Disciplinary versus Integrated Curriculum: The challenge for school science

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The impending Australian national school curriculum leads to important questions about what knowledge should and shouldn’t be included in a curriculum and how the included knowledge should be arranged. Dominant modes of curriculum in the twenty first century suggest there is established, canonical knowledge that is included in school curricula within disciplines such as physics, mathematics, history and literature, and that the disciplines themselves almost always provide the structure of the school day (Scott, 2008). This is widely referred to as a disciplinary, or traditional, approach to curriculum. Current, education-based debates, however, question the assumption that there is a corpus of disciplinary received wisdom that is beyond criticism (Kelly, Luke, & Green, 2008). Disciplinary knowledge is translated in curriculum documents throughout the world into key criteria, standards, or educational outcomes that are narrowly focused on what is readily measurable, or amenable to standardized achievement testing. As more and more attention in schools turns to the issue of preparing students for high-stakes tests, there is a real risk of reducing the opportunities for students to engage in more contextual, issue-based and applied learning that does not fit within the boundaries of the traditional disciplines. The problem is acute in science where there is considerable evidence that students are disengaged with the way it is currently taught in Australia and other western countries.

In this article we will explore the conundrum that faces Australian curriculum developers and curriculum consumers about the issue of disciplinary versus integrated approaches to curriculum, particularly within the broad subject area of science.

Integrated and Disciplinary Approaches to Curriculum

A number of progressive school programs exist that can only be described as ‘different’ from the traditional approach to curriculum in that they are at odds with the hegemonic disciplinary structure of schooling and deliver programs that can be described as ‘integrated’. All curricula include some form of disciplinary knowledge; it is the structure of the curriculum and the underpinning issues that drive the curriculum that determines whether the curriculum can be considered disciplinary or integrated. Examples of integrated curricula go by a number of names, for example, contextualized instruction (e.g., Rivet and Krajcik, 2008); authentic tasks (e.g., Lee and Songer, 2003); community connections (e.g., Bouillion and Gomez, 2001); science technology and society (e.g., Pedretti, 2005); place-based education (e.g., Gruenewald and Smith, 2008); democratic schools (e.g., Apple and Beane, 1999); futures studies (e.g., Lloyd and Wallace, 2004); and, youth-centered perspective (e.g., Buxton, 2006). All include approaches to education that involve students looking towards multiple dimensions that reflect the real world and are not bounded by the disciplines.
A specific example of an integrated approach was found in a school we worked with in the northern suburbs of Perth. The Year 6 and 7 classes in the school were working on a science-based project about the ‘health’ of a local lake. During Science, students learnt about concepts like water quality and aquifers. They tested the quality of the water in the local lake and completed a number of individualized investigations on related topics such as the breeding of midges (a small insect) in the shallows of the lake. In Society and Environment students examined human development in their local region and the impact that has on the lake. In English they participated in an extended hypothetical debate and role play of different advocate groups about the development of the surrounding environment and the recreation that should be allowed in the lake. One of the features of integrated curricula is that the knowledge that is taught and learned is determined by issues that are relevant to the students. In this way, there tends to be more connectedness and application of knowledge to the issue of concern. In integrated approaches to curriculum students are generally given long periods during the school day to research areas of interest to them. They are guided and supported by the teacher, but the focus is on the student being an active learner. Assessment tends to be individualized; for example, it may take the form of a portfolio of work completed by the individual. This is in contrast with traditional approaches to curriculum where disciplinary knowledge drives the curriculum and lessons are sequenced in ways that allow students to develop conceptual understanding in a highly structured and cumulative manner. Traditional approaches to school curriculum involve students studying separate subjects that are independent and disconnected from each other, taught at different times during the day by specialized teachers. Predominant forms of assessment include written tests and examinations. Integrated approaches to curriculum remain a contentious issue with ardent commentators presenting a number of arguments either supporting or opposing its implementation in schools (Hatch, 1998). These arguments have tended to be either epistemological, focused on the structure and utility of knowledge, or affective, focused on students’ attitudes and engagement with science. On the epistemological front, disciplines, it is argued, create a sense of order about the complex world and provide students with the specialized knowledge they need to solve complicated, discipline-based problems or create rigorous explanations of focused aspects of the world. Disciplines are considered important human achievements that have provided the best answers to fundamental questions about the world that human beings have generated. In contrast, supporters of curriculum integration argue that knowledge in the real world is holistic and the division of knowledge into subjects for teaching and learning in schools is an unnecessary historical tradition and simply a practical method to deliver a curriculum (Hatch, 1998). On the affective front of the debate, supporters of integrated approaches refer to the statistics showing adolescent disengagement with traditional approaches to schooling and suggest that integrated approaches motivate and interest students in ways that disciplinary content, delivered by traditional pedagogical means, fail to do (Senchak, 2008). Other commentators go further and suggest that the reason why integrated approaches to teaching and learning tend to be more engaging for young people is that they better reflect the realities of students’ experiences outside school; “it makes learning more applied, more critical, more inventive, and more meaningful for students” (Hargreaves et al., 2001, p. 112). Apple and Beane (1999) explain that integration:

Apple and Beane’s comments, made in 1999, reflect another powerful argument that is currently impacting the perceived role of science within the curriculum, that of connection to ‘real problems’, ‘real lives’, and the ‘real world’. Jenkins (2007) argued that students need better, more realistic ideas about the multiple realities of what constitutes science in the real world and wonders “whether a subject-based curriculum can provide students with the inter- and cross-disciplinary perspectives required to respond to challenges of this [global] kind” (p. 278).

**The Real World of Science**

Adolescent high school students of today are interested in real-world science. The problem, Ravetz (2005) explained, is that real-world science is where facts are uncertain, values are in dispute, stakes are high, and decisions urgent. These factors make these topics difficult to define, difficult to assess, difficult to teach and controversial to include in the high school science curriculum. Further, Ravetz (p. 11) bids, “[f]arewell to the old classifications, such as physics, chemistry, biology” and welcomes “new ones, like GRAIN – short for genomics, robotics, artificial intelligence and nanotechnology”. Ravetz claimed that these new sciences involve a complex of issues and that, whatever the solutions, they will not be determined by science alone; neither will they be simple or easy. He refers to them as “scientific perplexities” (p. 33).

One example of a contemporary scientific perplexity is the notion of environmental sustainability. Ravetz (2005) claimed that the growing realization, since the 1960s, that our industrial civilization is unsustainable, that we are polluting ourselves and exhausting key resources, has changed our perception of reality. This change, according to Ravetz, is a revolution in thinking, somewhat akin to the Copernican revolution or the revolution of Charles Darwin’s Theory of Evolution by Natural Selection. This notion of a ‘paradigm shift’ is also reflected in the writings of Fritjof Capra (e.g., 1982) who claimed that, “we live today in a globally interconnected world, in which biological, psychological, social, and environmental phenomena are all interdependent” and that “the holistic conception of reality, [is] likely to dominate the present decade” (Capra, 1996, p. xviii).

There is a common thread in many integrated programs in schools of connections with the environment (Wallace et al., 2007). A quick glance at the most recent National Association for Research in Science Teaching (NARST, 2009) annual international conference program reveals terms like socio-ecological systems; biodiversity curriculum; invasive species; diversity beliefs; renewable energy course; ecosystem relationships, environmental literacy; environmental decision-making; environmental behaviour change; global warming; climate change, environmental moral dilemmas; and, eco-justice. For example, Zandvliet & Nelson (2009) found that in integrated, experientially-based courses in environmental education, students’ perceptions of their classroom learning environment were much closer to the classroom environment they preferred compared with traditional classrooms. Real world scientific perplexities, including the issues of environmental sustainability, are clearly becoming part of the real world of science education.

**Science as a discipline**

We note a dissonance in the metaphors in the literature about science in our modern, global society of the twenty first century. On one hand, metaphors reflect ‘holistic’, global science: on the other hand, the metaphors reflect the ‘fragmented’ nature of science as disciplines. For example, Capra (1996) argued that the mechanismistic, easily quantifiable models of science of a bygone era are in opposition to the holistic awareness of today’s scientific phenomenon. In biology, Capra explained, the cell can no longer be considered simply as a fundamental building block of life and that it must be thought of in symbiotic partnership with organelles and other cells. Chaos theory, as described by Briggs and Peat (1999), encourages scientists to go beyond their mathematical

and scientific origins and embrace myth, mysticism, poetry, literature, art, religion, and philosophy and create an interconnected view of the universe, our world, our society, and ourselves.

In stark contrast to these holistic views of science, others point to the fragmentation of ‘science’ into a chaotic array of sub-disciplines or specialties. Carter (2008) explored the implications of globalization for science education and noted the “increase in the sheer size and scope of contemporary science research in increasingly fragmented sub-disciplines” (p. 625). Moreover, Jenkins (2007) argued that science in schools is promoted as a “coherent curriculum component” but further argued that, in reality, it “fosters an untenable but enduring notion of a unifying scientific method that ignores important philosophical, conceptual, and methodological differences between the basic scientific disciplines” (p. 265). These conflicting images of science as a fragmented or holistic discipline are reflected in the array of university courses offered under the umbrella of science. At one end of the spectrum are programs such as those offered by the newly developed Centre for Integrated Human Studies at The University of Western Australia which bring together the sciences, social sciences, arts and humanities to focus on the nature and future of humankind. At the other end of the spectrum, The University of Western Australia has a plethora of units and subjects that can be selected from 37 science majors from Cell Physiology to Soil Science as well as 39 named programs from Environmental and Natural Resource Economics to Neuroscience and Nanotechnology. At the high school level of education, however, curriculum in most schools is locked into a strictly disciplinary approach.

**Barriers to Integrated Science Curricula**

A number of factors significantly affect the success or failure of integrated programs in high schools (Pang & Good, 2000). These include factors related to the teachers such as subject matter knowledge and qualifications, pedagogical content knowledge, their beliefs about and experiences of schooling, as well as their instructional practices. Other factors might be contextual, such as administrative policies, curriculum guidelines, assessment and reporting processes, and school traditions such as discipline-based departments.

Another barrier to curriculum integration is community wariness that integrated teaching approaches might be ‘watering down’ the curriculum (Wallace et al., 2007). Research has found that while college-educated, middle class parents espoused support for open, integrated, multicultural, student-centered education, their narratives revealed an actual preference for conservative practice. They preferred factual, tightly-sequenced, subject-area-bound, Western-oriented curricula because, the authors suggest, generations of their class have had relatively uncontested success within this traditional approach to curriculum (Brantlinger & Majd-Jabbari, 1998). An integrated curriculum is not consistent with the expectation from many people that schooling should be academically oriented, emphasizing written work and individual study and focused on examinable concepts and ideas (Kaplan, 1997).

**Science Learning**

Evaluations of science learning that result from integrated programs of work in schools have produced notoriously ambivalent conclusions. In a review of the literature from the 1940’s to the early 1990’s, Vars (1991) found more than 80 normative or comparative studies reporting that, on standardized achievement tests, students in various forms of integrated programs performed better than, or at least as well as, students enrolled in separate subjects. In contrast Marsh (1993) tracked some of the major research on integration from the USA, UK, and Asia over the previous 50 years and found that there was limited evidence of either a positive or a negative
effect. Assessment of learning tends to focus on the disciplinary content and neglect other factors that may be more consistent with an integrated approach to teaching and learning. Some studies have attempted to incorporate broader and more holistic perspectives into their evaluation of student learning, focusing on outcomes such as student motivation, attitude, cooperation, and capacity to transfer and apply knowledge. In the 31 studies included in her meta-analysis, for example, Hurley (2001) noted anecdotal evidence that curriculum integration has a positive impact on attendance, student behaviour, knowledge of academic resources, study habits, student enthusiasm, and student engagement.

The Purpose of School Science

There are different views about the purpose of schooling and the purpose of learning science in school. High school science was traditionally seen as a passage to higher education and career choices for those students talented and interested in science. From this perspective the purpose of school science may be twofold; first, to prepare future scientists with the knowledge and skills needed for their future careers; and second, to enable students to score highly in tertiary entrance examinations and to improve their chances of accessing desirable courses at university. In more recent years the purpose of learning science in school has been described in a different way that reflects the need for a scientifically literate population. From this perspective, the purpose of school science is to provide an education that will be of value to students over a lifetime, irrespective of their careers, and thus highlights the scientific needs of all students. Scientifically literate students tend to be described in a practical way, being able to solve practical problems for health and survival, in a civic way, being able to participate more fully in debate and decision making, and in a cultural way, being motivated to know about science as a human endeavour (Shen, 1975).

Integrated approaches to the teaching and learning of science in school are more consistent with students becoming scientifically literate because they are more likely to be given the opportunity to solve practical problems and participate in debate and decision making than students who participate in a traditional, disciplinary approach to school science.

Powerful Knowledge

Two very different perspectives can be brought to bear on the issue of the purpose of school science and the notion of knowledge as power. It is evident that teachers, parents and even students themselves consider subjects with everyday, integrated knowledge to be ‘soft’, that is, not easily tested, subjective and open to debate. Subjects containing ‘hard’ academic knowledge are those that are testable, objective, and well established (de Brabander, 2000). In other words, the more discipline-based the subject, the higher its academic status and, conversely, the more integrated, the lower its academic status. This perception bestows considerable power on discipline-based subjects. In Western Australia, if students take high status subjects such as Physics, Chemistry and Calculus, their tertiary entrance scores are scaled up to give them a better chance of entering university. Consequently, students who take these subjects also have a greater chance of entering courses at university, such as medicine and law, that are likely to result in high status, highly paid professions. Young (2008) defines powerful knowledge with reference to what knowledge can do or what intellectual power it gives to those who have access to it. He claims that the main reason parents send their children to school is in the hope that they will achieve powerful knowledge. Young also points out that in modern societies, powerful knowledge is, increasingly, specialized knowledge.

Our own recent research (e.g., Venville et al., 2008), however, illuminated a case study of integrated classroom teaching and learning that contrasted with this view that only highly
disciplinary knowledge can be considered powerful knowledge. As previously mentioned, we observed middle school students participating in an integrated project about the health of a nearby lake. The implemented curriculum varied from student to student because the teacher enabled each one to pursue different aspects of the issue of the health of the lake that interested them. The science considered in the project was integrated with content from other school subjects including Society and Environment, English, Mathematics, Art, and Technology and Enterprise. The kind of learning observed in this case study could also be considered to be ‘soft’, that is, difficult to test in an objective way, subjective, and relatively open to debate. In this case study, the absence of high-stakes testing enabled a broad spectrum of content to be considered at inconsistent depths by different students and a broad spectrum of innovative teaching strategies. The teachers justified these approaches by claiming that the students, “need stimulation”, and that the approaches helped students to “respond”, gave them “ownership”, made them “empowered”, “connected to their own world”, “changed their attitudes”, and finally, resulted in them “actively making decisions and changing their world”.

We contend that the very factors that were considered to render the topic about the health of the lake as low status were the very factors that also indicated the power for students of this approach to learning. The power of the knowledge taught and learned during the case study was that it was integrated and provided the students not only with powerful scientific knowledge but also with powerful values in social and civic responsibility, power to think in ways that are appropriate to the problems and issues that face the community in which they live, power to communicate and debate these issues, and power to think about ways that these problems and issues can be addressed.

Conclusion

We have considered a number of points of tension around which the issue of curriculum circulates. The first point of tension is that curriculum can take the form of a discipline-based approach or an integrated approach. Commentators present convincing arguments for both approaches in schools. The second issue is that real-world science includes a number of complex ‘scientific perplexities’, including environmental sustainability, that are difficult to consider from within a single discipline and, at the same time, require a depth of knowledge from a number of disciplines to understand. The third issue is that science itself reflects opposing metaphors that suggest it is becoming more holistic and interconnected and more fragmented and disparate disciplines at the same time. The fourth issue is that there are a number of factors that impact on the implementation of an integrated curriculum with the status quo seeming to be a disciplinary approach. The fifth issue is that science learning outcomes that have been measured from integrated approaches to curriculum are neither excellent nor poor. Measuring learning outcomes other than content knowledge that may be more relevant to an integrated curriculum is difficult and often ignored by both teachers and researchers. The sixth point of tension is that while the purpose of school science has been redefined in recent years to develop scientific literacy in all students, the practices and realities of school science remain consistent with more traditional views that the purpose of school science is to educate the elite. Finally, powerful knowledge has traditionally been knowledge from within the highly defined and highly insulated school disciplines. While this continues to be the case in most school contexts, there is mounting evidence that integrated teaching and learning can leverage a different kind of power for students.

All seven tensions discussed add to the complexity of what should be included in the Australian national science curriculum and to the contentiousness of how science should be taught in schools. The intended educational outcomes for young Australians (National Curriculum Board, 2008) is that students should develop “deep knowledge within a discipline that shapes the ways
in which problems are represented, considered and solved, and provides a foundation for development of multidisciplinary capabilities” (p. 5). The framing paper that outlines the approach to the new national science curriculum is consistent with this espoused outcome in that it focuses on the big ideas of science, such as energy, sustainability, and models and theories, as well as the major concepts from the science disciplines. The important question is about the degree to which we can abandon science as coherent, well-insulated, and established disciplines that offer students a profound framework of knowledge and processes on which to base their learning. Is school science under threat from curriculum integration and new, holistic world views? How can science as a school subject coexist with more holistic approaches to teaching and learning? These are important questions, the answers to which will become evident as the national science curriculum is implemented in coming years.

Grady Venville was appointed as the inaugural Professor of Science Education at the University of Western Australia in January 2007. She is known internationally for her research in science education, particularly in the fields of curriculum integration and students’ cognitive understanding of complex scientific ideas such as genetics.

References


