One Semester Of Physics: What Difference Does It Make To Non-Physics Majors?

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Abstract
How does a semester of physics impact on students who will go on to major in disciplines other than physics, and to what extent do their experiences depend, if at all, on whether the subject has been designed specifically for non-physics majors? In this national study, supported by funding from the Australian Learning and Teaching Council (ALTC), we have surveyed students about their expectations and experiences in 35 subjects taught to non-physics majors from 22 Australian universities. Over 7000 completed surveys were returned for analysis. The surveys were carried out at the beginning and end of one semester and sought student views on matters including whether they expected links to be made between the physics subject and their major area of study, and whether they found the laboratories a positive learning experience. Here we report preliminary qualitative and quantitative findings from this study which suggests that student experiences of the subject cannot be related directly to whether the subject has been specifically designed for non-physics majors. The laboratory experience of non-physics majors is revealed as a matter deserving of attention, as 15% of all comments made to an open-ended question referred negatively to the laboratory experience compared to 4% describing positive experiences.

Introduction
This work is part of a project funded by the ALTC under the Discipline Based Initiatives program. The project Forging New Directions in Physics Education at Australian Universities is national in scope and brings together physics academics from 26 universities. A strand of the project aims to clarify, identify and promote good practice in physics service teaching (Kirkup et al. 2007) and is the focus of this paper.

There are several reasons for considering the support that physics provides to other disciplines. For example, trends prevalent in some disciplines (such as the biological sciences) towards a greater reliance on quantitative methods of the type promoted by physicists (Bialek and Botstein, 2004) may be a catalyst for curriculum development in physics subjects designed for non-physics majors. It is also important to recognise the need to support those going on to teach physics in high school but who are likely to take only one semester of physics at university (Harris et al. 2005). Such ‘non-specialists’ are ambassadors for physics in schools, with a key role in increasing the awareness of the contribution of physics to society. Experiences of physics at university will shape their attitudes towards physics and, by natural extension, those of the students that they teach. Dissatisfaction with physics subjects taught to non-physics majors can be traced back many decades (Caswell, 1934). As an example of early concerns, Havighurst (1933) reported:

Our elementary physics courses, with few exceptions, do not meet the need of the student who wants to get from his study a contribution to his general education. There is no doubt that our loss of students is partly due to our failure to give them what they need.

In 2007 we devised two complementary surveys in order to seek the views of students, most of whom were not destined to major in physics, on their expectations and experiences of the first year physics subject in which they were enrolled. The surveys were trialled at a large Australian metropolitan university in spring semester 2007 to assist in refining the questions, as well as giving clues to matters of most concern at a local level, but that may also have validity on a national scale. The study found that student experiences of the value of the physics subject to their degrees did not change significantly over the course of the semester but that their expectations that links would be made between the physics and their major were not matched by their experiences. Details of the results of the trial are published elsewhere (Kirkup at al. 2008). A matter of concern that did emerge from the 2007 study relates to the provision of laboratory-based experiences. On entering the subject, students were neutral or slightly positively disposed towards the prospect of working in a physics laboratory. By the end of the semester, student responses, both quantitative and those expressed through feedback to an open-ended question, pointed towards a less than positive laboratory experience. As part of this project we are keen to establish whether the findings of the survey administered to non-physics majors at many universities are consistent with those of the preliminary survey.
Methodology

Surveys
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. A subset of the questions appearing in the survey, which relates to student perceptions of the relevance and value of the subject, as well as their laboratory expectations/experiences, is shown in Table 1. 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 survey questions.

Table 1: A subset of survey A (expectations) and survey B (experiences) questions. Question 1 is identical in both surveys. The other questions show clear expectations/experiences links. A full list of questions can be found in Kirkup et al. (2008).

<table>
<thead>
<tr>
<th>Survey A</th>
<th>Survey B</th>
</tr>
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<tbody>
<tr>
<td>Q1 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>Q3 I am keen to see how this subject links to my major area of study.</td>
<td>There are clear links between this subject and my major area of study.</td>
</tr>
<tr>
<td>Q7 I am looking forward to doing labs in this subject. The labs in this subject were a positive learning experience.</td>
<td>The labs in this subject were a positive learning experience.</td>
</tr>
<tr>
<td>Q9 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>
</tbody>
</table>

An open-ended question, asking students to describe any particular expectations they might have (survey A) or experiences of the subject (survey B) was included in the surveys.

In total, over 4400 responses to survey A were returned and over 3000 to survey B. The subjects surveyed were categorised in order to reveal the relationship, if any, between the type of subject and the student expectations/experiences of that subject. Three types of subject have been identified previously which are designated as model 1, 2A and 2B (Kirkup et al. 2007). In model 1 subjects, physics majors and non-physics majors are taught together. These subjects, which are generally calculus-based, are prerequisites for later stage physics subjects. Model 2A subjects only enrol non-physics majors and are quite conventional first year physics subjects, but are predominantly algebra-based with no obvious orientation towards other disciplines, such as engineering or the biosciences. Model 2B subjects again contain only non-physics majors but have an intentional, deliberate or overt orientation towards a particular clientele, be they majoring in (as examples) engineering, bioscience, or sports science. We conjectured that 2B subjects, which were specifically designed for non-physics majors in mind, would attract more positive responses to questions 1, 3 and 9 than models 1 and 2A, those subjects that were less deliberately oriented to the major. Based on information supplied by subject coordinators or subject details available online, 11 subjects were categorised as model 1, 13 subjects as model 2A and 11 subjects as model 2B. The subject surveyed in the 2007 study was categorised as a model 2B subject.

Recruitment of subjects
The subjects surveyed were originally chosen in consultation with the project team’s contact person at each of the participating physics departments. The 22 departments involved encompassed a representative cross-section of Australian universities with an extensive geographic spread: six from New South Wales, four each from Victoria and Western Australia, three each from Queensland and South Australia and two from the ACT. Some subjects chosen, like the one used in the 2007 trial, were only populated by non-physics majors, whilst others had a mixture of non- and possible- physics majors. The contact person at each department was responsible for the administration of the surveys. In order to make the analysis processes more efficient, the surveys were formatted to allow for digital scanning.

Results
Data have been categorised in Fig. 1 in order to reveal relationships between expectations and experiences that may be related to whether the subject being studied is classified as model 1, 2A or 2B.
Links with Major
Irrespective of whether the subject surveyed satisfied the requirements to be categorised as model 1, 2A or 2B, the responses to Q1 indicate that by the end of the semester it has become less apparent to students that the subject is a valuable part of the degree compared to the beginning of the semester. Similar shifts are discovered for other questions related to links between the major and physics (i.e. Q3 and Q9).

Figure 1: Means of expectations and experiences responses to Q1, 3, 7 and 9, categorised by type of subject.

With regard to the open-ended question in survey A, Fig. 2 shows that 5% of all responses reveal that students expect links to be made to their major, for example: “I expect that the Physics will be applicable to Aviation.”

Figure 2: Percentage of open-ended responses commenting on laboratories and links to major.

In survey B, 5% of open-ended responses also mentioned links to major, though only 1% made positive comments: “… useful for both my life and my subject” and 4% negative: “[you should] try to relate this subject back to relevant areas of Engineering.”

Laboratory expectations/experiences
Figure 1 shows the mean scores of the laboratory related question (Q7) in Survey A and B categorised by the type of subject. As with relating to links, the mean score show a definite shift from moderately positive scores (of about 3.4 to 3.8) to scores which are less positive (about 3.2 to 3.5), irrespective of whether students are enrolled in
model 1, 2A or 2B type subjects. Concern about laboratory experiences is further reinforced by student responses to the open-ended questions. In survey A, 6% of responses mentioned the laboratories: “[I expect you to] explain the experiment before we start the laboratory.” By contrast, Figure 2 shows that for survey B 19% of total responses related to the laboratory experiences, with 4% of comments positive: “labs provided opportunities to repeat topics learnt and deepen our understanding” and 15% negative: “more hands on, smaller groups in labs”, “labs are not helping in the overall understanding of [the subject]”, “labs were soul-numbingly bad.”

Discussion

For the questions analysed so far in surveys A and B there is little indication in the data that the type of model 1, 2A or 2B in which students are enrolled has an dominant influence on students views of the subject. The finding that the mean survey B score for the questions relating to links (Q1, 3 and 9) is less than the mean score 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 surveys of subjects that have scored well on Q1, 3 and 9 are being examined in more detail to probe which factors have resulted in above average scores.

The laboratory based question also 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 open-ended responses on 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 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.

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