

## Why do physics? Where does it really lead?

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**Abstract:** *In the first half of 2008, a survey was distributed to a wide range of physics graduates across Australia. It is a major component of an effort to provide a realistic answer to the questions – Why do Physics? Where does it really lead? – based on the experience and perspective of real physics graduates in the workforce. The survey was the product of the Working Party on Physics Graduates in the Workforce, part of a project funded by the Australian Learning and Teaching Council (ALTC). It sought to reach graduates from all Australian universities with physics or physics-related courses, both undergraduate and postgraduate. 171 replies were received, with over 70% recommending a major in Physics as useful training for a career in their field. Of those who didn't, over 70% 'recommend a smaller component of physics' in a student's training. While a positive response is not too surprising from this sample, it is nonetheless a strong endorsement of physics training from those who have survived the experience. But what was good about the training? More importantly, what wasn't? In describing graduate attributes, most responses strongly agreed that undergraduate physics developed problem solving skills, but communication and planning skills and awareness of ethical and social issues were all relatively neglected at both undergraduate and postgraduate levels. The responses clearly stated that all these need more emphasis. Using survey data and subsequent interviews, plus a similar survey of employers, the Working Party will construct a perspective on current physics training with suggestions on where changes in emphasis might be required.*

### Introduction

The results reported here form part of the physics project, *Forging New Directions in Physics Education at Australian Universities*, funded by the ALTC Discipline Based Initiatives program. One component of this project is *Physics Graduates in the Workforce*. This graduate project aims to identify graduate destinations and employer expectations and explore the diverse employment opportunities available to Australian physics graduates to determine the suitability of current course content, structures and learning activities. The practical outcomes will be web-based information including:

- Who employs physics graduates?
- Comments on *course* and *work* experience and satisfaction by graduates and employers; and
- Individual graduate profiles.

In this paper we report on the type of physics graduates sampled by the survey and just one aspect of their responses – the graduate attributes developed in their training.

### The survey

The graduate project has been centred around a national survey (online at [http://www.physics.usyd.edu.au/~obyne/carrick/carrick\\_intro.html](http://www.physics.usyd.edu.au/~obyne/carrick/carrick_intro.html)) that has attracted feedback from 171 graduates representing 22 Australian universities with physics or physics-related courses, both undergraduate and postgraduate. Further comments from selected graduates and feedback from employers are currently being analysed.

The size of the survey, with its emphasis on physics nationally and at all university levels, makes it unique in Australia. In comparison, an earlier AUTC project survey (2004–5) included a set of interviews with just six Australian graduates of 3-year physics programs only (Mendez, Pollard, Aharma, Mills, Gribble et al. 2008). Rodrigues, Tytler, Darby, Hubble, Symington and Edwards (2007) interviewed 17 graduates, targeting the 'lost voices' of *science-trained* graduates (not just physics) working in other areas. These surveys should be compared to the analysis of over 1300

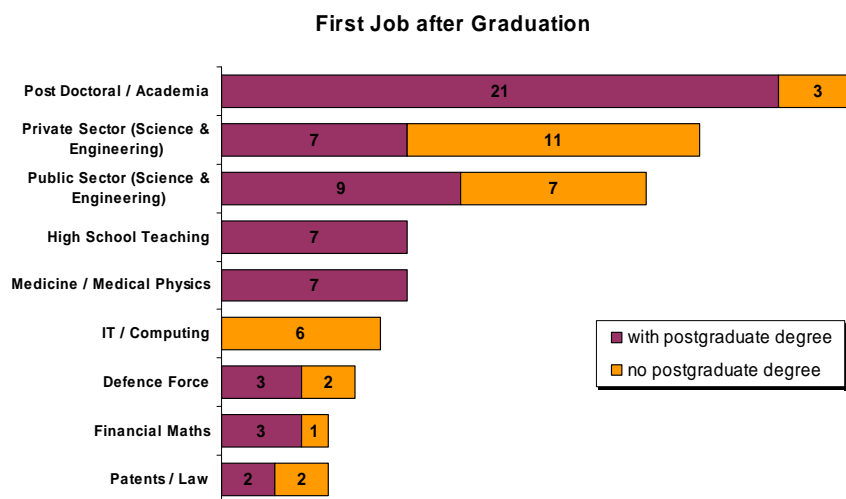
responses from *science* graduates in the report by McInnes, Hartley and Anderson (2000), in which physics graduates are not separately identified.

The graduates were contacted by working with staff in physics departments at each university. The intent was to use their alumni databases to contact a large number of graduates, but this only happened effectively at The University of Sydney. In that case, 51 responses were received from approximately 500 alumni contacted by email. In most other cases, contact was made with a small number of recent graduates where valid email addresses were known.

The sample of the data that follows concentrates on 108 respondents who graduated after 1990 and therefore represent relatively recent experience of university training and the job market. 42% of these graduated since 2000. The male-female ratio is 2:1. The majority of respondents come from just seven universities, but these span a wide range, both in size and location (The University of Adelaide, Central Queensland University, Murdoch University, RMIT University, The University of Sydney, The University of New South Wales, University of Technology, Sydney).

The study by McInnes, Hartley and Anderson (2000) suggests that 80% of *science* graduates are in full-time employment. The value is around 90% in the current survey.

The sample is certainly not unbiased, but it does present a broad cross-section of the physics graduates. This is demonstrated by the distribution of the graduates' first jobs after graduation (Figure 1), although the distribution for their main/current job is very similar. The large number of positions in academic research positions arises because the people who choose to respond are often those who identify strongly with their physics background. Considering only the 40% of respondents without postgraduate qualifications largely removes those in academic research positions and affects other categories to different extents.



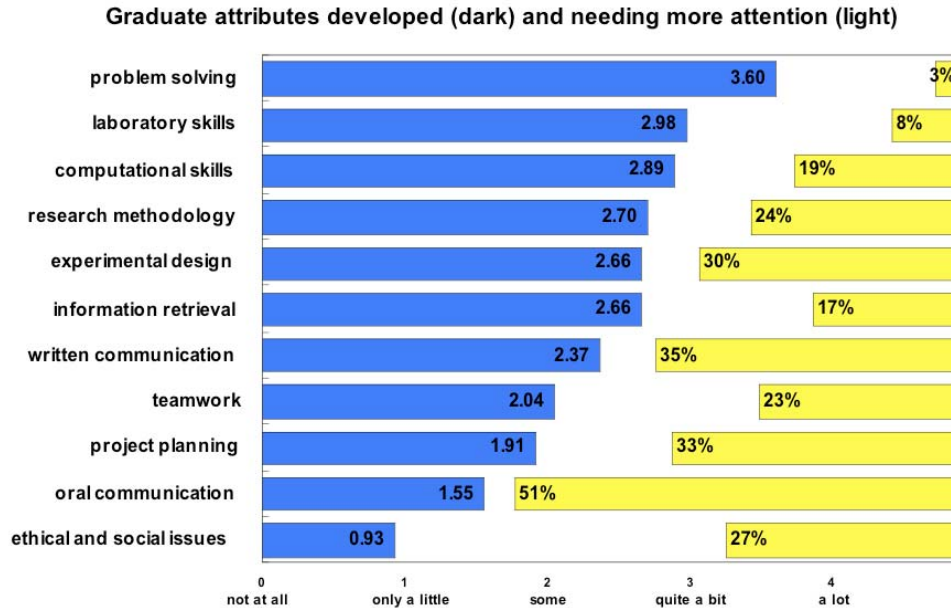
**Figure 1.** Broad areas of employment categorised on the basis of respondents description of their role and employer, respondents with and without a postgraduate qualification are added to produce to full bar length

## Physics as useful training for the workplace

Has a physics education been an advantage to the graduates responding to the survey? Over 80% agree that it has, with the remainder split between being unsure and feeling they gained no advantage. Given this, it is not surprising that almost as many respondents recommend a major in physics as useful training for a career in their field. Of those who did not, only one in four suggested that some physics was *not* useful training for their current job. Overwhelmingly, graduates refer to the range of

skills they acquire, rather than any specific knowledge, as the primary benefits of physics training.

The survey offered a list of graduate attributes (also sometimes called generic attributes or generic skills) and asked respondents to what extent they believed these attributes had been developed, or needed more attention, in their undergraduate and postgraduate degrees. Figure 2 shows the distribution of these answers for undergraduate degrees only.



**Figure 2.** On the left is the ranking by graduates of the attributes developed in their undergraduate physics degree, in terms of the scale along the bottom. A difference of more than 0.30 between categories is statistically significant. On the right are the percentages of graduates who believe that a particular attribute needs more attention.

Clearly, problem solving is the most developed skill, with laboratory and computational skills significantly further back in second and third place. In contrast, it seems ethical and social issues are hardly touched upon in undergraduate physics and oral communication is very poorly developed. Project planning also ranks quite low. For almost all skills, these results do not depend on whether the graduate went on to complete a postgraduate degree. With the exception of research methodology, their impression of the usefulness of their undergraduate degree in developing these skills is unchanged. In at least some universities, the difference with research methodology may reflect a real difference in experience offered to those students who were identified early as potential postgraduates.

Not surprisingly, when asked whether graduate attributes needed to be further developed, the ranking tends towards the inverse of the earlier list. Oral communication clearly stands out as the main area of concern, with written communication also in need of more attention. Practical skills in project planning and experimental design are also a concern.

Ethical and social issues most obviously spoil the symmetry between skills developed and those needing more work. Whilst all graduates report that it is given scant consideration, only one quarter of them believe it requires more emphasis in undergraduate physics. This attitude is captured in one fascinating response that didn't '... think ethics needs to be considered as much in physics as other fields such as biology and psychology ...'!

When asked if any of the graduate attributes are better developed in another undergraduate course there is a mixed response, with almost half say that the majority of attributes weren't better developed in their other courses, while others clearly disagree. Some mention that they were equally well developed in other areas, mostly mathematics and engineering.



A smaller number of responses ranked the graduate attributes gained in postgraduate physics training with somewhat different results. Written communication skills are now on top of the rankings, presumably because of the strong emphasis on writing papers and the thesis. Problem solving remains a highly developed attribute during this period but laboratory work is now at the bottom, perhaps because a large number of PhDs are theoretical in nature and therefore many candidates never see a laboratory after their undergraduate years. Ethical and social issues are again at the very bottom of the rankings. All other graduate attributes have increased in their development from the undergraduate years and there were fewer suggestions of attributes needing further development.

## Discussion

The perceived lack of skills related to communication among physics graduates is a common theme in surveys of science graduates. Rodrigues et al. (2007), for example, found that focus groups of science graduates working on ‘priority research areas’ emphasised the need for skills such as communication and problem solving – in contrast to the emphasis on knowledge and technical (e.g. laboratory) skills they experienced in their courses. McInnes, Hartley and Anderson (2000) also report that science students see considerable gaps between attributes they gained from their undergraduate science degree and what they see as important to their current employment. A further gap to be considered is the one between the graduates’ perceptions and those of their employers. Employer responses in the small AUTC survey (Mendez et al. 2008) reveal less faith in graduate skills in experimental design and project planning than the students had themselves. This issue is currently being analysed from a small number of employers’ responses to the current survey.

How effectively an undergraduate degree can provide some of these skills is open to question.

## Acknowledgements

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