Commonly known, commonly not known, totally unknown: a framework for students becoming researchers

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Published online: 26 Oct 2007.

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Commonly known, commonly not known, totally unknown: a framework for students becoming researchers

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Providing undergraduate students with research experience has been asserted as a way of reinventing university education. This assertion lacks both substantial empirical evidence and a coherent theoretical framework. In this paper, the authors consider both research and theory relating to undergraduate research and present the Research Skill Development framework, which can be used to both chart and monitor students' research skill development. An example is given of the practical application of this framework, together with associated preliminary research findings. Further related research directions are also suggested.

> I am neither especially clever nor especially gifted. I am only very, very curious.
> – Albert Einstein

Introduction

Since the time of The Boyer Commission (1998), undergraduate student research has become an imperative for research-intensive universities. This has been correlated with increased participation in postgraduate research (Lopatto, 2004; Gonzalez-Espada & Zaras, 2006), with one study (Bauer & Bennett, 2003) suggesting that PhD completion rates were doubled for students who had participated in undergraduate research. Increased completion rates will be of major interest to research-focused academics because they are part of the funded measures of research-excellence in some countries (the Research Assessment Exercise in the United Kingdom, Performance-Based Research Funding in New Zealand and, probably, the anticipated Research Quality Framework in Australia). Undergraduate research has also been associated with higher levels of student satisfaction and with their perceptions of generic skill

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development (Kardash, 2000; Hathaway *et al.*, 2002; Ishiyama, 2002; Bauer & Bennett, 2003; Seymour *et al.*, 2004). As well as being of considerable educational significance, in Australia at least, measures of such indicators are linked to the substantial dispensation of money as per the Teaching and Learning Performance Fund (DEST, 2006). Curiously, studies of undergraduate student research typically lack a strong empirical basis, with a scarcity of 'research findings upon which sound evaluation strategies might be grounded' (Seymour *et al.*, 2004, p. 493). One of the reasons for this may be the lack of theoretical framework from which to conceptualise undergraduate research across all disciplines.

This paper posits research and the development of research skills as both a product and a process of university education. This involves students learning how to research within a specific discipline, akin to Griffith's (2004) 'research-orientated teaching'; it also involves students conducting their own research, as per Griffiths' 'research-based teaching'. We represent student research as a continuum of knowledge production, from knowledge new to the learner to knowledge new to humankind, moving from the commonly known, to the commonly not known, to the totally unknown. Students may be positioned at various stages along that continuum. Many commence undergraduate studies already familiar with the process of developing knowledge new to themselves. Few come to postgraduate studies ready to explore or create knowledge new to humankind. A dilemma for staff and students alike is how to chart the movement along this research continuum and how to facilitate that movement.

This paper is developed on the premise that, in order to engage in meaningful research, students would benefit from the explicit development of their research skills, as would the staff guiding that development. The focus of this paper, then, is to present a framework for the Research Skill Development (RSD) of coursework students. The framework is for lecturers who want to conceptualise how they will facilitate this development. It is also for educational leaders concerned about student ratings and research funding issues, and for researchers wanting to study research skill development and the links between teaching and research. In the paper we first explore the relationship between undergraduate education and university research. Next, we consider just what is understood by research skill development and outline studies that have been carried out into the concept in the undergraduate years. We then present our RSD framework and its application to a particular course of study, and the findings of a one-year pilot study with emergent research questions for the main study currently underway.

Undergraduate education and university research

Undergraduate education has historically been seen in conflict with academics' research agenda (Lane, 1996; Sample, 1972). Boyer's revolutionary reconceptualisation of scholarship, motivated by a concern to 'break out of the tired old teaching versus research debate' (Boyer, 1990, p. xii) suggested possibilities other than that seemingly entrenched 'truth' of research and teaching as necessarily competing

endeavours. Teaching and research may not be in opposition; they may be inextricably linked with each other (Brew, 2006).

This corresponds to Boyer's vision of 'a more inclusive view of what it means to be a scholar' (1990, p. 24). Within this vision, universities are perceived as 'ecosystems' made up of 'communities of learners' (The Boyer Commission on Educating Undergraduates in the Research University, 1998). This ecology, The Boyer Commission says:

> …depends on a deep and abiding understanding that inquiry, investigation, and discovery are at the heart of the enterprise…Everyone at a university should be a discoverer, a learner…The teaching responsibility of the university is to make all its students participate in the mission. (p. 9)

Within this paradigm, students are perceived as researchers who 'observe and participate in the process of both discovery and communication of knowledge' (The Boyer Commission on Educating Undergraduates in the Research University, 1998, p. 18). Universities are 'scholarly communities' (Huber, 2003) and the purpose of undergraduate education is to induct students into that community. Lave and Wenger (1991) speak of learning as being 'configured through the process of [the learner] becoming a full participant in a socio-cultural practice' (p. 29), with learning corresponding to 'increasing participation in communities of practice' (p. 47). The 'beginner' develops 'an increasing understanding of how, when and what about old-timers collaborate, collude and collide' (p. 95); they learn to become members of a research community (Coppola, 2001; Brew, 2003a). This initiation is an integral part of all education. Lane (1996) cites one of the 'best examples' of the integration of teaching and research as 'the cracker-jack first grade teacher questioning his or her class' (p. 1), leading them in a process of inquiry 'to create their own knowledge by guiding their inquiries and reinforcing their discoveries' (p. 1). Research skill development can be seen as an underlying principle of all education and not restricted to 'researchers' engaging in activities that compete with their teaching demands.

Undergraduate research: theory and practice

A key issue is to define undergraduate research. Dominick *et al.* (2000) reviewed 400 articles on undergraduate research, concluding that few of them 'address this basic question. Most…simply accepted the proposition that research was whatever a faculty member and student decided what it was' (p. 5). Lane (1996), too, acknowledged the problem of definition, citing a US Supreme Court judge's comment in relation to obscenity, that 'I can't define it but I know it when I see it'. Others have striven for a definition of what undergraduate research experience might entail. Healey (2003), for example, specifies the aim of research experience, namely to develop students' understanding of, and abilities to carry out, research. He says that programs should 'induct students into the role of research in their discipline and present knowledge as created, uncertain and contested' (p. 15), this conflicting with

the notion of teaching and learning as primarily concerned with the transmission and assimilation of knowledge.

In terms of actual practice, Bauer and Bennett (2003) report that, before the mid 1980s, there was little commitment to undergraduate research and that the 'basic structures and methods of undergraduate instruction in the nation's research universities have remained largely unchanged' (p. 211). The Boyer Commission on Educating Undergraduates in the Research University (1998) claimed that the efforts made up until that time were 'timid, sporadic, limited, and unavailing' but, a few years later, Seymour, *et al.*, found a 'large number of programs and models' (2004, p. 494) associated with undergraduate research. The incidence of undergraduate research may be somewhat dependent on the particular discipline area. There has been a considerable tradition of research among science undergraduates (Reisberg, 1998; Evans & Witkosky, 2004), although perhaps less so in the physical sciences (Healey, 2003). The imbalance of research education towards the sciences and away from the humanities may relate to the typical research processes and traditions within the disciplines (Reisberg, 1998), science research often being carried out by teams whereas research in the humanities is more often a solitary activity (Healey, 2003). Students within different disciplines also report different perceptions of research activity. A study by Robertson and Blackler (2006) found that students from the discipline of English perceived themselves to be engaged in research, in collaboration with lecturers, from the first year of study, whereas Physics students perceived that it was their lecturers alone who undertook research.

As well as interdisciplinary variations, there are also different approaches to providing undergraduate research experiences. One, which closely mimics traditional postgraduate research, has students carrying out a project under the supervision or mentorship of a staff member. This may involve the student pursuing the research alone (Reisberg, 1998; Ward *et al.*, 2003) or in collaboration with the staff member (Evans & Witkosky, 2004). A variation of this is for students to work collaboratively on a short- or long-term research project (Johnson *et al.*, 2002; Healey, 2003). Some programs require students to communicate their findings through mini-conferences or in journals (Dominick *et al.*, 2000; Brew, 2003b; Sivilotti & Weide, 2004), sometimes incorporating processes of peer editing (Coppola, 2001). In some cases, whole programs are constructed using a project-based inquiry model (Major, 2002; Healey, 2003).

Studies into undergraduate research

Studies have been carried out into the perceived learning outcomes of undergraduate research. Bauer and Bennett (2003) report that most of these studies indicate 'high levels of satisfaction' for students with the associated learning outcomes in terms of research-specific skills. In their own study, Bauer and Bennett took a wider perspective, surveying alumni regarding their development of 'general cognitive and personal abilities and skills' and correlating those with whether and how much the respondents had participated in undergraduate research, this being defined as

'collaboration between undergraduates and their faculty research sponsors' (Bauer & Bennett, 2003, p. 215). Their findings were that those who had participated in undergraduate research rated that experience highly, the highest ratings being given by those who had spent the greatest amount of time in undergraduate research. Those with undergraduate research experience also reported 'significantly greater enhancement' of eight identified cognitive and personal skills and abilities compared to those not in such programs and, as noted earlier, were more likely to undertake a higher degree, being twice as likely as non-participants to complete doctoral studies. Similarly, a study by Ward and colleagues (2003) indicated that students perceived that engaging in research facilitated learning to a greater extent than traditional courses. Students specifically acknowledged the extent to which their practical and 'advanced technical skills' had been developed, and frequently included words such as 'joy' and 'wonderful' when speaking of their research experience. Similar benefits were identified by Reisberg (1998) who found that, for students, researching was 'more exciting and academically rewarding' than lecture-based approaches to teaching and learning. Dominick *et al.* (2000) claimed that, through research activities, students gained 'deeper understanding for their subject matter'. Seymour *et al.* (2004, p. 493) identified a raft of skill and attitude-based benefits, including personal/professional gains, improved thinking as a scientist, clarification or confirmation of career plans and enhanced career/graduate studies preparation. As well as enabling students to 'learn more efficiently', Evans and Witkosky (2004) identified another benefit, namely, that staff were encouraged to maintain their research efforts, a sentiment echoed by Jonte-Pace (2003), who claimed that the impetus provided by undergraduate student research enabled staff to 'move forward more efficiently and productively' with their own research.

These positive views are not shared by all. Reisberg (1998) reported that although staff identified good outcomes for students, providing undergraduate students with research experience ate into the time available for their own research. He also judged such experiences as sometimes trivial in purpose, citing Ronald Dotterer, Dean of the Liberal Arts College at Salisbury State, as saying that it was sometimes difficult 'to tell the difference between a research project and, say, a challenging homework assignment' (p. A46). Evans and Witkosky (2004) expressed other reservations in relation to undergraduate research programs. They maintained that not all students were suited to research, that it conflicted with a general approach to learning that involved convergent processes with pre-determined outcomes, that research facilities were inadequate and that undergraduate research programs often entailed students carrying out the professor's research rather than undertaking their own. Healey (2005) similarly reported students perceiving themselves as 'primarily recipients of research, rather then actors in its production' (p. 194).

Despite concerns such as these, the prevailing perspective is generally one of support for the notion of undergraduate research. The Boyer Commission on Educating Undergraduates in the Research University (1998) was particularly committed to that possibility, in accord with the Dewey principle that learning is primarily 'based on discovery guided by mentoring rather than on the transmission

of information' (p. 15). They advocate that, commencing with the freshman year, students should be provided with as many research opportunities as possible, exploring diverse fields, through internships and collaborative projects, and communicating the results of their enquiries. This, they say, should be followed through in subsequent years, culminating in a capstone experience in their final year. They identify the most important task facing universities now as being 'to define in more creative ways what it means to be a research university committed to teaching undergraduates' (p. 38).

A framework for research skill development

The sentiment inherent in much of the discussion in the earlier sections is that research is an entity separate from and unrelated to student coursework and assignments. This suggests that, at some stage, perhaps enrolling in the honours year, masters or PhD, a student suddenly begins to research, whereby no development of research skills having occurred in the undergraduate years. The alternative view we presented constructs research much more broadly, such that:

> The word research is used to cover a whole range of activities including very high level, professional focused research…right through to a quick online search for references…and everything in between. (Johnstone cited in Lane, 2006, p. 226)

Johnstone's explanation of why there are such differing understandings of the term 'research' fits with the concept being treated as a continuum, which ranges from researching a few articles to engaging in professional focused research. Such a continuum is quite visionary, allowing research to be seen as a learning endeavour from the quick online search end to the professional focused research end. If all enquiry tasks are considered to play a part in student research skill development, even from the earliest years of schooling, then a more holistic, coherent and continuous view of student research may evolve.

The emerging question is why there has been only limited recognition of explicit undergraduate research. Undergraduate research is possible; it is presently being conducted in some disciplines, yet many of the problems raised earlier remain as barriers to its wider implementation. One of these problems, at least, is potentially addressable: the conceptual difficulties faced in facilitating student research skills. This could be addressed by a framework that helps academics conceptualise how they could explicitly facilitate student research skill development.

Research is motivated by a need to know about, or a curiosity about, how things are, and what things do or may do. This initially requires no specially developed skills, just a capacity to wonder, as was stated by Einstein, who claimed that his redeeming feature, in terms of research, was not cleverness or giftedness, but that 'I am only very, very curious.' Although we may question his self-assessment in relation to cleverness and giftedness, what he says does underscore the pre-eminent characteristic of research, namely, to wonder why. To research, we embark on a voyage of discovery launched by curiosity or need. Children have this capacity to wonder early in life.

However, to be maintained, this desire to embark on inquiry needs to be nurtured. The education of students should lead them to ask research questions of increasing sophistication, specificity, depth and breadth, which set them on a journey towards making the unknown known.

Conceptualising and facilitating this journey is a task for all educators, and especially lecturers of undergraduates. At most levels of education, students research knowledge that is unknown to themselves, but which is commonly known to others. This research takes place from primary school, through secondary and on into tertiary, and typically takes the form of assignments that are prescribed by others. As a student's education progresses, their research moves into a discipline discourse with concepts, language and conventions unknown to those outside that discipline. Research, at this level, is into the commonly not known. As students become well acquainted with the canon of a discipline and its research techniques, they may be ready, probably at postgraduate level, to research gaps into or even extend the field into areas previously unknown to humankind.

Whether researching into the commonly known, the commonly unknown or the totally unknown, the process may equally be labelled researching or learning; 'research is learning' (Brew, 1988 cited in Brew & Boud, 1995, p. 267). Assignment tasks frequently require students to be actually involved in a process of research into the commonly known, although this is seldom made explicit and may not even be recognised as such by teacher or student. All associated activities that could be broadly identified as 'research' can be located on the research continuum, placing, say, a Year 3 school library or Internet research assignment along the same continuum as PhD research. The associated set of skills are often the same, but what varies from primary school to PhD is the degree of rigor, the level of specialisation and complexity of the discourse, the scope, depth and methodological framework applied to the inquiry process, and the extent of 'unknownness' of the topic under research. The fundamental facets of inquiry are, however, identical, with common processes being acted out across all research endeavours.

This notion of the commonality of research processes underpins the two models we drew upon to identify facets of research, namely, the ANZIL (2004) Standards and Bloom's Taxonomy (Bloom *et al.*, 1956). We have argued elsewhere for the relevance of the ANZIL Standards (Willison & O'Regan, 2005). These Standards comprehensively describe 'the skills or competencies that together make for effective and appropriate use of information' (CILIP, 2005), this use being an essential and major part of the research process. Bloom's Taxonomy was developed initially to 'help one gain a perspective on the emphasis given to certain behaviours by a particular set of educational plans…so that it becomes easier to plan learning experiences and prepare evaluation devices' (Bloom *et. al.*, 1956; p. 2). Although the Taxonomy was first published fifty years ago, it has been consistently applied to teaching and learning contexts since that time (see, for example, Ormell, 1974; Furst, 1981; Anderson *et al.*, 1994; Krathwohl, 2002) and so provided another widely-applicable framework we considered relevant to research-as-learning. Drawing together elements from these two models led us to specify six facets of the research process,

namely, that student: embark on inquiry and so determine a need for knowledge/ understanding; find/generate needed information/data using appropriate methodology; critically evaluate information/data and the process to find/generate them; organise information collected/generated; synthesise and analyse new knowledge; and communicate knowledge and understanding and the processes used to generate them.

As well as these facets, there are variables that span across the whole research process. One of these is the degree of knownness, which was discussed previously. Another is the degree of student autonomy in the research activity. Autonomy is widely acknowledged as an important aim in education (Boud, 1988; Bruce, 1995; Butler, 1999; Fazey & Fazey, 2001). Autonomy in the research context ranges from student engagement with closed inquiries directed towards a pre-determined outcome, involving a high level of structure and guidance, using prescribed methods and processes, through to open inquiries involving high levels of autonomy and self-determination in terms of what is investigated and how that is done. Inquiries can be classified as 'closed' (lecturer specified) or 'open' (student specified) in relation to: the question, hypothesis or aim of the task; the procedure followed or equipment used; and the answer, resolution or need for further inquiry which is arrived at (Hackling & Fairbrother, 1996).

Drawing together the facets of research with the degree of student autonomy, we devised a conceptual framework, based on an earlier formulation (Willison & O'Regan, 2005), from which to hang conceptions of student research skill and its development. The Research Skill Development framework[1] (see Figure 1) is a table, the rows of which correspond to the six major student research facets; the double-ended vertical arrow suggesting that the movement through the different facets of research is not linear, but frequently recursive. Students researching may find, for example, whilst synthesising (Facet E) information and data, that they need to reframe their research question (Facet A). Nevertheless, there is a general progression from Facet A, leading ultimately to Facet F. The five columns in the table represent the degree of student autonomy, with Level I corresponding to a low degree of autonomy, describing students working at a level of closed inquiry, requiring structure and guidance, and Level V corresponding to a high degree of autonomy, whereby the student is functioning at a level of open inquiry.

Each cell in the table identifies the activities that a student operating at a particular level will typically engage in to carry out some aspect of research. For example, for Facet A, the descriptor for Level I is *Responds to questions/tasks arising from a closed inquiry,* whereas the corresponding descriptor for Level V of the same facet is *Generates and responds to self-determined questions/tasks based on experience, expertise and literature.* These descriptors demonstrate that movement from Level I to Level V is towards greater autonomy and self-determination. A similar progression is evident for each of the facets across the various levels. There is no intrinsic value implied by higher degrees of autonomy *per se.* In fact, it may be appropriate at any stage of their research skill development for a student to engage in Level I or Level II tasks, if the context demands it. This need is related to a phenomenon we might call 'autonomy
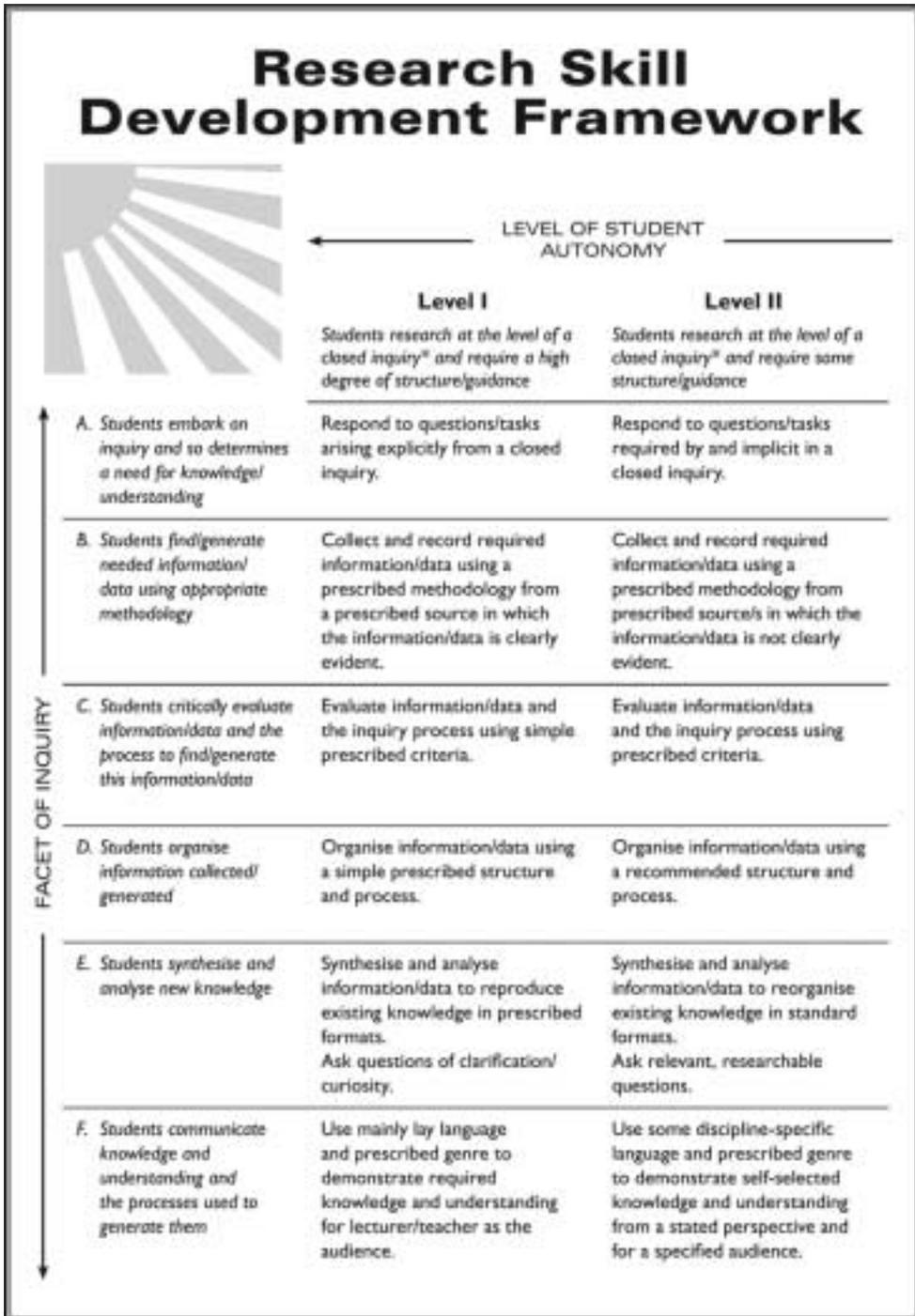
in context'. Students functioning within a certain context may become more autonomous, taking greater responsibility for their research inquiries; that is, moving towards Level V. Then, as context changes (e.g. the content is conceptually more complex or new skills are required), there may be a need for learning involving Level I or II tasks. 'Autonomy in context' suggests that, with increasingly difficult contexts, there is need once again for structure and specific guidance. As familiarity and success in this new context increase, the degree of autonomy can also increase.

Thus, the labelling of the facets and levels with successive letters and numbers is not meant to imply that a student progresses linearly through them in an orderly, pre-determined way. Lane's (1996) 'cracker-jack first grade teacher' may provide an environment in which first graders are encouraged to inquire in ways described by Level V. Postgraduate research students may be functioning initially at Level II. Nor will a student necessarily, at any one time, be functioning at the same level for all the specified facets. The progression for each student is recursive and context-, task- and discipline-specific. An individual student may engage in research behaviour that corresponds to their own individual pathway through the table, moving to higher or lower levels in each facet depending on the variables of context, task and discipline. For example, a student may, at some time in some context, be functioning for Facet A at Level II, for Facet C at Level IV and for Facet D at Level III, and at another time, in another context, their position may be represented by a different cluster of cells.

Students may go though many Level I to Level V cycles when researching the commonly known in undergraduate studies (or earlier). As they progress towards researching the commonly unknown, they may move through those same cycles several more times, finally arriving at the cutting edge of research into the totally unknown. Yet, here again, they may need guidance, maybe at PhD level or postdoctoral studies, starting at Level I or II, until the autonomy of Level V is realisable, and at which point the student is applying the 'standards' of rigor and impact (Glassick *et al.*, 1997) required to generate knowledge new to humankind.

The RSD framework is designed primarily as a conceptual tool for diagnosis and planning, promoting understanding and interpretation of both potential and realised student research skill development. It is not an attempt to objectively specify precise descriptors of student behaviours at certain levels. This reflects the fact that such an attempt would be fraught with intrinsic difficulty, because such descriptions' 'clarity, explicitness and objectivity are largely spurious. They give the impression of precision, only because we unconsciously interpret them against a prior understanding of what is required' (Hussey & Smith, 2002, p. 225). The framework is trans-disciplinary, and so must be open to the multiple interpretations of a multiplicity of disciplines. This means that there is no sense of comparability between disciplines 'but the depth and detail of the knowledge, or the level and sophistication of the skills, will be established by the…activity' (Hussey & Smith, 2002, p. 228) and by the disciplinary context (Hussey & Smith, 2002).

The critical issue is the usefulness of our framework in terms of its application to the real world. As Dewey (1908) said, 'ideas are essentially intentions…the idea is

Research Skill Development Framework

LEVEL OF STUDENT AUTONOMY

FACET OF INQUIRY	Level I	Level II
	Students research at the level of a closed inquiry* and require a high degree of structure/guidance	*Students research at the level of a closed inquiry* and require some structure/guidance*
A. Students embark on inquiry and so determines a need for knowledge/ understanding	Respond to questions/tasks arising explicitly from a closed inquiry.	Respond to questions/tasks required by and implicit in a closed inquiry.
B. Students find/generate needed information/ data using appropriate methodology	Collect and record required information/data using a prescribed methodology from a prescribed source in which the information/data is clearly evident.	Collect and record required information/data using a prescribed methodology from prescribed source/s in which the information/data is not clearly evident.
C. Students critically evaluate information/data and the process to find/generate this information/data	Evaluate information/data and the inquiry process using simple prescribed criteria.	Evaluate information/data and the inquiry process using prescribed criteria.
D. Students organise information collected/ generated	Organise information/data using a simple prescribed structure and process.	Organise information/data using a recommended structure and process.
E. Students synthesise and analyse new knowledge	Synthesise and analyse information/data to reproduce existing knowledge in prescribed formats. Ask questions of clarification/ curiosity.	Synthesise and analyse information/data to reorganise existing knowledge in standard formats. Ask relevant, researchable questions.
F. Students communicate knowledge and understanding and the processes used to generate them	Use mainly lay language and prescribed genre to demonstrate required knowledge and understanding for lecturer/teacher as the audience.	Use some discipline-specific language and prescribed genre to demonstrate self-selected knowledge and understanding from a stated perspective and for a specified audience.

* Inquiry may range from closed (lecturer specified) to open (student specified) in terms of: i) question, hypothesis or aim of research; ii) procedure or equipment; iii) answer, resolution or further inquiry (Hackling and Fairbrother 1996).

The Research Skill Development framework was devised by John Willison and Kerry O'Regan.
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www.adelaide.edu.au/clpd/materia/projects/rsd/

LEVEL OF STUDENT AUTONOMY ⟶

Level III	Level IV	Level V
*Students research independently at the level of a closed inquiry**	*Students research at the level of an open inquiry* within structured guidelines*	*Students research at the level of an open inquiry* within self-determined guidelines*
Respond to questions/tasks generated from a closed inquiry.	Generate questions/aims/ hypotheses framed within structured guidelines.	Generate questions/aims/ hypotheses based on experience, expertise and literature.
Collect and record required information/data from self-selected sources using one of several prescribed methodologies.	Collect and record self-determined information/data from self-selected sources, choosing an appropriate methodology based on structured guidelines.	Collect and record self-determined information/data from self-selected sources, choosing or devising an appropriate methodology with self-structured guidelines.
Evaluate information/data and the inquiry process using criteria related to the aims of the inquiry.	Evaluate information/data and the inquiry process comprehensively using self-determined criteria developed within structured guidelines.	Evaluate information/data and the inquiry process rigorously using self-generated criteria based on experience, expertise and the literature.
Organise information/data using recommended structures and self-determined processes.	Organise information/data using structures and processes suggested by provided guidelines.	Organise information/data using self-determined structures and processes.
Synthesise and analyse information/data to construct emergent knowledge. Ask rigorous, researchable questions based on new understandings.	Synthesise and analyse information/data to fill recognised knowledge gaps.	Synthesise and analyse information/data to fill self-identified gaps or extend knowledge.
Use mostly discipline-specific language and appropriate genre to demonstrate knowledge and understanding within a field from a scholarly perspective and for a specified audience.	Use the language of the discipline and appropriate genre to address knowledge and understanding gaps from several perspectives for a self-selected audience.	Use the language of the discipline, choosing appropriate genre to extend knowledge and understanding, from diverse perspectives for a range of audiences.

Figure 1.   The Research Skill Development Framework.

true which leads us to what it purports' (p. 85). The framework we have presented here offers more than a conceptual model. One major purpose is to promote lecturers' and students' awareness of the process of research skill development. Lecturers can anticipate and diagnose students' positions, set goals and plan appropriate courses of action, developing in students a vision of the big picture; students can see where they are going and what is required. They can become increasingly autonomous in specific contexts, and can then proceed to increased depths of rigor of inquiry in new contexts. We see one practical application as being both to chart and to anticipate students' development as researchers. It can, therefore, be used to inform course design, to frame assessment and learning tasks and to identify students' development at any time as well as their progression over time. A pilot study into undergraduate research skill development (Willison & O'Regan, 2006a; 2006b) has shown that an existing course of study may be modified successfully according to the RSD framework. This modification resulted in the explicit development and assessment of student research skills over a year within coursework requirements, and has proven to be efficient for the academics involved and highly satisfactory for students (Willison & O'Regan, 2006b).

Practical application of the research skill development framework

The pilot study, conducted in 2005, involved two lecturers and 120 students in two successive Human Biology courses. The main research benefits of this study were that it allowed us to evaluate and refine the framework, to generate research questions for a subsequent, more extensive study, and to formalise the associated research procedures and data-gathering requirements. Providing a coherent approach to the development of research skills enabled students to progressively acquire such skills in a structured and systematic way. There were some additional benefits, notably productive collaboration between researchers and lecturers, between lecturers and students, and between students and students. It is also possible, although this needs further verification, that student research skill improved during the course of the year more than would have been possible without the framework.

The lecturers took existing assessments and modified them in simple but effective ways informed by the RSD framework. They used the framework to devise marking criteria for three assessments[2] that reflected the RSD framework. This meant that the framework provided an in-common way of viewing assessments throughout the year. Feedback to students was also couched in the language and context of the RSD framework, further contributing to a consistency that was maintained throughout the courses. This was true, even though the first semester assessments were literature research only, and the second semester task required students to integrate literature with their own field research.

The results of the three assessments provided a numerical measure of student research skill development in the Human Biology context. Analysis of the results indicated that student research skill developed substantially over the year. The mean and modal student results moved forward by one level over the course of a year; however,

at this stage it is not appropriate to make any particular claims in relation to those movements. There were four clusters of students whose results fell outside this general, more predictable, pattern of movement. Those students scoring initially at the extremes (very high or very low) ended up with more middling marks, some of the initially middle-range students progressed to substantially higher scores, and others of this group dropped out completely. Several of these movements were unexpected and raise a number of questions. Why did students who started poorly improve to average? And why did the better students at the start become so average? We could ask, too, about the considerable improvement of some of the originally mean/median students. Why did these students improve to become the top achievers, scoring more than one standard deviation above the mean final score? We anticipate that the next phase of the pilot study will answer some of the questions through interviews with students in these clusters.

These initial questions have evolved into the following set of more formal research questions that we are now addressing in present research:

1. What are the factors that caused the research skill development observed in each of the non-typical clusters and for the more typical students?
2. What is the correlation between end-of-first-year research skills and undergraduate degree grades? What is the correlation between end-of-first-year research skills and participation/completion in postgraduate studies generally and research degrees particularly?
3. What is the range and frequency of levels of research skill development that undergraduate courses in many disciplines facilitate? To what extent are there similarities of these within a university, a discipline, a faculty, a State, a university cluster (e.g. Gof8), a country?
4. What are the similarities and differences of research skill development between different cohorts in the same course?
5. What is the profile of entry research skill in the context of each first-year course of one university?

Our ongoing task will be to progressively explore these and other emergent questions as we continue the process of applying the RSD framework to a range of learning, teaching and research situations; to 'exploit further the link between learning and research in the design of courses' (Brew & Boud, 1995, p. 272), as well as in the design of further studies, including 'the impact of research-based learning on student intellectual development' (Jenkins *et al.*, 2003, p. 180). Of particular interest will be the adoption and adaptation of the framework to other disciplines. The framework has been recently utilised by lecturers in Engineering, with anecdotal evidence of a high degree of student skill development, and lecturer and student satisfaction. Interviews with supervisors of PhD students from seven disciplines suggested that the framework may be applicable up to PhD proposal submission for international students, students who's previous study was in a different but related discipline, or whose previous studies lacked any explicit research (Willison, 2006). The use and limitations of the framework in different

contexts need to be recognised and published, to facilitate its appropriate and extended use.

Conclusion

The relationship between research and undergraduate education in higher education has long been problematic. Boyer's re-visioning of scholarship has led to a reframing of that relationship and a reinventing of undergraduate education as an induction into the research culture of a university. This has seen pockets of realisation, whereby undergraduate research involvement has contributed significantly to enhanced student experience of programs, graduate employment outcomes and postgraduate research participation. However, in general, implementation of and rigorous study of these phenomena have, to date, been somewhat sporadic and haphazard, especially lacking any real theoretical underpinning. Conceptualising student research skill development and actualising it in the early years of undergraduate studies is critical if our global society is to provide quality researchers to deal with the challenges of the early, middle and late 21st century. Moreover, as noted previously, there are numerous skill and satisfaction gains made by those who participate in undergraduate research, but who do not necessarily progress to postgraduate studies; research skill development, from low degree of autonomy to high degree of autonomy, is relevant for all undergraduate students.

A framework encapsulated within the boundaries of a single table cannot, of course, represent the complexities and variability associated with all student researchers within all situations. What we do offer in the RSD framework is a way to conceptualise research skills across a student's educational lifetime. This framework potentially provides a way of planning an environment that encourages inquiry of deeper understanding and greater synthesis, and that is more applied, more thoroughly analysed and better evaluated than may be possible by more ad hoc arrangements. We offer the RSD framework as a means of accommodating the development of research skills at all levels and across all discipline areas.

We anticipate that this framework can both inform and describe a whole range of research activities and have begun to test this in real teaching/learning contexts. We plan to build on our preliminary research into its application, both in the field and in meta-analysis, of the literature. We invite others[3] to do likewise, to test the RSD framework's capacity to guide practice, and to be a starting point for studies of coursework students researching the commonly known, the commonly not known or the totally unknown.

Notes

1. The RSD framework is available at www.adelaide.edu.au/clpd/rsd
2. Human Biology and other disciplines' marking criteria are available at the web address above.
3. Join the discussion on coursework RSD at the wiki discussion page. Navigate through the address above.

Acknowledgements

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