Reflections on context-based science teaching: a case study of physics for students of physiotherapy

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Abstract: *Secondary Science teaching around Australia has been undergoing radical changes over the past decade. As most states move towards a context-based secondary syllabus, there is a danger that tertiary science teaching will be left behind. I will report on an ongoing project to contextualise a first-year physics course for students of physiotherapy, experiences in implementing changes, and outcomes for both students and staff.*

Although there are drawbacks to contextual teaching in the tertiary environment (such as lack of preparation time, the breadth of physics concepts covered, and stretching the boundaries of one's own understanding as a teacher), the benefits for students' interest and motivation, as well as their learning outcomes are significant. Based on data from informal student feedback, assessment performance, and standard closed question course surveys, I will show that physics based in the context of physiotherapy challenges students to develop an understanding of the relationship between physics and their profession, and allows the scope to analyse real problems involving treatment modalities at a deeper level than traditional approaches. The focus on thinking and critical analysis means a reduced emphasis on definitional and mathematical rigour, but allows students with and without background in physics and mathematics to be challenged to learn at a deep level.

Introduction

Over the last decade, the syllabi for high school physics around Australia have been evolving from an approach based around set conceptual content to one in which the concepts are taught using a contextual approach. The advantages of contextual teaching are that students can link physics to their lives in the 'real world', and are usually more motivated. Whitelegg and Parry (1999) discuss the advantages of teaching physics in context, both by applying previous knowledge to real life situations, and by initially learning physics through analysing these situations. Although the latter option has obvious advantages for student perceptions of the relevance of a course, it is pointed out that there is an inherent danger that students will be unable to generalise their knowledge outside the context in which it was initially learned. A new syllabus with this second approach is currently undergoing trial in Queensland (Queensland Studies Authority 2004). This has a similar philosophical basis to syllabi successfully introduced in Victoria (Lye, Fry and Hart 2001), New South Wales (Binnie 2004), and other states, but allows greater flexibility for teachers in choosing contexts, and mandates that core concepts (e.g., momentum) be covered in a number of differing contexts to assist students to appreciate that general principals are transferable between contexts.

Given that contextual teaching of physics is seen as advantageous at the high school level, especially for capturing student interest and, potentially, increasing enrolment (Binnie 2004), it seems reasonable to consider the value of context-based teaching at tertiary level. There has been some research at universities into the effect of embedding traditional physics problems into a context on student perception and performance (Park and Lee 2004). However there has been little, if any, work on teaching physics through contexts in the tertiary setting. Here, I will report on an ongoing project that aims to do this.

The risks of moving a course in one step, from a traditional non-contextual approach to a fully contextualised approach are high, so over the past four years, I have progressively implemented changes to a first-level physics service course for physiotherapy students. There are between 100 and 120 students each year, only about half of whom have completed secondary physics, or an introductory tertiary physic course. A large proportion of the others (about 30% of the entire class) have little confidence with mathematics. Aside from assessment, the course learning activities consist of one two-hour lecture and a one-hour tutorial each week. As a separate part of the course, students receive lectures and practical experience relating to clinical applications of many treatment modalities.

The initial emphasis was on fully contextualising the assessment regime, then moving towards contextualised tutorials and lectures in the following years. The rationale for choosing assessment as the initial focus is that, if students find the work they are required to do links into their field of interest, they will engage with the material at a deeper level, instead of merely memorising what is required. This process of deeper conceptual learning must be re-enforced by appropriate forms of assessment so that 'constructive alignment' (Biggs 1999) is achieved within the course. Changing the assessment regime necessitated some changes to other learning activities, in particular, small tutorial assignments had to be marked each week to encourage continuous learning for students. This continual assessment (Gibbs 1999) is essential in allowing students to develop the ability to analyse physiotherapy treatments in terms of the underlying physics. In designing the assessment items, it was important to use those that 'elicit qualities of the type being sought' (Rowntree 1987) as well as avoiding those whose sole purpose is grading. A final piece of sage advice which should be heeded by all physics educators, is that although different assessors may not agree on the worth of a student's work, one should 'resist, nevertheless the temptation to concentrate on qualities and abilities that are more routinely measurable and less likely to provoke disagreement among assessors' (Rowntree 1987), since these are likely to be less influential in the student's development.

In an attempt to meet all of these aims (Rayner 2002), I introduced two major assignments, in which students are required to analyse situations from physiotherapy using physics. In answering these, students are expected to demonstrate understanding of physics concepts, and how these can be used to explain a treatment. The weekly tutorial assignments were designed to assist this process through the analysis of smaller, more defined situations with support from tutors. A small examination component was used to check that students had learned the analytical process. Over the three years since this initial change in assessment, I have sequentially changed the tutorial format to be more directed to qualitative description of physics concepts in physiotherapy treatments, the lectures have been re-designed to give an overview of the physiotherapy modality and the underlying physics concepts before teaching the physics in detail, and finally individual assignments were replaced with group work, to encourage constructivist learning approaches. This year, I will attempt to fully contextualise lectures. The aim will be to take the physiotherapy treatment (e.g., ultrasound), as a point of departure from which the underlying physics concepts can be analysed. This approach should complete the move to challenging students to develop an understanding of the relationship between physics and their profession, and allow them sufficient scope to analyse real problems involving treatment modalities at a deeper level than before.

Outcomes

The effects of the contextual changes to the course on student learning have been evaluated by surveying their educational background and how they describe core concepts before they enter the course, informal written feedback received throughout the course, guided feedback questionnaires at certain points in the course, assessment outcomes, and University of Queensland centralised formal course/teaching evaluations. The data from centralised evaluations are shown in the table below. Results are the average of responses on a 5 point Likert scale. For comparison, evaluations of my teaching in a more traditional course, as well as the range from lower to upper quartile averages for 'first-level science/mathematics courses of 100 students or more' are also given.

Group	**PHYS1160 2001**	**PHYS1160 2002**	**PHYS1160 2003**	**PHYS1002 2002**	**Mid Quartiles**
Emphasise thinking over memorising	4.20	4.61	4.35	3.98	3.70 - 4.16
Learning skills improved	3.60	3.88	3.52	3.38	3.25 – 3.74
Overall rating of teaching	4.30	4.61	4.19	3.86	3.77 – 4.28

The feedback, both informally, and via questionnaires has been very positive regarding relevance and the value of what students learn (e.g., ‘As for the assessment - excellent! I like the questions because I think I am actually going to learn something. I think you’ve done a great job in making it relevant.’). They have particularly appreciated the assessment, but have been critical of any non-contextual material presented in lectures. Some students with a high school physics background resent the fact that they need to ‘think’ and explain their reasoning to complete the assessment items, rather than ‘formula fit’. Interestingly, there seems to be very little link between achievement in this course and prior study of physics. Generally, even those with a physics background cannot describe central concepts at the start of the course. No attempt has been made to directly test their ability to do so at the end of the course, but their use of terminology, and description of inter-relationships in their assignment responses indicate that the majority of students have developed a clear understanding. Most also demonstrate significant insights into the physiotherapy treatments analysed, with assignment marks generally being above 80%. However, under the stresses of examination conditions, the average result drops to around 60%, with only a few students achieving at a high standard.

Implementing contextual physics has been a challenge, and is quite time-consuming. However, it is a thought provoking process, involving continuing learning on the part of the teaching staff, and hence can lead to greater motivation for staff with an intrinsic interest in teaching. It can be difficult to find sufficient tutoring staff with the necessary confidence in their own ability to guide discussions, and interact with students. Authentic contextualisation was also very difficult, and required that I visit a number of practising physiotherapists to learn about treatments in detail. I also feel that passing responsibility for this course to another staff member is not as easy as for a traditional ‘content-based’ course, since teaching in this way requires an understanding of both the underlying educational philosophy, and some of the intricacies of physiotherapy practice. Availability of staff is also crucial, since this form of constructivist teaching requires constant interaction between staff and students. In 2003, I was absent for a two-week period during semester, and this lead to reduced learning outcomes (see survey scores at the beginning of this section).

Although this contextual approach has been very successful in this course for physiotherapy students, broadening its application to more general courses could be more complex. Contexts would need to be carefully chosen to interest students, and concepts covered in multiple contexts to encourage students to generalise - this is not really an issue in the current course, since physiotherapists only need to understand physics in their work context. One other effect of contextualising courses is that if students believe the course to be much more relevant, then they may have more negative opinions about other courses they are taking simultaneously. As an example, a number of the students in my 2002 class had strong complaints about their anatomy course and one of the two physiotherapy courses, whereas before 2001, almost all student complaints were about the physics course.

Conclusion

The introduction of contextual physics to the course for physiotherapy students has been very successful, both in terms of students’ perceptions of the course, and also in the depth and relevance of learning outcomes. The level of motivation, and students’ satisfaction with their achievement are also high. Although the physics is learned in a very specific context, some students have developed sufficient interest to apply some ideas to their everyday life. While this outcome only occurs for a small number of students, it is encouraging, and suggests that the approach could be applied to more general courses in the sciences, so long as each core concept is covered in multiple contexts, and the process of generalising from the specific examples is explicitly required (e.g., by setting assignments on different contexts from those taught).

I believe there is a need to attempt the implementation of context-based curricula in other tertiary courses, since students coming from high schools may soon have the experience of being taught physics in a way that is directly relevant to their lives. How would these students react to a traditional approach to physics teaching at University? No doubt they may be discouraged by the abstract nature of traditional physics teaching, unless they were to accept an explanation of the rationale for such an approach.

The development of context-based courses offers an opportunity to increase student numbers, as it has successfully done at secondary level. It is also likely that students coming out of such courses will have a greater appreciation of the place of physics within their world, and a deeper conceptual understanding than those who have experienced content-oriented courses.

Finally, as with any change in teaching practice, the enthusiasm generated by a new approach usually has positive effects on both teaching staff and students. By keeping up-to-date with new contexts, this allows the context-based course to evolve continuously - so both students and academics can maintain a fresh and interested perspective on physics into the future.

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