

Understanding the scope of undergraduate research: a framework for curricular and pedagogical decision-making

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Published online: 20 March 2013
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Abstract This article critically examines existing models and different ways of understanding undergraduate research to argue that there is a need for a coherent framework for student research that can contribute to curricular and pedagogical decision-making. A framework derived from analysing and integrating models of undergraduate research within the literature and from investigation in different countries is presented and explained. This framework graphically highlights the curricular and pedagogical choices involved where it is intended to engage students in research and inquiry. The article then indicates how it has been and can be used and discusses implications for research and practice.

Keywords Curriculum · Pedagogy · Inquiry-based learning · Research-based learning

Introduction

Twenty-first century society presents critical challenges for higher education. Commentators have talked about the speed of change; about increasing complexity and ambiguity; about globalization and global interdependency; about the ways in which technology is changing how people communicate with each other; and about the huge physical and social problems requiring multi-disciplinary, global solutions (see for example, Bauman 2000, Giddens 1999; Barnett 2000). Steinberg and Kincheloe (1998, p. 6) argue that we are living in an era of ‘radical doubt where the certainties of tradition are rejected and knowledge is contested.’ It is a postcolonial, pluralistic context in which people are required to deal with constantly changing knowledge; where every day people come across ideas that are not only different but radically different to their own.

What kind of higher education curriculum is appropriate in this context and how can academics be helped to implement it? Universities have a responsibility to prepare students for professional life, so how are students to be prepared to expect changes in their

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knowledge? How are they to be prepared to deal with different knowledges? In short, how are they to be prepared to cope with the ambiguities and super-complexities (Barnett 2000) of twenty-first century society?

In response to these challenges, there has been growing interest and practice in engaging undergraduates in research and inquiry. Making the case for student research, Steinberg and Kincheloe argue that in such a context, students should become educated:

at the frontier where the information of the disciplines intersects with the understandings and experience that individuals carry with them ...[This] is the point where knowledge is created (constructed). (Steinberg and Kincheloe 1998, p. 9).

Drawing on the work of Dewey and Friere, they argue that a good education should enable students to critically evaluate both the world in which they live and received knowledge. Barnett (1997, p. 110) similarly argues that ‘What is required is not that students become masters of bodies of thought, but that they are enabled to begin to experience the space and challenge of open, critical inquiry (in all its personal and interpersonal aspects)’. Kellett (2010), also arguing for student research, comes to a similar conclusion. We are living in an era of ‘radical doubt where the certainties of tradition are rejected and knowledge is contested’ she writes (p.6). This, she suggests, behoves researchers to rethink their current practice.

In responding to these contemporary challenges, many higher education initiatives emphasise student engagement, participation and inquiry. Undergraduate research seeks to emphasise these and, in addition, emphasises epistemological aspects such as knowledge production and dissemination, critical evaluation of existing knowledge and dealing with unforeseen problems and challenges, as well as ontological aspects, such as changing the being of students, developing their personal and professional capabilities and influencing their perceptions of themselves. Undergraduate research is a student-focused way of bringing research and teaching together. Through it, students can contribute to the academic project of the university.

Through research, Steinberg and Kincheloe (1998, p. 6) suggest, students ‘learn to live with the ambiguity that comes with the critical domain’. Neary (2010), drawing on the ideas of Walter Benjamin, argues that to engage students in research is to ‘provide for the possibility of progressive social transformation through practical action’. This is necessary at a time when, as he argues, there are ‘practical imperatives driven by the avoidance of disaster beyond human imagination’ (Neary 2010, p. 3). Brew (2006) similarly argues for higher education to develop scholarly knowledge-building communities in universities where academics and students work in partnership to solve such problems. Involving students in investigation into aspects of the world relevant to their degree study can also capture the questions that students bring to universities. As Neary (2010) argues, it shifts students from being viewed as, and acting as, consumers of knowledge into students being engaged in the active production of knowledge.

Introducing research and inquiry into undergraduate education, however, poses numerous challenges. In recent years there have been a number of attempts to understand the benefits and challenges of research experiences for students, to provide coherent rationales for it, and to map the scope in frameworks and models (see for example, Beckman and Hensel 2009; Healey and Jenkins 2009; Laursen et al. 2010; Levy and Petrulis 2012; Lopatto 2009; Steinberg and Kincheloe 1998). A key question is: how can academics, academic departments and institutions be assisted in taking the many varied and complex decisions that are needed at different levels? This is the central question of this article. Its aim is to present a new conceptual framework which highlights the various

decisions needing to be taken when implementing research-based experiences for students. The framework derives from a critical analysis and an attempt to integrate existing curriculum models and pedagogical approaches.

The paper has its roots in a 4-year program of work in Australia carried out initially under the auspices of a nationally funded project designed to enhance student engagement through research and inquiry and more recently through a series of institutional projects. The work has involved study tours overseas; staff and student development programs including regional and institutional meetings and an on-going institutional working group, undergraduate scholarships, hosting a national summit and an international undergraduate research conference; as well as carrying out a number of research projects on aspects of undergraduate research.

The parameters of research-based learning that are being integrated in the paper are first established. The paper then provides a critical analysis of two widely-used frameworks for understanding student research: Healey and Jenkins (2009) and Levy and Petruilis (2012), in order to establish what is needed in terms of a new model. Again through an analysis of the literature, the paper then explores in detail the complexity of the decisions that need to be incorporated in a new research-based learning framework. In the final part of the paper, the new model is presented. The model has been trialled in a number of staff development workshops with academics, so the paper discusses ways in which it has and can be used and concludes with implications for further research and practice.

The scope of the undergraduate research curriculum

In this paper, research-based learning curricula are taken to include all the opportunities provided for students to gain experience in planning and carrying out research, learn research skills appropriate to the discipline, and pursue and present research, that they encounter during their degree. Both in the literature and in practice, courses with research-based components have tended to be considered quite separately from research experiences initiated by researchers and outside of students' formal classes such as vacation scholarship programs. However, all the opportunities to engage in research during their time at university, whether in formal classes or outside of them, constitute, for students, the experienced curriculum and, as such, need to be considered together. As Knight (2001) argues, higher education is a matter of complex learning:

Amongst other things it is about unending disputes, subtle concepts, large amounts of information to be organised and remembered, and emerging understandings of the nature or structure of the subject or area itself (Knight 2001, p.369).

Knight further suggests that learning environments 'with their discourses, practices, interactions, tasks, patterns of power and resources' (p.377), contribute to learning in many more ways than are contained within formal, rationally defined curricula with stated learning outcomes and related forms of assessment.

It should be noted that different forms of undergraduate research arise from different areas of the university, different discourses and practices and different motivations. Indeed, different forms are present to varying degrees within different countries and there is considerable variation in how and whether such initiatives are supported by governments, by research funding agencies, by industry and indeed by universities themselves (Brew 2010; Healey and Jenkins 2010; Higgs 2010; Spronken-Smith and Walker 2010). They are as much the domain of research as teaching and learning in higher education; academics in

their teaching role tending to focus on courses and curricula and final year projects; and in their researcher role tending to focus on research experience programs outside formal classes.

Whether academics are engaging in undergraduate teaching or engaging in research, curriculum decisions have to be taken about the overall structure and framework of the undergraduate research experience, what it is intended students should gain from it and how and whether their work is to be assessed. Sometimes curriculum decisions are taken at an institutional level, for example, when there is a decision to implement a summer vacation research experience across the whole campus. Sometimes the decision-making is at a departmental or course team level, for example, when a decision is taken to move the particular degree program to a problem-based or inquiry-based curriculum. Research-based learning pedagogies are enacted by individuals and course or subject teams within particular curricula frameworks including traditional ones, and there are a number of decisions that have to be taken regarding the particular pedagogies through which learning is to occur. The model presented in this paper aims to integrate different forms of undergraduate research into a coherent model specifying the different curricular and pedagogical decisions needed.

In the context of a growing number of approaches to engaging undergraduates in various forms of research and inquiry, there is a need for a wholistic conceptual framework which can encompass the wide variety of ways in which research can be experienced and can contribute to student learning. A practical framework is needed which specifies the various curricular and pedagogical decisions that have to be made if students' learning is to benefit from a relevant range of research experiences. The purpose of such a framework or model is to assist academics to more effectively and more confidently implement a wider range of experiences for their students. However, it is important to first examine existing frameworks that seek to elucidate different forms undergraduate research can take.

Frameworks for understanding undergraduate research

In some countries, work to understand and implement undergraduate student research has grown out of attempts to develop the relationship between teaching and research. Specifically, Hattie and Marsh's (1996, p.533) seminal study which challenged academics to 'increase the circumstances in which teaching and research have occasion to meet,' has been influential. Elsen et al. (2009) and Spronken-Smith and Walker (2010) each argue respectively that engaging students in research and inquiry-based learning are ways of strengthening the links between research and teaching.

Healey and Jenkins (2009) proposed a framework specifying different forms of research-based learning which was specifically designed to strengthen this relationship and it has become widely used in institutions, as any internet search will testify. In this framework, undergraduate research and inquiry are seen along two dimensions. The horizontal axis focuses on research content on the one hand and on research processes and problems on the other, and the vertical axis distinguishes students as participants and students as audiences for research (see Fig. 1). Healey and Jenkins (2009) argue that whether students are engaging in research in their courses or outside the curriculum by, for example, participating in events, seminars and special undergraduate research programs, they should engage in research in all of the four ways indicated in this model.

Again arising from an attempt to map the linking of teaching and research in the student experience, a related framework was proposed by Levy and Petrulis (2012). This was

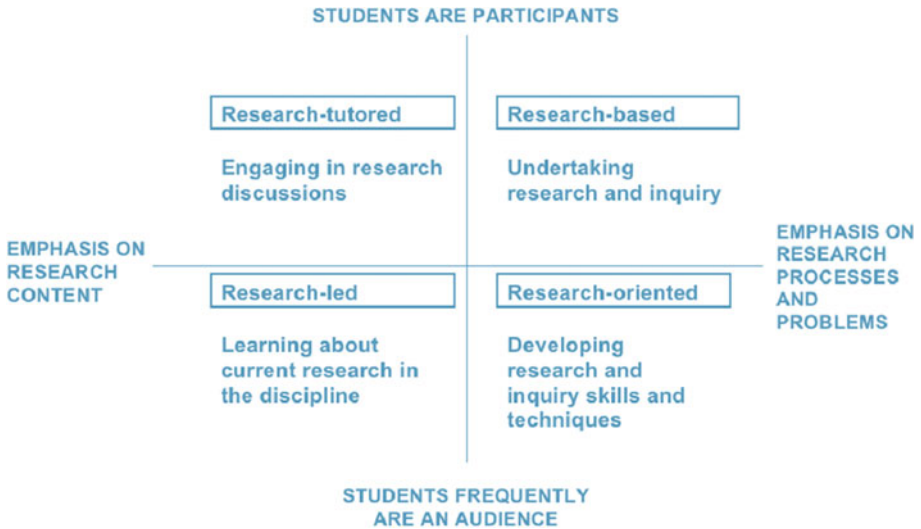
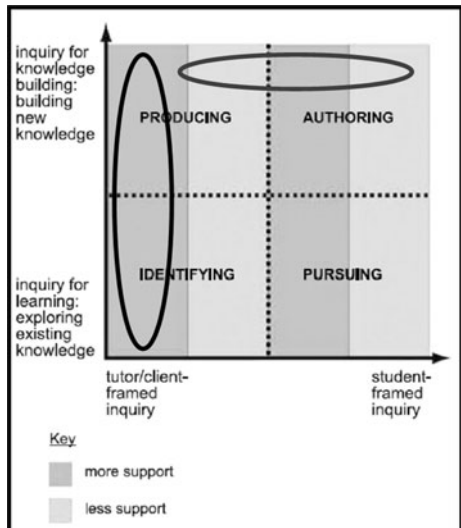


Fig. 1 The nature of undergraduate research and inquiry (Healey and Jenkins 2009, p.7)

designed to enable the mapping of student activity according to who frames the inquiry (cf. the horizontal axis indicating the distinction between student-directed and tutor- or client- directed inquiry) and whether students are acquiring existing knowledge or are developing new knowledge (cf. the vertical axis). So, for example, in a problem-based curriculum, the inquiry is essentially directed by the tutor but the student is engaging both in acquiring existing and creating new knowledge (cf. the vertical oval in Fig. 2). A student engaging in undergraduate research where they choose their own question and frame the inquiry may be supervised by the tutor but the student’s focus may be on developing new knowledge (cf. the horizontal oval in Fig. 2). A client-directed inquiry would be when a student is undertaking an internship, for example, in industry or for the community.

Fig. 2 Inquiry based learning (Levy and Petrusis 2012, p.97)



It is clear that these frameworks are helpful for academics in thinking through aspects of research and/or inquiry-based learning, but they have some limitations. For example, it is difficult to see how students can be developing research and inquiry skills when they are an audience for research as suggested by the Healey and Jenkins model. Further, in that model, there is no space given to where students are engaging in debates about the history, sociology and philosophy of research. The Levy and Petruilis model lacks clarity, for example, about what is meant by ‘more support’ and ‘less support’.

Further, these authors do not explore the consequences of conflating curriculum and pedagogy. Indeed, they do not distinguish them. However, this is an important distinction in the context of educational decision-making because while pedagogical decisions are likely to be the preserve of the person teaching the course or subject, curriculum decisions are often taken at a departmental or even institutional level, as, for example, when there are decisions taken to embed particular graduate outcomes throughout the degree or program. Differentiating levels of decision-making in this way highlights important questions about the power teachers do or do not have and who or what has the authority to decide on particular aspects of the teaching and learning.

If each model is looked at from a curriculum perspective, then questions arise about the overall structure of the course, for example, about the balance of tutor-framed and student-framed inquiry and about the extent to which students are acquiring existing knowledge as opposed to building new knowledge. In the case of the Healey and Jenkins’ framework, it does not specify who initiates the inquiry and there are questions about the balance of research-led, research-tutored, research-oriented and research-based learning in the overall curriculum as well as how these relate to the learning outcomes and assessment. Neither framework can explain or assist with the overall curriculum design where there are inquiries which are negotiated by student, tutor and client. Many examples of student inquiry lie at the confluence of all four quadrants in each model so a framework that specifies how these are to be accommodated within the overall curriculum is needed. Further, these models do not distinguish different levels and types of student outcome i.e. why the student is engaging in research of these different types. Nor do they indicate what the relationship of the inquiry is to how it is assessed and to the students’ overall assessment.

If on the other hand the frameworks are looked at from a pedagogical point of view then questions arise about how each of them accounts for the integration of the different elements, for example, where the emphasis is on content as much as processes and problems (Healey and Jenkins 2009) or where the student is acquiring existing knowledge in order to ‘author’ or generate new knowledge (Levy and Petruilis 2012). Neither model explains to what extent the nature of the project influences or determines the type of undergraduate research and inquiry, for example, if it is a funded project. Nor do they account for differences in the nature of knowledge and different views about how and whether knowledge is discovered or generated, for example, in different disciplines. No account is given in these models of the distinction between what the student does and what it is intended students should achieve.

What is clear is that implementing an undergraduate research and inquiry curriculum, or putting elements of undergraduate research and inquiry into one requires a number of complex choices to be made. How are course teams and academics to make choices between different approaches and what choices are they to make? How are teachers and/or researchers or mentors and supervisors to decide what form of research-based learning is appropriate for a given student or students at a particular time and within a particular disciplinary curriculum context? What are the elements that make a curriculum research-

based? How are researchers and teachers to navigate their way through what is in fact a complex and perplexing domain? These models provide no or little guidance on these issues. Clearly a different model is needed.

In attempting to understand and develop the relationship between teaching and research, these models inevitably simplify a complex terrain. In doing so they conflate both teacher-focused pedagogies where the focus is on the teacher and there is an intention to transfer information to students, and student focused pedagogies where the focus is on the student and on conceptual change (Prosser and Trigwell 1999). Pedagogies of student research can, admittedly, be seen as a way of integrating teaching and research. Indeed, Brew (2006) has argued that undergraduate research is a student-centred way of thinking about doing this. However, such pedagogies need to focus primarily on students' learning and how students actively engage with research, i.e. they need to be student-focused. Teacher-focused approaches such as lectures, where students are predominantly an audience and the teachers' attention is focused on their own research and telling students about it, fail to recognise the importance of undergraduate research as a way of radically transforming students' higher education experiences and ultimately higher education itself. To principally think of student engagement in teacher-focused ways, ties considerations of student research to a hybrid pedagogy based on traditional approaches where often the main focus is on academics' research and how to put that into the curriculum and not on student learning.

Brew (2006, p. 32) goes some way to addressing this in presenting a model of the relationship between teaching and research which has implications for the curriculum. She argues that universities should progressively become scholarly knowledge-building communities where academics and students work together to learn and to solve problems of the world. This, she suggests, involves expanding ideas about what constitutes research, building knowledge which starts with what students as well as academics want to learn, engaging collaboratively with students in scholarly activities, teaching in ways that put learning at the centre, and building communities of scholars of all levels, abilities and experience. Her model has implications for the kind of institutions universities would become if student research were taken seriously and it suggests the kinds of underlying assumptions that are appropriate to research-based curricula. However it does not provide guidance on how academics are to make curricular or pedagogical decisions and it does not specify implications for how students are to learn through engaging in research.

In order to move towards a framework capable of encompassing both curricular and pedagogical decision-making, it is important to examine accounts in the literature of specific initiatives that engage undergraduates in research. That is the focus of the next section.

Research-based curricula and pedagogies discussed in the literature

Numerous and varied accounts of engaging undergraduates in research exist in a range of different disciplines (see for example, Chang 2006; Cuthbert et al. 2011; Elsen et al. 2009; Karukstis and Elgren 2007; Roberts et al. 2010; Shaffer et al. 2010). There also exist a variety of studies designed to indicate how to further undergraduate research-based learning experiences. These include: ways to develop research skills (Willison and O'Regan 2007); broadening participation in undergraduate research (Boyd and Wesemann 2009; Strayhorn 2010); motivating students to engage in it; developing research in the community; developing a research community or culture (Desai et al. 2008, Garde-Hansen

and Calvert 2007; McLinden and Edwards 2011); and how to disseminate student research (e.g. Mabrouk 2009; Spronken-Smith et al. submitted for publication).

Research and/or inquiry is a central or important component in problem-based learning and inquiry-based learning. Problem-based learning (PBL) has been in use particularly in the medical education field for many years. Boud and Feletti (1997, p. 2) describe it as: ‘a way of constructing and teaching courses using problems as the stimulus and focus for student activity’. That activity often takes the form of research or inquiry. Typically, PBL is a whole of curriculum approach adopted for an entire degree program by a faculty or department, although attempts to implement parts of PBL within specific subjects or units of study are not unknown (Boud and Feletti 1997). Inquiry-based learning (IBL) in its purest form also describes a whole curriculum. Levy and Petrulis (2012, p.3) argue that it ‘places the student inquiry at centre stage, and in which all learning tasks, assessments, resources and guidance are designed to support the inquiry process.’ However, they also acknowledge that IBL describes ‘a range of pedagogical approaches.’ While the use of these kind of curricula appears to be growing, much more common are curricula in which a variety of pedagogical practices exist alongside each other within a more or less traditional pattern of lectures, tutorials, laboratory sessions, continuous assessment and examinations.

Tensions

Some of the complexity of approaches is captured in the tensions which Beckman and Hensel (2009) argue exist on a number of continua (Table 1).

While there are clearly pedagogical consequences depending on how these tensions are resolved, a number of these continua focus on decisions that need to be made at the curricular level. There may, for example, be a desire to focus on the processes of engaging with research or alternatively getting students to produce some kind of research outcome. Another question is about who initiates the project and defines the questions to be addressed. It may be that the researcher initiates the project and defines the questions that the students investigate and indeed there is an art to defining a question for an undergraduate that is appropriate for their level of skills and knowledge and for the period of time that they are to be engaged in the project. Sometimes though, it is the students who define the problem to be investigated. Alternatively, within a particular curriculum it may be the community or external organisation that defines the questions to be addressed. These questions can only be answered in the overall context of the curriculum and there is a complex interaction between curricular intentions and research intentions.

Table 1 Tensions in defining undergraduate research (Beckman and Hensel 2009, and updated by Healey and Jenkins 2009)

Student, process centered	↔	Outcome, product centered
Student initiated	↔	Faculty initiated
Honors students	↔	All students
Curriculum based	↔	Co-curricular fellowships
Collaborative	↔	Individual
Original to the student	↔	Original to the discipline
Multi-or interdisciplinary	↔	Discipline based
Campus/community audience	↔	Professional audience
Capstone/final year	↔	Starting year one
Pervades the curriculum	↔	Focussed

Another overall curriculum decision highlighted by Beckman and Hensel is about who should be engaged in undergraduate research; whether it is Honours students and high achieving students who are so engaged (which in Australia may mean the 12 % of students staying on for a final (Honours) year), or whether all students should be. A further tension is whether undergraduate research takes place outside of the curriculum, for example, in vacation scholarship programs, or is research that students conduct within the formal curriculum; perhaps through assignments and tutorials within specific subjects or in whole courses or programs, for example, across year levels or at whole of degree level e.g. PBL, IBL. Again these are basic curriculum decisions. Whether research is to pervade the curriculum is also a question of overall curriculum design.

The tensions about whether undergraduate students are to carry out research collaboratively or individually and whether undergraduate students are required to generate new knowledge or to investigate knowledge that is already known, may be questions for pedagogical decision-making. In some ways the tension between interdisciplinarity and discipline based research is likely to be taken at a curricular level, although within the context of an overall traditional curriculum, a teacher may wish to regard this as a matter of pedagogy. Questions about who is the audience for the research, for example, peers in a seminar or presentation session or the wider community including professionals and industrialists, are also likely to require pedagogical decisions.

Attitudes to engaging students in research

Pedagogies of student research inevitably rest on academics' ideas about students and on students' attitudes to research. If students are to engage in research-based learning, having positive attitudes and appropriate perceptions of research among both staff and students is critically important. The research literature suggests that this is not always the case.

Wilson et al. (2011) studied academics' perceptions of an undergraduate research degree set up as a central initiative in their university. They have argued that some academics have limited conceptions of how students develop research capability and that this can limit the ways in which students can learn through research and the opportunities for research that are presented to them. This suggests that curriculum decision-making in regards to research-based courses, does not always translate into the kinds of research experiences at the pedagogical level that course designers anticipate.

Since the mid-1990s interest in understanding students' experiences of research has flourished (see for example, Jenkins et al. 1998; Turner et al. 2008; Zamorski 2002). Related to this are studies of students' perceptions of what research is (see for example, Meyer et al. 2005) and their perceptions of research in particular universities including the extent to which their ideas are related to the disciplines they are studying (Robertson and Blackler 2006). A small number of studies have examined students' perceptions of learning research skills. Murtonen and Lehtinen (2009), for example, found that students in Finland and the USA dislike learning about research methodology and have difficulty in learning either quantitative or qualitative research methods that they do not feel in tune with. In a study by Turner et al. (2008) less than a third of the students surveyed in three institutions in Canada and the UK reported developing research skills. And indeed, this is perhaps not surprising when it appears, from a study by Wagner et al. (2011) that the knowledge-base in respect to the pedagogy of developing research skills is sparse.

Willison and O'Regan (2007) have addressed this issue by developing the Research Skills Development Framework (RSD) which provides a way of mapping the progressive development of students' research skills across a course or program of study (Table 2).

Table 2 Simplified research skill development framework (From: Willison and O'Regan 2006)

INCREASING LEVELS OF AUTONOMY					
FACETS OF INQUIRY	Level 1 closed inquiry high degree of structure/ guidance	Level 2 closed inquiry some structure/ guidance	Level 3 closed inquiry working independently	Level 4 open inquiry within structured guidelines	Level 5 open inquiry within self- determined guidelines
Embark & determine a need for inquiry					
Find/collect information/data					
Critically evaluate					
Organize information					
Synthesise, analyse and apply					
Communicate					

This framework specifies increasing levels of student autonomy as they progress in the development of their research capability. It also draws attention to the different facets of inquiry that students need to experience at different levels of autonomy. However, while this framework has been of practical help in a number of contexts (Willison and O'Regan 2007), it neglects aspects of research which are not traditionally considered as 'skills' such as the overall curriculum context and structure and considerations of disciplinary knowledge. It does not take account of whether those making decisions about how to engage students in the suggested ways have the authority to implement them.

The new 'wheel' model

Working to integrate a wide variety of forms of research-based learning experiences at both the curricular and the pedagogical levels that progressively develop students' capacities to engage with research, requires a framework specifically to overcome the various limitations of existing models. It needs to take account of the complexity of implementing undergraduate research and inquiry as demonstrated in the above discussion. It needs to accommodate research experiences for individual students working alongside academics in research internships or research experience scholarships, as well as experiences for large or small classes of students within their degree program and at any level therein. It needs to capture curricular decision-making for the benefit of universities, departments, teams and individuals engaged in course design. It needs to take account of the extent to which particular individuals and groups at differing levels of the institution have the authority to make decisions about specific aspects of curricula. And it needs to specify for individual teachers and researchers concerned to engage undergraduates in research-based learning experiences, the necessary pedagogical decisions to be taken. Figure 3 presents the suggested model.

This model facilitates the identification of the choices to be made in developing research-based pedagogies within a course or program or attached to a research project and/or in developing a research-based learning curriculum. It does this by mapping the complexity of the decisions needing to be made. The model has been developed

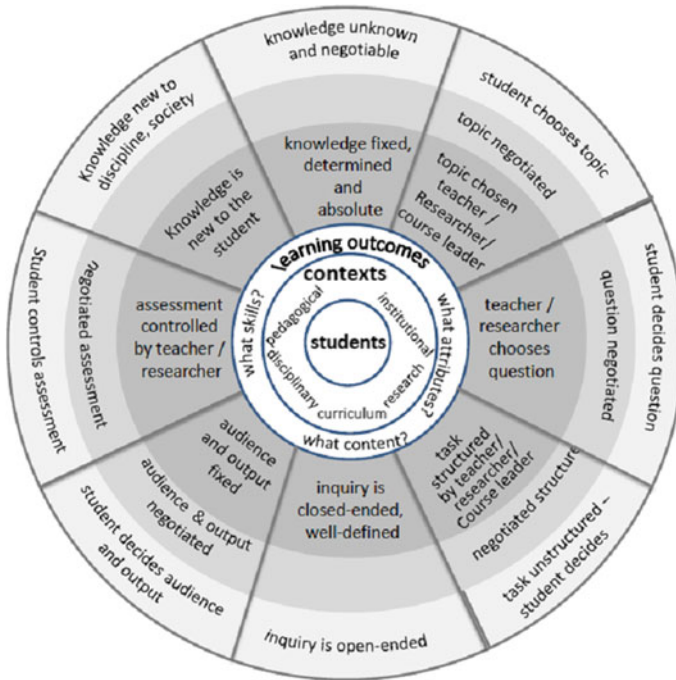


Fig. 3 A wholistic model for Research-based learning decision-making

progressively through discussion with colleagues and trialled and evaluated in a variety of academic development workshops.

This circular or ‘wheel’ model integrates decisions about the curriculum context including the nature, number and type of students, learning outcomes including disciplinary knowledge acquisition and attributes, capabilities and skills to be developed as well as, the nature of knowledge and the nature of the tasks to be completed and how they are to be assessed.

Students

The model places students in the centre. They are indeed its central focus. Their backgrounds and level of study (e.g. high achieving students or students of all abilities; first, second, third year etc.), as well as how many of them there are to be accommodated form the context for the initiative and need to be taken into account, and, in fact drive any curriculum decision-making. Students can be engaged in research and inquiry right from the start of their degree. Some research may only be possible with large numbers of students and some may only be possible with small groups or individuals. These are contextual factors that critically influence curricular and pedagogical decision-making.

Context

Working out from the centre of the circle the unshaded area highlights the context. This includes the institutional and departmental contexts, and the teaching and learning and

research policy contexts as well as the external societal context. The disciplinary context will also determine the range of options available. These all affect curriculum decisions in different ways and determine who has the authority to make them. Awareness of the limitations and the opportunities presented by the context is important in curricular and pedagogical decision-making.

Learning outcomes

Ideally the learning outcomes specified would progressively enable students to acquire the skills, capabilities and attributes as well as knowledge appropriate to the discipline in such a way as to ensure that when they graduate they will be able to meet the twenty-first century challenges mentioned above. However, decisions about what skills, attributes and knowledge students are to acquire are increasingly being taken at the program level and may be driven by institutional strategies, for example to implement research-based learning across a campus, or to specify expected generic attributes to be demonstrated in all courses. Mindfulness about the freedom or constraints in specifying learning outcomes appropriate in particular disciplinary contexts is important in making decisions.

Shaded areas of the model

Decisions in the shaded areas of the model are crucially dependent on decisions about students, context and learning outcomes. It is, for example, very difficult for an individual lecturer to implement a fully formed inquiry-based learning curriculum when all her colleagues are presenting straightforward lectures and there is no institutional support for it. So pedagogical decisions are dependent on the overall shape of the curriculum much of which may be decided elsewhere.

The wheel-like structure enables the integration of elements of the RSD described above, for example, different levels of student autonomy which are important in developing research capability (shown by the darker or lighter shading round the centre of the model). However, there is no suggestion here that students or curricula are focused consistently on a particular level of autonomy for all of the aspects of the inquiry they are engaged in, which is the case with models based on a matrix. The segments are like pieces of cake. You can eat different pieces of cake in different ways. You can choose to eat the outside of a piece of cake or the inside or the middle. Thus it is perfectly possible, and indeed desirable in most cases, to mix the different levels in the different segments. Numerous examples of research-based learning do this and it is this that makes the model dynamic. For example, even when the supervisor structures the research, there may be parts of it which need to be negotiated or decided by the student. Further, the levels shown by the different shadings are not mutually exclusive. For example, a particular investigation may result in knowledge that is new to the student and also new to the discipline. Many projects may include some knowledge which is fixed and well known and some which is unknown and negotiable. Research which is initially well-defined may turn out to be more open-ended than originally envisaged. This tells us something about this particular conceptualisation of research-based learning; it is a tool for thinking through the ramifications of particular curricular and pedagogical decisions when it is desired to engage students in research-based learning. It does not prescribe what or how this should be done.

Unlike traditional ways of thinking about a curriculum in terms of content, lectures and classes, and assessment, this model integrates critical elements of the research process. Importantly, the separate segments of the wheel specify, in turn, aspects of research, for

example: the kind of knowledge to be explored; choosing the domain of inquiry (the topic); choosing the question(s) to be addressed; structuring the investigation; how the work is to be presented and assessed and finally what the outcome is in terms of new knowledge and/or understanding. Innovatively, therefore, the pedagogy for student research derives much, if not more, of its impetus from research traditions as from learning and teaching. As a tool for curriculum decision-making this focuses attention on what the students are to do and the means by which they are to do it.

Application of the new model

To use the model in devising the overall curriculum, the course team, department, teacher or researcher (the supervisor or mentor; the person or persons with the authority to decide what needs to be achieved in a particular course or program) may start in the middle and specify which students, how many there are, what year they are in and what their educational backgrounds are. They may then consider the context; whether they are concerned to devise a formal program of study or whether this is a one-off experience for a student. Then they can consider the learning outcomes they want students to achieve: the knowledge, skills and attributes that they hope will result as a consequence of the student(s) engaging in research. In some cases this may be negotiated with an external body which is perhaps responsible for funding or accrediting the program or even for deciding the structure of students' learning experiences. The shaded areas of the wheel then map the pedagogical choices that have to be made.

These will depend on earlier ones regarding the students and the learning outcomes. They may also depend on negotiation with external partners, for example, where community-based or work-based learning projects are concerned. As mentioned above, the framework provides for increasing levels of autonomy as you move outwards. So for example in a traditional curriculum, an academic wishing to engage students in research may wish to set the questions to be addressed but leave the student free to decide on the structure. Or they may set a strict structure, but leave the student free to decide on the topic. This is a point where earlier models fall down since they tend to assume that high levels of structure are associated with low levels of autonomy or that the lack of teacher-defined structure is associated with students taking decisions over outcomes and assessment, for example.

In trialling the model, teachers often found it difficult to focus initially on what they wanted students to achieve (the learning outcomes). This may be because these have been decided within the overall curriculum framework, because they are too open-ended to be closely specified or it may simply be that these academics lacked experience in designing curricula in this way. Deciding on content is often the first priority in curriculum design. In workshops, academics often had a research-based activity in mind that they wanted students to engage in. The framework could then be used as a checklist for ensuring that all the necessary details of implementation were considered at the outset.

The wheel model can also be used to analyse or compare particular research-based learning initiatives and for diagnosis of existing practice. So for example, Chang (2006) describes the way his undergraduates' research is a routine part of their course work. All of the students work on independent research projects that share a common theme. At the end of the year students' project work including reading notes, results of literature searches, photocopies of materials obtained, data, laboratory notes, annotated bibliographies, reports etc., are made available for the next year's group of students. A book of this work has now been published (Chang and Jackson 2009). Analysing this using the above research-based

learning framework the teacher decides on the topic within which the students choose a question to be addressed. There are parameters for how the task is structured within which the student is free to inquire as they decide. The teacher also decides on the outcome and assesses students' work. But again, what students find is quite open ended and the teachers do not know what the students will come up with. The resulting knowledge was quite new to the discipline as well as to the students and teachers.

As well as describing how the framework can be applied, it is also important to establish what it cannot do. It is not designed to describe the nature of research or knowledge. It does not address teacher-centred ways of putting research knowledge into the curriculum (Healey and Jenkins' 'research-led' category). It assumes students' active engagement in research in a number of different ways. In suggesting that academics as teachers and/or as researchers may wish to begin by thinking about the students and student learning outcomes, the framework suggests a process for successful implementation of research based learning, but it does not specify desirable outcomes, nor what teachers should decide, nor is it prescriptive of what constitutes appropriate or 'correct' research-based learning. It opens up the possibility of ways to prepare students for professional life in contemporary society as discussed in the introduction, but it recognises that academics, departments and institutions may be cautious in their approach to what could be viewed as a radical agenda. How specifically to implement research-based learning experiences for students is a matter of academic judgement and will no doubt be related among other things to disciplinary understandings of the nature of research.

Conclusion

This paper has critically examined existing models of undergraduate research-based learning and presented a new model designed to elucidate the curricular and pedagogical decisions that need to be made when introducing research into the undergraduate experience. Clearly, further research is needed into how teachers can and do use the model in making decisions in particular circumstances. For example, it would be useful to compare disciplinary differences in the ways the framework is used. Research is also needed into the different ways in which the model can be used at the institutional, departmental and course team levels to clarify understanding of the decisions that need to be taken and to examine issues of power and authority in curriculum and pedagogical decision-making more fully than has been possible here. By highlighting distinctions between curricular and pedagogical issues, the paper draws attention to the fact that some academics wishing to implement research-based learning pedagogies may lack the authority to make decisions about the overall curriculum. How and whether this slows implementation of innovations in curriculum design in this area provides an interesting focus for future research.

Undergraduate research is a powerful way of engaging students (Kuh 2008). Research and inquiry-based learning experiences have the capacity to stimulate students' interest. However, to do this they need to begin with what students want to learn, to provide opportunities for students to explore the questions that they bring to the subject. They need to tap into students' desires to learn about particular subjects, to address the questions they have in their minds, and to challenge students intellectually.

So in talking about developing the curriculum as a process of research and inquiry this paper has provided a framework for academics, course teams, departments and institutions to think about ways to engage students in the excitement of discovering new ideas; education that provides support for students preparing them to be critically reflective of the

society in which they live and developing their capacity to find and judge evidence, to be open to different knowledges and capable of using and presenting knowledge in different ways. This starts with recognizing the interests and capabilities of students. It starts with listening to the questions that they bring. It starts with recognising and, indeed, honoring the important work that they will have to do in addressing the challenges of humanity in the twenty-first century and beyond.

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