Studies in Higher Education

ISSN: 0307-5079 (Print) 1470-174X (Online) Journal homepage: http://www.tandfonline.com/loi/cshe20

# Academics' perceptions of the purpose of undergraduate research experiences in a research-intensive degree

Anna Wilson , Susan Howitt , Kate Wilson & Pam Roberts

**To cite this article:** Anna Wilson , Susan Howitt , Kate Wilson & Pam Roberts (2012) Academics' perceptions of the purpose of undergraduate research experiences in a research-intensive degree, Studies in Higher Education, 37:5, 513-526, DOI: 10.1080/03075079.2010.527933

**To link to this article:** https://doi.org/10.1080/03075079.2010.527933

Published online: 20 May 2011.

*Studies in Higher Education*
Vol. 37, No. 5, August 2012, 513–526

Routledge
Taylor & Francis Group

# Academics' perceptions of the purpose of undergraduate research experiences in a research-intensive degree

Anna Wilson[a,b]*, Susan Howitt[c], Kate Wilson[b] and Pam Roberts[a]

[a]*Centre for Educational Development and Academic Methods, The Australian National University, Canberra, ACT 0200, Australia;* [b]*Research School of Physics and Engineering, The Australian National University, Canberra, ACT 0200, Australia;* [c]*Research School of Biology, The Australian National University, Canberra, ACT 0200, Australia*

The inclusion of research experiences as core components of undergraduate curricula implies that students will be exposed to and situated within the research activities of their university. Such experiences thus provide a new prism through which to view the relations between teaching, research and learning. The intentions and actions of academics supervising these activities will be strongly influenced by their beliefs regarding the nature of research, and the relation between research and learning in the undergraduate context. Surveys of academics supervising such experiences reveal a range of intentions, only some of which address the higher order and critical thinking skills associated with research or independent learning. This may indicate a lack of deep reflection on the purpose of exposing undergraduates to research, but may also be due to the predominance of a hierarchical view of the process by which one makes the transition from student to researcher.

**Keywords:** academic staff; educational intention; research–teaching nexus; research training; undergraduate research experiences

## Introduction

The recommendation of the Boyer report (Strum Kenny 1998, 18) that all undergraduate students 'should be able to engage in research in as many courses as possible' grew out of a belief in the connection between teaching and research – the so-called *teaching–research nexus* – and a perception that that connection can enhance the learning experiences of students. However, the nature and even the existence of the teaching–research nexus which provides the impetus for these experiences remains the subject of some debate (see, for example, Brew and Boud 1995; Hattie and Marsh 1996). Despite this uncertainty, many institutions in Europe, the USA and Australasia have embraced the report's recommendations, particularly those research-intensive universities that are in a position to exploit academics' research programs to provide distinctive research experiences to their undergraduates (Krause et al. 2008). The involvement of undergraduate students in research-based activities supervised by active researchers provides an opportunity to examine the relations between teaching, learning and research in a context where all three might be expected to be present.

Perhaps surprisingly, the literature examining undergraduate research experiences has tended to be quite independent of the literature on the nature of the connections

*Corresponding author. Email anna.wilson@anu.edu.au

ISSN 0307-5079 print/ISSN 1470-174X online

http://dx.doi.org/10.1080/03075079.2010.527933
http://www.tandfonline.com

between teaching and research. Although encouraged or justified by the notion of the teaching–research nexus, a distinct avenue of research focussing on students' experiences, and their perceived learning gains, has emerged (Hunter, Laursen, and Seymour 2006; Kardash 2000; Seymour et al. 2004). This focus contrasts with that of the literature on the teaching–research nexus, which tends to be on academics' perceptions of the nature of research and the nature of teaching, or on institutional policy aimed at increasing the links between teaching and research (Blackmore and Fraser 2003; Gottlieb and Keith 1997; Krause et al. 2008; Rowland 1996). A notable contribution to this area lies in the work of Jenkins and Healey (Jenkins 2004; Jenkins, Healey, and Zetter 2007), which has examined the various forms of research-led or research-based education adopted by higher education institutions in Europe, the USA and Australasia in some detail. However, while these authors have gathered data on the range of ways in which teaching and research are currently brought together, they have not explicitly looked at the ways in which the connections between teaching and research are experienced by academic staff or students when engaging in such activities.

Undergraduate research experiences, and the intentions of academics offering them, provide a prism through which to examine the teaching–research nexus in a context where it is directly relevant to student learning. This article presents the initial findings of an ongoing study of academics involved in providing undergraduate research experiences and other research-led components as part of a science degree program at a research-intensive Australian university. We find a range of perceptions of the purpose of the program itself and also of the individual undergraduate research experiences for which the academics were responsible. We suggest ways in which these variations might reflect a range in underlying assumptions regarding the relationship between undergraduate learning and the process by which we become researchers.

## The teaching–research nexus and undergraduate research experiences

A great deal has been both written and said about the relationship between research and teaching in higher education in recent years. However, despite the perception that a strong relationship 'is generally understood to be a defining feature of a modern university and of academic identity' (Robertson and Bond 2005, 509), it has proved difficult to identify quite what the nature of the relation is, or to determine its effects on the lives of academics or students in higher education institutions. Indeed, there are some who argue that no such link exists. Typically, quantitative studies have found no evidence for a significant correlation between research and teaching performance indicators (Feldman 1987; Hattie and Marsh 1996; Hughes 2005). However, as pointed out by Brew and Boud (1995), the metrics used to assess both teaching and research performance in correlational studies have generally been based on an instrumentalist view of both activities. Several qualitative studies focussing on the experiences of individual academics, rather than performance indicators or institutional atmospheres, have suggested that many academics believe that, in an ideal world, research and teaching should be intimately connected, and that active researchers are the best teachers (Neumann 1992; Ramsden and Moses 1992; Robertson and Bond 2001). This belief has led to a tendency in much of the literature on the teaching–research nexus to assume that constructive links between teaching and research do exist, and are waiting to be uncovered by suitably 'robust and extensive' research (Wareham and Trowler 2007, 2). Recognising this oversimplification, Jenkins has suggested that

'there is not a single teaching–research relationship, there are many relationships. Indeed, perhaps we overstate or distort these relationships by referring to "a" or "the" teaching–research nexus' (Jenkins 2004, 30). In their 2007 article on linking teaching and research, Jenkins, Healey, and Zetter concluded that links between teaching and research are not inevitable and natural, but instead have to be created in disciplines and in university departments.

In spite of the nature of the relation between research and teaching remaining ill defined, it has become one of the key components of rationales for the purpose of the higher education sector. The concept of the teaching–research nexus has become enshrined in university policies and mission statements, and indeed in New Zealand law (Robertson and Blackler, 2006). This development has in part been motivated by changes in the social context of higher education. The acquisition of content knowledge is no longer valued for its own sake, partly because such knowledge, and associated technical skills, can rapidly become outdated, but also because people are likely to change jobs and duties several times during their working lives. Instead, the skills that are most valued in a university graduate are the inquisitiveness, the logical approach and the adaptability that characterise a lifelong learner. Universities have thus been seeking new approaches to teaching to help meet these new demands. Since the desired generic skills are in many respects similar to those needed to become an effective researcher, the inclusion of research-focussed components in undergraduate degrees provides an apparently easy route for universities to improve the generic skills of their graduates, while at the same time increasing the integration of research and teaching activities.

The conflation of training for lifelong learning with the appealing idea of a constructive relation between research and teaching has thus led to an increasing use of undergraduate research experiences, particularly in science degrees, since, on a somewhat superficial level, placing undergraduates in research groups can be seen as integrating teaching and research. Undergraduate students' experiences of research have subsequently been the subject of several studies, recently reviewed by Seymour et al. (2004). Most studies suggest that students generally enjoy such experiences, but it is not clear whether students view their research experiences as learning activities, or indeed whether the type of learning that occurs is strongly related to research practices or the development of the student as a researcher (Howitt et al. 2010; Seymour et al. 2004).

Adopting the view that there is not one single, simple form of the teaching–research nexus, we might imagine that one way in which teaching and research are connected is through the perceptions of researchers of the nature of learning and the transformation from student to researcher. Another might be the way in which students perceive the nature of research and the process by which they develop into a researcher. These perceptions will be present in the way in which both academics and students engage in undergraduate research experiences. Previous studies have shown that the supervisor of an undergraduate research experience is one of the most significant determinants of the perceived success or value of the experience to the student, and suggested that a cognitive apprenticeship model might best describe the learning process that takes place (Howitt et al. 2010; Hunter, Laursen, and Seymour 2006; Russell, Hancock, and McCullough 2007; Seymour et al. 2004). The beliefs of the supervisor regarding the nature of research and researcher training are thus likely to have a significant impact on the potential research development of the student.

In this article, we present the initial results of an ongoing study of both supervisor and student experiences of the inclusion of research activities in an undergraduate

degree. We investigate the perceptions of academics involved in the provision of undergraduate research experiences in a science degree at a research-intensive university. We focus on their perceptions of the purpose of the program and their intentions in providing undergraduate research experiences. Other aspects of the research findings are reported elsewhere (Howitt et al. 2010; Wilson et al. 2007).

## Context for the research

The Boyer report (Strum Kenny 1998) promoted the view that research universities should capitalise on their expertise and exploit the teaching–research nexus by providing *all* undergraduates with research experience. While very few universities have completely embraced this idea, many have wholeheartedly embraced the notion of providing research experiences for their 'best' undergraduate students.

This study was carried out at a research-intensive university in Australia, which at the time was structured along the lines of universities in the USA such as Princeton, consisting of a research-only arm (staffed by research-only academics) and a research and teaching arm (staffed by teaching and research academics). In the sciences, the ratio of research-only to research/teaching staff was approximately 4:1, with the imbalance somewhat more extreme in the physical sciences than the biological and life sciences. All teaching staff were also active researchers. The undergraduate body consisted of generally high-achieving students, of whom in the sciences typically 20% would go on to undertake a higher degree by research. The university had a prior history of exposing undergraduate students to research through a Distinguished Scholars Program, which introduced high-achieving students to researchers across the campus, and through summer research scholarships.

In 2003, partly in response to the Boyer report recommendations (Strum Kenny 1998), the University introduced a new science degree, the Bachelor of Philosophy (PhB: Newitt 2007). The explicitly-stated aim of the program was to provide a research-based education for elite students to better prepare them for future research careers. This program, which is restricted to the top 1% of school-leavers, provides students with opportunities to undertake research at a high level from the beginning of their undergraduate degree through the inclusion of six or more research-led projects and courses. A high degree of flexibility in the choice and sequence of courses means that the degree is also somewhat self-directed. The research projects ensure that the PhB students obtain a greater experience of research than most undergraduates.

The first three years of the degree include at least six research-focussed experiences which replace standard lecture courses, and which are chosen by the student with advice from a mentor. The broad aim is that these experiences should provide substantial research training and experience. The program requirements stipulate that at least three of these courses should take the form of extended undergraduate research experiences, where students conduct a semester-long research project under the supervision of an active/expert researcher. Throughout this article, we use the term undergraduate research experience to refer to such projects. Up to three other research-focussed courses may take the form of standard lecture courses supplemented by a research-based component worth 20–30% of the course grade, which typically take the form of a mini project, a more free-form laboratory practical or more challenging problems. Throughout this article we refer to such experiences as research-led course components.

By mid-2006, when the surveys described below were conducted, the program had been under way for three and a half years. It thus provided an opportunity to study the processes emerging in a firmly research-led degree. The academics who were involved in the study had between them supervised more than 100 students in more than 100 projects. Supervisors received no formal training and few of them had read the available guidelines. Their views of the nature and purpose of undergraduate research experiences were, therefore, predominantly informed by their own experiences as researchers and by the institutional culture. Because of the nature of the degree (as a program explicitly aimed at producing research-ready graduates), it might be expected that the academics involved would act according to their (perhaps unarticulated) beliefs about the nature and practice of research, and how one learns to be a researcher.

## Approach

The study focussed on variation in the ways in which academics perceived the purposes of both the program as a whole and the individual research-based components in which they were involved within the program.

All academics who had been involved in the provision of the research-focussed components of the PhB in the first three and a half years of its operation were surveyed. This group consisted of 87 academics across separate research-only and research–teaching areas of science. It included academics at levels B to E of the Australian Academic Classification, where level B is an early career position and level E is an elite position attained by only a small fraction of academics, usually towards the end of their careers. Our intention was to find out about their perceptions of the program aims, their intentions when providing the main program elements (the undergraduate research experiences), and what educational and developmental outcomes they expected for students from their undergraduate research experiences.

The surveys consisted of four short ‘demographics’ questions aimed at establishing the range of disciplines sampled, the number of projects and students supervised by the respondents, and whether or not they had read the program guidelines or course outline. These were followed by a series of open-ended questions focussing on academics’ perceptions of and intentions within the program. Respondents were asked for their perceptions of the aims of the PhB program as a whole, and then what they thought the aims of the research-based components included in the degree program were, as distinct from the overall aims of the program. They were also asked about the specific learning outcomes they intended when supervising undergraduate research experiences, and again when supervising research-led coursework components. Finally, they were asked to describe concerns and benefits, both for themselves and for the students.

The surveys were administered in hard copy via internal mail. Each survey was personally addressed and included a short note thanking the participant and assuring them that their responses would be kept anonymous, and a chocolate frog (as an incentive to participate). Of the 87 surveys that were sent out, 41 were returned completed within four weeks. Responses were obtained from researchers in disciplines across the biological and physical sciences, with a small majority (24) from the physical/computational sciences. Thirty-seven respondents had supervised at least one undergraduate research experience, and 12 had supervised at least one research-led course component. Undergraduate research experience supervisors had supervised between one and

18 students, with more than half having supervised four or more students. Less than half had read the program description or guidelines. Some respondents (15 of 41) had difficulty with the question asking for intended learning outcomes, and left it unanswered, wrote question marks, or explicitly stated that they did not understand the question. This may reflect that several of the academics supervising undergraduate research experiences were in research-only positions, and so were likely to view undergraduate research experiences through a 'research-only' lens. The language of learning outcomes may also be unfamiliar to such academics.

Our analysis approach was informed by the methods of phenomenography (Marton 1981), which may be appropriate when the focus of a study is the range of possible experiences and perceptions of people in a given situation or context, and the ways in which those experiences and perceptions vary. We started by adopting the constant comparative method (Maykut and Morehouse 1994, 127–48) to identify recurring themes within the data. Initially, the surveys were read in their entirety with the intention of identifying major themes and differences in academics' perceptions of the purposes of engaging undergraduates in research, and their intentions when supervising such research. Common phrases and ideas were identified and used to develop categories describing the range of these perceptions and intentions. This process was carried out independently by two of the authors. There then followed an iterative process of rereading the surveys and refining the categories, which was repeated until a stable set of categories emerged.

During this process it became clear that, although strongly related, academics' perceptions of the purposes of the overall program aims showed a different type of variation compared to their perceptions of the purposes of the individual research-based components of the program.

## Academics' perceptions of the purposes of the program

Two different dimensions to academics' perceptions of the purposes of the program emerged from the survey responses, one relating to what the program is intended to deliver and the other to who benefits from the program. The responses relating to the perceived program aims can be described using the schema shown in Figure 1. In this figure, the horizontal axis represents the focus of the academics' perception of the aims of the program in relation to research, while the vertical axis represents the focus in relation to the students and the institution.

Responses associated with the lower left-hand quadrant (labelled A) show a focus on benefits of the program to the institution but little focus on the research aspect of the program: the aim of the program is believed to be 'to attract high quality students to the [university]', 'to give them a broader education and keep them at [university]', and the program is seen as little more than 'a promotional tool' for the institution.

Responses associated with the lower right-hand quadrant (category B) show academics thinking about the program as a means of recruiting talented, extremely able students into the institution's (or more specifically their own) research programs: the aim of the program is 'to fast track people into research' and 'to build Honours and PhD levels', and the academics 'expect the students to be well-prepared to carry out a PhD' on completion. The program is therefore seen as being of most value to the individual supervisor and, through them, the institution, with the research aspect paramount.

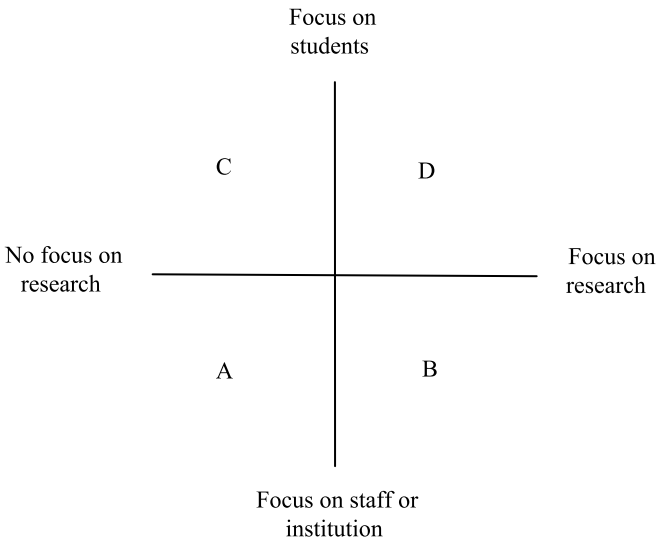


Figure 1. Academics' perceptions of the aims of the PhB (Science) program.

Responses associated with the upper left-hand quadrant (category C) show a strong focus on benefits to the student, but only a weak focus on the research component of the program. Responses in this category focussed on content knowledge and excellence within conventional coursework. For some academics, the program is seen primarily as an opportunity to provide 'advanced training' for high achievers, with the aim of 'giv[ing] excellent students a chance to show their worth and capitalise on it'. For others, the program offers different possibilities for more tailored content, such as the 'possibility to tailor courses to [their students'] interests'. These two ideas are combined in the belief that the main aim of the program is 'to give outstanding students an opportunity to develop their interests way beyond the strictures that apply to more average students'.

Responses associated with the upper right-hand quadrant (category D) show a strong focus on the research training aspect of the program, as well as a focus on the student as the beneficiary of the program: the aim of the program is 'to provide a more post-grad like experience to u-grads. To get the PhBs into the research culture ASAP', to give the students the chance to 'do their own thing under reasonable guidance', and 'to give excellent students the best possible research training'.

## Academics' perceptions of the purposes of the research-based components of the program

Perceptions of the purposes of the research-based components emerged from responses directly addressing this question, the intended learning outcomes described by supervisors and the benefits and concerns identified. They can be divided into the following six categories: retention or selection, research exposure, advanced learning or de facto streaming, developing scientific research skills, thinking like a researcher, and entry into the research culture.

### *Retention or selection*

As with the overall program aims, several of the descriptions of the aims of the undergraduate research experiences provided by survey respondents displayed a focus on benefits to the individual academic or the institution more than the students. The undergraduate research experiences were seen as a means of allowing top students to 'experience [the university's] cutting edge research' in order to 'encourage students to do post-grad at [the university]'. They were also seen as units which were included to 'fit with the [university's] image as a research-intensive uni'. As well as helping to increase articulation into research degree programs, undergraduate research experiences were seen by some academics as providing a useful selection criterion by which to 'test a student's suitability for research' before allowing them into their research group. Consideration of the educational potential of the program, whether in terms of intellectual challenge or in terms of preparation for research, was effectively absent in such responses. This point of view was also evident in the concerns raised that 'the program is designed more for [the university's] benefit than the students' benefit', and in the perception that the only benefit to supervisors is 'exposure to a good student who might come back for a PhD in my lab'.

### *Research exposure*

In this category of response to the aims of the undergraduate research experiences, academics saw their main purpose as providing students with stimulation, motivation and an enhanced desire to do research. They described the aims of the undergraduate research experiences as to provide 'a taste of research' or 'excitement about research', with a large number simply stating 'research exposure'. Some supervisors felt the purpose of the undergraduate research experiences was to 'give students a feel for current research topics in a number of different fields', thus providing them with a breadth of experience as well as motivation. However, the role of the student in such experiences is positioned as largely passive, and the student is not perceived by the supervisor to be participating in authentic research activities.

### *Advanced learning or de facto streaming*

Several academics saw the research experiences as providing advanced or more challenging learning constrained to a conventional conception of undergraduate learning through coursework: 'advanced training for particularly able students'. Their aims when providing undergraduate research experiences were described as 'to provide challenges to PhBs commensurate with their abilities. A sort of de facto streaming'. Learning outcomes for undergraduate research experiences included that the student should 'go beyond the standard curriculum' and that the project should 'fill gaps in learning'. From this perspective, learning outcomes for research-led course components were focussed on additional content, whether to provide more depth or more breadth of knowledge. Responses in this category showed emphases on transmission, additional training in basic skills or knowledge, or the presentation of material in a different way from conventional lectures. This view was clearly present in several of the concerns regarding undergraduate research experiences raised by these staff, particularly that 'too much emphasis is placed on "research" and not enough on fundamental advanced coursework', 'The best preparation for research is to know what has

already been done' and that 'Students can avoid essential background material in rushing to glamorous courses which interest them'. The idea that students might be actively engaged in research was absent from such responses.

### *Developing scientific research skills*

Several academics saw the undergraduate research experiences as a means to provide training in the kind of generic skills that are useful to a research scientist. Undergraduate research experiences were expected to improve students' skills in 'report writing, literature search and working independently', 'to develop practical laboratory skills' and to 'teach students to critically evaluate and plan experiments'. Thus, the undergraduate research experiences in the program were seen as a means of professionalising the students' approaches to research and research-related activities. In this category, the students are seen as experiencing some aspects of research rather than simply being exposed to the research of others, but the primary emphasis is on the development of research-related or discipline-specific technical skills and knowledge. The expected learning outcomes for undergraduate research experiences associated with this category focussed on improved report writing, the ability to undertake a literature search and (sometimes highly specific) laboratory techniques. Learning outcomes for research-led course components included critical reading skills and the ability to design experiments through involvement in more free-form practical exercises. However, students were not expected to actively do research.

### *Thinking like a researcher*

As in the previous category, responses from academics illustrating this conception of the aims of the undergraduate research experiences focussed on the benefits to the student in terms of preparation for future research. They differ from the previous category in the type of learning the undergraduate research experience is expected to promote. Undergraduate research experiences were seen as a means to teach students about the nature of research and scientific method – they were described as improving the students' 'understanding of the process of research'. Some academics articulated what that might mean: undergraduate research experiences '[allow students to] experience the challenge of independent thinking' and 'introduce students to a research environment and teach scientific approaches and thinking'. They are also used to 'give students a taste of what a real investigation is all about – both positive and negative aspects'. Such supervisors saw the students as engaged in research activities with an important developmental aspect to the process. The intended learning outcomes for undergraduate research experiences included 'experience in *real* research, not some organized prac', that students should be able to 'Achieve a simple result i.e. complete a research project that was posed as a direct problem to solve', and that they should 'develop flexibility in tackling problems through examples of [research experiences]'. Learning outcomes for research-led course components included an 'awareness of limitations' of research methods.

### *Entry into the research culture*

A final category that emerged from the responses was related to the student's entry into the research community and focussed on the student's interactions with research

Table 1. Correlation between perception of the aims of the overall program and the undergraduate research components of the program.

| | Undergraduate research experience aims | | | | | |
|---|---|---|---|---|---|---|
| Program aims (from Figure 1) | 1 (selection/ retention) | 2 (research exposure) | 3 (de facto streaming) | 4 (technical skills) | 5 (conceptual change) | 6 (research enculturation) |
| Sector A | ■ | | ■ | | | |
| Sector B | ■ | ■ | | | | |
| Sector C | | | ■ | ■ | | |
| Sector D | | | | ■ | ■ | ■ |

academics. The aims of the undergraduate research experiences were seen as the provision of mentoring through one-to-one contact and individual supervision. The undergraduate research experiences were thought to be included in the program to 'give students contact with wider [university] community', acting as the 'frontline in which students interact with researchers' and hence being seen as 'the jewels in the crown of the program'. Learning outcomes for projects associated with this category included confidence as well as skills, and it was hoped that the students would 'develop interaction skills', participate in 'real experiments as part of a lab group' and gain an 'understanding [of the university] and its faculty, pursuits, academic life'.

### Correlations between perceptions of the aims of the program and the purpose of providing undergraduate research experiences

Each of the six categories described above was strongly correlated with one or more particular perceptions of the overall aims of the program (see Figure 1), as illustrated in Table 1. Those respondents who saw themselves or the institution as the main beneficiaries of the program were most likely to be unable to articulate intended learning outcomes for the undergraduate research experiences they supervised; in contrast, those who saw the program as genuinely research-focussed and for the benefit of the student were most likely to provide detailed learning outcomes and to view the undergraduate research experiences as opportunities for a variety of types of learning. Respondents who saw the use of undergraduate research experiences as an exercise in selection or retention (category 1) exhibited an exclusive focus on the institution or themselves as the beneficiaries of the program. A focus on transmission/reception of content as the aim of undergraduate research experiences (category 4) was associated with views of the degree as providing challenge and extension to bright students, but could be associated with a view of either student or institution as the main beneficiary. In contrast, learning outcomes such as improved critical thinking and enculturation into research were exclusively associated with a view of the program as student-centred and research-rich.

## Discussion

The six categories described above reveal a substantial range of perceptions of both the role of the student in undergraduate research experiences and the potential benefits and learning outcomes from undergraduate research experiences. In categories 1 and

2, the student is seen as largely passive but may gain motivation for further study. In category 3, the student is seen as engaging in more advanced learning of a similar type to that experienced in more conventional courses, which in science have often historically had a strong content focus and transmission flavour. In category 4, the student is seen as potentially acquiring practical and/or discipline skills useful to a researcher. In category 5, the student is seen as changing the way in which they think, potentially undergoing a personal transformation. In category 6, the student is seen as entering into and becoming a part of the research culture. While all may describe useful learning experiences, the six categories can be seen as following a loosely hierarchical structure, with an expanding perception of the potential for student learning and personal development from category 1 to category 6.

In the introduction to this article, we suggested that (particularly where a cognitive apprenticeship model of student learning is appropriate) the beliefs of the supervisor will have a significant impact on the experiences of the student. When academics have only a limited perspective on the potential aims of undergraduate research experiences, sophisticated learning outcomes may be less likely. However, there are several possible reasons why some academics' responses were limited to categories 1 and 2, which may indicate that intended student learning outcomes could go beyond those articulated. In the same way that students remain positive about undergraduate research experiences, despite being frequently unable to identify higher-order learning gains (Howitt et al. 2010; Seymour et al. 2004), supervisors may feel that students do become more ready for research through their undergraduate research experiences, but may still not articulate how or why. Descriptions of the purpose of undergraduate research experiences as 'research exposure' may reflect an implicit emphasis on introduction to the culture of research as part of the process of becoming a researcher. In their study of the benefits of undergraduate research experiences identified by academics and students engaged in summer research programs in liberal arts colleges, Hunter, Laursen, and Seymour (2006) found that supervisors focussed on the professionalisation of students, supporting such an interpretation. On the other hand, the less sophisticated responses in the present study may also reflect cynicism brought about through the increasingly market-led nature of higher education. The program was initiated at a time when local demographic change was predicted to produce a decline in the number of students entering tertiary education, leading to a reduction in the number of potential graduate students. Combined with an increasingly market-driven view of higher education, this resulted in increased competition between universities for the most talented students. At the time of the survey, the program had been running for only three and a half years; academics who at this time held a strong perception of the program as nothing more than a recruitment strategy may change their views of the learning opportunities inherent in undergraduate research experiences after longer involvement in the program (if their experiences are positive).

The types of potential learning identified in categories 3 to 6 can usefully be compared to Dahlgren's distinction between quantitative and qualitative knowledge (1984). The potential learning associated with conceptions in categories 3 and 4 can be characterised as the acquisition of discipline-specific knowledge and skills, which may be associated with a more quantitative view of knowledge and with the conception of knowledge as externally determined. In these conceptions, students can acquire existing knowledge and skills from their supervisor; although there may be a student-centred approach to the delivery of these knowledge and skills, there is no conception of the student as a creative agent. In contrast, the potential learning associated with

conceptions in categories 5 and 6 is essentially personal, with the student seen as undergoing conceptual and intellectual change. Conceptions in these categories may thus be associated with a more qualitative view of knowledge, as well as with an intrinsically student-centred approach that allows for a constructivist view of learning.

A common view of the process by which one becomes a scientific researcher stipulates that the student must first master foundational knowledge, only later going on to utilise these characteristics of the discipline to understand and explore new problems (Robertson and Bond 2001). This hierarchical conception of the acquisition of research skills reflects the distinction between types of knowledge or learning evident in the categories described above. Indeed, these categories can also be seen as steps to becoming a researcher:

(i) acquiring an essential knowledge base (category 3 to 4);
(ii) acquiring an essential skills base (category 4);
(iii) learning to think like a researcher (category 5); and
(iv) entering the research culture (category 6).

Our data suggest that some academics may believe that steps (i) and (ii) must be completed before steps (iii) or (iv) can be embarked upon, resulting in conceptions of the potential learning outcomes of undergraduate research experiences as limited to categories 2 to 4. This aligns with a view that scientific research results from the rigorous application of defined methodologies, leading to the accumulation of new and more complex knowledge. Such a belief implies that the existing body of knowledge and skills must be mastered before real research can be undertaken, implying that it is difficult for an undergraduate to participate in, rather than observe, research. In contrast, responses in categories 5 and 6 suggest that some academics believe even undergraduates can be brought into the research culture and enabled to adopt a research outlook. This may indicate that those academics do not share the rigidly hierarchical conception of development as a researcher held by some of their colleagues. These results imply that academics hold a range of conceptions of research and the process by which a student develops into a researcher, including conceptions that emphasise creativity and personal development.

So what are the implications for ideas of the teaching–research nexus? If the research and teaching activities of a university are connected through the common element of learning (Brew and Boud 1995), then the way in which students are perceived to learn how to be researchers is a crucial element of that connection. We suggest that a hierarchical conception of the development of a student into a researcher constrains the ways in which academics can understand research and teaching to be linked. This in turn narrows the range of potential learning outcomes that they envisage when including research in the undergraduate curriculum, which may negatively impact the possibilities for student learning through research experiences. In such a conception, discipline-specific content knowledge and skills are seen as essential prerequisites to research but may also be seen as distinct from research; undergraduate teaching may be seen as the delivery of those knowledge and skills alone, and undergraduate learning as the acquisition of those knowledge and skills prior to taking the next steps. In contrast, where it is recognised that ‘inquiry, investigation and discovery are the heart of the enterprise, whether in funded research projects or in undergraduate classrooms’ (Strum Kenny 1998, 9), and that research and teaching are two aspects of the single process of learning, an expanded range of

potential benefits of undergraduate research experiences can be recognised and potentially achieved.

## Conclusions

Surveys of academic staff involved in the provision of research projects and research-based coursework components in a research-intensive degree reveal a range of perceptions of the purpose of the program and its research-based components. The data revealed two main dimensions to perceptions of the overall program aims – who the beneficiaries are (academics, institutions or students) and whether the research aspect of the program is part of academics' perceptions of the program aims. These two dimensions were also evident in perceptions of the purposes of individual research experiences within the program; however these purposes also showed a pattern of increasing sophistication and richness, suggesting that academics may be aware of several different types of potential learning outcome. The data suggest that immersive undergraduate research experiences are not always seen as such by supervising academics. They also suggest that academics' perceptions of undergraduate research experiences may be connected to their assumptions about how one learns to be a researcher, and thus reveal implicit or unarticulated aspects of the connection between research, teaching and learning. If supervising academics can be encouraged to articulate how they believe undergraduate research experiences prepare students for research, and what and how the students learn through undergraduate research experiences, these connections may become explicit and thus accessible to the student, potentially increasing their potential for learning.

## Acknowledgements

The authors would like to thank Gerlese Åkerlind for helpful discussions and comments on the manuscript.

## References

Blackmore, P., and M. Fraser. 2003. Research and teaching: Making the link. In *Towards strategic staff development in higher education*, ed. R. Blackwell and P. Blackmore, 131–41. Philadelphia, PA: Open University Press.

Brew, A., and D. Boud. 1995. Teaching and research: Establishing the vital link with learning. *Higher Education* 29: 261–73.

Dahlgren, L.-O. 1984. The outcome of learning. In *The experience of learning*, ed. F. Marton, D. Hounsell, and N. Entwistle, 19–35. Edinburgh: Scottish Academic Press.

Feldman, K.A. 1987. Research productivity and scholarly accomplishment of college teachers as related to their instructional effectiveness: A review and exploration. *Research in Higher Education* 26: 227–98.

Gottlieb, E.E., and B. Keith. 1997. The academic research–teaching nexus in eight advanced-industrialized countries. *Higher Education* 34: 397–420.

Hattie, J., and H.W. Marsh. 1996. The relationship between research and teaching: A meta-analysis. *Review of Educational Research* 66, no. 4: 507–42.

Howitt, S.M., A.N. Wilson, K.F. Wilson, and P. Roberts. 2010. 'Please understand we are not all brilliant': Undergraduates' experiences of an elite, research-intensive degree at a research-intensive university. *Higher Education Research and Development* 29, no. 4: 405–20.

Hughes, M. 2005. The mythology of research and teaching relationships in universities. In *Reshaping the university: New relationships between research, scholarship and teaching*, ed. R. Barnett, 14–26. Maidenhead: Open University Press.

Hunter, A.-B., S.L. Laursen, and E. Seymour. 2006. Becoming a scientist: The role of undergraduate research in students' cognitive, personal and professional development. *Science Education* 91, no. 1: 36–74.

Jenkins, A. 2004. A guide to the research evidence on teaching–research relationships. York: Higher Education Academy. http://www.heacademy.ac.uk/embedded_object.asp?id=21570&file.

Jenkins, A., M. Healey, and R. Zetter. 2007. Linking teaching and research in disciplines and departments. York: The Higher Education Academy. http://www.heacademy.ac.uk/assets/York/documents/LinkingTeachingAndResearch_April07.pdf.

Kardash, C.M. 2000. Evaluation of an undergraduate research experience: Perceptions of undergraduate interns and their faculty mentors. *Journal of Educational Psychology* 92, no. 1: 191–201.

Krause, K.-L., S. Arkoudis, R. James, R. McCulloch, C. Jennings, and A. Green. 2008. The academic's and policy-maker's guide to the teaching–research nexus. Australian Learning and Teaching Council Report. http://trnexus.edu.au.

Marton, F. 1981. Phenomenography: Describing conceptions of the world around us. *Instructional Science* 10: 177–200.

Maykut, P., and R. Morehouse. 1994. *Beginning qualitative research: A philosophic and practical guide.* London: Falmer Press.

Neumann, R. 1992. Perceptions of the teaching–research nexus: A framework for analysis. *Higher Education* 23: 159–71.

Newitt, P. 2007. Stimulating our talented: The Bachelor of Philosophy (Honours) program. In *Proceedings of the Science Teaching and Learning Research Including Threshold Concepts Uniserve Science Conference in Sydney, September 2007.* http://science.uniserve.edu.au/pubs/procs/2007/28.pdf

Ramsden, P., and I. Moses. 1992. Associations between research and teaching in Australian higher education. *Higher Education* 23: 273–95.

Robertson, J., and G. Blackler. 2006. Students' experiences of learning in a research environment. *Higher Education Research & Development* 25: 215–29.

Robertson, J., and C.H. Bond. 2001. Experiences of the relation between teaching and research: What do academics value? *Higher Education Research & Development* 20: 5–19.

Robertson, J., and C.H. Bond. 2005. The research/teaching relation: A view from the edge. *Higher Education* 50: 509–35.

Rowland, S. 1996. Relationships between teaching and research. *Teaching in Higher Education* 1: 7–20.

Russell, S.H., M.P. Hancock, and J. McCullough. 2007. The pipeline: Benefits of undergraduate research experiences. *Science* 316: 548–49.

Seymour, E., A. Hunter, S. Laursen, and T. Deantoni. 2004. Establishing the benefits of research experience for undergraduates in the sciences: First findings from a three year study. *Science Education* 88: 493–534.

Strum Kenny, S., 1998. The Boyer Commission on educating undergraduates in the research university; reinventing undergraduate education: A blueprint for America's research universities. Stony Brook, NY: State University of New York. http://naples.cc.sunysb.edu/Pres/boyer.nsf/.

Wareham, T., and P. Trowler. 2007. Deconstructing and reconstructing 'the teaching research nexus': Lessons learned from art and design. In *Online proceedings of the All Ireland Society for Higher Education conference on Teaching and Learning in the Changing World of Higher Education in Maynooth, Ireland, August 2007*, ed. L. Carey, S. Huntley-Moore, A. Jordan, S. Magennis, and B. McMullin. http://www.aishe.org/events/2006-2007/conf2007/proceedings/paper-21.doc.

Wilson, A., S. Howitt, K. Wilson, and P. Roberts. 2007. Research-led education: Challenges and experiences, In *Proceedings of the Science Teaching and Learning Research Including Threshold Concepts Uniserve Science Conference in Sydney, September 2007.* http://science.uniserve.edu.au/pubs/procs/2007/30.pdf.