

Innovative Learning Environments as Complex Adaptive Systems: Enabling Middle Years' Education

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Abstract In a period of post-industrial education, how can we understand school learning environments i.e. educational spaces and practices that are concurrently physical, social and cultural? How might theoretical constructs that deal with ideas associated with 'complexity', 'emergence' and 'self-organisation' aid our interpretations of learning environments in the knowledge era? This chapter explores the emergence, co-evolution and mutual adaptation of the physical, social and cultural practices in three schools (primary and secondary) that attempted to develop contemporary pedagogical cultures of practice between 2008 and 2011 in non-traditional learning spaces. Employing theoretical frameworks derived from the literature on 'complexity theory' and 'complex adaptive systems theory', this chapter explores the influences of new socio-spatial contexts for learning (i.e. innovative learning environments) on the engagement of middle years' students. To conclude, an argument is put forward for considering school learning environments, schools and school systems as 'complex adaptive systems': educational settings that can 'learn' in response to positive feedback loops to provide dynamic socio-pedagogical cultures of practice that are aligned with current middle years' educational theories.

Introduction

This chapter presents research into middle years' learning environments that was undertaken between 2008 and 2011 as part of a Ph.D. study titled *Engaging spaces: Innovative learning environments, pedagogies and student engagement in the middle years' of school*. For the purpose of the project, learning environments were considered to be educational spaces and practices that are concurrently physical, social and cultural. The study was situated in three schools in Melbourne, Victoria

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and Australia and was associated with an Australian Research Council Linkage project titled *Smart Green Schools*.

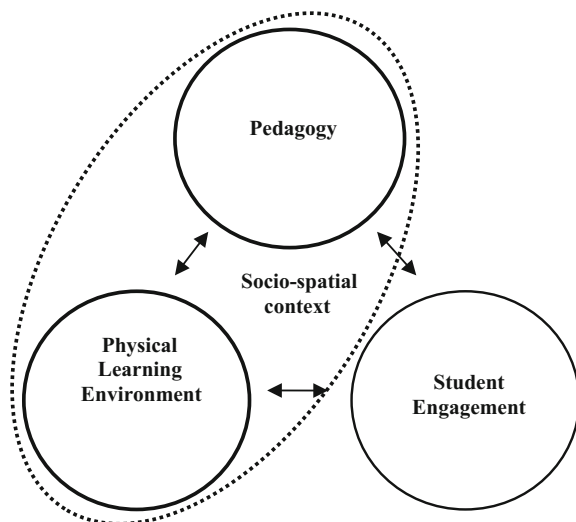
The research was framed by the ongoing discourse about middle years' education reform and inertia of incumbent middle years' pedagogies. The Middle Years Research and Development (MYRAD) Project (DEET 2002, p. web) typifies the reform agenda highlighted in the literature. To advance middle years' education, this report recommended:

- Strengthening teacher–student relationships;
- Involving students in decision-making about content, process and assessment;
- Presenting authentic tasks that require complex thought and allowing time for exploration;
- Inclusion of processes involving cooperation, communication, negotiation and social competencies; and
- Providing for individual differences in interest, achievement and learning styles.

However, the reform agenda outlined in the literature appears to have suffered from what Elmore described as the inertia of resident school cultures that result in school communities powerfully resisting change (Elmore, 1996; Fullan et al. 2007). Indeed, it is generally agreed that reform initiatives in the middle years' have not been widely adopted (Cartmel 2013; Pendergast 2006; Pendergast and Bahr 2005).

Situated at the intersections of physical learning environments, pedagogies and student engagement (see Fig. 1), this chapter makes explicit the theoretical analysis that was undertaken to interpret qualitative field data collected across three sites (schools) as part of a multiple case study (Bryman 2004). The aspects of the study that are presented here are those associated with the following questions:

Fig. 1 The study's field of inquiry: the relationships between physical learning environments, pedagogies and student engagement



- How are innovative learning environments and contemporary constructivist pedagogies collectively influencing socio-pedagogical cultures in the middle years and what impact is this having on student engagement?
- How can the effectiveness of innovative middle years learning environments be assessed for their influence on pedagogical practices and student engagement?

In response to the research questions—and as emerged from analysis of the field data—this chapter is divided into three main findings and discussion sections:

- The development of new socio-pedagogical cultures in innovative learning environments;
- Emergent behaviours and student engagement; and
- The overall effectiveness of innovative learning environments.

These sections are preceded by a brief outline of the research design and a discussion about the theoretical frameworks that were used to analyse and interpret the field data. This discussion includes an introduction to the literature on ‘complexity theory’ and ‘complex adaptive systems theory’. These conceptual tools were used to:

- (a) Explore the influences that new socio-spatial contexts for learning had on middle years’ socio-pedagogical cultures and student engagement;
- (b) Discuss the effectiveness of the innovative learning environments; and
- (c) Identify how the educational effectiveness of innovative learning environments can be assessed.

To illustrate particular phenomena, the findings are supplemented with quotes extracted from interviews and focus groups with school leaders, teachers and students—critically championing their voices.

Research Design

A critical analysis (Ewert 1991; Habermas 1971, 1974, 1989) of middle years’ learning environments in three Melbourne-based schools was undertaken using multiple case study (Bryman 2004), ethnographic (Bryman 2004) and participatory action research methodologies (Cohen et al. 2007; Mattsson and Kemmis 2007).

The research design was informed by critical social theory (Habermas 1971, 1974, 1989), a middle-range theory that suggests that through trying to change a social setting, the nature of its social context may be revealed, and understandings of its function and potential may be attained. Whereas “critical theory tries to understand why the social world is the way it is and, through that process of critique, strives to know how it should be” (Ewert 1991, p. 356), critical social theory takes this process a step further by exploring knowledge derived from periods of change, or emancipatory praxis.

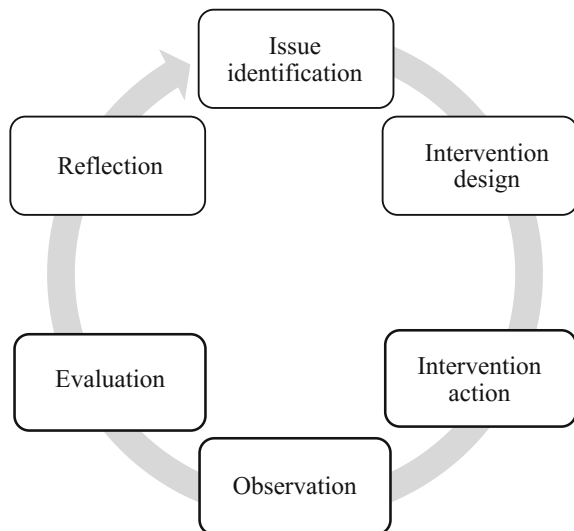
Carr and Kemmis (1986) identified critical social theory as a theoretical perspective that legitimised the adoption of action research and advocated this perspective as the most rational way to think about research in education. They suggested that critical educational research should aim to transform education, rather than merely attempt to explain or understand moments in the transformative process. Carr and Kemmis (1986, p. 156) described the role of critical research in education as follows:

A critical educational science ... has a view of educational reform that is participatory and collaborative; it envisages a form of educational research which is conducted by those involved in education themselves. It takes a view of educational research as critical analysis directed at the transformation of educational practices, the educational understandings and educational values of those involved in the process, and the social and institutional structures which provide frameworks for their action...critical educational science is not research on or about education, it is research in and for education.

In keeping with Mattsson and Kemmis' (2007, p. 204) suggestion that participatory action research (PAR) may "contribute to the development of individuals' or groups' capacities for organisational and structural change", the PAR phase of the study facilitated a dialogical process that furthered each school community's understandings of their socio-spatial settings and socio-pedagogical cultures—ultimately leading to some significant spatial and pedagogic changes in the participating schools.

The PAR phase involved collaborating with school leaders, teachers and students to investigate emergent issues related to the relationships between innovative learning environments, pedagogies and student engagement. A framework adapted from Cohen et al. (2007) directed the PAR methodology at each participating school. This is outlined below and illustrated in Fig. 2:

Fig. 2 Participatory action research framework/cycle. Adapted from Cohen et al. (2007)



1. Issue identification—Form understandings of the social setting in its current state and create a vision for the future of the setting;
2. Intervention design—Consider how the social setting could be improved to match the vision and subsequently design interventions;
3. Intervention action—Implement interventions;
4. Observation—Form understandings of the social setting during the process of changing the social setting (the emancipatory process), potentially revealing hidden dependencies and assumptions made by social actors;
5. Evaluation—Evaluate the social setting in its changed form;
6. Reflection—Reflect on the changes observed; and
7. Repeat all of the above as required.

Three case study sites (state funded public schools) were selected for the study using a process of convenience sampling (Bryman 2004): one was a primary school and two were secondary schools. These schools catered for significantly different numbers of students (between 270 and 2100), were geographically distributed across the Melbourne metropolitan area, served communities across the socio-economic spectrum, and the designs of the ‘innovative’ learning spaces found at each varied in significant ways, yet also had common spatial elements.

Given the focus on the theoretical analysis of learning environments through the lenses of complexity theory and complex adaptive systems theory—and for brevity—the three participating schools are not described in this chapter, although they are referred to as Suburban High School, Inner City Primary School and Seaside Secondary College, respectively. Details about each school, including details about the design of their learning spaces, may be found in another book chapter, *Addressing the spatial to catalyse socio-pedagogical reform in middle years’ education* (Cleveland 2016).

Data were collected between September 2008 and September 2010 using a variety of qualitative methods. These included the observation of teaching and learning (including prior to and following the provision of new learning spaces); semi-structured interviews with school leaders, teachers and students; focus groups with teachers; and design-oriented workshops with school leaders, teachers and architects.

The qualitative data collected were analysed using a process of thematic narrative analysis adapted from Riessman (2008). The data from individual cases (observational notes, interview transcripts and summary notes from focus groups and workshops) were not fractured into thematic categories for cross analysis; rather, individual cases were maintained intact for coding. Attention was paid to both micro and macro contexts by preserving the data within each case in long chronological sequences, allowing the finer details of the stories embedded in the data to be interpreted within historical contexts. Through the interpretation of individual cases, understandings of the socio-spatial settings and socio-pedagogical cultures of practice at each school were formed (Cleveland 2016).

The study’s focus on periods of change (emancipatory praxis) aligned well with the interpretive theoretical frameworks/analytical lens used i.e. complexity theory

(Heylighten 2008; Heylighten et al. 2007; Law and Urry 2004) and complex adaptive systems theory (Davis and Sumara 2006; Heylighten 2008; Urry 2008). Informed by critical social theory, the approach and the multiple case study, ethnographic and PAR methodologies gave rise to a research design that enabled deep insights into processes of ‘emergence’, ‘co-evolution’ and ‘mutual adaptation’ to be gained across multiple sites. Furthermore, the longitudinal design (data were collected over two years) enabled processes of ‘self-organisation’ and ‘learning’ on the part of the participant schools to be recognised as they responded to change over time (i.e. ‘positive feedback loops’) in their systems.

Further details about complexity theory and complex adaptive systems theory (i.e. the theoretical frameworks used to analyse the field data) are discussed below.

Complexity: Theoretical Frameworks for Analysing Innovative Learning Environments

Complexity and Sociology

Complexity theory was established during the 1980s in a move away from Newtonian reductionist models of scientific inquiry. In Newtonian models, phenomena are reduced to their simplest components in an attempt to objectively investigate and describe a system’s properties. Conversely, complexity theory posits that it is impossible to achieve accurate understandings of a system’s properties through the application of reductionist approaches because such models do not deal adequately with the emergent properties of systems produced via dynamic interactions between agents and/or components (Heylighten 2008). Heylighten, Cilliers and Gershenson (2007, p. 11) outlined complexity theory/science as follows:

What distinguishes complexity science is its focus on phenomena that are characterized neither by order ..., nor by disorder ..., but that are situated somewhere in between ... In a truly complex system ... components are to some degree independent, and thus autonomous in their behaviour, while undergoing various direct and indirect interactions. This makes the global behaviour of the system very difficult to predict, although it is not random.

Since the 1990s, complexity theory has grown in parallel with postmodern philosophy (Heylighten et al. 2007) and has been used by sociologists seeking nonlinear analyses of structure or agency/action. Law and Urry (2004) argued that social science in contemporary society is more about connection and flow than about nineteenth-century concepts of territorial boundaries. They suggested that inherited sensibilities in the social sciences are under pressure from complexity theory and identified it as a useful lens through which to investigate, but not predict, ‘emergent’ and ‘self-organising’ systemic properties associated with nonlinear systems that involve people.

Complex Adaptive Systems

Complexity theory has given rise to the concept of complex adaptive systems: systems that “spontaneously organize themselves so as to better cope with various internal and external perturbations and conflicts” (Heylighen 2008, p. 2). Urry (2008) identified such systems as being simultaneously economic, physical, technological, political and social and described them as powerful systems in the contemporary world. He suggested that these self-organising systems are characterised by the presence of ‘positive feedback loops’ which ensure a state of continuous change within a particular system. The dynamic and nonlinear nature of these systems is also thought to create systems that ‘learn’ as they respond to changes in the system (Davis and Sumara 2006).

Complex adaptive systems may be contrasted with systems governed by ‘negative feedback loops’. Law and Urry (2004) suggested that complex adaptive systems cope well with turbulence or shocks because change is a consistent aspect of the function of these systems. They suggested that static systems, governed by negative feedback loops, have difficulty dealing with shocks or stresses because change is not common to, or welcomed, by such systems. While systems informed by negative feedback loops try to re-establish equilibrium within the system when disruptive events occur, complex adaptive systems, governed by positive feedback loops, allow adjustments to be made to the system in response to change agents.

Emergence, Co-evolution and Mutual Adaptation

The concept of ‘emergence’ is central to complexity theory. In a sociological context, emergent properties may refer to the development of regularities of behaviour that transcend the components of a system. Emergent behaviours cannot be attributed to the component parts of a system and emergent properties of a system cannot be reduced to individual factors/parts (Urry 2008). Rather, emergent behaviours occur as the result of the nonlinear and dynamic interactions that take place within a complex adaptive system.

It is believed that complex adaptive systems generate emergent social behaviours through ‘co-evolution’ and ‘mutual adaptation’. Urry (2008, p. 265) commented on these ideas as follows:

Because of how systems co-evolve and mutually adapt it is almost impossible for social groups to anticipate what in certain circumstances would be the means of effecting appropriate system change. So although many social groups are seeking to realize various projects of change it is enormously hard to do so in ways that produce anything like the intended outcomes.

In addressing the concept of co-evolution, Walby (2003) suggested that complexity theory can now be used to re-frame accounts of social change as co-evolution may replace the notion of cause and effect between agents/entities.

Complexity Theory and Education

Davis and Sumara (2006) presented ‘complexity thinking’ as an appropriate attitude for educators and educational researchers. They identified a ‘complex perspective’ as one that supported subjective understandings of “interpersonal dynamics, cultural evolution and issues regarding the unfolding of more-than-the-human world” (Davis and Sumara 2006, p. 3).

Further to this, Cohen et al. (2007) suggested that conducting educational research through the lens of complexity facilitated a holistic view of phenomena—including individuals, families, students, classes, schools, communities and societies. They described complexity theory as an emerging paradigm in educational research and elaborated on the role of complexity theory as follows (p. 34):

Complexity theory, a comparatively new perspective in educational research, offers considerable leverage into understanding societal, community, individual, and institutional change ... In addressing holism, complexity theory suggests the need for case study research methodology, action research and participatory forms of research, premised in many ways on interactionist qualitative accounts, i.e. looking at situations through the eyes of as many participants or stakeholders as possible. This enables multiple causality, multiple perspectives and multiple effects to be chartered ... research in education could concern itself with the symbiosis of internal and external researchers and partnerships. Just as complexity theory suggests that there are multiple views of reality, so this accords not only with the need for several perspectives on a situation (using multi-methods), but resonates with those tenets of critical research that argue for different voices and views to be heard.

Complexity Theory and School Architecture

This chapter builds on the discourse initiated by Uptis (2004, 2010a, b) regarding the connections between complexity theory, educational practices and school architecture. Uptis explored schools as complex systems and discussed the dynamic interactions between social and physical agents within and beyond schools. She put forward the notion that educational reform could not happen within the context of traditional school buildings and suggested that there was opportunity for architects and educators to effect change in building structures to better align the environments in which students learn with contemporary educational philosophies and practices.

Findings and Discussion

Complexity theory and complex adaptive systems theory are used here as conceptual tools to discuss and develop understandings of the emergent behaviours that occurred in the case study schools, to assess the effectiveness of the innovative

learning environments in these schools and to develop ideas regarding the role of architecture in a complex adaptive system of education. These, and related matters, are discussed below.

The Development of New Socio-Pedagogical Cultures in Innovative Learning Environments

The Case Study Schools as Complex Adaptive Systems

Throughout this section, an argument is developed for the case study schools to be conceived of as complex adaptive systems. This is not a new idea. Bower (2006), Cohen et al. (2007), Davis and Sumara (2006), Semetsky (2005) and Sumara and Davis (2009) all promoted complexity theory as an appropriate lens through which to explore the complex nature of schools and school reform. While these academics focused largely on the social components of these systems, the conception of ‘the school’ as a complex adaptive system that is promoted here includes the physical environment as part of the system—a conception that is aligned with that of Uipitis (2004), who identified physical space as an important agent in these nonlinear and dynamic systems.

Creating New Socio-Spatial Contexts for Learning

The creation of physical learning environments that were composed of purposeful, diverse and interconnected settings enabled particular spaces to be appropriated for specific learning activities. For example, the first floor layout in each of the seven School Within School (SWiS) buildings at Suburban High School included a) intimate settings for reflective or individual work, b) areas for collaborative or active work, c) spaces to gather tutorial groups and d) large areas for cohort meetings and other communal experiences (see Fig. 3). Similar settings were found and/or developed at the other two schools.

Accommodating 150 students from Year 7–9 (in year-level cohorts of 50 students working with three teachers), the interconnected nature of these settings in the SWiS buildings at Suburban High School provided students with the opportunity to shift between learning modalities without having to wait for access to an appropriate setting during a subsequent lesson—as had been the case only months before in traditional classroom environments. In these innovative learning environments, a variety of pedagogical encounters was supported. New socio-spatial contexts for learning emerged as purposeful settings became better integrated. Different settings mediated different forms of social interaction due to their structure and the types and arrangement of furniture items. However, it was the linking of these settings physically and socially, via more geographically distributed pedagogical

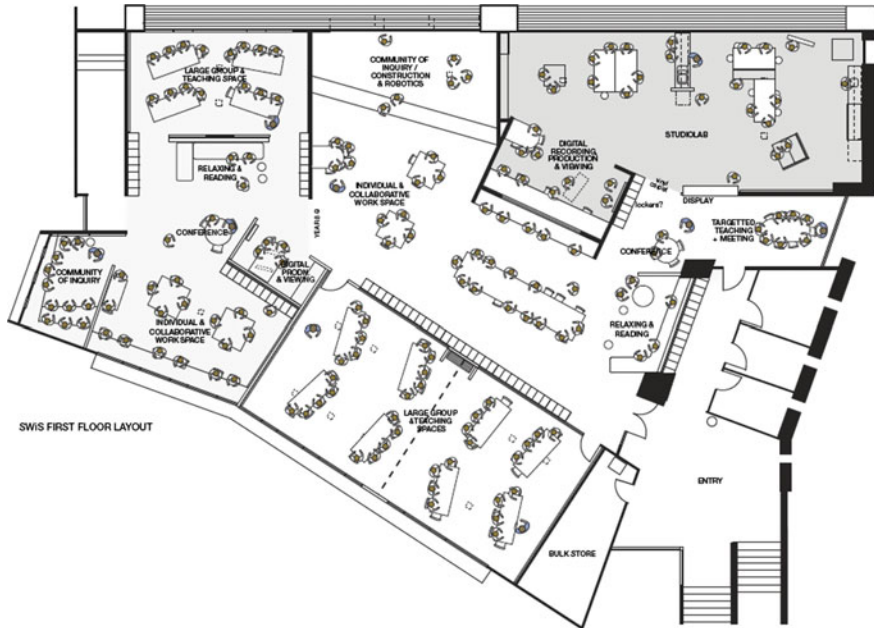


Fig. 3 Suburban High School, School Within School (SWiS) building first floor plan (image: Hayball & Mary Featherston Design)

approaches, that gave rise to a new social dynamic. The resulting flow of people, materials and information between purposeful settings meant that teachers and students were able to interact with each other in new ways to develop a variety of desired learning behaviours.

New Socio-Spatial Contexts for Learning and Curriculum Integration

New socio-spatial contexts for learning also provided new opportunities for curriculum integration. Indeed, a number of teachers suggested that curriculum integration was more likely to occur in these new contexts than in traditional classrooms. Opportunities for curriculum integration appeared to be supported by the integration of diverse settings and by the new social dynamics that were emerging.

Despite these opportunities, curriculum was, however, not integrated as commonly as might have been expected, nor as often as was desired by school leaders. Explanations for this in the high schools appeared to be associated with the devotion of teachers to their favoured disciplines and with the externally mandated curriculum, assessment and reporting frameworks they were obliged to follow. Additionally, the integration of curriculum appeared to be limited by issues associated with the management of learning resources. For example, staff at both high

schools struggled to provide resources for hands-on/craft activities in ‘wet area’ settings. The issue of who was responsible for purchasing and managing these materials was observed to slow the integration of curricula and the development of pedagogies that involved hands-on learning experiences. This tension was somewhat overcome by allocating an art teacher to one of the teacher teams at Seaside Secondary College. Her inclusion in the socio-spatial context not only supported the resourcing of the wet area, but also facilitated the expanded use of this setting as a site for interdisciplinary activities.

Characterising the Socio-Pedagogical Cultures that Emerged Within New Socio-Spatial Contexts for Learning

Culture was described by Jackson and Smith (1984) as a system of shared meanings that are dynamic and negotiable. Further to this, they suggested that culture may have spatial qualities and be associated with a sense of place. In discussing this link between culture and place, Dovey (2008) suggested that most theories of ‘place’ stem from philosophy, social theory and geography and are aligned with terms such as, ‘identity’, ‘community’, ‘character’ and ‘home’. He believed, however, the common definition of place, as “a location experienced as meaningful within a larger spatial context” (p. 45), was too narrow. His contention was that “places frame and construct social programs and representational narratives, as they are framed and constructed by them” (p. 45).

Informed by these theories about culture and place (Jackson and Smith 1984; Dovey 2008), the new socio-pedagogical cultures that emerged in the case study schools are discussed below. These emerged as teachers and students developed new conceptions of place through their interactions with each other and with their physical surrounds.

Even amidst some of the ongoing tensions that existed in the case study schools, the new socio-pedagogical cultures that emerged were significantly different from those that had preceded them. School leaders reported that earlier cultures had been characterised by teacher-directed activities that provided students with limited choices regarding how they might engage in learning activities and interact with other students. They also reported that cultures had largely been defined by individual teachers and had differed between the spaces defined by traditional classrooms. However, the socio-pedagogical cultures that emerged within the new socio-spatial contexts in the case study schools supported teachers and students in adopting new roles and identities.

As teachers employed constructivist pedagogies, they progressively abandoned enforcing rigid social expectations on students and allowed them to develop their own approaches to learning. In addition, team-teaching structures liberated teachers from traditional roles and allowed them to become more collaborative practitioners. This change in role enabled them to communicate with students more frequently as individuals, rather than as collectives. Thus, the cultures that developed were increasingly accepting of student-directed learning and diverse activity.

Students formed new identities as they harnessed opportunities to become more self-reliant. Rather than wait for instructions from teachers, many students demonstrated increased initiative and independence. The majority of students relished their relative freedom. This was demonstrated through their behaviours and communicated during interviews. Many teachers also shared in this opinion, including Assistant Principal, Clare, at Suburban High School (28/1/2010):

We have found that if the students feel comfortable in the environment they are in they settle down without rules and their work ethic improves. The students are now being treated and respected as individuals and seem to be emotionally settled and ready to learn. The relationship between students and teachers is much closer... It is something to do with the groups of 50, the teams of teachers and the spaces.

Of course, some students took the opportunity to ‘opt out’ and not consistently participate in learning activities. These evasive students required additional attention from teachers in order to keep them ‘on task’.

New Socio-Pedagogical Cultures, Student Behaviour and Control

A positive characteristic of the new socio-pedagogical cultures was that students were generally well behaved. This led to a pervading sense of calm, as students settled into learning activities without the need for teachers to use ‘standover tactics’ to control their behaviour. Allan (26/8/2009), a teacher at Inner City Primary School, attributed improved student behaviour to the new social structures that had emerged following the refurbishment of the Year 5/6 area. He commented as follows:

So instead of that kid being in the classroom where the teacher is telling him off half the time because he is a behavioural issue, he is actually in an environment where there are three teachers who are giving him support and guiding him through ... it has a lot to do with the structure.

Assistant Principal, Clare, at Suburban High School (16/9/2009) also suggested that student behaviour had improved in their new learning environments:

We have the two most challenging Year 8 groups in the school. They were so challenging that we could hardly manage them in term one [prior to occupying the school’s new buildings]. But now that is not the case at all. Their behaviour has improved. They are the ones that we got the Minister [State Minister for Education] to walk through, and work with, when she visited.

Further to this, Assistant Principal, Clare (16/9/2009), suggested that teachers did not have to spend as much time trying to ‘control’ students because more students were engaged more of the time. She went on to say that “the fear was that as soon as you let them out of that little box your ability to control that behaviour and modify that behaviour might be reduced, but it hasn’t been at all”.

It appeared that the new socio-pedagogical cultures that emerged in the case study schools acted as overarching ‘control measures’ to guide student participation in constructivist learning experiences. The complex education systems that evolved

were framed by new physical, pedagogical and temporal arrangements and exhibited self-organising properties. The overall influence of these emergent cultures was that they supported improved student behaviour and engagement (discussed below).

Emergent Behaviours and Student Engagement

The objective in this section is to describe how a select few agents—principally those associated with innovative learning environments and constructivist pedagogies—interacted to influence students’ behaviours and their engagement in learning activities. As cause and effect relationships can be difficult to identify in complex systems, it is important to qualify these findings by saying that student engagement was influenced by interactions between many agents—only a few of which were to be identified. This perspective is in keeping with Fredericks et al.’s (2004, p. 59) description of student engagement as a multidimensional construct that is “malleable, responsive to contextual features, and amenable to environmental change”.

Signs of Student Engagement

Fredricks et al. (2004) identified three engagement subtypes: behavioural engagement, emotional engagement and cognitive engagement. They described each of these as follows:

- *Behavioural engagement* draws on the idea of participation; it includes involvement in academic and social or extracurricular activities and is considered crucial for achieving positive academic outcomes and preventing dropping out.
- *Emotional engagement* encompasses positive and negative reactions to teachers, classmates, academics and school and is presumed to create ties to an institution and influence willingness to do the work.
- *Cognitive engagement* draws on the idea of investment; it incorporates thoughtfulness and willingness to exert the effort necessary to comprehend complex ideas and master difficult skills (p. 60).

The following discussion draws on 15 months of regular observation of students in the case study schools.

Observations of Small Group Activities

Students’ body language was identified early in this study as a useful indicator of student engagement. Body language provided evidence of students’ willingness to participate in learning activities (behavioural engagement), revealed their reactions

to teachers, classmates and events (emotional engagement) and exposed their readiness to exert effort to master difficult concepts or skills (cognitive engagement).

Observation of collaborative small group activities revealed that students who sat with their heads close together, looking at and discussing common learning materials, were highly engaged, while those who sat even a small distance apart, perhaps just leaning back on their chairs, were less engaged. These less engaged students demonstrated little interest in looking at or discussing common learning materials.

Researchers who have studied student interaction and dialogue in small group settings have reported similar findings (e.g. Wilks 2005). Webb (1982) suggested that student interaction was influenced by characteristics of the individual, group and setting, and identified an individual's role in group interaction as an important influence on learning. Lodge (2005) described dialogue as a vehicle for engagement and suggested that student engagement was often expressed in excitement, raised energy levels, and physical proximity. As the proximity between students was often mediated by furniture items, these findings had spatial implications, suggesting that furniture items that enabled students to sit close together supported deeper engagement in collaborative group activities.

Observation also indicated that small collaborative groups operated better when there was some distance between groups (i.e. groups were dispersed). It appeared that although high student density was desirable within groups, it was not desirable between groups. Some distance between collaborative groups appeared to have a calming effect that allowed students to stay focused and involved in the activities of their group. These findings aligned with those of Weinstein (1979), who found that high levels of student density across open-plan learning environments were associated with dissatisfaction, decreased social interaction and increased aggression on the part of students.

Observations of Teacher Led Activities

Higher levels of engagement were observed when tutorial or discussion groups were limited to 15–17 students, as such numbers generally allowed students and teachers to sit facing each other. When arranged in circles or semicircles, the proximity between students in groups of this size was found to be close enough for them to feel part of a functioning unit. When students were gathered in larger groups, these functioning units tended to break down—especially when teachers gathered student cohorts of 50–75 and attempted to engage them in discussions for more than a few minutes. Even groups of 25 students appeared to be too big to support the engagement of all students due to restricting face-to-face interactions with other members of the group. In support of these observations, students made the following comments:

In a smaller group we get more say. If there are 75 kids you won't get to choose really what you want. But if it is a smaller group you get more say about what to do ... I like it when it is not too big (Rowan, Inner City PS student, 15/12/09).

When we divide into smaller groups, we can better understand what we are supposed to be doing (Shanti, Suburban HS student, 29/10/09).

It seemed that the longer a discussion/activity went on, the smaller the group size needed to be for the discussion/activity to be productive. The key factor that appeared to influence this relationship was the need for face-to-face contact between group members.

Students' Geographic Experiences and Student Engagement

The geographic experiences that were afforded by the innovative learning environments in the case study schools appeared to have a positive influence on the engagement of the majority of students. The buildings mediated social settings in which most students felt comfortable and the majority of students appeared to be more engaged when able to move and inhabit settings as they wished.

The relative geographic freedom that students experienced appeared to not only support their physical transition between learning activities, but also their mental transition between activities. With regard to the high levels of student engagement, Craig (26/8/2009), a teacher at Inner City Primary School, made the following comment:

All indications are that our kids are engaged, the parent feedback is that the kids haven't ever been happier at school, the vast majority of them ... there is no one in here that is just dumping their head on the table going, you know this is boring ... I think it has been contained really well, particularly compared to other times at the school [in the past], where we had big problems with the Year 6 s acting up and getting bored over the last six months [of the school year], thinking it is a waste of time.

Enabling students to participate in a range of pedagogical encounters within the same overall learning environment was found to foster positive outcomes. High levels of engagement were supported by:

- Opportunities for students to engage in a range of diverse activities;
- Opportunities for flexible group arrangements that offered students regular transition between working on their own and as members of groups; and
- Access to a variety of learning materials and resources.

These findings corroborated with those reported by Weinstein (1979), who identified connections between more 'humane' spaces and better attendance, greater participation and more positive attitudes towards the class, the instructor and classmates.

Constructivist Learning and Student Engagement

The new socio-pedagogical cultures that emerged in the case study schools provided opportunities for students to move beyond learning experiences that were primarily directed by teachers to participate in constructivist learning activities (Strommen and Lincoln 1992). These opportunities allowed students to show initiative and take ownership of their learning—a situation they appeared to relish. Daniel (29/9/2009), a student at Suburban HS, made the following comment in relation to an opportunity that he and his peers were given to pursue a project of their choosing:

During immersion week we had to make a product that was environmentally friendly. We could either make it or draw it and we actually made it. We made a solar panel charger ... I got to work with my friends and we made this, like, huge model that actually worked.

Assistant principal, Clare (16/9/2009), at Suburban HS also commented on this situation. She recalled a conversation a female colleague had with students in which they expressed their desire to have ownership and control over their learning:

She asked them, 'do you like doing this project?', and they all said 'oh we love it'. And she said, 'why do you love it kids'? And they said, 'because we are in control ... and it is great because we can do what we want, when we want to do it, and we can move around and this is really fun'. And one of them said, 'we know it is English and stuff but you wouldn't think so. English is good because you get to do other stuff, so you don't realise that you are learning even when you are'.

Teachers at both Inner City Primary School and Seaside Secondary College also reported that student engagement was higher when students were provided with opportunities to work on constructivist, project-based activities that enabled them to work individually or in small groups on multiple aspects of a task, across a variety of activity settings. Allan (26/8/2009), a teacher at Inner City Primary School, described the engagement of students when making choices about which pieces of work they should put in their portfolios:

It's about students being concentrated on the task. Totally on task—going through, looking at their work, making judgements about the work, talking to their mates and saying, 'what you think about this piece of work'?... Can you read that for me? Do you think I have learnt about paragraphs in that?... For me it (quality student engagement) looks like, kids at computers working on their own, kids at computers working with a friend, kids sharing, kids working individually, kids focused on their learning and thinking about their learning. Finishing tasks because they want to complete aspects of their learning, or they want to show their learning. And it's not just to prove it to the teacher or to get a mark. It is so they can say, 'I am putting this in my portfolio because I really want to show you that this is what I have learned, and that I have been engaged in this task'... It is not about getting A,B, C, 9/10 or 8/10 (marks). It is actually about showing learning.

Interaction with Teachers and Student Engagement

Student engagement was supported by team-teaching arrangements. Individual teachers were able to take on a number of different roles and spend significant

amounts of time with those students who required additional support, while other teachers moved around to attend to the needs of those students who required less teacher direction. To this end, Craig (26/8/2009), a teacher at Inner City Primary School, reported that, “we have had feedback, direct feedback from students and parents, telling us that they really enjoy having more than one teacher”.

It was acknowledged by teachers and school leaders that collective efficacy within teacher teams was important to ensure that students did not ‘slip between the cracks’ and avoid participating in learning activities. Nevertheless, a few students still managed to avoid ‘doing the work’ by quietly moving to remote areas of learning environments, beyond the clear view of teachers. Allan, a teacher at Inner City Primary School, suggested that these students could be a little difficult to keep track of. However, he was of the opinion that once the new education model at the school became better established they would be better equipped to ensure the needs of all students were addressed.

ICT and Student Engagement

The resource that really enabled students to maintain high levels of engagement while working with some independence from teachers was information and communication technology (ICT). Near ubiquitous access to ICT at all three schools enabled students to frequently transition between physical and virtual/digital media. This did not mean that students used computers all the time. In general, students did not appear to be any more or less engaged in tasks when using pen and paper or computers—so long as they could transition between these media as required.

Teachers across the case study schools identified that consistent access to ICT enabled students to work well on their own, even when other students were working within close proximity. This observation indicated that ICT supported student engagement in individual activities. In addition, students were observed to work well in pairs on computers. Such collaborative efforts often supported rich dialogue between students, aiding their engagement in academic tasks and supporting knowledge transfer between students. Of course, some students abused their relative freedom and played online computer games; however, such behaviour was observed infrequently.

Such findings aligned well with Monahan’s (2005) conclusions that technologies can operate as extensions of space and computers can reinforce or challenge traditional expectations about spatial arrangements and pedagogical practices. These observations also suggested that the emergence of hybrid learning environments (Skill and Young 2002; Weiss 2007) followed a nonlinear path that involved both students and teachers contributing to the development of new pedagogical practices and the creation of connections between people, environment and technology. Certainly, the emergence of hybrid, or blended, learning environments was associated with contemporary ideas about pedagogy, integrated curricula, individualisation of learning, learning through cooperative group work and a focus on higher-order thinking (Zandvliet and Fraser 2004).

The Overall Effectiveness of Innovative Learning Environments

The participatory action research (PAR) methodology that was central to this study explored the development of space and practice in the case study schools. At Suburban High School and Inner City Primary School, the PAR focused mainly on how innovative learning environments could be used to support the development of new pedagogical models. At Seaside Secondary College, the PAR developed into an educational visioning and spatial design project, following the school's decision to update the physical environment in a selected space called the Hub. Across the sites, the common theme that was revealed via the PAR process was that the effectiveness of innovative learning environments was primarily a function of how well space and practice aligned.

The Effectiveness of Innovative Learning Environments: A Matter of Alignment

This research revealed that the effectiveness of innovative learning environments is primarily associated with how well particular pedagogies, curricula, assessment practices and social factors are supported by, or aligned with, particular environments. With regard to constructivist pedagogies, the effectiveness of innovative learning environments was found to be associated with the ways dynamic 'complex' interactions were supported by particular spaces.

Gaining insight into the educational visions, or philosophies, behind spatial designs was found to be essential for evaluating the effectiveness of innovative learning environments. For example, some visitors to Suburban High School who were not privy to the schools' objectives were witnessed to report negative reactions to the design of the school's new buildings. They suggested that the learning environments were too busy, too noisy and provided too little containment for the delivery of a high-quality education. Once new pedagogical practices were given a chance to emerge, however, the new learning spaces performed well when examined through the lens of the schools' educational vision. Indeed, many of schools' spatio-pedagogical objectives were met within the first year of occupation. The new spaces enabled team-teaching approaches, catalysed the adoption of constructivist pedagogies, facilitated social connectedness within learning communities, supported collaboration between students and between students and teachers and provided opportunities for students to pursue personalised learning goals through inquiry-, project- and problem-based learning activities.

Furthermore, it was found that the effectiveness of innovative learning environments was closely related to how well collaborative socio-pedagogical cultures could be supported by physical surrounds. For example, the effectiveness of the

Year 5/6 learning environment at Inner City Primary School was demonstrated on two occasions when two of the three regular teachers were away. With only one regular teacher and two casual relief teachers, the continuity of the educational programme was hardly disrupted. The sole regular teacher was aware of the day's schedule for all 75 students and did not need to change any of the day's activities. Indeed, the casual relief teachers were sparingly required as the students were able to pursue self-directed activities that required only infrequent input from the teachers. The team-teaching structures that had been put in place negated any potential disruption to the students learning that may have occurred due to the absence of the teachers. The effectiveness of the learning environment was associated with the socio-pedagogical dynamics that had emerged within this environment: dynamics that had been enabled by the spatial design and developed through regular discussions between teachers and students about how people should interact and use their environment to support learning. Allan (26/8/2009), a teacher at the school, commented:

I think that another very, very, very, powerful part of it is the student voice and the learning partnership. So from day one ... the three of us talked with our kids, and the language has always been, 'the team' ... We are all responsible for what happens in here in terms of learning. We are all responsible for our own learning and we are all equally responsible for each other's learning. So that notion of the team, of sharing, of working together, of shared responsibility, as well as individual responsibility, founded on values, trust and respect [is important] ... I think, you couldn't have done it as powerfully in an individual classroom as you can do it in a collective sense because the teachers are modelling it. The teachers are living every minute of the day and so therefore the culture is a living, breathing, vibrant thing.

Although the effect of spatio-pedagogical reforms on students' academic outcomes was beyond the scope of this research, the positive influences of the spatial and pedagogical reforms implemented in the case study schools were confirmed by the words and actions of the teachers and students.

Conclusion

Conducting this research through the lens of complexity theory and complex adaptive systems theory facilitated a holistic view of phenomena. These conceptual tools offered an intrinsically subjective (Heylighten et al. 2007) perspective on the settings in the participant schools, a perspective that dealt with uncertainty, connectedness, self-organisation, emergence over time and development through adaptation and change (Cohen et al. 2007). This perspective allowed societal, community, institutional and individual change to be recognised and multiple perspectives and multiple effects to be simultaneously chartered.

In conclusion, the most prominent of the interactions between learning environments, pedagogies and student engagement is highlighted below.

The Emergence of New Socio-Spatial Contexts and Socio-Pedagogical Cultures

The study revealed that innovative learning environments and constructivist pedagogies interacted to create new socio-spatial contexts for learning. These supported the flow of people, materials and information between purposeful activity settings and enabled teachers and students to develop a variety of new learning behaviours that were in keeping with contemporary middle years' educational theory (e.g. Barratt 1998; Beare 2000; Carrington 2006; DEET 2002; Hill and Russell 1999; Pendergast 2006; Pendergast and Bahr 2005).

Subsequently, new socio-pedagogical cultures emerged through complex and nonlinear interactions between the social and physical components of these socio-spatial contexts. Framed by new physical, pedagogical and temporal arrangements, these cultures of practice frequently exhibited self-organising properties and often acted as overarching 'control measures' to guide student participation in an array of learning experiences.

Student Engagement in Emergent Socio-Spatial Contexts and Socio-Pedagogical Cultures

The socio-spatial contexts and socio-pedagogical cultures that co-evolved and mutually adapted in the participant schools were observed to have a positive overall influence on student engagement. Engagement was supported by opportunities for students to engage in diverse activities, transition between working on their own and as members of various sized groups, and access to a variety of learning materials and resources. Students were most highly engaged when working on constructivist, project-based activities that enabled them to work individually or in small groups on multiple aspects of a task, across a variety of activity settings.

Student engagement was supported by team-teaching arrangements. Collective efficacy within teacher teams was important to ensure that students did not 'slip between the cracks' and avoid participating in learning activities. Collaboration between teachers improved as teachers became more comfortable working within new socio-spatial contexts and gained vital experience working together. In situations where both teachers and students recognised their 'collective responsibility' and their role as part of 'the team', the ensuing democratic socio-pedagogical cultures that emerged had a pronounced positive influence on student engagement.

Access to ICT enhanced student engagement when students were required to work independently of teachers. Access to online information and a variety of presentation media supported students as they engaged in constructivist

inquiry-based projects, enabled them to frequently transition between physical and virtual/digital media and helped break down boundaries between learning at school and at home. In agreement with the findings of Zandvliet and Fraser (2004), the emergence of hybrid (blended) learning environments was found to be associated with contemporary ideas about pedagogy, integrated curricula, individualisation of learning and learning through collaboration. In addition, nonlinear interactions between people, environments and technology contributed to the emergence of hybrid (blended) learning environments and the development of new pedagogies. These emergent practices demonstrated that in-class (physical) and out-of-class (virtual/online) activities could be integrated and that these learning experiences could be highly engaging.

The Effectiveness of the Innovative Learning Environments in the Case Study Schools

The socio-pedagogical cultures that best supported constructivist pedagogies and student engagement were characterised neither by social order, nor by disorder, but by social dynamics that were “situated somewhere in between” (Heylighen et al. 2007, p. 11). Indeed, these settings functioned best when students (social components of these complex systems) were partially independent and autonomous in their behaviour, while undergoing direct and indirect interactions with their environment, technologies, peers and teachers.

These findings indicated that the effectiveness of these innovative learning environments was associated with how well they supported complex interactions i.e. a product of how well particular pedagogies, curricula, assessment practices and social factors were aligned with the environment.

Assessing the Educational Effectiveness of Learning Environments

If innovative learning environments are to be assessed for the ways they support constructivist pedagogies and student engagement, they must be assessed within the context of the educational systems that they are intended to support. Therefore, subjective assessments that are based on the opinions of people who have experienced the complex physical and social interactions that occur in these settings are required i.e. the effectiveness of a learning environment cannot be assessed objectively, or in isolation from the educational programme that it is intended to support. Insight into the educational visions behind spatial designs is required for the effectiveness of innovative learning environments to be properly assessed.

The Role of Innovative Architecture in a Complex Adaptive System of Education

Internationally, the majority of schools and schooling systems are governed by negative feedback loops. This means that schools and their supporting agents are often highly resistant to change and do not deal well with turbulence or shocks to the system. The majority try to maintain the homeostatic nature of the system in preference to making adjustments to adapt the system to new circumstances. In the increasingly globalised world, rapid change has become the norm and schooling systems need to learn how to make regular adjustments if they are to remain relevant to students and the needs of society. Thinking of learning environments, schools and school systems as complex adaptive systems may help them respond more effectively to the current and future needs of individuals, school communities and wider society.

This study showed that, when well designed, innovative architecture can enable middle schools to function as complex adaptive systems and self-organise to cope with a variety of pressures and disturbances. Replacing traditional classrooms and educational systems designed around notions of industrialisation with spaces and educational models that can facilitate connection and flow (Law and Urry 2004) was observed to support pedagogical innovation and the emergence of new socio-pedagogical cultures that were characterised by individualised learning, collaborative learning, integrated curricula and formative assessment practices. Furthermore, these cultures were found to support constructivist learning experiences and generally high levels of student engagement.

Not only that these dynamic and nonlinear systems were able to ‘learn’ (Davis and Sumara 2006) as they responded to positive feedback loops. Such ‘learning’ enabled middle years’ cohorts to self-organise to a significant degree to cope with a variety of pressures and disturbances, while supporting contemporary learning experiences aligned with current middle years’ educational theories (e.g. Barratt 1998; Beare 2000; Carrington 2006; DEET 2002; Hill and Russell 1999; Pendergast 2006; Pendergast and Bahr 2005).

References

- Barratt, R. E. (1998). *Shaping middle schooling in Australia: A report of the National Middle Schooling Project*. Canberra, NSW: Australian Curriculum Studies Association.
- Beare, H. (2000). *Creating the future school*. London: Routledge Falmer.
- Bower, D. F. (2006). Sustaining school improvement. *Complicity: An International Journal of Complexity and Education*, 3(1), 61–72.
- Bryman, A. (2004). *Social research methods* (2nd ed.). Oxford: Oxford University Press.
- Carrington, V. (2006). *Rethinking middle years: Early adolescents, schooling and digital culture*. Crows Nest, NSW: Allen & Unwin.
- Cartmel, T. (2013). Crafting the middle years mosaic. *Primary and Middle Years Educator*, 11(3), 3.

- Carr, W., & Kemmis, S. (1986). *Becoming critical – Education, knowledge and action research*. Philadelphia: Falmer.
- Cleveland, B. (2016). Addressing the spatial to catalyze socio-pedagogical reform in middle years' education, 27–49. In Fisher, K. (Ed.), *The translational design of schools. An evidence-based approach to aligning pedagogy and learning environments*. Rotterdam: Sense Publishers.
- Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education*. New York, NY: Routledge.
- Davis, B., & Sumara, D. (2006). *Complexity and education: Inquiries into learning, teaching, and research*. Mahwah, NJ: Lawrence Erlbaum.
- DEET. (2002). *Middle years research and development project: Executive summary*. Department of Education, Employment and Training, VIC. www.eduweb.vic.gov.au/edulibrary/public/curricman/middleyear/research/MYRADEExecSummary.doc. Accessed March 25, 2008.
- Dovey, K. (2008). *Framing places: Mediating power in built form*. New York, NY: Routledge.
- Elmore, R. F. (1996). Getting to scale with good educational practice. *Harvard Educational Review*, 66(1), 1–26.
- Ewert, G. D. (1991). Habermas and education: A comprehensive overview of the influence of Habermas in educational literature. *Review of Educational Research*, 61(3), 345–378.
- Fredricks, J. A., Blumenfeld, P. C., & Paris, A. H. (2004). School engagement: Potential of the concept, state of the evidence. *Review of Educational Research*, 74(1), 59–109.
- Fullan, M., Hill, P., & Crevola, C. (2007). *Breakthrough*. Heatherton, VIC: Hawker Brownlow Education.
- Habermas, J. (1971). *Towards a rational society*. London: Heinemann.
- Habermas, J. (1974). *Theory and practice*. London: Heinemann.
- Habermas, J. (1989). *The structural transformation of the public sphere*. Cambridge, MA: The MIT Press.
- Heylighen, F. (2008). Complexity and self-organisation. In M. J. Bates & M. N. Maack (Eds.), *Encyclopedia of library and information sciences*. New York, NY: Taylor & Francis.
- Heylighen, F., Cilliers, P., & Gershenson, C. (2007). Complexity and philosophy. In J. Bogg & R. Geyer (Eds.), *Complexity science and society*. Oxford: Radcliffe Publishing.
- Hill, P., & Russell, J. (1999). Systemic, whole-school reform of the middle years of schooling. *National Middle Years of Schooling Conference, March 1999*. Centre for Applied Educational Research, University of Melbourne.
- Jackson, P.A., & Smith, J. (1984). *Exploring social geography*. London: George Allen & Unwin.
- Law, J., & Urry, J. (2004). Enacting the social. *Economy and Society*, 33(3), 390–410.
- Lodge, C. (2005) From hearing voices to engaging in dialogue: Problematising student participation in school improvement. *Journal of Educational Change*, 6(2):125–146.
- Mattsson, M., & Kemmis, S. (2007). Praxis-related research: Serving two masters? *Pedagogy, Culture and Society*, 15(2), 185–214.
- Monahan, T. (2005). *Globalization, technological change, and public education*. New York: Routledge.
- Pendergast, D. (2006). Fast-tracking middle schooling reform: A model for sustainability. *Australian Journal of Middle Schooling*, 6(2), 13–18.
- Pendergast, D., & Bahr, N. (2005). *Teaching middle years: Rethinking curriculum, pedagogy and assessment*. Crows Nest, NSW: Allen & Unwin.
- Riessman, C. R. (2008). *Narrative methods for the human sciences*. Thousand Oaks, CA: Sage.
- Semetsky, I. (2005). Not by breadth alone: Imagining a self-organised classroom. *Complicity: An International Journal of Complexity and Education*, 2(1), 19–36.
- Skill, T. D., & Young, B. A. (2002). Embracing the hybrid model: Working at the intersections of virtual and physical learning spaces. *New Directions for Teaching and Learning*, 92, 23–32.
- Strommen, E. & Lincoln, B. (1992). Constructivism, technology and the future of classroom learning. *Education and Urban Society*, 24(4), 466–476.
- Sumara, D., & Davis, B. (2009). Complexity theory and action research. In S. Noffke & B. Somekh (Eds.), *Educational Action Research*. London: SAGE Publications.

- Upitis, R. (2004). School architecture and complexity. *Complicity An International Journal of Complexity and Education*, 1(1), 19–38.
- Upitis, R. (2010a). Complexity and design: How school architecture influences learning. *Design Principles and Practices: An International Journal*, 3(2), 123–134.
- Upitis, R. (2010b). *Raising a school: Foundations for school architecture*. South Frontenac, ON: Wintergreen Studios Press.
- Urry, J. (2008). Climate change, travel and complex futures. *The British Journal of Sociology*, 59(2), 261–279.
- Walby, S. (2003). *Complexity theory, globalization and diversity*. Paper presented at the Conference of the British Sociological Association.
- Webb, N. M. (1982) Student Interaction and Learning in Small Groups. *Review of Educational Research*, 52(3), 421–445.
- Weinstein, C. S. (1979). The physical environment of the school: A review of the research. *Review of Educational Research*, 49(4), 577–610.
- Weiss, A. (2007). Creating the ubiquitous classroom: Integrating physical and virtual learning spaces. *The International Journal of Learning*, 14(3), 77–84.
- Wilks, S. (2005). *Designing a thinking curriculum*. Camberwell, Victoria: ACER.
- Zandvliet, D. B., & Fraser, B. J. (2004). Learning environments in information and communications technology classrooms. *Technology, Pedagogy and Education*, 13(1), 97–123.