uses made of the competencies developed by graduates of the degree as to the demands of the discipline itself.”

Rodrigues et al, 2007

A physics service subject can offer important opportunities to broaden a student’s vision of the scope of science, while at the same time cementing an awareness of the specific relationship between physics and their chosen major and how that relationship is likely to develop in the future. The service subject is also able to promote the development of generic graduate capabilities which are of value irrespective of whether or not the student pursues a career in science upon graduation (Rodrigues et al 2007).
5. What constitutes good service teaching? The academic voice

5.1 Overview

The literature is a source of guiding principles and approaches to supporting good teaching. However, the fact that such sources are generally detached from the practice of service teaching is revealed by the lack of consideration of factors impacting on service teaching. This means that it is vital to secure the insights of physics academics engaged in service teaching. To this end, and in order to establish an informed consensus with respect to good practice, we asked physics academics with contemporary experience in service teaching to consider the question “what constitutes good practice in teaching a subject designed for non-physics majors?”

5.2 Methodology

25 academics from 12 universities attending an ALTC project workshop at Sydney University in September 2007 were asked to propose indicators of good practice and to distinguish, if possible, between general good practice and that which is of special relevance to service teaching. The working party leader, project officer and members of the service teaching working party subsequently reviewed the responses and ranked the indicators based on the frequency with which each was mentioned by an individual at the workshop. Approximately 75 responses were ranked. The (arbitrary) ranking scheme used is shown in Table 4.

<table>
<thead>
<tr>
<th>Ranking</th>
<th>What the ranking means</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>&gt;6 people mentioned this indicator</td>
</tr>
<tr>
<td>B</td>
<td>2-6 people mentioned this indicator</td>
</tr>
<tr>
<td>C</td>
<td>1 person mentioned this indicator</td>
</tr>
</tbody>
</table>

Table 4: Key to ranking of responses on indicators of good practice.

The outcome of the ranking process is shown in Table 5.

<table>
<thead>
<tr>
<th>Good Practice</th>
<th>Rank</th>
<th>More specific emphasis for NPMs</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Builds on students’ experience</td>
<td>A</td>
<td>Context/site of application of the physics has meaning for the student</td>
<td>A</td>
</tr>
<tr>
<td>Curriculum not overloaded</td>
<td>B</td>
<td>Recognises the future use to which students may apply the principles learned</td>
<td>A</td>
</tr>
<tr>
<td>Aims &amp; goals clearly stated</td>
<td>B</td>
<td>Contexts employed have explicit relationships with the major area</td>
<td>A</td>
</tr>
<tr>
<td>Offers challenges to students (whether students are above or below average)</td>
<td>B</td>
<td>Students are made aware of the role that physics has played/plays in the development of their major area of study</td>
<td>B</td>
</tr>
<tr>
<td>Theory and practice of physics clearly linked</td>
<td>C</td>
<td>Specific elements (e.g. the laboratory program) are set in contexts which have a bias or flavour derived from the NPMs’ discipline area(s)</td>
<td>B</td>
</tr>
<tr>
<td>Students at risk identified early and supported</td>
<td>C</td>
<td>Curriculum developed is updated by a group containing representatives from the NPMs’ discipline area(s)</td>
<td>C</td>
</tr>
<tr>
<td>Provides timely, individualised feedback to students</td>
<td>C</td>
<td>Aims and goals clearly relate to graduate attributes articulated by NPMs’ discipline area(s)</td>
<td>C</td>
</tr>
<tr>
<td>Improves student self-confidence</td>
<td>C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5: Ranked indicators of good practice in physics teaching.
We remark that the indicators given an ‘A’ ranking in Table 5 align well with those mentioned in the literature (see, for example, Kember et al, 2008).

‘Context/site of application of the physics has meaning for the student’ ranks highly amongst the responses of the lecturers attending the workshop. Evidence from other sources would suggest that many academics, even within the serviced disciplines, would support the notion that physics should be learned for its own sake, i.e. without any special emphasis on applications to the student major (Kirkup et al. 1998). We speculate that, as most academics taking part in the workshop had a special interest in service teaching, their views may not be representative of the physics teaching community as a whole with regard to their emphasis on the importance of the applications of physics.

6. What constitutes good service teaching? The student voice

Inspired by the top three ranking indicators of good practice in service teaching shown in Table 5, we devised two student surveys. The first included questions aimed at revealing student expectations of the subject with regard to links being made between physics and their chosen (or intended) major. The second survey was designed to reveal whether their experiences of the subject, over the course of the semester in which they were enrolled in the subject, matched their expectations.

6.1 Developing and trialling expectations/experiences surveys

Intentions

Through surveying students we wished to establish the impact of a single semester of physics on students destined to major in disciplines other than physics. A prototype survey was devised and trialled to uncover expectations and experiences of non-physics majors enrolled in a first year physics subject. In order to assist the development of the survey, we trialled the surveys on bio/medical science majors at a large metropolitan university. We wished to:

- explore student views of the value of physics to their major area of study,
- determine whether those views were transformed over the course of the semester,
- examine themes relating to service teaching which might provide direction for a larger survey and have relevance on a national level,
- establish the extent to which students expected links to be made between the physics they studied and the discipline in which they were (or were likely to be) majoring,
- provide points of comparison, for example on laboratory experiences, with the same surveys administered nationally,
- revise the survey questions (if appropriate) in the light of student responses (for example, in order to improve the clarity of the questions).

Surveys

Survey A (expectations) was designed to be administered at the beginning of semester and survey B (experience) at the end of the semester, but before the start of the examination period. The surveys were deliberately brief as students are faced with a plethora of surveys every semester and survey fatigue is a frequent and legitimate complaint among students. Survey A examines students attitudes towards physics and expectations of the subject they are about to commence. Survey B consists of identical, or complementary, questions. After trialling the survey and seeking advice from a teaching and learning specialist, some questions were revised (questions 2, 4, 6 and 7). The revised questions formed part of a larger survey which was administered by 22 Australian universities (see Section 7).
Several questions were designed to draw out whether students expect the relevance of physics to their major area of study to be manifest and whether, having reached the end of the subject, that expectation was realised (see questions 1, 3, and 9). Other questions aimed to uncover student general attitudes towards physics and the study of physics (questions 2, 4, 8 and 10). In such a short survey we did not wish to cover too much ground, but as mathematics is so important to the study of physics, and laboratories (at least in terms of time) are major contributors to the first year experience in physics, we included questions on each of these (questions 5 and 7 respectively).

<table>
<thead>
<tr>
<th>Question</th>
<th>Survey A</th>
<th>Survey B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td>It is apparent to me that this subject is a valuable part of my degree.</td>
<td>It is apparent to me that this subject is a valuable part of my degree.</td>
</tr>
<tr>
<td>Q2</td>
<td>Only unusually able people are capable of understanding physical principles in science. (Only people with an extraordinary ability are capable of understanding physics).</td>
<td>Only unusually able people are capable of understanding physical principles in science. (Only people with an extraordinary ability are capable of understanding physics).</td>
</tr>
<tr>
<td>Q3</td>
<td>I am keen to see how this subject links to my major area of study.</td>
<td>I am able to appreciate the links between this subject and my major area of study.</td>
</tr>
<tr>
<td>Q4</td>
<td>I am anxious about studying this subject this semester (I believe an understanding of physics will benefit my studies in other areas of my degree).</td>
<td>I am anxious about my upcoming exam in this subject. (I believe an understanding of physics will benefit my studies in other areas of my degree).</td>
</tr>
<tr>
<td>Q5</td>
<td>I am confident that my mathematics background is sufficient for me to be successful in this subject.</td>
<td>I believe my mathematics background was sufficient for me to be successful in this subject.</td>
</tr>
<tr>
<td>Q6</td>
<td>If offered, I would take advantage of extra maths support that was directly related to the maths in this subject. (I expect to do well in class tests in this subject).</td>
<td>My achievements in class tests in this subject exceeded my expectations.</td>
</tr>
<tr>
<td>Q7</td>
<td>I am looking forward to doing labs in this subject.</td>
<td>I enjoyed the labs in this subject. (The labs in this subject were a positive learning experience).</td>
</tr>
<tr>
<td>Q8</td>
<td>If it were possible, I would have avoided taking this subject.</td>
<td>I would advise others to avoid taking this subject if at all possible.</td>
</tr>
<tr>
<td>Q9</td>
<td>I expect the links between this subject and my major area of study to be made obvious throughout the semester.</td>
<td>The lecturers succeeded in linking this subject to my major area of study.</td>
</tr>
<tr>
<td>Q10</td>
<td>I expect to have to work harder in this subject than in my other subjects this semester.</td>
<td>I worked harder in this subject than for my other subjects this semester.</td>
</tr>
<tr>
<td>Q11</td>
<td>What final grade are you aiming for in this subject?</td>
<td>What final grade are you aiming for in this subject?</td>
</tr>
<tr>
<td>Q12</td>
<td>Did you study physics to year 12 at school?</td>
<td>Did you study physics to year 12 at school?</td>
</tr>
<tr>
<td>Q13</td>
<td>Open-ended question: Please describe briefly any particular expectations you have as you begin your study in this subject.</td>
<td>Open-ended question: Please describe briefly your experience of this subject, and in particular what you think might be done to improve the subject.</td>
</tr>
</tbody>
</table>

Table 6: Survey A (expectations) and Survey B (experiences) questions. The revised versions of the questions (used in the national survey) are parenthesised and shaded.

Questions 1 to 10 use the standard 5-point Likert scale, where the multiple-choice responses range from strongly disagree to strongly agree, with neutral in the centre. Question 11 is also multiple-choice, the response categories are: don’t know, pass, credit, distinction and high distinction.

**Subject surveyed**

The physics subject chosen for the trial was populated wholly by NPMs drawn from the biological/medical sciences, half of whom had not completed year 12 physics. The subject consists of 3.5 hours of lectures/tutorial and 2.5 hours of laboratory time each week. The laboratory and lecture material were in-step and all the students did the same experiment at the same time. About 150 responses were obtained for each of surveys A and B, representing a response rate of 85 to 90%.
6.2 Results

Multiple-choice questions

After assigning a number to each of the response categories on the Likert scale (strongly disagree = 1, disagree = 2, neutral = 3, agree = 4 and strongly agree = 5), the mean expectations scores (survey A) and experiences scores (survey B) were calculated for each of the first ten multiple-choice survey questions. The majority of questions were worded in such a way that higher scores correlated with positive expectations (or experiences) of the subject. Questions 2 and 8 were exceptions to the rule, as good expectations (or experiences) of the subject would be anticipated to elicit negative responses.

The mean expectations score was subtracted from the mean experiences score on matched questions in surveys A and B. A positive difference indicates that the students’ experiences exceeded their expectations and a negative difference indicates the converse; a value close to zero suggests that experiences closely matched expectations. In order to be able to rank questions 2 and 8 on the same scale, the process was reversed with the experiences score subtracted from the expectations score. Questions 4 and 6 were omitted from this analysis as the links between corresponding questions in surveys A and B in the original version of the questionnaire were absent or tenuous. Figure 1 shows the questions ranked in order of change.

In order to establish whether any of the differences were statistically significant a t-test was performed on each. A two-tailed, two sample equal variance distribution was used in performing the t-test. The results are presented in Table 7. The t-test revealed that the large differences associated with questions 3, 5, 7 and 10 are statistically significant (p < 0.05).

![Figure 1: Mean expectations (survey A) and experiences (survey B) scores for the 2007 trial survey responses ranked by the differences. Note that calculation of the Q2 and Q8 differences are reversed (explanation in text).](image)

<table>
<thead>
<tr>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q5</th>
<th>Q7</th>
<th>Q8</th>
<th>Q9</th>
<th>Q10</th>
</tr>
</thead>
<tbody>
<tr>
<td>p</td>
<td>0.58</td>
<td>0.88</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>0.23</td>
<td>0.37</td>
</tr>
</tbody>
</table>

Table 7: Statistical analysis of differences between expectations and experiences means (for individual survey questions).
Questions 1, 2, 8 and 9 showed no statistically significant difference between surveys A and B, denoting that experiences were closely matched to expectations. In general, non-significant differences are worthy of consideration. For example, a low score on corresponding questions in surveys A and B would be a matter requiring exploration, i.e. absolute values for responses may be as important as, or more important than, changes that occur over a semester.

Question 5, “I am confident that my mathematics background is sufficient for me to be successful in this subject”, was the only one for which experiences significantly exceeded expectations. The responses at the beginning of semester suggested students were unsure of this statement (indicated by a mean score of 3.37 which is close to the neutral value of 3) but by the end of semester they were much closer (mean of 3.73) to agreeing with the statement. We conjecture that students were concerned that a physics subject would require an amount of fluency with mathematics that they did not possess, but that experience of the subject showed them that their mathematical abilities were adequate for the purposes of satisfying the requirements of the subject.

The three questions in which experiences were significantly less than expectations were question 3 (seeing clear links), question 7 (enjoying the laboratory) and question 10 (work harder than in other subjects). Question 10 is useful for gauging student perceptions of the effort expended in this subject relative to other subjects s/he is taking but is not a question in which a preferred direction of response can be unequivocally stated. The other two questions can shed some light on areas requiring further examination. In particular, the responses concerning the laboratory suggest that a review of the laboratory program or its implementation be considered. Students went from feeling neutral about the laboratory component at the start of semester (mean of 3.10) to rather negative about it by the end (mean of 2.59).

**Open-ended question**

The last question on surveys A and B was open-ended and sought to qualitatively probe the expectations and experiences, respectively, of students taking the subject. About half the survey participants responded to this question. The most common expectations and experiences that emerged are given in Table 8.

<table>
<thead>
<tr>
<th>Expectations</th>
<th>Experiences</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The subject should be made interesting. (6)</td>
<td>1. Concerns relating to the provision of laboratory experiences. (22)</td>
</tr>
<tr>
<td>2. The subject will be challenging/difficult. (6)</td>
<td>2. The lectures/lecturers were interesting. (15)</td>
</tr>
<tr>
<td>3. Shouldn't have to stay until end of lab session as already have a full timetable. (6)</td>
<td>3. Should provide more worked examples as well as working solutions to the resource book. (8)</td>
</tr>
<tr>
<td>4. Should be able to see links with major area of study. (5)</td>
<td>4. There were a number of class tests issues. (7)</td>
</tr>
<tr>
<td>5. The subject will require a lot of maths and calculations. (5)</td>
<td>5. The subject was challenging and difficult. (4)</td>
</tr>
<tr>
<td>6. I will learn new things. (5)</td>
<td>6. There should be more links made between labs to lectures and/or theory. (3)</td>
</tr>
</tbody>
</table>

Table 8: Dominant student expectations and experiences. Number in brackets denotes number of student responses.

The open-ended responses support a number of the observations that emerged in the mean score differences shown in Figure 1. The experiences section affirms student frustration with the laboratory component of the subject. Moreover it provides useful information, detailing student concerns with the design and implementation of the laboratory program:
“Better lab sessions i.e. more interesting experiments, better lab tutors.”
“Improve the labs, making them more interesting, with better explanations from tutors rather than the vague and confusing explanations that were often given.”

More encouragingly, the second most popular response category (in the experiences section) details a positive attitude towards both the lectures and the lecturers.

“X and Y’s lectures were very interesting, especially when demonstrations were carried out.”
“The lectures given were very interesting and involving for the students, X did very well in explaining concepts and the way he taught (writing notes on the projector during lectures was great).”

6.3 Discussion

Surveys A and B were designed specifically for matters relating to students not majoring in physics in mind. The survey was valuable in teasing out areas of particular concern. In the trial of the surveys it was apparent that students were neutral or positively disposed toward laboratories on entering the subject, but that their experiences fell short of their expectations. The open-ended responses gave substance to the issues of most concern and form the basis of detailed considerations.

As a result of the surveys the laboratory program for this subject has undergone significant revision.

The trial of the surveys suggested that they have the potential for uncovering national themes. For example, a question prompted by the preliminary study is “to what extent are laboratories physics experiences for non-physics majors a national issue?” In order to answer this question and explore student views relating to service teaching on a national scale (such as the importance of linking physics to their major area of study), we contacted university physics departments across Australia to seek their participation in a nationwide survey.

7. Expanding expectations/experiences surveys to 35 subjects from 22 universities

7.1 Overview

Service teaching working party members, numerous HODs and teaching academics in physics departments across Australia were pivotal in expanding the reach of the expectations/experiences surveys. We surveyed students enrolled in 35 subjects taught to non-physics majors in 22 Australian universities spanning the Australian Capital Territory, New South Wales, Queensland, South Australia, Victoria and Western Australia. Over 7500 completed surveys were returned for analysis. The surveys were carried out at the beginning and end of the autumn semester 2008. There was good representation from GO8, ATN, as well as rural and regional universities. Table 9 lists all 22 participating universities.

<table>
<thead>
<tr>
<th>Adelaide</th>
<th>ADFA@UNSW</th>
<th>ANU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Central Queensland</td>
<td>Curtin</td>
<td>Edith Cowan</td>
</tr>
<tr>
<td>Flinders</td>
<td>LaTrobe</td>
<td>Murdoch</td>
</tr>
<tr>
<td>New England</td>
<td>Newcastle</td>
<td>New South Wales</td>
</tr>
<tr>
<td>Queensland</td>
<td>QUT</td>
<td>RMIT</td>
</tr>
<tr>
<td>South Australia</td>
<td>Swinburne</td>
<td>Sydney</td>
</tr>
<tr>
<td>UTS</td>
<td>Victoria</td>
<td>Western Australia</td>
</tr>
<tr>
<td>Western Sydney</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 9: Universities participating in the national expectations/experiences surveys.
7.2 Methodology

Administering surveys

The questions comprising surveys A and B are given in Table 6. Survey A, designed to examine student expectations, was administered to students in week 1 or 2 of autumn semester 2008. Survey B, which considered student experiences, was administered at the end of the semester but before the formal examination period. The contact person at each physics department was responsible for coordinating the time and place for administering the survey, collecting the completed surveys and returning them to the project officer for analysis. The option of keeping copies of the completed surveys (for personal analysis) was available to each department, however the project team was responsible for analysing the complete data set. Once this analysis was completed, departments were sent a copy of their individual results. A selection of the overall results was made available on the project website (www.physics.usyd.edu.au/super/ALTC), with any information leading to the identification of departments or individuals removed.

Scanning and analysis of surveys

Surveys were prepared in computer scan-able format to facilitate the data management process. The Quality Unit (PQU) at UTS was responsible scanning 4414 Survey A and 3109 Survey B responses and embedding the data in Excel spreadsheets, which were then handed over to the project officer.

Subsequent data analysis was carried out in the Excel spreadsheets. The analysis was chiefly statistical, with the main component involving averaging the quantitative multiple-choice questions. Mean values for individual questions were thus obtained, both for the overall data set and for each of the 35 subjects. A parameter for each subject was proposed, the index of change (IOC), which is a measure of how well students’ experiences matched their expectations (see Section 7.4).

Majors participating in survey

Students completing the surveys were asked to declare their majors. While recognising that some students may not accurately relay their major, we believe that Table 10 gives a fair representation of the diversity of NPMs that routinely enrol in first year physics subjects across Australia.

<table>
<thead>
<tr>
<th>SCIENCE</th>
<th>Agricultural Science</th>
<th>Archaeology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anatomy</td>
<td>Animal Science</td>
<td>Biochemistry</td>
</tr>
<tr>
<td>Astronomy</td>
<td>Astrophysics</td>
<td>Biomedical Science</td>
</tr>
<tr>
<td>Biological Science</td>
<td>Biology</td>
<td>Cell Biology</td>
</tr>
<tr>
<td>Biophysics</td>
<td>Biotechnology</td>
<td></td>
</tr>
<tr>
<td>Chemistry</td>
<td>Computer Science</td>
<td>Conservation Biology</td>
</tr>
<tr>
<td>Earth Science</td>
<td>Ecochemistry</td>
<td>Environmental Science</td>
</tr>
<tr>
<td>Environmental Chemistry</td>
<td>Ecological Science</td>
<td>Ecology, Behaviour and Evolution</td>
</tr>
<tr>
<td>Evolutionary Biology</td>
<td>Food Science</td>
<td>Forensic Investigations</td>
</tr>
<tr>
<td>Forensic Science</td>
<td>Geology</td>
<td>Geochemistry</td>
</tr>
<tr>
<td>Geophysics</td>
<td>General Science</td>
<td>Genetics</td>
</tr>
<tr>
<td>Health Science</td>
<td>Human Biology</td>
<td>Human Movement</td>
</tr>
<tr>
<td>Immunology</td>
<td>Industrial Chemistry</td>
<td>Life Sciences</td>
</tr>
<tr>
<td>Marine Biology</td>
<td>Marine Science</td>
<td>Material Science</td>
</tr>
<tr>
<td>Mathematics</td>
<td>Medical Biochemistry</td>
<td>Medical Imaging Science</td>
</tr>
<tr>
<td>Medical Microbiology</td>
<td>Medical Radiation Science</td>
<td>Medical Science</td>
</tr>
<tr>
<td>Meteorology</td>
<td>Microbiology</td>
<td>Molecular Biology</td>
</tr>
<tr>
<td>Multidisciplinary Science</td>
<td>Nanotechnology</td>
<td>Nanoscience</td>
</tr>
<tr>
<td>Neuroscience</td>
<td>Nutrition</td>
<td>Occupational Health and Safety</td>
</tr>
<tr>
<td>Ocean and Climate Science</td>
<td>Oceanography</td>
<td>Oenology</td>
</tr>
<tr>
<td>Optometry</td>
<td>Pathology</td>
<td>Pharmacology</td>
</tr>
</tbody>
</table>
Table 10: Range of majors surveyed.

7.3 Responses to multiple-choice questions

**Overall data set**

As explained in Section 6.2, the mean expectations score was subtracted from the mean experiences score, for each question. A positive difference indicates that students’ experiences exceeded their expectation for that question, and a negative difference indicates the converse. Figure 2 shows the consolidated data for all responses with questions ranked in order of positive to negative change.

The answers to the questions in the experiences survey were consistently biased towards less favourable responses when compared to the matching questions in the expectations survey. *t*-tests revealed that all questions except question 5 (where there was no change between expectation and experience scores) show statistically significant differences. Emphasising the main features shown in Figure 2:

- The mean scores relating to questions on links with major (1, 3 and 9), value to other areas of their degree (4), and laboratories (7) as obtained in the experiences survey were significantly less than the mean scores of the corresponding questions in the expectations survey.
- The mean scores for question 6 in the experiences survey indicates that students on average performed less well in their class tests than they had expected to.
- The mean scores for question 8 for the expectations/experiences surveys indicates a bias towards advising others to avoid the subject. (But note that in both the expectations and experiences surveys, the mean score is less than the neutral score of 3.)
- The change in the mean score for question 2 (“Only people with an extraordinary ability are capable of understanding physics”) suggests that more students came to believe this over the course of the semester. (But note that in both the expectations and experiences surveys, the mean score is less than the neutral score of 3.)
Figure 2: Aggregated data for all subjects surveyed showing the mean response to each multiple-choice question in surveys A and B. The questions are ranked according to how well the experiences matched the expectations (the change is shown graphically on the RHS).

By subject

Aggregating the data causes variation on a local scale to be obscured. In order to investigate trends at the local level we collapsed the overall data set and looked at the differences in expectations/experiences for each subject (see Figure 3 for each question’s corresponding plots).
Q3. There are clear links between this subject and my major area of study.

Q4. I believe an understanding of physics will benefit my studies in other areas of my degree.

Q5. I am confident that my mathematics background is sufficient for me to be successful in this subject.

Q6. My achievements in class tests in this subject exceeded my expectations.
Q7. The labs in this subject were a positive learning experience.

Q8. I would advise others to avoid taking this subject if at all possible.

Q9. The lecturers succeeded in linking this subject to my major area of study.

Q10. I worked harder in this subject than for my other subjects this semester.

Figure 3: Difference (experience – expectation) scores for each question, by subject. A positive difference (bar above the axis) indicates that experiences exceeded expectations. [Note that, due to circumstances beyond our control, three subjects did not participate in survey B.]
Four of the questions (1, 4, 6 and 9) performed only moderately across the board, with few if any subjects able to sustain the expectations at the start of the semester. This is of concern as three of the four questions deal with the links and worth of the subject to the major/degree.

7.4 Index of change (IOC)

In order to create an indicator that captures the change that occurs between student expectations and experiences for each subject, and which combines the responses to the questions where there is a preferred direction in the responses, we propose an index of change (IOC). The IOC is defined as the mean of all the questions’ (experience – expectation) scores. An individual IOC value is calculated for each subject.

Two points to note:
1. Question 10 “I worked harder than in other subjects” is not included in the calculation of IOC as there is no clear-cut preference (from our point of view) for either a positive or negative change.
2. As stated previously, in questions 2 and 8 the experiences score was subtracted from the expectations score as a good experience of a subject would be anticipated to elicit negative responses for these questions.

An IOC was calculated for each of the 32 subjects (three subjects did not complete Survey B). Of these, one subject produced a positive IOC. Thus, almost all subjects produced a negative IOC. We used t-tests to determine whether the overall measure of change between student expectations and experiences was statistically significant. 23 subjects were found to have significantly declined, with 9 subjects displaying no significant change (see Figure 4).

![Figure 4: Index of change, IOC, for 32 subjects.](image)

One of the areas of interest to the project involved determining whether the different subject model types afford different experiences to students. To this end we grouped all 35 subjects into one of the three models (1, 2A and 2B) and re-plotted the IOC data shown in Figure 4. Table 11 details the breakdown of the 35 subjects and Figure 5 shows the IOC data grouped by model.
Table 11: Categorisation of subjects conforming to models 1, 2A and 2B. The three subjects marked with an * did not complete Survey B.

<table>
<thead>
<tr>
<th>Model</th>
<th>1</th>
<th>2A</th>
<th>2B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject Numbers</td>
<td>1, 7, 14, 15, 16, 18, 24, 28*, 30, 31*, 32</td>
<td>3, 6, 8, 9, 12, 17, 20, 21, 22, 23, 25, 29, 35</td>
<td>2, 4, 5, 10, 11, 13, 19, 26, 27*, 33, 34</td>
</tr>
</tbody>
</table>

A chi-squared test indicates the probability of the observed distribution of significant IOC values in Figure 5 is 0.12, and is therefore not statistically significant. Despite the lack of statistical significance we believe that the relationship between the subject model and the IOC is sufficiently interesting to warrant further investigation.

7.5 Responses to open-ended questions

An open-ended question was included which asked students to describe any particular expectations they had (survey A) or overall experiences (survey B). The responses were sorted into a number of categories that emerged as the analysis took place. A number of open-ended responses were not able to be classified due to a variety of reasons (including being very specific, unintelligible, derogatory, silly, etc).

For Survey A, 1681 students (total n = 4414) provided open-ended responses to the question “please describe briefly any particular expectations you have as you begin your study in this subject”, which represents a response rate of 38%. The major categories the responses can be placed in were:

- want to learn, better understand physics
- think physics is difficult
- think physics is interesting, fun
- continuation, consolidation of high school physics
- want to see links to major, degree
• expectations regarding labs, experimental work
• expectations of lots of examples, practice problems, tutorials
• concerns about passing
• lots of maths, concerned
• want help to be available
• think it will benefit career

The breakdown of responses by category is shown in Figure 6. A significant proportion of incoming students appear keen to study physics. Over a quarter of all students answering this question were interested in learning and or better comprehending physics. Although one-sixth of these students feel that physics is difficult, one-tenth think physics is interesting. 6% of responses mention wanting to see links with the major and expectations concerning the laboratory work.

Figure 6: Survey A open-ended response categories.

Categories derived from the open-ended responses to survey B were:

• want more examples, practice problems, tutorials
• NEGATIVE comments concerning labs, experimental work
• think physics is too difficult
• think physics is interesting, fun
• NEGATIVE comments concerning teaching staff
• NOT a good learning experience
• a good learning experience
• POSITIVE comments concerning labs, experimental work
• NEGATIVE comments concerning links to major, degree
• POSITIVE comments concerning teaching staff
• physics was NOT interesting, fun, enjoyable
- maths involved too difficult
- need extra assistance from staff
- large (NEGATIVE) jump from high school physics
- POSITIVE comments concerning links to major, degree
- concerns about failing
- positive correlation with high school physics
- not enough maths, too easy

A higher percentage of students answered this question, with 1817 responses (total n = 3109), a response rate of 58%. The breakdown of responses by category is graphically shown in Figure 7.

The biggest request is that more examples and practice problems be given. Not surprisingly students are keen to secure all the help they can to pass the subject. The laboratory component is heavily biased towards negative comments as are the links made to the major and degree. This is now explored in more detail.

7.6 Links to major and laboratories

Survey B open-ended responses indicate that linking the subject with the major and laboratory work are issues deserving further attention. This aligns with the findings of the earlier study used to trial the questions (see section 6.2). As these are issues that were also addressed in the multiple-choice questions, we draw attention to them and bring together related student perceptions. We present (in Figure 8) revised versions of the graphs seen in section 7.5, showing the percentage of open-ended responses both issues received.
Figure 8: Percentage of open-ended responses commenting on links to major and laboratories.

Figure 9 shows a breakdown of the negative responses to the labs. The key messages are:

- improve the links between the laboratories and the lectures
- revise the laboratory notes
- review the support given in the laboratories by the demonstrators to the students
- revitalise the laboratories to make them more appealing

7.7 Well performing subjects regarding links to major

The subset of multiple-choice questions which deal with student perceptions of the relevance and value of the subject as it relates to their major and/or degree is shown in Table 12.
Survey A | Survey B
---|---
Q1 | It is apparent to me that this subject is a valuable part of my degree. | It is apparent to me that this subject is a valuable part of my degree.
Q3 | I am keen to see how this subject links to my major area of study. | There are clear links between this subject and my major area of study.
Q9 | I expect the links between this subject and my major area of study to be made obvious throughout the semester. | The lecturers succeeded in linking this subject to my major area of study.

Table 12: The subset of survey A (expectations) and survey B (experiences) questions dealing with the links between physics and the students’ major area of study.

The survey A and B responses to questions 1, 3 and 9 were summed for each subject. Using the Likert scale, if all students awarded the highest score (5) to all three questions, then that subject would have cumulative score of 15. By contrast, if all students awarded the lowest score (1) to all three questions, then that subject’s cumulative score would be 3. Figure 10 shows the score for all subjects completing surveys A and B.

Figure 10: Combined scores for questions 1, 3 and 9 for both surveys A and B for all subjects.

With a few exceptions the expectations scores were quite high, with an average value between 11 and 12. The experiences scores, however, did not match expectations for the three questions under consideration. Closer inspection indicates that some subjects (notably 5, 16 and 20) show high expectations scores which are matched by high experiences scores. Other subjects (notably 7, 10, 12 and 29) show a substantial decline from expectations to experiences scores. Although subject 7 showed a substantial decline in its mean score, there were only six responses to survey B for this subject, making any conclusions tentative at best.

We now look more closely at those subjects that underwent the least and most change. Figures 11 and 12 respectively show the frequency of the open-ended comments made by students in the least change subjects (5, 16 and 20) and those in the most change subjects (10, 12 and 29). The students in the least change subjects made only one negative comment with respect to links to the majors (out of 148 total comments), but at the same made only three positive comments. By contrast, there were 19 negative comments (out of 169 total comments) in the most change subjects and not a single student commented positively about the links. These findings from the open-ended response questions are consistent with the findings from the multiple-choice questions concerning the links (1, 3 and 9).
Figure 11: Frequency of comments made by students enrolled in subjects that showed least change between the expectations and experiences as revealed by the analysis of questions 1, 3 and 9.

Figure 12: Frequency of comments made by students enrolled in subjects that showed most change between the expectations and experiences as revealed by the analysis of questions 1, 3 and 9.
If we compare the frequency of negative comments relating to laboratory experiences, we find there is little difference between those subjects showing least change, with 14 negative comments (out of 148 total comments, equal to 9.5%), and those subjects that showed most change, which accumulated 20 negative comments (out of 169 total comments, equal to 12%). This finding points to the physics laboratory experience, for students not majoring in physics, as being an issue even in those subjects that have otherwise been viewed positively by students in the way in which the subject related physics to their major area of study.

7.8 Acting on results: the academics’ perspective

To bring substance and specificity to the consideration of the features of service subjects that succeeded in marrying high experience scores with high expectations scores, we asked the co-ordinators of subjects 5, 16 and 20 (who we now identify) to give an overview of each of their subjects. We also requested they reflect on what facets of the subject may have facilitated the positive student response. We present below unedited versions of their reflections which also contain details of subject content, descriptions of the student cohort and assessment information.

Physics for Medical Radiation (University of South Australia) – MODEL 2B subject

Co-ordinator - Nick Mermelengas

Introduction
Medical radiation technologists have been trained at the University of South Australia and its predecessors, since the 1970s. A new four year Bachelor of Medical Radiation Science began this year with streams in Medical Imaging, Nuclear Medicine and Radiation Therapy. The new program includes four “Physics for Medical Radiation” courses, two each in the first and second years.

Unit content
The two first-year, algebra-based courses, were specifically designed to introduce the physics knowledge and understanding required by radiation technologists. The content includes basic mechanics, electricity and magnetism, atomic physics, electronics, the physics of medical imaging and radiation therapy. The courses are presented as follows: two lectures and one tutorial session per week plus one two-hour laboratory session per fortnight. The first semester laboratory sessions cover electrical basics and radioactivity and the second semester sessions cover the physics of X-rays.

Assessment
Assessment consists of six fortnightly quizzes worth 20%, six fortnightly laboratory reports worth 20% and a final examination worth 60%. A weekly set of exercises, consisting of formative conceptual questions and numerical problems, is discussed in the tutorials.

Student cohort
The Tertiary Entrance Rank for the Bachelor of Medical Radiation Science was in the mid-nineties. Physics is not listed as either a prerequisite or as assumed knowledge. Consequently, of the 89 students enrolled, only 29% had completed year 12 physics. In general terms, the student cohort is a highly motivated and high-achieving group with an impressive work ethic. Despite many students expressing a concern about their lack of physics background, the final results in semester one were excellent with an average mark of 76%.

Results of the survey
The students enrolled in “Physics for Medical Radiation 1” completed a survey at the beginning (Expectations) and end (Experiences) of semester one, as part of the Service Teaching strand of the project “Forging New Directions in Physics Education in Australian Universities”. On the basis of
these surveys, the course was ranked in the top three out of 35 in the area of the relevance and links between physics and the students’ major area of study.

Comments and conclusion
The primary reason this course was ranked highly by the students themselves, I believe, is the fact that the course was deliberately designed from the beginning to provide the physics knowledge required by radiation technologists. A typical student comment was: “information taught related directly to our profession, similarly the practicals”. Other reasons include a simple and well-organised course structure and assessment structure: “having quizzes every two weeks meant we were able to stay on top of our workload”, as well as the use of an excellent textbook (Physics of Radiology by A. B. Wolharst). Finally, the nature of the student group itself was an important factor. In general, they are an intelligent, hard-working and pleasant group of people and they were a pleasure to teach. On a lighter note, I was amused to read the following student comment “Nick is wicked!” However, shortly after, I came across the following comment: “Our prac teacher, Richard, is awesome”. The question arises; does “wicked” or “awesome” win bragging rights?

Physics and Materials (University of Western Sydney) – MODEL 2A subject

Co-ordinator - Ragbir Bhathal

Introduction
Physics & Materials is a first year unit for engineering students at the University of Western Sydney (UWS). It is taught only in the first semester in the first year of a four year engineering degree. It is a compulsory unit for all students studying various engineering disciplines (electrical, civil, telecommunications, environmental, computer, robotics and mechatronics) at UWS. It is also a requirement by Engineers Australia that the students do at least one semester of physics in their engineering course. Physics is seen as a fundamental subject for engineering studies.

Engineering applications
Unlike pure physics students who are usually satisfied with "physics for physics sake" phenomena and explanations, I find that engineering students want to know the practical engineering applications of physics that is taught to them. They also need to be convinced of the relevance of physics to their engineering studies. This is quite different to the attitude of physics majors who are studying physics. Hence, at various and appropriate points in the lectures it is essential to provide the students examples of how the principles and theories of physics which they are taught in the lectures are used in real life engineering situations. For example, when we are studying the mathematical formulation of waves and wave phenomena students are informed how the study of waves has applications in the building of bridges, and the acoustics of concert halls. They are also given illustrations of how the wave equation is used in the study of the properties and propagation of electromagnetic waves, how wave phenomena are used in telecommunications, the construction of telescopes and the study of the atomic structure of matter. A practical on standing waves is used to illustrate the nature and properties of waves and wave phenomena. The students find the visual representation of the mathematical formulation of waves in the practical exercise extremely useful for their understanding of the nature and properties of waves.

Historical aspects
In the course of delivering the lectures I also briefly discuss at appropriate points in the lectures the historical aspects of the development of concepts and theories in physics. This gives students an insight into how creative physicists and engineers formulate and arrive at concepts and theories to understand a phenomenon or solve a technical problem. I also provide snippets of some of the interesting aspects of the lives and personalities of physicists, such as Galileo and the Inquisition, Newton's apple and the discovery of the laws of motion, the Bernouli family and fluid mechanics,
etc. Students appreciate these little bits of information and these asides enhance and make the lecture much more interesting and lively. I have also found that a little bit of humour helps to liven up the lecture and gets students attention.

**Practicals**

In general, the reasons for doing the practicals in the first year engineering physics unit can be grouped under three broad headings: cognitive (improving students' understanding of physics and testing whether the theory works), affective (practicals are interesting and exciting and help promote positive attitudes towards physics and engineering) and skills (developing skills to manipulate equipment, observing and measuring; learning processes such as predicting, inferring and evaluating; working as a member of a team and understanding of scientific enquiry). The practicals have been found to be useful tools for reinforcing the understanding of the concepts and theories which are taught in the lectures. They have also provided the students with the skills of planning and executing the experiment to obtain measurements and observations with which they can test the predictions from the theories. In the process they learn the scientific method, one of the most powerful means of validating the theoretical foundations of physics.

**Learning outcomes**

At the completion of this unit, it is expected that students will be able to:

- Explain the basic principles of physics and their applications in engineering.
- Analyse and solve numerical problems relating to physical systems.
- Plan, conduct and document experiments performed in the laboratory.
- Interpret the results of experiments against the theory including the estimation of experimental uncertainties and carry out dimensional analysis.

**Unit content**

The unit is calculus based and students are expected to have done at least HSC mathematics with calculus. The topics include units and dimensional analysis, linear, circular and rotational motion, applications of Newton's laws, conservation laws, wave phenomena, electricity and magnetism, atomic and nuclear structure, geometrical and physical optics, molecular structure and condensed matter, thermal properties of matter, fluid mechanics, degradation and sustainability of materials. Degradation and sustainability of materials has been added to the unit syllabus at the request of Engineers Australia. The unit is presented as follows: three one hour lectures and one one hour tutorial per week, one two hour practical per fortnight. In addition to the above students can access on a weekly basis a set of on-line tutorial problems for further practice. The textbook for this unit is University Physics by Young, H. D. and Freedman, R. A.

**Assessment**

Assessment consists of a mid-year class test worth 20%, five fortnightly laboratory reports worth 10%, a practical examination worth 10% and a final examination worth 60%. A weekly set of numerical problems based on the lectures for the week are discussed in tutorial classes. These are not assessable but are used to discuss difficulties students are having trying to solve the problems. It gives the students an opportunity to get face to face assistance which they find extremely useful. Students are also given problems which they can do on-line for further practice. They use the MasteringPhysics online tutorial and assessment system. They get immediate feedback from the computer software. Students find this computer based on-line tutorial system useful for enhancing their understanding of the unit content and also for revision purposes.

**Results of the survey**

The students enrolled in the Physics & Materials unit completed a pre (Expectations) at the beginning of the semester and a post (Experiences) at the end of the semester survey as part of the Service Teaching Strand of the ALTC/Carrick Project, Forging New Directions in Physics Education in Australian Universities. 35 units were submitted by 22 universities for the survey. On the basis of
these surveys, the unit Physics & Materials was ranked in the top 3 out of 35 units in the area of relevance and links between physics and the students' major area of study. The three top units were from UWS, Flinders University and South Australia University.

The survey showed that:
(a) the students found the unit to be a valuable part of their degree ($\Delta BA = -0.09$)
(b) the students were able to see clear links between what was taught in the unit to their major area of study ($\Delta BA = -0.06$)
(c) the students felt that the lecturer succeeded in linking the material taught in the unit to their major area of study ($\Delta BA = -0.04$)

Comments and conclusion
The main reason for the good performance of the unit Physics & Materials in the survey I believe was that the unit was designed to illustrate how the principles and theories of physics have practical applications in the areas of engineering studies that the students were studying. In short, the students could see the relevance of physics in engineering. I also believe that the brief asides on interesting aspects of the lives of physicists and engineers and the historical aspects of the development of theories and concepts both enlivened and stimulated an interest in physics and engineering. The tutorials and hands-on physics practicals which illustrated the material covered in the lectures also assisted the students in understanding and appreciating the theoretical foundations of physics and their applications in engineering. It is also interesting to note that the yearly Student Feedback on the Unit (SFU) surveys conducted by the University of Western Sydney have always returned high ratings for this unit. The independent ALTC/Carrick survey validates the conclusions of the UWS Student Feedback on the Unit surveys for this unit. In conclusion, I must say that the students we taught were highly motivated individuals who had decided in their high school days to become engineers and builders of the nation. One of the most exciting things I found in teaching them was the great diversity of their cultural backgrounds, views of the world and value systems. They represent the face of modern Australia in the 21st century.

Physics 1A / Physics 1A (extended) (Flinders University) – MODEL 1 subject

Co-ordinator - Jamie Quinton

Fostering Students’ Love of Physics
Are you worried about Physics major student numbers? There is no doubt that we are all concerned with the ongoing decline in Physics across Australia. When I arrived at Flinders University in 2003 the first year Physics program was quite ‘old’ and ‘stale.’ Through declining staff numbers during the 1990s, the material taught at first year level had been whittled down to the ‘essential' content that needed to be covered for students who planned on progressing to second year Physics. Revision of the efficacy of the laboratory course had not occurred for several years and the equipment was... well... let's just say rustic. Most notably, there was an apparent lack of focus on the student experience (which I felt was the crucial driver for maximising experience, retention, and if not these, then at least the overall perception of the relevance of Physics). Rather, the focus appeared to be on the content that was covered. At the time, it was observed (and have continued to do so over some years now) that many science academics expect that if a student accumulates a specific collection of facts, the process through which they acquire them provides all of the training they will need. Indeed, to make a contentious sweeping generalisation, this seems to be quite a prevalent ethos in Physics. I found teaching into Physics 1A at that time to be quite demoralising and resolved to promptly improve the situation. With student retention as a primary objective and a focus on their positive learning experience as a route to success, the entire 1st year program was revised in 2005 from the ground up (with the exception of the constraint that we deliver three lectures and one tutorial each week, and one laboratory each fortnight). I would like to relate some key aspects of our first year topic, which has contributed to a tripling of the rate of retention in Physics at Flinders.
Structure and Content

The 1st semester topic (at Flinders, 'subjects' are called 'topics') Physics 1A contains Cosmology, Classical Mechanics, Waves and Oscillations, Sound and Light and Special Relativity. The topic has remained calculus-based and is undertaken by students who tend to major in Physics within the BSc course or another enabling Science such as Mathematics, Chemistry, or Nanotechnology (the extended version of the topic is taken by students in the Enhanced Program for High Achievers who elect to do it). Enrolment is typically ~60 students (with typical TER >70) in Physics 1A and ~8 students in Physics 1A (extended, with typical TER >90). The topic is assessed in the following manner: Competency tests (3 of these spread over semester, worth 0%, but must be successfully completed before the student is allowed to sit the final exam), 1 take home assignment each week (taken from assigned tutorial questions, worth 10%), online (fortnightly) quizzes (10%), practical reports (x6, worth 30%), and the final exam (worth 50%, but the students must pass it as a requirement for successful completion of the topic).

Maintaining student engagement

The topic is designed to foster student engagement. The content is placed in a deliberate order to start and end with content that is less familiar (and thus hopefully not repetitive from year 12) to the student, and is interesting, or better yet - captivates the students. Starting with cosmology makes a strong positive first impression, and provides a vehicle for the linking of concepts from the more traditional, 'essential' content later as they are covered). In addition, the laboratory course has been redesigned to maximise the experience of the students, and most importantly, follows the thematic areas of the lectures as closely as possible. The competency tests occur in weeks 3, 7 and 11 of semester, and students must achieve a minimum score of 70% in each and all tests in order to be allowed to sit the final examination. Where a student does not achieve that score, they are supported through extra tutorial sessions and re-sits once each week to successfully complete the requirement. The majority of students complete these tests without great difficulty, as the questions are set at an elementary level and are worth a zero or a full mark, with the idea being “this is the minimum knowledge that must be attained in 1st year”. In combination with the weekly assignment tutorial question that is marked and feedback provided, these maintain student engagement with the material throughout the semester. In addition to the formal topic structure, in 2008 we also ran a Transition to University Physics activity during Orientation Week that allowed the Physics 1 students to meet each other, their lecturers and tutor, and higher year students. Through a series of fun activities, the students feel comfortable with each other and their teachers before going to their first lecture. This reduction in student anxiety, in my opinion, increased the impact of the first set of lectures.

Survey Responses and Analysis

This topic scored very well in questions 1, 3 and 9 of the expectations and experiences surveys of the ALTC project, in particular on questions 1, 3, and 9, which were, namely

- It is apparent to me that this subject is a valuable part of my degree.
- I am keen to see how this subject links to my major area of study.
- I expect the links between this subject and my major area of study to be made obvious throughout the semester.

Being a topic for Physics majors, any Physics 1A topic (you would think) would not need to work too hard to get good scores on these questions, as it is relatively easy to provide relevance of Physics content to a Physics major. However, I believe that the key influence that turns good scores into very good scores is the student experience that we provide.

Some student responses included (Expectations: “I expect to become a lot more competent in real life situations after this! School never gave me that!” “I expect to be able to learn and apply physics in a practical sense, not just learn theory.” “I expect this subject to help round out my understanding of biology, looking at it in new ways.”) and (Experiences: “It has been highly enjoyable. Physics is awesome man!” “Overall, Physics 1A was a positive learning experience. Labs helped me get a better understanding of the topic.” “Very relevant, information that was presented was applicable to daily
life.” “With what I have experienced for this topic I truly enjoyed lectures. Most of the time they were entertaining.” Of course, you will never be able to please everybody. Consider these! “Although pracs may be improved, more fun needed. i.e. blow up stuff!” “Include more interesting topics like superstring theory, Hold screening of good documentaries.” It is pleasing that our students had a quite positive experience, but there is still room for improvement (I’d prefer that the student experience exceeds their expectations). Finally, I’d like to ask some thought-provoking questions. We are all passionate about Physics - that is of course why we are Physicists. How do you share that passion with your students? Do you feel that you create the optimal learning environment in your classes? In that environment, what is it that you do to ensure its efficacy? How do you reach your students? Do you attempt to teach them from inside their comfort zone, or do you try to make them come into yours?

7.9 Features of academics’ reflections

A theme that emerges from the co-ordinators’ comments is the passion with which they have developed their subjects. Student engagement is given high priority: “Fun activities”, “applications [of physics] to the building of bridges” and “a subject deliberately designed to provide the physics knowledge required by radiation technologist” were cited as factors that promoted engagement.

Examples abound in Ragbir Bhathal’s account of where the physics related to engineering were deliberately included to emphasise to students the relevance of physics to their engineering studies. Nick Mermelengas also emphasised the importance of relevance and also characterised many of students as highly motivated and high achievers. Student comments included by Jamie Quinton in his piece, such as “information that was presented was applicable to daily life”, indicate that students appreciated the lengths taken to emphasise the utility of the physics taught.

Regular tests were credited by Jamie Quinton as important in maintaining student engagement and it is notable that Nick Mermelengas also incorporated several short quizzes, which were valued by students as they allowed them to “stay on top of our workload”.

Underpinning the approaches adopted in the design and delivery of their subjects was the positive attitude of the academics towards their students and a commitment to continuous subject development: “it is pleasing that our students had a quite positive experience, but there is still room for improvement” (JQ), “…they were a pleasure to teach” (NM) and “one of the exciting things I found in teaching them was the great diversity of their cultural backgrounds” (RB).

7.10 Value of the surveys

A brief survey was sent to the academics who administered the surveys to gauge their opinion of the value of the surveys. The four questions they were asked were as follows:

1) Have the results from the expectations/experiences surveys that you received for your subject(s) been of value to you? If so, can you say briefly in what way(s)?
2) Are there additions/modifications that you would suggest to the surveys to make them more useful?
3) Was there anything surprising in the student survey responses?
4) (Assuming you are required to carry out a student survey at the end of the semester.) Do you think the A/B surveys are of more value than your ‘standard’ end of semester survey? If so, in what way(s) are they superior?

There was general consensus that the expectations surveys had been valued (question 1) and indeed in some cases the findings had been acted upon promptly:
“The results were of great value for me, especially where the changes in perception of certain aspects were statistically significant.” And from the same academic: “Based on these data, I've modified the teaching strategy in the second semester. As a result, the preliminary student feedback was very positive, and their understanding of the subject and its main concepts has improved significantly compared to the same semester in 2007.”

Other academics responding to question 1 wrote:

“Of definite value, yes! We have used them to inform our practices of assessment and topic delivery.”

“Yes, the results have been valuable in identifying aspects which we can improve, and also aspects which we probably can't change but can explain better to the students.”

With respect to possible modifications to the questions (responding to question 2), some were unsure and one made the point:

“I thought they were reasonably comprehensive while remaining focused on expectations and experience. My concern would be that if more questions were added, it would dilute the overall quality of the survey. I believe that you will get the most well-thought out responses from the fewest possible number of questions.”

Academics did admit that surprises were contained within the survey responses (question 3):

From one academic: “Labs are not seen as a positive and valuable experience and in [the expectations survey], more students would advise others not to take physics.”

Another academic also remarked on comments made by students about labs:

“It was interesting to note that we still need to work on our lab experience for the students (given that they were redesigned a few years ago). It further suggests that the lab experience dominates the students’ perceived experience.”

When comparing the expectations/experience surveys with their usual end of semester surveys (question 4), the consensus was that each survey was focusing on something different, such that they were regarded as complementary, rather than competing surveys.

“I cannot compare the value of expectations/experiences surveys with our standard survey on the same scale. To me, they all are very valuable (maybe because I am a new academic, so any feedback is important), but in different ways - like apples and oranges.”

Another academic remarked:

“These surveys are more valuable because they provide information relating to the 'service' nature of the course which is not captured in the standard Student Evaluation survey …The before/after aspects of these surveys are not captured in the end-of-semester survey.”

And finally:

“I believe that they certainly complement the existing student evaluation (SET) process. However, the ALTC project surveys provided a better measure of the holistic student experience, as these were explicitly measured against the students own expectations, rather than against a generalised perception (which occurs with open-ended questions in SET). SET questions deal with bottom-up (specific details), rather than the overall experience (which these surveys did), in general.”
7.11 Discussion

For the questions analysed so far in surveys A and B there is some indication in the data, though not conclusive, that the type of model 1, 2A or 2B in which students are enrolled has an influence on student views of the subject (see Figure 5). This issue requires further exploration. The finding that the mean survey B scores for the questions relating to links (Q1, 3 and 9) is less than the mean scores for the corresponding question in survey A is consistent with that found in the pilot study of 2007. Question 9 in particular, with the shift of the mean score from something approaching 4 in survey A to a mean score of 3 in survey B may be of concern, especially for model 2B subjects, as this points to a lack of success in linking the subject to area in which students are majoring.

The laboratory based question showed that student experiences did not match their expectations, irrespective of the type of subject they were enrolled in, and this is strongly reinforced by the responses to the open-ended questions. More detailed analysis of the open-ended responses concerning labs is called for, including whether there is any relationship between the type of subject and the frequency of negative comments. This work also points to a need to look more specifically at the physics laboratory experience of students who are not majoring in physics, in order to establish which laboratory related issues, such as the relevance, resourcing, or links to lectures, are most highly regarded by students.

8. Final comments and reflections

We believe that this study into identifying, promoting and disseminating good practice in service teaching has been extremely valuable and has offered evidence instead of anecdote with regard to student expectations and experiences of a physics service subject. Did we learn anything that we couldn’t have guessed before we began this project? We guessed that there would be a relationship between the extent links were made between a student’s intended major and the student’s experience of the subject, and this was supported by this study. What did surprise us was the extent to which physics laboratories in service subjects are regarded almost uniformly poorly across many institutions. We conjecture that while subjects might have done well in linking the physics to the major with respect to content, the same special effort may not have been put into designing a laboratory experience for students in service subjects that similarly links physics to the major area of study. This project is not able to answer this question, nor whether such a special effort would make a difference. We guess that it would, but addressing this question must be a focus of another project.

The results presented in this report represent a subset of what can be derived from the survey data collected. We believe that a thorough consideration of responses to the questions in Table 6 will offer further insights into student perceptions of the value of the service subject to their immediate and future needs.

Acknowledgements

We acknowledge the large number of physics academics across Australia who administered and collated the surveys reported here. We also acknowledge the excellent support provided by Mr Antoine Goarin (and his staff) of the Planning and Quality Unit at UTS. Support for this work has been provided by the Australian Learning and Teaching Council, an initiative of the Australian Government Department of Education, Employment and Workplace Relations.
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