Lessons to Educators From Recent Studies About Employability For Research-Trained Graduates

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Keywords: science careers, working scientists, employability

Abstract

This paper aims to stimulate discussion around the career prospects and training of postgraduate students in the sciences. It presents a summary of recent studies that address the careers and career-prospects of research-trained science graduates. It examines what research-trained graduates say about their career prospects and employability while drawing on data that illustrate the real likelihood they will forge a long-term career in research or academia. It also considers the cultural changes needed to broaden the understanding of the employment outcomes of research-trained science graduates and offers practical suggestions for fostering these changes.

Introduction

Scholars, advisors to governments, and the media have issued multiple warning reports, papers, and commentaries about the value of science to society, the imminent shortage of trained scientists, and the need to better prepare science graduates for their careers (Alberts, 2008, 2009, 2011; Austin and Alberts, 2012; Benderly, 2015; Harris, 2012; OECD, 2006; President's Council of Advisors on Science and Technology, 2010; Tobias, 1996). Perhaps in response, a series of recent reports funded by both governments and independent organisations has addressed the state of science and maths education in schools and universities (Ainley, Kos, and Nicholas, 2008; Dobson and Calderon, 1999; Goodrum, Druhan, and Abbs, 2011; International Council for Science, 2011; Marginson, Tytler, Freeman, and Roberts, 2013; PCAST, 2010; Universities Australia, 2012a; Universities Australia, 2012b). These reports provide excellent data on the numbers of students who study science and maths at secondary and tertiary level. They also clearly explain the problems with current secondary and tertiary science and maths curricula. An issue that these studies largely ignore, however, is science graduate employment pathways.

There are several significant recent studies that address science careers and science graduate employability in research (Gascoigne, 2012; Gibbs and Griffin, 2013; Rodrigues, Tytler, Darby, Hubber, Symington, and Edwards, 2007; Rohn, Curry, Harris, McCracken, Grant, Thomas, Buch, Dartnell, and Hartkey, 2011). These papers speak directly to the problems encountered by research-trained PhD graduates as they forge a career in a research field. Although a proportion of research-trained science graduates do *not* intend to become researchers when they enter a PhD, this is not always understood, supported, or explored by their project supervisors and their host university (data to support these statements is presented and examined later in the paper). The purpose of this paper is to stimulate discussion around career development options for research-trained science graduates. It will (i) present a summary of these papers, (ii) discuss their implications for science educators, and (iii) offer suggestions for changes in practice that science educators can adopt and encourage.

The Science situation in the United Kingdom

The first study to be examined comes from the United Kingdom (UK). In 2011 Science is Vital, a self-described 'grassroots campaigning group with the aim of protecting and championing science in the UK' (Rohn et al, 2011; p.4) conducted a consultation with people working in science at over 160 institutions across the UK. The resulting report is focused on the pressing issue of postdoctoral scientists, and the challenges they face in finding stable work (particularly once they have passed the early-career fellowship stage).

The authors made a call to over 17 000 UK researchers who had signed an earlier petition in support of research funding in the UK (Rohn, 2010). Because of the nature of the petition, most of those contacted were researchers with a personal interest in scientific funding. The most problematic issue identified by the approximately 750 respondents was the short-term nature of science funding, with 49% of people ranking this as their top concern from a list of seven pre-identified issues. In open responses (n = 432), the two most-mentioned problems were job security (67% of respondents) and career fragmentation (37%). Clearly, these are both issues associated with short-term contracts and unreliable funding streams.

Although one would expect these results from scientists who depend on research funding for their career and their livelihoods, the survey responses came from a diverse pool of people, with roughly 20% of participants from each of the following groups: students, early postdoctoral scientists, late postdoctoral scientists, principal investigators, and 'other'. The study participants were not simply complaining about their personal circumstances, but were, instead, commenting passionately on the UK scientific career path itself. Study participants described systemic problems in the funding structures that favoured new graduates over experienced scientists, punished those who took non-traditional paths in science, and disadvantaged people (mostly women) who had taken time out for family responsibilities. They also lamented the waste of talent and money associated with such a system; pointing out that scientists churn quickly through PhD and early-career postdoctoral positions, then 'fall off the pyramid' (Rohn et al, 2011; p.11) as their grant funding opportunities expire and they are unable to find long-term work in science.

The authors point out that only a small proportion of the students currently completing a PhD will gain an academic position and state that an effort must be made to 'give PhD students more suited to non-research jobs an earlier, but positive, exit from the academic system, before they get trapped' (Rohn et al, 2011; p.16). The authors make several recommendations for improving British science. One of them is to 'provide improved career advice for those starting a PhD (and for those nearing the end of their projects)' (p.16) because, as they rightly point out, 'the myth that a PI position waits for all needs to be corrected' (Rohn et al, 2011; p.16).

Career support for researchers in Australia

A 2012 study conducted by ACOLA (Australian Council of Learned Academics) addressed the question of PhD graduate employability as it aimed to develop a best practice approach to supporting research careers in all disciplines (Gascoigne, 2012). The study used a survey (n = 1203 respondents) and workshops (n = 55 participants) to gather data. Like the Science is Vital study (Rohn et al, 2011), this work drew responses from a wide demographic sample in terms of discipline, age, career stage, gender, and place of work. Amongst the researchers who engaged with the study, experienced scientists were well represented; over 40% of participants worked in engineering, the natural sciences, or technology and almost 60% of the participants were aged 30 or older.

This study produced more hopeful responses from its participants than Rohn et al (2011), possibly because of the questions asked and the answer options provided in the pre-populated survey instrument. Almost 50% of participants rated a research career as 'Very attractive', frequently choosing to describe their work as interesting, important, and stimulating. The researchers clearly gained satisfaction from 'finding solutions to intractable problems […] making a difference, helping people, and being able to follow a problem from conception to solution' (Gascoigne, 2012; p.14). Gascoigne noted, however, that respondents from the humanities were more positive about their research careers than were natural scientists. The humanities respondents were also older than the scientists. It is possible that more established researchers, rather than PhD or postdoctoral workers on short-term contracts, represented the humanities, however the demographic data to support this suggestion are not provided in the report.

Participants were also asked to choose the worst thing about a research career from a selection of six options. The majority (52%) chose 'Uncertain job prospects'. When asked to choose areas in which the Australian research system performed poorly, over 50% of participants chose 'little assistance in career development as researchers become more experienced' (61%) and 'does not provide systematic advice on possible careers in research' (53%). These two choices are very important, because they highlight the limited sense of guidance and trajectory experienced by those who are being funnelled into research careers.

Scientist respondents spoke about the problematic job market and the lack of transparency around science employment. They felt their employment opportunities were both limited and obscure; this feeling was not dispelled once they graduated and in some cases it intensified. One postdoctoral biochemist stated 'I am yet to meet a single PhD student who was told how hard it would be to get a job at the other end' (p.27), while another natural scientist said 'I'm not valued in my role […] nor do I have any prospects of career progression or diversification of skills' (p.31).

The report calls for an open discussion of the different careers available for research higher degree graduates, an explanation of the stages of careers in research, and an explication of the skills required to move between jobs or up the career ladder (Gascoigne terms these items 'articulated career pathways in research'). The report also highlights the need for mentoring, information, and practical advice for young researchers. A third key recommendation is that research higher degree training be diversified to include more transferable skills, such as media training, project management, and grant writing.

The American research landscape

In the USA the situation is similar. Gibbs and Griffin (2013) address the career pipeline for PhD students in North America by documenting the experiences of 38 recent PhD graduates in the biomedical sciences. Many of the study participants had pursued their PhD and postdoctoral work without clear career goals or mapped pathways. During this time the participants were exposed to vicarious and personal learning experiences that shaped their outcome expectations and career choices. Unfortunately many of these experiences were negative and marginalising, particularly for women and scientists from underrepresented minority backgrounds. Again, the participants cited structural barriers that included long training periods, low pay, restricted funding opportunities, and a highly competitive job market. These pressures have also been cited by Stephan (2012) who states that only 14% of PhD graduates in the USA will obtain a faculty position. Although the five-year strategic plan for science, technology, engineering, and mathematics education in the USA promises reform (National Science and Technology Council, 2013), it is unlikely to create the sweeping changes needed to employ all PhD graduates as tenured academic researchers.

Indeed, the outlook for PhD graduates who want to enter a research pathway in the USA looks increasingly grim. A very recent study (Garrison, Justement, and Gerbi 2015) reports that after three decades of growth, the American postdoctoral population is contracting sharply. From 2010 to 2013 the postdoctoral population in the USA declined by 5.5% with males, females, USA nationals and non-citizen workers all affected by the downturn.

Is there life beyond the research rut?

The Garrison et al (2015) study may not be all bad news. The authors suggest that the reduction in postdoctoral numbers depends on multiple factors. One of these is a contraction of funds in the American granting system but Garrison and co-authors also cite data that show people are spending less time as postdoctoral researchers before moving on to other jobs. In addition, survey data tables from the National Science Foundation (2012a; 2012b; 2014; 2015) show that, although the number of new biological and medical sciences PhD graduates has increased each year from 2010 to 2013, fewer and fewer each year have definite plans to begin postdoctoral research. This suggests that more people are making a 'rational response to a tight academic labor market with low compensation and uncertain prospects for success' (Garrison et al, 2015 p.43) and actively choosing alternative careers, rather than being forced into them out of desperation. As Garrison et al (2015) say, 'moving into other employment settings without pursuing a postdoctoral position may be the right decision for many recent Ph.D. graduates.'

It is not unusual for science PhD graduates to choose a non-research pathway. Indeed, data from the UK and New Zealand show that, in both countries, migration out of the research career pathway is very common. In fact (and perhaps rather surprisingly) only the minority of science PhD graduates pursues a research pathway after graduation (Figure 1). The 47% of UK graduates and 25.4% of New Zealand graduates who do proceed into the research workforce frequently move out of it after a few years, and like the USA, only a very small proportion (less than 2%) ends up as a long-term academic researcher. Clearly there are plenty of PhD graduates who make the choice to do something other than research and at least half of PhD graduates make that choice before they become a postdoctoral early career researcher.

This conclusion is backed up by a cross-sectional survey and set of interviews of 469 graduate students in biomedical science at a large public university in California (Fuhrmann, Halme, O'Sullivan, and Lindstaedt, 2011). This study showed that, around two years into their PhD, many students make a shift away from their initial aspiration to direct an academic research laboratory. The authors suggest that this time frame coincides with the first 8-10 months that the student spends in their permanent research group (after they have completed their temporary PhD rotations). They further suggest this is enough time for a PhD student to become socialised into the laboratory, and to begin to understand the pressures and employment concerns their group-mates experience. They realise that they are likely to become mired in the difficulties reported by the researchers in Gascoigne (2012) and Rohn et al (2011), and they make the proactive decision to choose an alternative career.

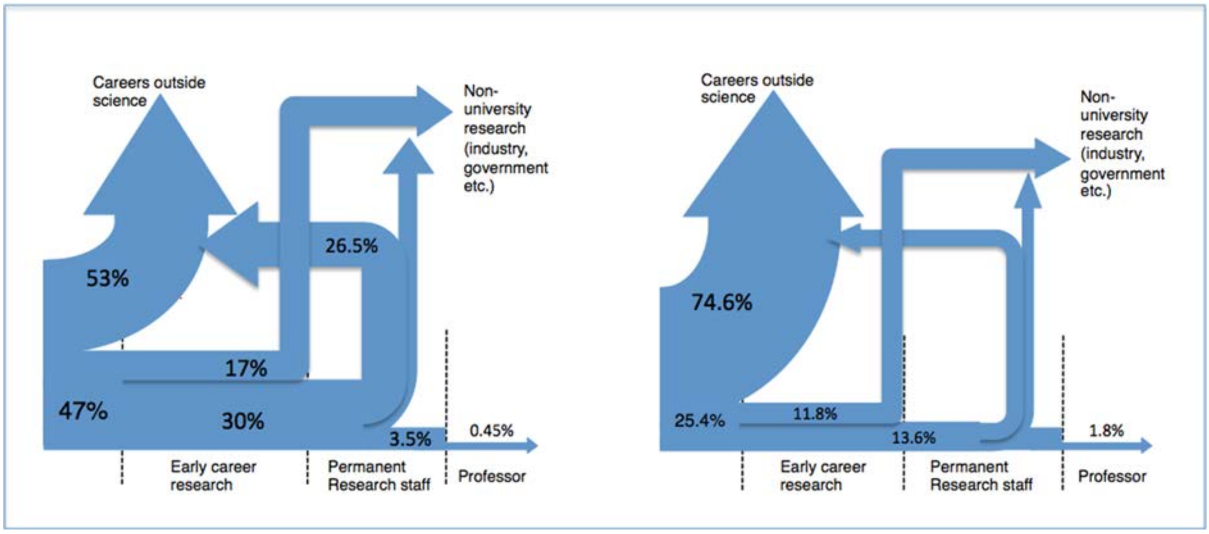

Figure 1: Career pathways for science PhD graduates in the UK (left) and New Zealand (right). **The three stages of a post-PhD research career are shown at the bottom of each diagram. The size of each arrow and the percentage labels represent the percentage of PhD graduates who pursue each pathway. People who move from a career outside science back into a research pathway are not represented in the data. Diagrams are adapted from publications by the Royal Society (2010) for UK data and the New Zealand Government (2010). Data for the UK are sourced from 2005-2009 while those for New Zealand are from 2006. In both data sets it is unclear whether 'professor' means 'tenured academic' or actual 'professor'.**

It should also be noted that, in the study by Fuhrmann and co-authors, almost 8% of the PhD students were not considering a research career at all and around 63% were keeping their options open by strongly considering both a research and a non-research career. These data indicate we need to (i) be aware that not all science students are solely focused on a research career and (ii) encourage students as they build their employability for and knowledge of non-research careers in science.

Practical approaches to supporting diversification in education and work pathways

Our science graduates are voting with their feet and choosing a variety of non-research careers. How can we help them become aware of and prepare for these careers? How do we normalise the idea that a non-research career is a common and successful outcome for a research-trained science graduate? Perhaps even more importantly, how do we influence education providers to focus more on the diverse opportunities available in science, rather than channelling students into research pathways? Below, I suggest practical approaches we can use.

Use university-ranking metrics that include career preparation activity

The tide has to turn on what is considered valuable for our Bachelors and PhD graduates in science. Fuhrmann et al (2011) ruefully note 'national funding agencies continue to use the traditional academic pathway as the formal definition of success' (p 247) and they recommend, 'funding agencies and review committees should explicitly re-define the description of a “successful” PhD graduate as one whose contributions promote the scientific enterprise’ (Fuhrmann et al, 2011; p.248).

In this age of competitive higher education there is pressure on universities to meet the external metrics of success imposed by funding agencies and review committees, and further pressure comes from international ranking systems (Olssen and Peters 2005). Although success in these rankings is used to compete for student market shares and available funding, not all ranking systems are created equal. Some, such as the Shanghai Jiao Tong University Index of Higher Education (SJTUIHE) rankings are almost entirely reliant on research publications and prizes as metrics – they do not use *any* reference to the educational programs or graduate outcomes in their calculations (Marginson 2007). It is widely acknowledged that it is very difficult to quantify teaching quality, but unfortunately most ranking systems deal with this difficulty by essential ignoring actual teaching practice and the mechanisms universities use to prepare their students for work (Marginson 2007). In fact, as Marginson says ‘there is a serious danger that the incentives triggered by rankings will deter universities from the renovation of pedagogy and curricula’ (2007; p.140).

There are other ranking systems, however, that consider graduate employability and university culture around work preparation. The QS Graduate Employability Ranking, launched in 2015, is a new mechanism to compare the employability of students from universities. Importantly, the ranking includes partnerships with employers and the presence of employers on campus as factors in the calculation of rank. Employability remains an important student driver for decisions around university enrolment, so the QS Graduate Employability Ranking, and the factors is uses in calculations, are likely to become noticed and valued by competitive universities. This will give curriculum designers the scope to provide more employment-related training for students. The developers of the QS Graduate Employability rating indicate they will add more factors in the future. Their initial factors were included after extensive academic consultation, so it will be worth our time as educators to engage in any future dialogue about new components of the ranking calculation.

Encourage students and academics to think about different types of scientists

How can we encourage diversification in the ways that PhD and postdoctoral scientists are trained and directed into the next steps of their careers? Evidence from a survey of 4019 PhD students at 39 tier-one U.S. research universities shows that PhD candidates at prestigious universities get relatively homogenous career advice from their supervisors (Sauermann and Roach 2012). In this 2010 study, PhD students in physics, chemistry, and the life sciences all reported that their supervisor most strongly encouraged them to enter a research-based faculty position, rather than to pursue a position in any other workplace.

We could view this as a form of supervisory failure, however we should also consider that supervisors are academics and they were usually trained as research scientists themselves. Naturally then, they will advise their students to follow a path along which they feel competent and comfortable to act as a guide and mentor. In addition, if they have grant funds, they will be keen to offer research positions to the talented young scientists in their care. The challenge is to help supervisors of postgraduate students and designers of undergraduate programs become more aware of and comfortable with non-research careers in science so they can future-proof their trainees. This challenge also applies to the designers of undergraduate science programs, particularly those at research-intensive universities.

What can we do to broaden our horizons? One particularly helpful reference for supervisors and curriculum designers is Garnham (2011). In this publication, written for the Science Council in the UK, Garnham explains that 'a science professional may have a career as a scientist, in science or from science' and she identifies scientists in roles as explorers, investigators, developers and translators, service providers, regulators, entrepreneurs, communicators, teachers, marketers, and policy makers. Garnham also gives examples of where these scientists might work, and how they contribute to science or how they help science contribute to society. The paper has been translated into two useful websites for students (Science Council 2016; Kowzun 2016) with an associated set of downloadable posters and tools. These examples and tools provide a solid platform on which to build and broaden young scientists' perceptions of future work options and the ways they can use science beyond the laboratory.

One problem with diversification of PhD training is the very real tension between the time needed for extra activities (be they formal courses or informal activities) and the amount of time required to achieve high quality and significant research outcomes. It is difficult to expect a PhD student to put in the manual and intellectual effort to produce world class results if they have to juggle their time between that work and the planning and networking required for a non-research career. Perhaps the answer is to offer an alternative type of PhD that caters to the student who wishes to complete a more limited research project while developing professional networks, interacting with industry and the community, and honing skills in management, writing, and communication.

Do more than include 'employability' graduate attributes in curricula and, instead, develop career-building skills in science students

There has been significant recent effort expended on defining graduate attributes and embedding these in university curricula (Hughes and Barrie 2010). Although this is an outcomes-based approach, there is a question mark over whether this practice improves *employment* outcomes for graduates. A UK study that examined 34 universities (Mason, Williams, and Cranmer 2009) found that explicitly teaching employability skills had no significant effect on employment outcomes for graduates, but in contrast, work placements were an effective way to improve employment outcomes. Although defining and assessing a set of desired graduate attributes can help us design cohesive, focused curricula, we should keep in mind that this practice is not enough to improve employability. Improving the employability of our graduates requires time, financial commitment, and real-world exposure to the workplace. Ideally, work-integrated learning should occur *in diverse environments* for both undergraduate and postgraduate science students, but as discussed before, this is not always possible for a busy PhD student.

Another option to increase a student's awareness of his or her own skills and attributes is an Independent Development Plan (IDP). An IDP, much like an annual review for an employee, helps a student examine their skills, goals, and values. It also helps them consider whether they are developing their 'career-building skills', which are defined by Bridgstock (2009) as 'the skills relating to finding and using information about careers, labour markets and the world of work and then locating, securing and maintaining work, as well as exploiting career opportunities to gain advancement or other desired outcomes' (Bridgstock 2009; p.37).

myIDP (Fuhrmann, Hobin, Lindstaed. and Clifford 2015) is a free website that allows science graduates to prepare and curate an IDP. The website was initially developed for the Federation of American Societies for Experimental Biology, who proposed an IDP framework for postdoctoral fellows. Consequently, the myIDP tools are targeted at PhD-level scientists, however more junior science students can also use the site to gain an idea of the types of skills they are developing while they study and the areas in which they can work upon graduation. Crucially, the website activities are self-paced and they encourage users to extract employability value from their extant activities. This approach circumvents the aforementioned tensions around supra-research training and work experience commitments.

Vote for politicians who support science in all its forms

The public discussion around funding for science usually focuses on medical research, but there are many other ways in which public money can be used to support science and its positive effects on society. The National Innovation and Science Agenda (Australian Government 2015) is an example of a more catholic approach to science support, and it may allow us to work towards improved and expanded perception of 'success' for science graduates. The agenda places a focus on translation of science research outputs into marketable products, support for science and technology entrepreneurship, and improved funding for collaboration between industry, researchers, and higher education institutions. Presumably these foci mean grant money for research laboratories that interact with the larger community. If this targeted funding lasts beyond one or two grant cycles it may be enough to sway supervisors, postdoctoral scientists, and PhD students to develop far more interest in the outside world, because the outside world starts to look like a welcoming and financially viable option.

Conclusion

Science students are voting with their feet and moving away from the traditional PhD and postgraduate research pathways. This is a good thing – the modern world needs science-trained workers who are logical problem solvers, critical thinkers, and advocates for the use of evidence in decision making. Our task as educators is to recognise that a non-research career in science is the norm, and to help our students prepare for their exciting and diverse futures. It is appropriate to close with a prescient 2009 quote from Bruce Alberts, Editor in Chief of *Science*.

> One senses that we are reaching a tipping point, where students who prefer to work in the world of public policy, government, precollege education, industry, or law will no longer be viewed as deserting science. Faculty and students can then begin to talk honestly about a whole range of respected, science-related career possibilities. This is crucial, because we must promote the movement of scientists into many occupations and environments if our end goal is to effectively apply science and its values to solving global problems (Alberts 2009).

It's time that we, as science educators, stop training scientists for academic research. Let's start training scientists for society instead.

Acknowledgements

My thanks go to Stephanie Beames, Louise Kuchel, Janet Hergt, and the anonymous reviewers of the paper for helpful reading and suggestions for this manuscript.

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