Researching networked learning generatively

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Abstract

The late C20th and C21st brought advances in the natural sciences and in ways of thinking about complex dynamic self-organising systems, yielding a powerful, state-of-the-art learning theory. According to this biologically based generative theory, learning (or knowledge-gaining) can be viewed as an adaptation, hedging our species' chances of survival. The present paper focuses on how a research methodology for investigating learning (including Networked Learning) emerges from this generative learning theory. We propose to illustrate this methodology by way of a recent Australian Research Council (ARC) funded project (in which both authors were Chief Investigators). That project explored the worth of casting young learners as e-designers as a novel way of helping their schools to understand and embed some educationally fruitful possibilities of Networked Learning approaches. Not only did these young students assume control over generating the curriculum content, but also the conception and, as far as possible, testing of their ideas through prototyping and evaluation of the resulting Networked Learning environment. Hence, an inherently generative research methodology was implemented. We report on the power of this methodology to elicit important insights into the learning that occurred and speculate on its broader research potential.

Keywords

Generative learning, Design-based research, Generative research methodologies, Networked elementary science and technology education, Innovations in learning.

Introduction

The emergent field of networked learning depends for its survival, at least at two levels, on the development of robust learning theory. First, if networked environments are to succeed in supporting learning, there is a need for principled learning design. Second and much less widely recognised, research itself is a paradigm case of learning. So, it stands to reason that approaches to researching networked learning must also be theoretically defensible.

Scholars in networked learning share with Education scholars generally the challenge of theorising learning. Some writers doubt that it is possible to theorise in the social sciences (for example, Ziman, 1978/1991). Others identify a variety of "approaches" (as distinct from theories) (Thagard, 1992, p. 245), perhaps recognising this pluralism as symptomatic of the difficulty of theorising in such domains.

In recent decades, a biological zeitgeist has swept many disciplines. Fields not previously treated as natural sciences, but instead considered human sciences, are now describing complex, dynamic self-organising systems: psychology (Thelen and Smith, 1994) and the development of human morality (Ridley, 1996), for example. Similarly, some Education scholars are beginning to consider learning as complex, dynamic, systemic and ecological (Maturana and Varela, 1987; Davis and Sumara, 2006).

However, learning, teaching and researching that pursue implications of considering Education to be biological, beyond a starting point recognition that it is so, are still exceedingly rare. In our research

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group, we have dedicated ourselves to this task. This paper explicitly explores some research implications of adopting such a biological position for Education – and for networked learning in particular.

We begin by showing how we have derived a state-of-the-art, biologically based, generative learning theory, at the intersection of biopsychology, evolutionary epistemology and neuroscience. We summarise our case for its power to explain learning, including with reference to our research group's tests of it over more than a decade. We then examine the case of our recently completed ARC supported, industry-linked project GENESIS (Generating e-Learning Systems in Schools), describing the project and then analysing the character of its research approach for features that make it generative. We conclude by speculating about the potential of generative methodology for researching networked learning more broadly.

A biologically based generative theory of learning

We have drawn on insights from biopsychology and evolutionary epistemology (Plotkin, 1994, 1997) and neuroscience (Edelman, 1992, 1993) to develop a biologically based, generative theory of learning (Schaverien and Cosgrove, 1999, 2000; Schaverien, 2005).

On this view, knowledge-gaining (or learning) is recognised as an adaptive behaviour (Edelman, 1992, 1993; Plotkin, 1994), hedging the chances of our species' survival, just as the streamlined shape of fish enhances their movement in water or the protective coloration of moths camouflages them from potential predators. Learning follows the classic Darwinian heuristic that defines natural selection: variants are generated, subjected to selection pressures and either survive to enter the next iterative selection cycle or are discarded. Such a view does not propose a biological analogy for learning. It recognises that learning *is* biological. Acknowledgement of the selectionist heuristic underlying learning yields a coherent picture of knowledge generation at three nested levels, each with its iterative cycle on its own time scale:

1. In the gene pool, on a time scale of generations, in which the genetic knowledge (that becomes a part of the phenotype of a living organism) is tested by environmental pressures, and fit organisms survive to reproductive maturity to hand their whole genetic complement on to their offspring;
2. In organ systems (including brains but also immune systems), in which (in the case of brains) ideas are generated, tested on their value and kept if they survive these tests;
3. In communities and cultures (including in the disciplinary histories of science, music, art, technology and so on), in which ideas are generated, tested and regenerated on communities' or cultures' values.

Pursuing implications of this biologically based generative theory

To discern whether learning, teaching or research approaches are generative, we first needed to distil the identifying features of a generative position. We recognised three (Schaverien and Cosgrove, 1999):

1. A central role for learners' values: ideas that align with them survive; those that do not are discarded.
2. A selectionist (g-t-r) mechanism of generate – test (on value) – regenerate, opposing a view in which developed knowledge is transmitted or absorbed through "information processing" or "transfer."
3. Development as unique to individuals, determined in real time, by possibilities emergent from learners' actions in each g-t-r cycle. If development is epigenetic, then teachers cannot easily anticipate universal (often time-locked and linear) learning pathways for students.

In these terms, we have been able to show that Peirce, Dewey, Bronowski, Piaget and other notable figures now appear presciently generative in their insights into learning (Schaverien and Cosgrove, 2000).

In science and technology education in particular, we have been able to progress earlier ideas about generative learning and teaching (Cosgrove and Osborne, 1985; Wittrock, 1974, 1994) by distinguishing six contiguous acts of learning: exploring, designing, making, operating, explaining and understanding (Schaverien and Cosgrove, 2000) and aligning them with the biologically based generative heuristic: exploring with generation, designing, making and operating with testing, and explaining and understanding with regeneration. Not all learning begins with exploration, and each act can follow from any other. However, analytical convenience is well served by thinking of these acts in these terms. When we re-examine a broad range of recent seminal science and technology learning research for these six acts, we can affirm its generative character (Schaverien and Cosgrove, 2000).

We have also tested this theory in a range of studies of learning and teaching, including in networked learning contexts (eg. Alexander, 2004; Cosgrove and Schaverien, 1996; Forsyth and Schaverien, 2005; Golja and Schaverien, 2005; Hall and Schaverien, 2001; Jackson and Schaverien, 2005; Schaverien, 2002, 2003; Shepherd, Clendinning and Schaverien, 2002; Schaverien et al., 2005a, 2005b). There, we have been able to document the degree of centrality afforded learners' values, the presence of generating and testing behaviour and the idiosyncratic nature of learning pathways taken. For example:

- A cohort of learners (aged from seven to 15 years) formulated an astoundingly rich mix of profound questions they wished to answer, in the networked learning research context of the GENESIS project that will be reported here (Alexander, 2004; Schaverien et al., 2005a).
- Postgraduate students, immersed in networked learning environments and networked discussion about that learning, generated and tested personal ideas about learning (Jackson and Schaverien, 2005).
- Ultimately, through conversations with their academic developer colleague, two multimedia development academics considered the feasibility and worth of radically re-engineering their subject (Golja and Schaverien, 2005).

Such studies have affirmed the power of generative theory to detect learning and offer fruitful explanations of it. First person explanations also appear consistent with our third person accounts (McCredie, 2007; Schaverien et al., 2005b; Jackson and Schaverien, 2005). We have also specified parameters of a generative approach to designing networked learning environments, helping instructional designers hedge the likelihood that learning will occur (Shepherd, Clendinning and Schaverien, 2002).

So, there is now a considerable body of evidence for the power of this biologically based generative theory of learning to recognise learning when it occurs and provide a robust account of it. If, as we believe, researching is a paradigm case of learning, then this paper provides a timely opportunity to consider what it might mean to research generatively, in particular in a networked environment. It is to this we now turn, using the ARC supported GENESIS project as an illustration. We first outline this project and then examine our research approach for its generativity.

The GENESIS Project

The GENESIS project investigated the worth of a novel strategy to address the failure of networked learning to embed itself, at significant scale, in schools. We wanted to see if this problem could be addressed by giving students significant equity in the development of networked learning systems. Varying numbers of students, initially aged from seven to 15 years, (at most 300 across 12 classrooms in three schools) participated over the project's three-year lifespan, and a leading partner teacher co-ordinated the participation of between three and eight teachers in each school. There were two Chief Investigators (the two authors of this paper), a doctoral researcher, a project manager and multimedia developers from the university's Institute for Interactive Media and Learning (IML) and a commercial software development company. The project proceeded through five phases as follows:

1. Students needed an agreed focus around which to develop a networked learning environment. Over several months, teachers elicited, from the 300 students, hundreds of their deepest scientific and technological questions. Project partners grouped children's questions, keeping their words, into a short list. Students voted for the question cluster they considered of highest priority for investigation: *How and why do we think? How come we're not born with all the knowledge we know now?*

2. Recognising this question's complexity, students framed contributing questions (for example, *What controls the brain? How does the brain function? What happens when we dream? Why do we remember and forget?)*, selecting one for their class. To prepare for investigating each, children's reactions and responses to it were collected, including their prior knowledge, comments, questions, experiences and wonderings. They asked: *How does our brain think? What is the brain made of?*

What controls our imagination? Children found good ways of exploring these questions, for example, by interviewing people, visiting places, referring to websites, books, videos and experiences available in their communities. They began to think about how they might design a networked learning environment to engage others with their investigations.

3. Two representatives from each of the 12 classes formed a Design Team. They spent two days at university working with multimedia developers and university researchers to draft a design for their networked learning environment. They acknowledged that much is still unknown about the workings of the human brain. They reasoned that investigating it would lead people to generate more questions than they might have answers for. They wanted to encourage such questioning. Students began to conceive of their networked learning environment as a learning journey, and negotiated and refined this idea in their schools. IML prepared a formal client brief from the children's specifications and presented it to them as clients in school meetings. Children redrew their specifications within budget and time constraints. The GENESIS Journey emerged: a networked environment where travellers embark on a journey of exploration. They walk along pathways and visit Houses and buildings, finding and reading, watching video of and engaging in networked discussion of the ideas, questions and investigations of others. Throughout its development, university researchers mediated between students and software developers.

4. Students pursued their own inquiries into the effectiveness of The GENESIS Journey, drawing on what they had learnt about gathering data in their earlier investigations. Their inquiries into people's uses of the environment were broad, including for example, the frequency of hits for each House, the nature of the learning occurring, whether past experiences affected people's responses and any gender-based differences. One student wanted to know if students explored in their own time.

5. Schools initiated a further project phase. They proposed and began to implement strategies for embedding GENESIS. In-school planning workshops were held at which students and teachers devised a school strategy for further work with The GENESIS Journey.

This methodology conforms to the increasingly well-accepted educational research paradigm of design-based research, "[blending] empirical educational research with the theory-driven design of learning environments, [thereby fashioning] an important methodology for understanding how, when and why educational innovations work in practice" (The Design-based Research Collective, 2003, p. 5). GENESIS' design-based research approach supported two complementary empirical tests: a test of the educational power of The GENESIS Journey networked learning environment and a test of its (in this case) generative theoretical foundations. Through the integrated theory-practice cycle of design-based research, both the networked learning environment itself and its foundational theory could be elucidated and refined. Of principal concern in the present paper, however, is the larger question of examining the extent to which the research approach was itself generative.

The GENESIS project: A generative research approach?

To decide this question, we must examine the GENESIS project's research approach to see if we can recognise the three central characteristics of generative learning: the driving force of (researchers') values; generating and testing of (researchers') ideas on their value; and epigenetic (research) pathways.

Can GENESIS researchers' values be identified and if so, what was their role?

The GENESIS project was a collaborative research and development project, so university- and school-based research partners strove to develop a shared set of values. Partners explicitly agreed on two key project values: the importance of increasing students' equity in the development of a networked learning environment and of scaling up networked learning in schools.

There is evidence at every phase that the first of these values was central to the research approach. For example, from the outset in Phases 1, 2 and 3, researchers worked to support students' creation of the subject matter of the planned networked learning environment, and student control of investigations

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(regardless of whether these were mandated in school curricula). In Phase 3, researchers supported students' development of their own agreed storyboard and their contribution of as much content as possible to populate it (although time and resource constraints prevented their actually building it). In Phase 4, researchers nurtured students' investigations of the worth for learning of their networked learning environment, according to their own criteria. In Phase 5, researchers ensured students took a leading role, with their teachers, in planning how to scale up GENESIS in their school. Similarly, project partners agreed on the importance of scaling up networked learning in schools, although initially it was less clear what this value actually meant to partners. Coburn's (2003) definition of scale-up assisted here. For her, scale-up was not necessarily a quantitative measure of the spread of an initiative across classrooms or schools. Scale-up could also mean a deepening implementation or teachers' increasing ability to address sustainability issues or a shift of ownership of the initiative. Project partners agreed on the value of scale-up in these broad terms.

Implicit in both these values, for the university researchers, was a generative view of learning. This learning theory informed their view of how the project phases should proceed, in anticipation and in real time. Over the project's lifespan, most school-based project partners and other participating teachers adopted a generative view of learning, too, and teachers' generating and testing of ideas about learning was a crucial and challenging counterpoint to children's learning. In fact, in Phase 5, there was evidence in the approaches teachers suggested and sanctioned for embedding GENESIS in their schools, that many teachers had come to value their adoption of generative teaching approaches and saw it as evidence of scale-up: as shift of ownership (from the university researchers) and increasing depth of implementation.

So, researchers' valuing of students' equity, of scale-up and, ultimately, of generative teaching approaches were central in the refinement of GENESIS' research approach.

Is there evidence that GENESIS researchers generated and tested ideas?

The GENESIS project's research design reveals evidence of those acts of learning that align with generating and testing. Such generating and testing cycles can be seen within and across project phases.

Throughout the GENESIS project, researchers deliberately *explored* a range of research ideas that would support the work of particular phases. For example, in Phases 1 and 2, so as to gain insights into children's deepest scientific and technological interests prior to and during their investigations, researchers conducted teacher workshops and school professional development meetings and visited classrooms to help teachers enact generative approaches. In Phases 2, 3 and 4, as children investigated their questions and designed their networked learning environment, researchers encouraged children to use varied media (including digital media) to record their ideas, and they videotaped naturalistic conversations with students in the course of their investigations (after Cosgrove and Schaverien, 1996). Researchers worked continuously to open out rather than to narrow the research information available, so as to understand details of the novel strategy well enough to explain its success or failure here. In a variety of ways, researchers ensured pooling of ideas - about investigations, environment design, evaluating the worth of their environment and strategies for project embedding.

Researchers tested the worth of their research ideas. At minimum, they required evidence that learning was occurring. We have described in detail elsewhere examples of children's unanticipated and profound ideas (Alexander, 2004; Schaverien et al., 2005a). Two examples give a sense of them.

Matt investigates dreaming

Thirteen-year-old Matt wanted to understand dreaming. He searched the Web for different theories, finding Freud's, Jung's and Crick and Mitchison's (1983). He tested them against what he found when he surveyed 50 children and teachers at his school about their experiences of dreaming. He concluded that none of these theories could yet be confirmed. However, he expressed a personal preference for Crick and Mitchison's, in that it was biologically plausible. It explained what dreams might *be* (a mechanism by which a brain might "get rid of unwanted information that the cortex can't store") rather than only what dreams might *mean*, as he suggested Jung's and Freud's theories did. Matt's inquiry was a sophisticated example of a young learner's attempt at theory advancement through generating and testing his ideas. His report, video of conversations with him and other information collected in his Dreams House provoked strong interest from visitors to the GENESIS Journey. Dreams House discussion boards were well patronised, too. Children debated many issues that had engaged Matt, and some that had not.

Kirsten tries to understand uniqueness

Eleven-year-old Kirsten expressed her interest in people's uniqueness early. She and Ashleigh devised a "drawing test" to collect data about it. They reasoned that by reading the same story to groups of children and asking them to draw what they imagined, they could collect evidence of uniqueness. They ran their drawing test, and researchers videoed their responses to drawings obtained. Their report and video of their discussion of their experiment provoked strong interest in The Drawing Test House and on the Drawing Test discussion boards. Children discussed what might cause uniqueness – whether it was differences in brain structure or in life experience or whether and if so, how these two might be related. Such conversation aligned with familiar debates about nature-nurture and with the frontier-edge concerns of a prominent neuroscientist (Edelman, 2005),

> The most important thing to understand is that the brain is 'context bound'. It is not a logical system like a computer that processes only programmed information; it does not produce preordained outcomes like a clock. Rather it is a selectional system that, through pattern recognition, puts things together in always novel ways. It is this selectional repertoire in the brain that makes each individual unique, that accounts for the ability to create poetry and music, that accounts for all the differences that arise from the same biological apparatus – the body and the brain. (p. 1)

As already noted, the GENESIS project was designed to test the worth of a novel strategy for scaling up networked learning in schools. It was therefore crucial that research approaches enable researchers to detect evidence of such scale-up, over GENESIS' lifespan, in the terms in which the research team understood it. In these vignettes and others like them, it was clear that students had not only learned, but they had engaged with this environment with depth and originality: their ideas often resonated with authentic philosophical and scientific enquiry in the culture. Many such resonances were apparent, not only with respect to contributing questions but also in answering the overarching GENESIS question: *How and why do we think? How come we have not been born with all the knowledge we know now?* For example, after his sustained investigations of human thinking, sixteen-year-old Daniel admitted approaching the view that "perhaps an organism is not built to understand itself." McGinn (1993, p. 23), a renowned New Mysterian, propounded this very question: "Are our own minds in principle intelligible to us?" Similarly, children's fascination with the overarching question itself anticipated by five years Plotkin's (2007) book, described on the fly-leaf as "[taking] on one of the big questions at the heart of the cognitive sciences – what knowledge do we possess at birth and what do we learn along the way?" Generating and testing research ideas were as much a part of the learning design as they were the research process, a factor that may well have reduced any artificiality, from the children's perspective, in data collection and analysis. Evidence of profound intellectual engagement on the part of many students suggests the ability of the research and learning design, together, both to effect and detect scale-up here.

What evidence is there of epigenetic development of GENESIS' research plan?

Key principles underpinning the GENESIS project and its overarching goal were clear from the start. However, the five-phase research process emerged in real time, as options formed during and after each phase. For example, ways of supporting children's investigations crystallised after children agreed a topic and implications of that topic could be unravelled. Their frontier-edge topic and learning-journey approach to engaging others with their topic online suggested the need for researchers to provide supporting materials for teachers, so as to avoid overly directing or simplistic information transmission approaches in classrooms. Perhaps the most persuasive evidence of idiosyncratic research pathways lay in the diverse directions schools took in scaling up GENESIS. In one school, a child's request initiated another GENESIS cycle, as a space odyssey. In another school, teachers adopted the GENESIS approach to teach a sustained Wetlands unit. The third school funded a professional development program, using GENESIS data and findings.

Summary and implications

The GENESIS project provides one illustration of how networked learning can be researched generatively. This generative research design was able to answer the question: Can a novel research strategy (of casting children as designers of a networked learning environment) help networked learning to scale up in schools? Researchers were able to generate and test ideas for their novel strategy on the basis of firmly held research values (of ensuring student equity, scale-up in agreed terms and consistency with generative learning theory). Constrained by these principles, research pathways emerged over the project's lifespan, enabling judgements to be made by the end of the research process as to whether and if so, in what senses, scale-up of networked learning occurred in participant schools. Though the project was highly resource intensive, there was evidence that scale-up was achieved. Implementations deepened over time (in that there was, for example, significant student learning). Ownership also shifted (in that schools noted growth in their own capacity and confidence with respect to specific aspects of the GENESIS implementation, including its generative teaching approaches). At the end of the project, two of the three schools took significant independent steps to embed aspects of the project. (The third school's leading teacher left her school at the end of the project, significantly limiting further scale-up there.) At the time of writing, two years after the project ended, initiatives in the other two schools are still active.

No doubt there is much that GENESIS researchers were unable to discover about their novel strategy, despite their searching, three-year enquiry. Nevertheless, it is also clear that generative learning theory supplied a robust framework for understanding learning substantively there. We can now speculate more confidently that generative theory provides a generic description of learning. In any case, the success of GENESIS' generative research approach provokes consideration of its potential for researching networked learning more broadly. As a new educational context, networked learning brings with it unanticipated challenges and off-the-shelf research approaches may well prove inadequate. Preservation of researchers' integrity in these circumstances of reform and uncertainty may well require humility: admission that the research task is itself a (we would say, generative) learning experience. Generating and testing research ideas, in real time, on carefully distilled general and specific research values, might well enable successful tuning of research approaches. By doing so, researchers might be better able to answer increasingly acute questions about innovative but as yet poorly understood educational environments.

The clear focus of generative approaches on what learners (rather than teachers) do and its capacity to theorise creativity suggest the potency of this theory for explaining learning, teaching and researching in networked learning contexts. Perhaps, in a political climate that increasingly values innovation, our case for the power of researching networked learning generatively might persuade those so far unconvinced by cases for learning and teaching generatively. If it does, then a crucial first step will have been made towards principled researching in the generation of knowledge about networked learning.

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Brief CV Notes

A/Prof. Lynette Schaverien is active in networked learning research in the Education Faculty where she directs the postgraduate e-Learning program. Her research interests include biological learning theory.
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