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Curriculum, teaching and powerful knowledge

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Abstract This paper examines the concept of 'powerful knowledge' and provides new perspectives on an important emergent theory for education. We claim that the key to attaining powerful knowledge is 'epistemic access' to the discipline, which is access of the generative principles of knowledge creation. We draw on 15 years teaching and researching a university science programme in which undergraduate ecology students are trained as researchers during the 3 years they attend university. Hence, there is close alignment between teaching students to do research and powerful knowledge. In addition, it has been suggested that the 'power' in powerful knowledge is realised in what is done with that knowledge, that its purpose is social since it allows the holder to make a better contribution to society. We argue that in addition to such an aspirational 'outcome', it can be part of the *process* of education and early acquisition of powerful knowledge can influence all subsequent formal and informal learning experiences as the student progresses though university. A model for powerful knowledge is presented in which there is the *possibility* of powerful action after graduation, but this remains in the theoretical realm while there is very little empirical evidence supporting such a hypothesis for ecology students. Powerful action also questions the limits of responsibility for a teacher.

Keywords Powerful knowledge · Epistemic access · Undergraduate teaching · Research-based curriculum · Authenticity

Introduction

This paper examines the concept of 'powerful knowledge' in the context of a university undergraduate curriculum in which students are trained as researchers. So far the theory of powerful knowledge has been presented in a variety of complex forms and with the intention

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of contributing to epistemological and sociological debates about curriculum design and content. Complexity is evident from the lack of a precise definition and because of the underlying claims to a foundation in social theory that has contested ideological outcomes. Furthermore, the idea of powerful knowledge has been developed in the context of high school and vocational education, but not for learning in a university, which is the context for this paper. However, we argue that the theory is not only relevant for the university but will be more easily understood by lecturers because higher order skills, such as critical thinking and epistemological insight (which are a key part of powerful knowledge), are the foundation of a higher education.

To contribute to the current debate, we have developed a set of conceptual ideas that explain how powerful knowledge is an appropriate aim and outcome that can be achieved through teaching undergraduate science students to become researchers. Although this approach to a university degree is quite novel, it reflects the critical traditions common to all subjects. In the ecology programme at the University of Otago, New Zealand, students start research training from the first day they enter university, and this apprenticeship thread runs through the 3 years of study. Students learn to formulate original research questions, write grant applications, design experiments, carry out fieldwork, evaluate data, review the work of peers, give seminars, and write reports and articles. This curriculum is modelled on the way in which academics themselves learn, and in particular knowledge of the postgraduate student experience serves as a guide to curriculum decisions and teaching.

The development of ecology has been described in a number of research articles (e.g., Harland et al. 2016) but both its purpose and how this form of education is understood continue to evolve. The teachers, which include the first author of this paper, continue to learn from experience, systematic inquiry into practice and exposure to educational theory. Any new concepts that seem to have promise are tested to see if they can provide better explanatory frameworks for what is currently done and guide future change (e.g. Wald and Harland 2017). The powerful knowledge concept has changed our ideas about curriculum, while at the same time teaching *for* powerful knowledge has allowed us to critique the theory. In doing so, an accessible model for powerful knowledge has been developed that should function for any university subject that uses similar pedagogical approaches.

The idea of 'powerful knowledge' first came to our attention through the work of Leesa Wheelahan (2007) and then later through Young and Muller (2013). One of the attractions of powerful knowledge is that it had immediate appeal; who would *not* want students to have such a thing (Beck 2013)? It captured our imagination and an inquiry was initiated to see if powerful knowledge could provide better explanations for the potential learning experiences of ecology students. On the surface it seemed to align with the curriculum aims; however, a closer examination of the theory presented a number of new challenges that required the course team to re-evaluate some challenging concepts. These included the purposes of a higher education and ideas about the knowledge, skills, and values that an ecology student ought to graduate with.

Because powerful knowledge is both contested and explained in different ways (Beck 2013), we have set out to reconceptualise the idea in a manner that is both theoretically defensible and accessible to teachers across higher education. We start with a brief account of the development of powerful knowledge and then consider how it has operated in the ecology curriculum. We suggest that powerful knowledge materialises from an authentic research-based undergraduate curriculum and the kind of personal and knowledge outcomes it generates.

What is powerful knowledge?

What makes certain forms of knowledge more powerful than others? Young and Muller (2013) address this question from the perspective of educational sociology and start by claiming that formal education needs a knowledge-based curriculum. They argue that this curriculum should aim for powerful knowledge, which is specialised knowledge that becomes powerful when it serves a particular purpose. Yet not all specialist knowledge qualifies as 'powerful' and to illustrate this idea these authors use the example of scientology. In addition, it is possible that everyday common sense knowledge can also serve powerful purposes. To get around these exceptions, it is suggested that powerful knowledge also has to have structure and be created and disseminated in specialised institutions because students need access to the structuring principles of disciplinary knowledge (Wheelahan 2007). For Young (2013), powerful knowledge has two key characteristics: (1) it is specialised, rather than general and (2) it is differentiated from the everyday experiences of learners. The first separates specialised discipline-based knowledge from general knowledge, and the second distinguishes between institutional and everyday knowledge. Effectively, however, the second characteristic is a derivative of the first, and specialised knowledge in a discipline is inevitably non-everyday knowledge. Making connections between the two knowledge types is required for generating new knowledge (Young 2008) but Bernstein, whose work has been influential in the framing of knowledge structures, argues that the two worlds are related rather than distinct from one another and because meaning is context-based but not context specific, this can create what he terms a 'discursive gap' (Bernstein 1996). A discursive gap is essentially 'the site for the unthinkable … the site of the *yet to be thought*' (Bernstein 1996: 44, emphasis in original). In other words, it is a gap between empirical data and theory building that requires particular forms of abstraction for new meanings to materialise. The most significant outcome of having context-independent theoretical knowledge is the potential to be able to generalise and suggest explanations beyond specific circumstances through an ability to imagine alternatives (Young 2008). The potential discursive gap is central to understanding how new and original knowledge can be created in research, and realising the gap's potential requires students to have the tools to understand conceptual knowledge structures (Wheelahan 2010). Young (2013: 196) goes on to say that:

> Powerful knowledge is powerful because it provides the best understanding of the natural and social worlds that we have and helps us go beyond our individual experiences.

Even with these claims, it is still not clear what any new power will enable those who have it to do, and what purposes then make it powerful. Young and Muller (2013) offer a brief hint for a possible answer in noting that: '*all* disciplines deal with the world we face which is both natural and social' (245, emphasis in original) and that the social is at the heart of powerful knowledge. In this argument, some forms of knowledge constitute a more worthwhile education because they prepare students for acting on behalf of society.

The importance of epistemic access

In order to understand specialised theoretical knowledge and to address what is presently 'not known', a student needs to learn the generative principles of disciplinary knowledge.

Understanding this is fundamental to powerful knowledge and the process has been termed 'epistemic access'. It helps the learner understand 'how' one might come to know something. It is a complex idea that is presently not clearly explained in the debate on powerful knowledge. Young (2009) suggests that it is access to academic subjects and disciplines that are denied in everyday experience, while Wheelahan (2007) describes it as the facility for drawing on the correct type of knowledge for a particular purpose. However, in later accounts, Wheelahan talks of epistemic access as entering 'the system of meaning so they [students] can understand the debates and controversies in it' (2014, p. 134) and also 'epistemic access to aspects of the world' (2015: 753). Morrow (2009: 70) has another view:

> Gaining access, thus, was learning how to become a participant in practice, and since academic practices have developed around the search for knowledge, access to an academic practice entailed epistemological access.

It is Morrow's interpretation that we consider most relevant to a university context and it can be re-phrased as learning subject methodology, or how original knowledge can be produced through research. In a university, it is common for students to be taught a subject for a few years before they experience this (if at all). Typically, in third or fourth-year, a research project is seen as a capstone event that serves to test theoretical knowledge and critical thinking, afford students the experience of generating their own knowledge, and select those who may be suitable for postgraduate research. This organisational principle is encapsulated in the idea of 'epistemic ascent' (Winch 2013). Winch argues that to move from novice to expert, the novice requires sufficient factual and theoretical knowledge to *allow* them to develop evaluative capabilities through exploration and research. In this case, a curriculum is hierarchically ordered and based on the conceptual structures of the discipline that require knowledge types (e.g., propositional, procedural, and conceptual) to be systematically organised and sequenced. This hierarchy of knowledge and learning is typical of teaching undergraduates in the natural sciences and a curriculum based on epistemic ascent still provides a degree of epistemic access. However, 'access' does not guarantee the learner will attain powerful knowledge, or use that knowledge wisely for society.

The relationship between powerful knowledge and society

Powerful knowledge is a socio-epistemic theory that includes the provision that the holder is able to apply knowledge in new contexts and in particular, engage in matters of public importance (Young and Muller 2013). Using powerful knowledge for social good seems to distinguish the theory from other critical traditions of a university education. Classically, this has been developing critical thinkers, although there are other ways of approaching education to empower students as social agents, including critical pedagogy (Freire 2000 [1970]). Critical pedagogy is emancipatory in the sense that it seeks to make the world a more equal and fairer place. It is predicated on two main curricula ideas. The first is that all disciplinary learning is situated in the social contexts in which students and teachers find themselves, and second that it is based on a curriculum process that problematises knowledge (see Kincheloe 2008). This strategy connects disciplinary knowledge and critical thinking to a social framework but it is not clear how well critical pedagogy would meet all the criteria for powerful knowledge.

For Wheelahan (2007), powerful knowledge is of utmost importance because those who have it then have access to the conversations and debates about society's values, be these

social, cultural, political, or economic. However, for Wheelahan, students also need powerful knowledge to flourish in the workplace, as jobs become more complex and difficult, and knowledge that includes a high level of abstraction is likely to allow workers to better adapt to new contexts. But in order to achieve social and employment outcomes, students need 'access to "disciplinarity" or disciplinary styles of reasoning so that they understand how knowledge is used and the broad criteria that need to be applied in evaluating the validity of arguments' (Wheelahan 2010: 2). Wheelahan (2010, 2014), therefore, aligns powerful knowledge with 'Mode 1' knowledge production (Gibbons et al. 1994). Mode 1 is the familiar Newtonian model of scientific practice that has been predominantly situated within an academic context. It is disciplinary by nature with a high degree of uniformity in terms of skills and experiences of those individuals involved. Those who pursue Mode 1 enjoy autonomy and are mainly held to account by the traditional peer review process of scientific publication. In contrast, Mode 2 is characterised by knowledge situated within a context of application, where from the outset of inquiry, it ought to be useful to someone (e.g. in society, industry, or government). As such, Mode 2 is oriented towards problem solving and it has greater sensitivity to its social impact, with social accountability and reflexivity as both the drivers of research and mechanism for quality control. It is trans-disciplinary, with experts from different fields working in collaboration, and organisationally diverse in terms of the institutions in which knowledge is produced. An important aspect underpinning the emergence of Mode 2 knowledge production has been the nature of the relationship between science and society. Gibbons and colleagues argued that Mode 2 reflects the decentralisation of theories and methods of knowledge production from academia to non-academic research institutions. They note that: 'Science is less the preserve of a special type of institution, from which it is expected to spill over or spin-off to the benefit of other sectors. Knowledge production is increasingly a socially distributed process' (Gibbons et al. 1994: 156). Young (2013) categorises knowledge learned for its own sake, as learning for 'internal ends', and knowledge for applied purposes, such as employability, as knowledge for 'external ends'. Concerns about different knowledge types are also important to vocational higher education and training (Wheelahan 2015) and also to primary and secondary education where learning is often seen as a means to an end (usually advancing to the next level of study or finding employment) (Young 2013). Wheelahan (2014) maintains that even in the context of vocational curricula for the professions, students must gain epistemic access to knowledge production in their field. This will not be achieved if the curriculum is purely based on 'Mode 2' knowledge production.

With respect to university curricula, there is no doubt that there has been a shift to more useful forms of subject knowledge, but utility is mostly judged by the economic imperatives of society that are presently driven by free-market neoliberal ideology (Harland et al. 2010). Outside of this market driven pressure, the propositions and values of powerful knowledge, which argue for a link between disciplinary knowledge and participating in wider societal debates, remains largely implicit. Such outcomes are more likely for social and inter-disciplinary subjects, but it is not clear if a person with theoretical knowledge in, for example, the discipline of chemistry could use that knowledge for participating in a debate about eliminating child poverty. This raises the question of what kind of powerful knowledge is needed in order to participate more broadly in society? Furthermore, there is an important question about responsibility for action and whether or not a lecturer or programme can assure that the advantages of a university education bestowed on a student do in fact have a positive impact on society, or whether this is simply an aspiration? In Fig. 1, we extend the idea of external ends to include all forms of knowledge useful to society. However, we still see the

Internal ends	Boundaries of graduate responsibility?	External ends
Private advantage Personal knowledge	⟷	Public advantage Knowledge for others

Fig. 1 The boundaries of graduate responsibility

relationship between a university education and life after graduation as problematic, in the sense that what a student does is typically unknown.

Young (2009) makes a clear distinction between powerful knowledge and 'knowledge of the powerful' with the latter term referring to those who decide what constitutes knowledge and who has access to it. The knowledge content of a curriculum is thus hegemonic because it is constructed by dominant social groups who use their position of power to generate wider social cohesion and consensus around particular ideas and values through complex political projects and alliances. This knowledge is also hegemonic in a structural sense because the education system is pivotal for reinforcing and reproducing social structures, and for processes by which these structures transform over time (Joseph 2002). Educators as well as others, therefore, need to identify the ideas and interests that are either hegemonic or in the process of becoming hegemonic and critically analyse them. We suggest that if university students have powerful knowledge then it may also allow them to do this analysis. In this sense, powerful knowledge itself should become hegemonic knowledge.

An abridged model of powerful knowledge

At this point we summarise the ideas presented so far and produce what we consider a simplified 'Young-Wheelahan' explanation of powerful knowledge for university education. In doing so, we are aware that we lose precision (Beck 2013) but at the same time clarify the theory and provide a working definition for a wide academic audience. Powerful knowledge, therefore, encompasses the following characteristics:

1. It is disciplinary specific, specialised, theoretical context-independent knowledge
2. It is produced and transmitted by subject specialists in educational institutions
3. It is knowledge that goes beyond individuals' everyday experiences

These characteristics allow those that have it to:

4. Evaluate arguments
5. Apply knowledge beyond specific contexts
6. Become responsible citizens who can engage in matters of public importance

Powerful knowledge is therefore specialised knowledge that is disciplinary-based but not confined to the discipline. It is differentiated knowledge that is distinguished from 'everyday' knowledge (gained from experience) and from 'inferior' knowledge (there is a caveat around quality because some claims to truth are better than others). Wheelahan (2007) argues that everyday knowledge is segmented in the sense that it is usually understood in the specific context in which it was gained and harder to transfer to new situations. In contrast, much of the

knowledge taught at university is specialised but can be powerful when it has the potential to transform knowledge itself.

Yet it can be argued that in today's society, with easy technological access to information and analysis, those who sit outside a formal university education experience may not be so restricted by everyday knowledge. However, the university offers a disciplined and guided journey of three or more years of dedicated study, and it is this type of unique institutional experience that can lead to powerful knowledge (Young and Muller 2013). Importantly, not all forms of powerful knowledge are equal with respect to making judgements about knowledge. For example, ascertaining what is inferior or superior requires a student to know how knowledge is produced.

> Unless students have access to the generative principles of disciplinary knowledge, they are not able to transcend the particular context. Students need to know how these complex bodies of knowledge fit together and to decide *what* knowledge is relevant for a *particular* purpose, and if they are to have the capacity to transcend the present to imagine the future.
> (Wheelahan 2007: 648, emphasis in original)

If this portrayal of powerful knowledge is accepted, then it could be argued that most current university students graduate with powerful knowledge, more or less. Unlike the school-level education Young focuses on or the vocational education that Wheelahan critiques, the critical traditions of higher education ensure that students are exposed to different subject areas (that may or may not be constrained within a discipline) and often, in the final year, some research experience that allows them epistemic access to knowledge. For this access to contribute to powerful knowledge, it would need to include the experience of learning about methods and sources of data as well as a research philosophy (in other words, ontological and epistemological understanding). In this sense, changes for teaching towards powerful knowledge in the context of the research-intensive university—in comparison to other educational contexts—may be more easily accepted and implemented. However, beyond the need for a clearer conceptualisation of powerful knowledge within this context, the translation of this concept into practice through the curriculum may pose challenges. It is unlikely, for example, that a brief encounter with research at third year is sufficient to develop meaningful epistemic access because it takes time to acquire the necessary depth of theoretical subject knowledge and methodological research expertise. The PhD is generally seen as the space for such an undertaking.

In the more traditional undergraduate curriculum, with its taste of research, it seems doubtful that students will become 'subject experts' if it is accepted that experts require epistemic access to the knowledge of the discipline. Such students may know many facts and theories but applying these (rather than epistemic skills) to different knowledge contexts (point 5 above) will be mostly ineffective. Such an undergraduate curriculum model would only ever meet the criteria for a weak form of powerful knowledge.

Does learning by doing research give powerful knowledge?

Do the academics that write about powerful knowledge have powerful knowledge themselves? The evidence from written articles suggests that they do. Most university lecturers (at least in the established research-intensive sector) acquire a high level of expertise in their research

field, starting with a postgraduate apprenticeship to gain a PhD. Craft mastery is then cultivated over a number of years through experience of both research and teaching. As such, a skilled researcher who teaches should, in theory, possess some, if not all aspects of powerful knowledge. If this were not the case, then there is little hope that a lecturer would be able to help others gain access to powerful knowledge. If these propositions are accepted, then the university researcher-as-teacher can provide a model for learning in a curriculum designed for powerful knowledge.

Ecology at the University of Otago is an example of undergraduate researcher development. In this programme, students serve a 3-year research apprenticeship and 'learning through doing research' is a curriculum thread that underpins the student experience (Jenkins et al. 2007, Strategy 2). There are three key principles that have guided teachers during the development of this course. The first is to teach undergraduates in the same way that academics learn through research; the second is to teach learners using the model of postgraduate supervision; and the third is to engage students in authentic research from the first day they enter university. Elsewhere, we have argued that the research-based curriculum developed in this programme include the three core values of authenticity—'real world' corresponding, existential self, and a degree of meaning. Thus conceptualised, an authentic research-based curriculum is likely to accomplish meaningful and long-lasting outcomes in terms of both the students' personality growth and professional development (Wald and Harland 2017).

With respect to powerful knowledge, experience, and ownership of the research process give both an understanding of how knowledge is produced and the facility to judge the worth of that knowledge. In support of this, Morrow (2009) sees disciplined inquiry as a prime epistemic value in teaching social science students to become participants in the field, and epistemic access is gained through research and inquiry-type experiences that form the backbone of a curriculum for powerful knowledge. This curriculum begins to free the student from reliance on authorised propositional forms of knowledge and teaches the structuring principles of disciplinary knowledge (Wheelahan 2007). Winch (2013), on the other hand, has argued that to become expert in a subject, the novice requires sufficient factual and theoretical knowledge before they become researchers. In such a model, the curriculum is hierarchically ordered and based on the authorised conceptual structures of the discipline to support epistemic ascent. However, ecology inhabits both worlds and has demonstrated that research training can be accomplished alongside other forms of knowledge acquisition. It is, however, important to get the level right for research training at each stage and we have adopted the idea of epistemic ascent *for* research capability and methods of inquiry. Research training then runs in conjunction with a more traditional (but reduced in volume) hierarchical curriculum. As students become adept at producing knowledge and more experienced with disciplinary styles of reasoning, the relationship they have with propositional forms of knowledge changes.

Hierarchical knowledge structures and specialist discourses (Bernstein 1996) are properties of a discipline, but disciplines evolve and university academics in the same science field may have different expertise and theoretical backgrounds that often require teams working together to solve research problems or teach a university programme. This context reflects ecology as students learn what is relevant to a research question and then construct their own theories in order to make a contribution to the field. Although the central ecological theories are taught in lectures, each student ends up with unique ecological knowledge but similar research skills. Ecology is now guided by the following objectives for student learning that reflect the Young-Wheelahan model:

1. Being skilled in producing one's own knowledge
2. Being able to evaluate knowledge claims
3. Being able to apply the skills of production and evaluation to different knowledge contexts over time
4. Being prepared to use knowledge wisely for the good of oneself and others.

(Harland 2017)

In principle, objectives one to three are the same qualities academics seek in their research. Objective four has recently been included but it is not known if students attain this through their studies, what values they enact after graduation, or the full extent the present curriculum contributes to social goals. The boundaries between private gain and public advantage are opaque but we argue that while the *potential* to contribute to society's debates is attributed to all members of society, epistemic access provides more advanced analytical tools, and student experiences of the discursive gaps found in authentic research will give them some confidence to engage with abstract thought and the unknown.

The research component of ecology is mainly focused on Mode 1 knowledge and might be described as 'pure science'. This focus presents both teachers and students with the challenge of relating specific university experiences to wider society, both when they are studying at university and after they graduate. Beck (2013) recognises these particular tensions and reasons that because disciplinary knowledge is often intrinsically theoretical, its ability to allow students to develop a critical appreciation of the world around them should be in doubt. Power from advanced subject knowledge is still limited and academics and students need more than this in order for their learning to operate in everyday situations and influence what will later become accepted as common sense or everyday knowledge.

In the taught part of the ecology curriculum, students learn about many issues facing society, such as climate change and global warming. However, the research component is largely directed by the students and tends to be focused on small-scale ecological problems. If a Frierian or critical pedagogy philosophy had been adopted for the taught curriculum, then students would likely be exposed to a much broader range of social challenges relating to ecology. However, to provide the space for learning through research, many of the less important hierarchically ordered facts and theories that previously constituted the ecology degree have been removed. There has always been a tension between depth and breadth in education (Beck 2013), and students now have less factual and theoretical knowledge than those of past generations, although there is no doubt that critical thinking and research skills are far more advanced.

Powerful knowledge has the potential to perpetuate the social privilege that is associated with acquiring theoretical knowledge and so may also be responsible for social exclusion (see Young 2009). However, all university students inherit some form of private benefit that has social impact, and so learning through research for powerful knowledge may just be a different form of privilege. Yet this is not a good enough reason for not teaching for powerful knowledge, as this would be taking a stand against higher education and its possibilities for higher order learning. To address these concerns, ecology students will need, at the very least, to recognise and understand the privilege afforded them through the ecology curriculum and what their responsibilities might be after graduation.

In addition, one of the most important aspirations for ecology has been to ensure *all* students have access to a worthwhile education, and learning through research was seen as a

way of providing this for everyone, regardless of ability. We work with students of different aptitudes and inclinations towards learning, and very few will work as ecologists after graduation. In this largely non-vocational context, cutting back on the volume of factual and theoretical knowledge to create spaces for powerful knowledge acquisition was not seen as a problem. It was reasoned that subject knowledge tends to be forgotten over time if it is not rehearsed or used (see Custers 2010), but once research skills are attained these are more likely to be sustained throughout life. In this sense, all students gain something of lasting value that empowers them through epistemic access to the generative principles of knowledge creation.

What is of particular interest is the purpose that powerful knowledge serves when students are studying at university. The way in which it has been theorised so far suggests that it is an *outcome* of education rather than part of the *process* of education itself. We argue that if teaching for powerful knowledge starts early, its acquisition can influence all subsequent formal and informal learning experiences as the student progresses though university, including the development of powerful knowledge itself. This argument is about developing evaluative capacity, the ability to judge the worth of knowledge and having the space and time in which to test knowledge beyond the specific disciplinary context in which learning occurred. There is some recent emerging evidence that ecology students, who also take other courses at university, have a different skill set to their non-ecology peers, and that they do use powerful knowledge in other academic and social settings (Harland et al. 2016).

A curriculum model for powerful knowledge

This model draws on the developing theories of powerful knowledge and takes into account what we have learned from the experience of teaching ecology and systematic inquiries into this research-based curriculum (Harland et al. 2016; Wald and Harland 2017) (Fig. 2).

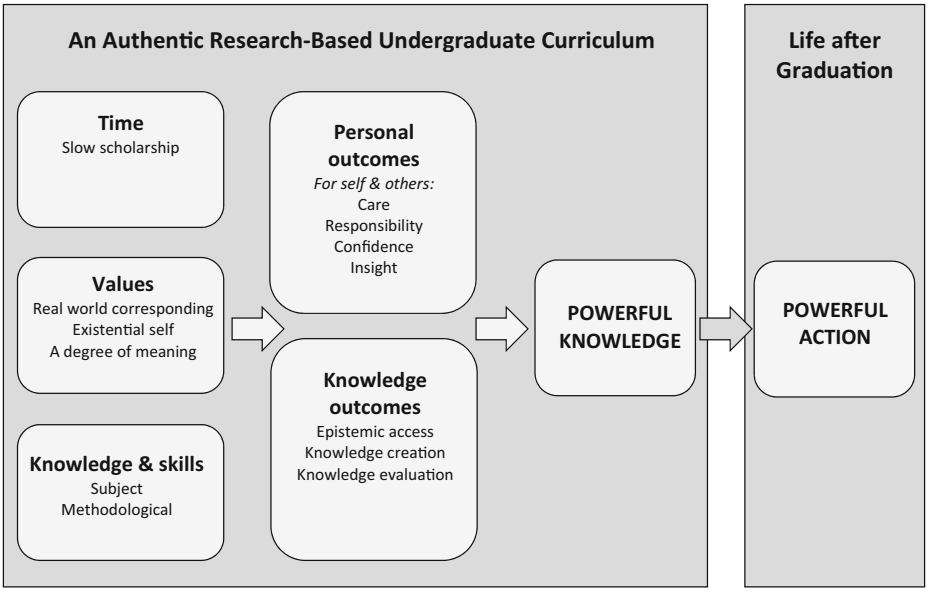

Fig. 2 An authentic research-based curriculum for powerful knowledge

Research training becomes the foundation of powerful knowledge and there are three practical components to consider. These are placed hierarchically to emphasise two phenomena that require attention in curriculum planning, namely time and values. The outcomes space is divided into personal and knowledge outcomes that form the basis of powerful knowledge. Finally, we suggest that powerful knowledge opens up the *possibility* of powerful action after graduation. These components are explained in the following sections.

Time

There is no point in embarking on a journey to teach students as researchers unless sufficient time and space are provided. Learning to do research requires deliberative spaces for thinking and knowledge development (Harland 2016), and it takes a novice student much longer to complete a task than an expert. In particular, reading research articles and synthesising information are time consuming, especially when the conventions of academia are not well understood by new university entrants. Another example is the peer reviews that students are required to carry out throughout the 3 years of study. Doing this effectively requires practice and application. In a second year course students spend about 6 h a week for 4 weeks on a single peer review exercise. Similarly, for Morrow (2009: 106):

> Access to an academic practice, like access to any fairly sophisticated practice, is not something that can be accomplished in an instant; it requires persistent and focused effort from the learner over a fairly extended period of time. Furthermore, because academic practices are essentially opaque, a 'normal' learner needs the reliable assistance of someone who already understands the practice and is very much dependent on the sympathetic, but impartial, judgements of such a person.

Values

Epistemic access is achieved through authentic research experiences that have the potential to produce genuinely new scientific knowledge as well as the potential to have a positive effect on students' existential sense of being and belonging (Wald and Harland 2017). Seeking authenticity sets a high bar when other forms of teaching students to do research are more common (see Jenkins et al. 2007). However, it has been clear that students highly value the idea that they are doing 'real' research and project ownership gives a degree of meaning that is important for instilling learner confidence and responsibility for learning and for others. Students learn about responsibility and ownership that ensures their work is of the highest possible standard.

Knowledge and skills

To achieve a high standard in research requires good subject, theoretical, and methodological knowledge. Combined, these allow epistemic access to how knowledge is produced in a discipline. At the same time, access gives students the ability to evaluate knowledge claims,

either published or proposed by teachers or peers. Like all curricula that demand the critical traditions of a university education, authentic research has critical thinking as its foundation.

The outcomes space for powerful knowledge

The most obvious outcome is the knowledge that students can produce and critically judge (criteria 1 and 2 in the Young-Wheelahan model). Since such knowledge outcomes rely on gaining epistemic access to how knowledge is being produced, students are well positioned to apply their skills to different knowledge contexts (criterion 3). The outcomes of having epistemic access and being able to produce and evaluate knowledge are all dependent on mastering critical thinking skills.

The other group of personal outcomes mainly concerns the students and how they are changed as learners in a social setting. In the programme there is much emphasis on working in a practice community and helping, rather than competing against, each other. This value often casts the students as 'teachers' and when responsibility is taken for a peer's learning, they will learn about themselves and their own work at the same time. As students progress through the programme, they slowly gain confidence in such abilities. These experiences and values are meant to prepare students to use knowledge wisely and for the public good (criterion 4). Ideally, these personal and knowledge outcomes equip students with powerful knowledge, which entails not only knowledge and epistemic access but also socially desired attitudes and values.

The curriculum is therefore designed to produce students with powerful knowledge but it stops at graduation because we have no way of knowing how powerful knowledge operates after this point. The limits of academic responsibility are brought into question here, but we use the term 'powerful action' which is a concept influenced by Barnett's (1997) ideas about critical action and critical being. Does a curriculum for powerful knowledge result in students using that knowledge wisely, and for the good of others? In New Zealand, the Education Act of 1989 requires universities to act as 'critic and conscience of society' while students have the freedom to question and test received wisdom and the freedom to engage in research (Education Act 1989). However, ecology teachers have yet to address the idea of critical conscience, which will require an engagement with values (Harland and Pickering 2011). Furthermore, all students will attain some powerful knowledge but both strong and weak achievements will be taken out into society. We are confident that the outcomes of authentic research can be quite sophisticated (for example, undergraduate students publish in international journals), but there are differences in student ability and not all will have the same degree or understanding of powerful knowledge.

Conclusion

In this paper we have offered a theoretically sound reconceptualisation of the appealing yet often elusive idea of 'powerful knowledge' (Beck 2013). Accordingly, powerful knowledge enables those who have it to produce and evaluate knowledge, to do so beyond a specific context and, hopefully, be prepared to use this ability wisely. Young and Muller (2013) make the case for the superiority of specialised knowledge of the type produced in universities but they also note that not all specialised knowledge is powerful. The difference is rooted in *how* that knowledge is produced. According to this view, established academic disciplines have

methodologically rigorous and systematic ways to produce and evaluate new knowledge, and this is typically regulated within a community of peers. Having insights into those methodological procedures is having epistemic access to knowledge claims, which is thus key for having powerful knowledge. Critical thinking is also pivotal and it serves as a foundational skill for all the knowledge outcomes that powerful knowledge entails.

Rather than being a purely theoretical endeavour, we have argued that equipping students with powerful knowledge can be achieved through an authentic research-based undergraduate curriculum (see Wald and Harland 2017). Teaching students as researchers in ecology achieves powerful knowledge as an outcome and a process in itself. Ecology teachers have long understood that when students are taught in this way, there is no longer any need to check off the long list of graduate attributes, personal and literacy skills that students are supposed to learn, as these are all embedded in the one goal of learning to do research.

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