Authenticity in learning for the 21st Century: Bridging the formal and the informal

Introduction

This paper attempts to discuss authenticity in learning for the 21st century by bridging between formal and informal learning environments. By 'formal', we refer to the school curriculum in which learning might be characterized as focusing on structured content, extrinsic motivation, and strict assessments. The informal refers to less structured activities, in which learning outcomes might not be explicitly foregrounded. Time and space is given for exploration, experimentation, developing interests, and intrinsic motivations. Assessments are less formal; and might take the form of peer-recognition and -critique to co-inform like-minded peers in their pursuits. We discuss two case studies that can be situated in this theme – one that incorporates principles of informal learning mediated by technology into a formal setting, and another which leverages learning points from an informal setting to link with the formal. While most studies discuss either the formal or the informal (Barron 2006), we attempt to bridge the two.

The paper begins by illustrating concepts of authenticity to make learning meaningful and engaging. Singapore's school system is a successful system. However, what can be done to make schools and learning more authentic for the 21st century? The discussion attempts to answer this by understanding how schools came about and to resituate principles of authenticity in learning that researchers are advocating in trying to mitigate the lack of authenticity in school learning. The central premise of authenticity is context as integral to meaningful learning (Zepke and Leach 2002). By this assumption, it follows that schools are

premised on de-contextualized knowledge and hence less authentic (Barron 2006; Collins 2006; Renzulli, Gentry, and Reis 2004). We propose ways of putting context back into the learning process and illustrate how authentic learning is achieved through two case studies mentioned earlier. The first relates to *Second Life* and how this technology might augment classroom learning by affording contextualized learning experiences in geography for secondary school students. The second case study illustrates how learning experiences in schools' Co-Curricular Activities (CCAs), appropriated as informal learning, can be bridged to impact formal learning in mathematics.

Learning from a community perspective

How was learning characterized before the advent of formal instruction? The online worlds and social media of today remind us of older constructs of communities that were defined by locality and face-to-face interactions. However, with the development of social media, community-collectives comprising members from different localities are able to unite in the pursuit of common goals in a manner not achievable in the past. The authenticity of learning, consistent with traditional notions of communities of practice, re-emerges in new ways facilitated by social media (Brown and Adler 2008).

The situation of authentic learning in rich social contexts is fundamentally not new. Literature in Communities of Practice suggests that communities exist because members possess similar mindsets and shared histories having faced challenges collectively (Lave 1996; Wenger 1998; Wenger 2000; Wenger, McDermott, and Synder 2002). They worked as a collective with a common

language and goal. As a collective – such as the craft trades of old – they become a collaborative community learning to face challenges and develop practices.

Consistent with this collective notion of social and identity likeness, apprenticeship and discipleship learning became the main means of instruction (Barron 2006; Brown and Adler 2008; Cope 2005; Lave 1991). Apprenticeship learning was effective. In apprenticeship learning, masters work with groups of disciples. Learning and instruction was very contextualized and *in situ* with clear goals and tangible products to be developed. For example in tailoring, they knew what the end goal of dressmaking would be. With this goal in mind, they began tutelage under the master to form that dress from its component parts (Collins 2006). In craft apprenticeship, it has traditionally been perceived that skills were the dominant learning outcome, but later studies suggest that values and beliefs of the craft were existent in the community over time as members interacted with one another over sustained social interactions (Brown and Adler 2008; Cope 2005; Lave 1991).

However, apprenticeship learning is inefficient, because only a few disciples can be taught by a master (Collins 2006). The pedagogy is about role modeling and practicing the craft (Barron 2006; Collins 2006). Disciples imitate and act in the rich contextual situation of the craft. In other words, contextualized learning has been the dominant way of learning authentically ever since humankind became more sophisticated (Brown and Adler 2008; Wenger 2000).

Communities of practice are not new but today, because of the work by Wenger and Lave (1991), research about communities of practice has become prominent. Before the advent of schools, everybody learnt in communities. In a community,

people shared similar ways of seeing meanings through a common history, mutually interdependent activities, and role performances. Thus, contextualized and socially rich learning evolved (Cope 2005; Wenger 2000).

An African saying goes "it takes a village to raise a child" (Clinton 1996). In a village, villagers face authentic challenges. The village becomes a rich contextual environment through which social interactions and meaning making occurs (Wenger 2000). Learning in a village is natural because of the physical, social, cultural, and interactional dimensions, which we refer to as context.

Contextualized learning occurs in a practice (Brown 2002; Brown and Adler 2008; Cope 2005; Lave 1991; Wenger 2000). For instance, teachers appropriate the eye of seeing learning and pedagogy through an enculturation process. The enculturation process in communities of practice relates to how people are enculturated into an appropriate way of seeing meaning. Members are enculturated in a community when they go beyond dialogue and begin to engage in actions and performances (Cope 2005; Lave 1991; Lave and Wenger 1991; Wenger 1998; 2000; Wenger, McDermot, and Snyder 2002). For example, teachers see meanings in unique ways, namely, with respect to how learning occurs for students.

When the concept of communities of practice is extrapolated to the learning of science, learning science is not just learning about the body of scientific knowledge but it is to think in the way scientists think (Brown 2002; 2005; Brown and Adler 2008). When members are enculturated in a discipline, they begin to see meanings in ways that communities of practitioners see it. Learning in a community of practice is powerful and effective because members directly

experience consequences of their actions based on the feedback they get (Nasir and Hand 2008). This kind of learning is much like learning on the job (Latham and Story 2006; Power 2010).

The learning that happens in communities of practice is consistent with Nonaka's model (Nonaka and Toyama 2003; Nonaka and Konno 1998) because learning occurs in a socialized setting; it appears in very tacit ways. Tacit knowledge forms as members talk about what they do. They begin to create anchored experiences of their actions and behaviors. They begin to make meanings of what works for their practice. From this tacit knowledge, people are encouraged to verbalize what they mean. This verbalized knowledge is made public and subsequently put into the community. In this process, others internalize those meanings by going under the tutelage of senior members. They learn by role modeling, by performing, and by receiving feedback. The process of making meaning is the crux of the matter. In this interactional way, knowledge-as-reified-artifacts are being produced constantly as they become part of the professional community and as they develop personal and public meanings of what they do.

Learning from a schooling perspective

Every discipline – science or mathematics - has developed over time its own body of knowledge. Schools have taken the established knowledge and they have made it explicit (Barron 2006; Brown 2002). These forms of explicit knowledge, which are typically de-contextualized based on generalized theories from respective disciplines, are represented into encyclopedias, textbooks, and multimedia. Before the recent awareness that knowing transcends explicit knowledge, educators and curriculum designers assumed that students learn through being instructed wholly

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on knowledge that is made explicit through language representations. But recent advocates like Polyani (1967) and Seely Brown (2002) advocate otherwise. In fact, seeing meaning involve the tacit, which far outweighs the explicit. Schools have overlooked the tacit dimension of knowledge and social interactions in context that occur through performing and doing-in-action (Brown 2002; Brown and Adler 2008; White 2008).

Before the advent of schooling, apprenticeship learning could not spread or level up the literacies of reading, writing, and arithmetic (Collins 2006). As is the nature of all well-intentioned policy to enact education, the intuitive desire is to spread and scale up any understood phenomena. In this case, we assume that policy makers want to spread and scale up literacy; the prevalent means is through direct instruction. Hence, consistent with schools' motivations to level up learners' literacy, explicit knowledge has been taken and placed into various educational media and disseminated into the population. In times past, only a small number of persons learnt under a master but now there are forty students in a classroom. In this affordance structure the predominant mode of interaction is the teacher imparting knowledge explicitly through direct instruction (Nasir and Hand 2008).

Polyani (1967) has claimed that one knows much more than what one can articulate. We have tacit knowledge beyond what we can make explicit. For example, while an experienced teacher may write about classroom management, a student-teacher would still not manage a class well, even after memorizing what had been written. This is because classroom management is more than just explicit knowledge, codified in text. It involves performance and one's experience of many classroom situations – these comprise the tacit dimension of a teacher's

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experience. This expertise can be dialogued among the community of teachers in order to augment it through theoretical understanding. In this way, cycles of theory and performance are experienced. Seely Brown (2002; 2005) - in reference to Polanyi (1967) – has said that knowledge, which can be made explicit, is only the tip of the iceberg. The unseen portion of the iceberg is the tacit knowledge formed through experience.

The key difference between the two approaches - learning through apprenticeship and learning in schools - is that schools have succeeded in scaling up only the explicit knowledge. Schools have not provided sufficient opportunities for students to enact their knowledge through performance in order to appropriate the intuitive, tacit knowledge (the bulk of the iceberg) (Barron 2006; Brown 2002; Brown and Adler 2008; Nasir and Hand 2008; Renzulli, Gentry, and Reis 2004). Unfortunately, it is precisely the tacit part of the knowledge that builds beliefs and the disciplinary ways of seeing meaning. These beliefs are formed by embodied interactions and enactments in the practice of the disciplines as more recently described in literature (Brown 2002; Brown and Adler 2008; Lave 1991; Wenger 2000). Hence, while schools try to simulate these interactions in classrooms among students, the authenticity of the disciplines can be modeled only by those who possess the traits and thinking (made overt) of practitioners in the respective communities.

Research that address limitations of schooling

Researchers have studied communities of practice and the principles derived from such studies have attempted to be introduced in classrooms. Hung and Chen (2007) distinguish between 'simulation models' and 'participation and co-determined interaction models'. In the former, such approaches are described as

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designing for a Community of Learners (CoL) (Azzarito and Ennis 2003; Boersma, Dam, Volman, and Wardekker 2010; Collins 2006; Rogoff, Matusov, and White 1996). Although educational researchers attempt to simulate social process when students interact with each other in classrooms, critics have also said that the actual rich authentic situations that occur in communities of practice cannot be simulated in the classroom setting (Boersma, Dam, Volman, and Wardekker 2010).

There have therefore been initiatives to reform schooling by fostering authentic learning in classrooms. These have been characterized by Hung and Chen (2007) as 'participation and co-determined interaction models'. These latter models infuse more contextualized learning and to use dialogic and dialectical modes of pedagogy and instruction. Descriptions such as "learning by doing" (Aldrich 2005; Schank 1995; Schank, Berman, and Macpherson 1999) in schools also seek to counterbalance the memorizing of knowledge with more practice, talk, and role-play (Barron 2006; Latham and Story 2006). We begin to see instances such as learning by performing in role within games and epistemic environments (Barab, Thomas, Dodge, Carteaux, and Tuzun 2005; Brown and Adler 2008; Chee 2001; 2010; Jan, Chee, and Tan 2010; Thomas and Brown 2009). These are forms of learning not just to "learn about" (Brown and Duguid 2000) the domain knowledge but to make decisions with tangible consequences. These approaches are more consistent with "learning to be" (Brown and Duguid, 2000) and with Wells and Wells' (1984) understanding that talk drives learning. Such learning designs represent attempts at authenticity that moves towards more social constructivist conceptions.

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The hypothesis is that if students perform in the first person, they appropriate the beliefs of that meaning making perspective that has been so powerful in communities of practice.

However, we believe that there is currently insufficient culture in schools to develop a language to talk about the learning, thinking, and meaning making process of any disciplinary content (Barron 2006; Collins 2006; Latham and Story 2006). Such enactments take much dialogue, cueing, mentoring, and initiation from the community to talk about learning and pedagogy. It is more a cultural change in schools and not just instituting instructional strategies to enable talk, although such approaches are a good starting point.

In such models of participation, learners operate within the actual contexts of practice through internships and other forms of practicum experiences. In co-determined interactions, learners have the opportunities to work with practitioners in a joint-collaborative relationship in which the learning process is co-negotiated. In this paper we illustrate two cases of how different aspects of authenticity might be enabled in the learning experiences of students by combining elements of simulation, participation, and co-determined interaction.

Putting context and authenticity back in learning

In Singapore schools, a de-contextualized form of learning has been successful in measuring students' performances through traditional pen-and-paper-based examinations. We have been able to level up the base literacy of primary school graduates (OECD 2010).

There is a need to begin to put the context back into de-contextualized learning and instruction. The subsequent sections propose three tenets as important to

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augment de-contextualized learning in schools. In the past, it was difficult to design for these augmentations but possibilities seem more apparent today, as technology may mitigate limitations of the assumptions of de-contextualized knowledge and large cohorts in schools. These augmentations to de-contextualization are framed in terms of putting back the: a) tacit, b) social-collective, and c) informal.

Putting the tacit back in learning

The first dimension of context to put back to de-contextualization is the tacit. Tacit knowledge is really about making students perform and act in the discipline, rather than just learn about the discipline. Consistent with developing personal knowledge (Brown 2002; Polayni 1967; Zepke and Leach 2002) one needs to find ways to provide students with such first person learning experiences. If constraints in logistics and costs mean that one cannot provide students with opportunities to engage with real-world communities, online platforms may be possible alternatives (Brown 2002; Brown and Adler, 2008; Barab et al. 2005; Collins 2006; Karagiorgi and Symeou 2005). How can one design for participation in a community by extending the interactions beyond the four walls of the traditional classroom, by extending the availability of expertise, and the diversity of participants?

Wenger (1998; 2000) has described the process of participation and verification within a community. Verification refers to the construction of artifacts representing that which one has experienced and participated in socially. The important point is that participation and verification are always in dialectical, two-way interaction. Thus, one should not be participating in a phenomenon for a long time and not be given the opportunity to produce explicit artifacts and knowledge

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about something. This interaction between participating in creation and the verbalizing thereof is a rich continual interplay. In one of the case studies described later, we illustrate an example of how spatial dimensions of an online space are leveraged to permit students to adopt the epistemic frame of geographers rather than to merely learn about geography.

Putting the social-collective back in learning

The second tenet consistent with what is being proposed about putting context back into the de-contextualized nature of much schooling is putting the social-collective back. The argument for the social-collective is that there are overlaps between tacit action and the sociality of the process within a community setting (Brown 2002; Brown and Adler 2008; Lave 1991; Wenger 2000). Historically, communication was limited to face-to-face interactions. Characteristic of such social forms of learning is the notion of apprenticeship with a view to enculturating the community's ways of seeing meaning. The community – acting in a manner congruent with the social distribution of expertise – appropriates and brokers values of a practice and encourages members to have a sense of identity and belonging.

Today, with technology such as social media, communication between peers and groups is far less limited by physical constraints. Thomas and Brown (2011) have suggested the notion of collectives to be more appropriate to describe a social participatory culture of learning in which individuals are exposed to multiple perspectives from within and across communities. In such a conception of collectives, individuals cross boundaries while remaining identified within their respective originating communities. Entry and exit norms of participation are less stringent and serve the goals of individuals.

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Learning becomes a much more dialectical experience. The social collective phenomena acts in a dialectical relationship with individuals' regulatory actions as they attempt to make sense of varying perspectives to meet their own needs. Brokering in this context is no longer a tight one-to-one relationship such as in an apprenticeship setting. In such conceptions, brokering involves the social collective and its constituent individuals appropriating ways of navigating different perspectives. Higher-order thinking is authentically practiced *in situ* as individuals engage in this kind of social participatory learning.

Thus, with the development of social media embedded within participatory cultures of learning, it behooves us to put the social-collective back into the learning process, especially in venturing beyond the classroom (Brown and Adler 2008).

Among his many insights, Vygotsky (1978) claimed that in any learning situation there are three dynamic interactions: 1) the teacher is always actively responding to the student; 2) the student is not passive but is a co-participant in that same active interaction, and 3) the learning environment is also dynamic. This shows that there cannot be a one-size-fits-all way of designing for learning. The teacher, consistent with 21st century dispositions, must be interacting with the changing dynamics between the learner and the learning environment. This is referred to as putting the social-collective back into the de-contextualized learning process.

How is it possible then to increase the quality and quantity of interactions in a classroom of forty students and one teacher? If sociality and interactions are important facets of learning, it behooves us to investigate ways in which one may creatively and intelligently use technology to increase the quality and quantity of

interactions in classrooms. For example, interactional environments such as GroupScribbles (Chen and Looi 2011) enable the synchronous aggregation of students' input and the display of synthesized views of their responses.

Leveraging aspects of the informal: putting the informal back in learning

The preceding tenets for putting context back into de-contextualized learning are prominent in the literature today (Brown 2002; Brown and Adler 2008; Lave 1991; Wenger 2000; Zepke and Leach 2002). To date, the third tenet has been less discussed; namely leveraging aspects of informal learning to address the de-contextualized nature of much schooling. By 'informal learning', we refer to learning that is less structured perhaps even messy. Literature on informal learning suggests that participants are inclined to tinker, experiment, and "mess around" with things as settings are relaxed and the stakes are low (Barron 2006; Nasir and Hand 2008).

In the process of "messing around", meanings are made. The learners themselves organize learning into more structured inquiry as they make sense of the messiness. The whole process is enacted by the people who are doing it rather than by the teachers who are planning for the instruction.

Literature is increasingly suggesting that what children are doing in informal settings can be very productive experiences in the process of learning "to be". Seely Brown (2005; 2010) has studied case examples of youths in informal settings, in particularly risk-taking and tinkering. In one of our studies in *World of Warcraft* (author 2011a), we discovered that youths in *World of Warcraft* are continually practicing 21st century literacies, such as managing complex resources and coordinating disparate teams. They rally others in the community and have

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leadership in raid sessions. They manifest the abilities to think on their feet because their decisions have widespread social consequences.

Seely Brown (2010) has cited youths in Maui, Hawaii who wanted to be champion surfers. They challenged each other and organized themselves in a study group. These youths learned how to surf in non-traditional ways by looking at how hell-riders performed their stunts. They appropriated the moves from a totally different discipline to surfing. Ultimately they became champion surfers. These are examples of how capitalizing on the collective phenomena in informal settings enables learning to be more meaningful and less contrived.

The paradigm has shifted away from an individualistic view of cognition and learning. As construed by the first schoolhouses, it is akin to the imperial system in ancient China in which the expectation was that the memorization and subsequent unadulterated "downloading" during examinations was desirable. This continues to be the dominant model in attempts to assess what learners know. In this paper we argue for a paradigm shift towards – to paraphrase Brown and Adler (2008) – "we participate (in a community, in a collective, social setting, in a powerful group phenomena; we participate in a participatory culture afforded by social media and group dynamics), therefore we are". Through participation in common practice, we develop an identity and a shared belief-system.

Seely Brown (2002) has said that it is the participatory culture that defines today's 21st century learning. Sociality is not a good-to-have support for learning but is the very contextual dimension in which productive learning occurs. Much learning in the formal curriculum is framed by the paradigm of intellectual and individual excellence. Pedagogies inherited from this perspective focus on the

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individual. Research in cognition, metacognition, and motivation has been construed with the individual as the unit of analysis (Barron 2006). It has been about the design of psychological constructs around the individual, divorced from the context and the social nuances of the environment. In this framing, context was theorized as noise. These kinds of individualistic foci led to the assumption that learning in schools can be legitimately de-contextualized.

Social media affords the creation of cultures less dependent on the individual as expert and are founded upon the socially distributed nature of expertise. By shifting the focus to the power of social groups, the power of context and the collective can be emphasized with respect to learning. Content should no longer be characterized by the curriculum as de-contextualized knowledge, but instead thought of as performative social roles in learning. There is a need to look into ways, in which classrooms can be augmented to let students participate in social settings and in rich contexts in which they can act and acquire tacit knowledge.

Our studies have focused on trying to see how the informal can be brought together with the formal to enlarge and augment the de-contextualized curriculum. What we mean by 'putting the informal into the formal' is to introduce or integrate the opportunities for tinkering and experimentation, loosening the hold of the traditionally structured curriculum.

In the second half of this paper, we share two case studies. The first case study is on the use of a three-dimensional collaborative platform in which the design of the learning-space affords tinkering and messing around. We have used *Second Life* as the platform, but this learning-space must be understood in the larger context of the curriculum and classroom in which the learning is enacted. We

have leveraged characteristics of learning more associated with informal learning – such as exploratory prototyping – and applied them to the derivation of first-principle understanding within the formal disciplinary domain of geography. In other words, we illustrate how learning environments in *Second Life* -- designed according to the principles of the *Six Learnings Curricular Framework* (Author 2009; 2011b; Author 2011c) -- has been used to augment the formal curriculum in geography to promote opportunities for students to operate in environments in which they can explore, manipulate artifacts, and express their naïve disciplinary understandings through tinkering. The second case study is in the context of school's CCAs, which we characterize as informal learning situations. In the latter study we observed how students were able to engage in powerful cognitive and regulatory actions as they took part in sports within a team environment. We not only illustrate the informal learning experiences but also attempt to bridge back to how they can impact formal learning in classrooms.

Methodology

The focus of this paper is to advance the argument that principles from informal learning might be leveraged to make formal learning more authentic. Two case studies were constructed using qualitative research methods, such as observations, informal open-ended interviews, field notes, and informal conversations with students, teachers, coaches, and parents, over a two-year period. Observations comprising field notes of students' learning experiences occurred regularly at least once a week. Interviews focused on individuals' learning experiences, strategies, and peers' learning approaches. The interviews were conducted twice a month. Each interview lasted approximately thirty minutes (Appendix 1 lists sample questions related to each case study). All interviews were audio-recorded and

transcribed for analysis. Artifacts produced by students, such as written accounts of learning experiences and expressions of students' conceptual understandings, were also recorded and / or archived. The data analysis process was iterative as we discussed observations, analyzed transcripts, and identified the learning experiences of students in both formal and informal contexts.

Case study 1 – learning Geography in *Second Life*

The work in *Second Life,* from which has arisen the Six Learnings Framework for curricular design in fictive worlds and virtual environments' (author 2009; 2011b; author 2011c), has centered on the learning of geography in Singapore schools. The intervention focused on foregrounding students' naïve pre- and mis-conceptions about geography and making them explicit for subsequent shaping and critique in a collaborative learning environment. A variety of curricular materials have been designed in association with this program; the lesson unit discussed here leverages the affordances of *Second Life* for terraforming.

At a state-funded school, three classes of forty students each – aged between 14- and 15-years, were tasked to terraform their own drainage basins. To articulate the problematic of the task, it has to be borne in mind that very little of the natural hydrological systems in Singapore remain, given its extremely urbanized environment; almost all rivers have been canalized and straightened. As such, geography students learning about hydrological processes and landforms from their textbooks do not have intuitive understandings of such basins from their own experiential repertoire.

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Each class of forty students was divided into equal groups of ten. Each group was given a plot of land in *Second Life* (Figure 1), which they could subsequently terraform into their respective representations of an authentic drainage basin.

"Insert Figure 1"

Training was provided to students and teachers; students' training focused on technical aspects of ensuring they understood how to use the technological platform. Teachers' training involved extended conversations about affordances of the platform for learning and transforming their pedagogical orientations towards how *Second Life* might augment the formal geography curriculum in order to better provide opportunities for contextualized learning.

In preceding sections of this paper we have proposed that increasing the contextuality of the learning environment involves putting the tacit and the social-collective back. In the case study described here, students collaborate to express their evolving intuitions and understandings of relatively complex concepts in geography. Further, in alignment with Gee's (2003) description of projective identity, students were appropriating the epistemic frames of professional geographers as they collaborated to analyze and interpret the landscape they found themselves operating in. Yet they could go several steps beyond what professional geographers are regularly doing, and that is namely to work together to manipulate landscapes at will. This facility created several rich teachable moments, an example of which is shown in Figure 2.

"Insert Figure 2"

Figure 2 is especially interesting because it demonstrates how the manipulability of the learning environment, together with its ability to legitimize student

experimentations with a sheen of authenticity, has surfaced the learners' inaccuracies of conception of hydrological features – in this case an oxbow lake – which has been terraformed in a geomorphologically improbable location.

If traditional pen-and-paper were used to teach these geography concepts, students would be required to draw long- and cross-profiles of rivers. It is likely they would arrive at a rather superficial understanding of these concepts; this would be even more likely in the case of students in Singapore for reasons already given. Even if authentic river-basins still existed in Singapore, students would still be unable to manipulate and play or tinker with the formations of rivers in true human scale; this was not the case in their respective terraformable basins. The manipulable nature of this environment afforded the learners to demonstrate their nascent and evolving understandings in more authentic ways than any pen-and-paper exercise could have. Misconceptions about geographical concepts would more easily surface. Teachers using this environment would hopefully be more able to spot students' misconceptions and to leverage on those as teaching points.

The premise undergirding the design of the learning environments described in this Case was to enable novice geographers to derive geomorphological understandings from first principles – in the particular example, the processes of denudation, erosion and orogenic uplift. As such, they achieved enduring understandings of these concepts, which equipped them with the wherewithal, and confidence to successfully attempt traditionally framed assessment tasks several cohorts above their grade level.

The design afforded the learners to express their understanding of hydrological concepts by *participating* in – and *co-determining* – the design of drainage basins.

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In this way, the learners made explicit their tacit intuitions about the discipline, and in so doing deduced first-principle understanding about these same concepts. In doing so, the learners were implicitly appropriating the epistemic frame (Shaffer, 2006) of professional geographers and geomorphologists in the field – they were learning *to be* geographers, rather than just learning *about* geography.

It is Lim's (2009; 2011) position that these kinds of three-dimensional, manipulatble environments are the new pen-and-paper of learning environments. One key advantage is that these kinds of environments afford opportunities for the manifestation of learners' evolving intuitions and understandings through the appropriation of epistemic frames in ways, which the traditional pen-and-paper environment not only do not, but simply cannot. Such manifestation through appropriation results in deep learning. In such fictive environments, meaning making is collaboratively enacted.

In traditional classrooms, teachers cannot come close to imitating or enacting this kind of pedagogy. In the examples of river basins that students created (see Figure 3), they are similar and yet they are also different. They are different because they are all differing expressions of understandings of what a river basin is. Some of these expressions are more accurate than others. These expressions all represent students' evolving and diverse understandings because they were created in a three-dimensional environment as opposed to merely sketched on paper, the third dimension afforded additional opportunities for expressing naïve understandings, and therefore additional opportunities to make mistakes, to defend decisions and – consequently – to learn.

"Insert Figure 3"

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Creativity becomes a way to concretize curricular goals and students' understandings of geography concepts. As students enjoy manipulating landscapes (and expressing their creativity), they are more willing to show their tentative representations for others to critique. This is a very important point. This will not happen in a traditional pen-and-paper lesson because the stakes are too high because of the semblance of the latter to traditional forms of assessment.

In a traditional classroom, it would also be very hard for the students to get a sense of the possible variations of a river basin. Figure 3 shows an example of how different groups of students' work are presented in *Second Life*. It is through this very permutation of three-dimensional representations of river basins that the diversity of processes of hydrology is fore grounded. Potentially, each point of similarity and difference is a teachable moment, which a geography teacher can leverage upon. Teachers should be able to adapt to the students' active participation within a dynamic geographical learning environment. Such a setting would be consistent with Vygotskian (Vygotsky 1978) perspectives.

Case study 2 – bowling

The preceding case study shows how affordances of informal learning, which are foregrounded through *Second Life* as students explored, experimented, and collaborated to learn about geography, may be bridged to formal ones. The second study focuses on CCAs which Singapore schools are engaged in; specifically, it attempts to study what happens with respect to the learning process in these non-formal settings, and how linkages can be made to the formal.

We chose to study a CCA in a school because – in the context of education in Singapore – CCAs come closest to offering young learners the after-school

experiences that have been well documented in literature on informal learning in American contexts (such as those afforded by after-school programs run by community centers). Consistent with the preceding study described, we are foregrounding the *principles* of informal learning as applied to more formalized school settings.

The aim of the second study was to investigate how affordances of schools' CCAs facilitate 21ˢᵗ century learning, such as in terms of how social regulatory dimensions of team spirit affect students' self regulatory behaviors. The study aimed to see how authenticity of the school context and competitions motivated students to excel in this sport. Observations of students' behaviors showed that they exhibited interest and passion in their undertakings. In turn, these created an authentic context for 21ˢᵗ century learning.

The study was conducted in a local primary school with the school bowling team consisting of thirty boys, from grades four to six. The sport is socially complex in that it is enacted through a structure of bowling federations, national championships, and national teams. These structures enable aspiring bowlers to become national team members through the national youth squad. Thus – like many others – this sport is situated in a cultural context in which the learning process has authentic dimensions, which extend beyond the school.

Two students were selected for in-depth investigations. They were identified because they represented typical profiles of students in the team who were dedicated to the sport. During observations, we paid more attention to these boys' learning experiences and conducted extra interviews throughout the study. The interviews revolved around both students' activities in the context of the school

team community, and reflections in terms of what they learned, how they felt about each training session, what mistakes they made, and how they could improve in the next training session. Although there were times when they could not articulate their thoughts, interesting and in-depth insights nevertheless arose.

Other than working as observers of the team's learning activities, the researchers also worked as brokers-of-learning for the two students selected. The roles of the brokers involved a) helping the students articulate and reflect on their learning experiences, b) catching moments to establish links between learning in formal and informal contexts by comparing and contrasting learning in both contexts, and c) helping the students to transfer their learning strategies across contexts to improve their performance in formal classroom learning.

In the following section, we present two in-depth examples to illustrate the nature of the learning processes, which took place in this informal setting.

Authentic learning experiences in informal settings

To contextualize the two case examples, our observations showed that primary school students are able to think about their own thinking and regulate their actions to a certain extent. The social pressures and dimensions of being in a team created impetus for these students to monitor and regulate their own actions with respect to their thinking.

We first describe Dixon. Dixon started learning bowling in kindergarten because his parents observed that he had talent. This recognition from social others reinforced Dixon's desire and motivation to do better.

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Dixon understood the importance of developing a disposition of perseverance, in order to perform well in competitions. He applied the term "mindset" to his efforts to think about his own thinking and performance:

> "The *mindset* that means like I can actually fail...that means not to say that in your mindset, *must say must achieve this, must achieve this*. Must try and try and try. That your mindset must be like a good thinking." (emphasis added)

Another example of the evolution of such a mindset happened when Dixon had a fever. He resolved to continue attending practice sessions because he was cognizant that his efforts would help overall team scores:

> "No, I didn't talk to myself, the people in the, for example like Mark, Jay encouraged me. Don't cry …come on…come on…this is just the first game. *And later I thought to myself that must be happy … regardless of my fever*."

In fact, so bonded were members of the bowling team that it became a factor why they wanted to do well in their studies and stay in that school. Because they were passionate about their CCA and the context of their sportsmanship was so enduring, they wanted to stay in that school as a group. Students set goals in their academic studies to ensure that they continued to do well and go to bowling competitions as a team. This observation implies that the power of sociality in the informal curricular of the school has effects to the formal, such as can be seen in this example of Dixon setting his academic goals:

> "Achievement goals like last year if your score is 70, this year I want to get 80 and above"

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Observations also showed that when set in a rich, authentic situation (such as bowling training sessions and competitions); students exhibited cognitive strategies. They could think about and analyze their weaknesses; in addition they successfully solicited the help of their friends to analyze what was wrong with their performances. They were able to think about their performance and, to some degree, regulate their actions. The coaches would record and playback their performances, such as to correct their hand-swing. We also encouraged that students use their own cameras to do likewise for each other, in order to augment this form of critique.

Observations showed that bowling concepts were not just abstract ideas held by students. They were concepts that involved performative enactments. Students' performance in each subsequent enactment would be refined, for example in terms of hand rotations. Thus, through iterative testing of their personal understandings of bowling, they engaged in a complex dialectic of theory and action. Through hypothesis testing, students began to develop embodied cause-and-effect understandings personal to themselves. In bowling, any given action does not result in reproducibly identical outcomes because of reasons like muscle execution and rotation and different lane conditions. This made hypothesis testing complex. Therefore, students had to use many rounds to validate their actions before they came up with respective personalized theories, as evidenced by statements such as: "I think this works because of …".

In this theory and performance interaction, students willingly subjected themselves to many rounds of trial and error because they wanted to excel. The important point to note is that hypothesis-testing and self- and peer-critique were natural outcomes because learning was situated in a contextually-rich setting.

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The roles of the broker

Based on our observations of students' learning experience in bowling, we found that the sport provided anchored learning experiences for them. The learning experience in bowling was something that students could relate to because they put a lot of thought in their actions; it was something they cared about, and they were setting goals within context. Tacit and social dimensions were embedded in this same context.

Our conjecture has been that such anchored learning experiences formed in informal settings are frames of references that enable students to transfer these same experiences into other contexts, albeit with assistance from a broker-figure. The assistance often involves dialoging with students to establish transfer.

The final case example describes John. While Dixon and John benefitted from strong parental support, John only started to bowl from grade four. John has a diagnosed learning disability in which his language development is slow. Because of his learning difficulties, John was not doing well in school. His grades from all subjects were in the fiftieth to sixtieth percentile. Consequently, John was discouraged. He felt that the many worksheets his parents, tutors, and teachers gave him were not helping because he could not intelligently articulate what his weaknesses and problems were. He had no strategy of coping with his learning difficulties.

Hence, we designed to help him monitor - and subsequently regulate - his actions and thinking as he received feedback. We particularly leveraged his anchored learning experiences in bowling. Lessons learned from bowling constituted these teachable moments because John had had a rich embodied experience that

included complex enactments, involving goal setting, thinking about his actions and modifying his actions after having analyzed his weaknesses. John was emotionally and conceptually attached to his learning experiences in bowling and these formed frames of reference, which we leveraged to help him compare them with his efforts in his formal academic studies. For example, when students set goals in bowling, we tried to help John use similar strategies in his academic studies. We term the process of dialoging and analyzing to find links for re-contextualization across contexts "metacognitive brokering". Working with brokers, teachable moments were captured when links between two contexts were discovered to enable transfer and re-contextualization.

The following protocol is an excerpt from a conversation between John and a broker-figure two days before a competition. It shows that John is reviewing his winning strategy to achieve (what he terms) "high score". It seems to illustrate that John's concept of high score stems from anchored experiences in bowling:

> Broker: *Let's run through the things you need to do* [during competitions].
> Broker: What do you do during practice throws?
> John: Calibrate.
> Broker: Which ball will you be using first during practice throws?
> John: Cobalt bomb [name of bowling ball] – my benchmark ball.
> Broker: And you will be doing this on the outside line?
> John: Yes.
> Broker: When will you start shifting in?
> John: If it over-hooks to the 1-2 pockets [a pocket is the space between the head pin and the third pin for right-handed bowlers. A ball that hits the 1-3 pockets scatters pins as though it has been swept with a broom].
> Broker: The first principle is: "select a first ball – likely your favorite ball – and start calibrating and shifting".
> Broker: How do you know if you have chosen the right ball?
> John: It does not matter, as long as it hits roughly to the pocket and I concentrate on my spares.

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> Broker: *Is that the winning strategy*?
>
> John: Coach just wants us to average 160.
>
> Broker: When do you start changing ball, say to your Uranium hrg [material of the ball]?
>
> John: When the Cobalt seems not to be working too well?
>
> Broker: When the lane is dryer?
>
> John: When I am confused and need an easy to control ball.
>
> Broker: The second principle is: when confused do simple bowling with tight curve and not big curve, including that of diagonal shot.

The broker-figure went on to find out how John had performed in his mathematics examination. It emerged that John's examination strategy was to attempt questions in strict sequential order. This prompted the broker-figure to ask John if he could draw parallels from bowling to inform a more effective examination strategy.

Through his interactions with the broker-figure John realized that the notion of high score could be transferred to mathematics. In the following protocol, John mentioned in his practice papers he had been averaging 75-79 marks. Thus, a teachable moment was identified when John could be helped to understand that the rich anchored experience of a high score in bowling could be transferred to his academic studies:

> *John: I have been doing many papers in school... I have been averaging 75 to 79 ... I want to get "high score"*
>
> *Broker: That's good. Did your strategies work?*
>
> John: As you told me, I did the easy questions first, and maximize the marks there ...
>
> Broker: Did you make sure that you understood each question correctly before solving the word problems
>
> John: Er ...
>
> *Broker: What did you do differently?*
>
> *John: I read out aloud the question to myself ... Underline important words ...*

> *Broker: Did the strategy work?*
>
> John: I guess so ...
>
> Broker: What else?
>
> John: I skip those questions, which I cannot do.
>
> Broker: Yes, leave those to your extra time at the end of the paper. Maximize those questions which you are confident about ...
>
> John: I get stuck with some questions ...
>
> Broker: There are 3 kinds of questions: those you are confident, those you are 50% confident, and those you don't know

From the preceding protocol it should be clear that the broker-figure attempted to help John analyze his strategy for getting high scores in mathematics. Through metacognitive brokering, John's grades gradually improved. John could take a rich, anchored experience from one context and re-contextualize it in his academic studies.

Conclusion

From the cases of learning geography in *Second Life* and bowling, preliminary implications can be drawn. Future work is needed to establish more generalizable implications about bridging formal and informal learning in order to make learning more contextualized.

First, students who have opportunities to articulate their learning develop ways of talking about their thinking. Early development of such fluency is important to enable students to experience and leverage tacit dimensions in learning.

A second implication is that when a pedagogy of experimentation exists in schools, learning becomes more authentic because students can anchor learning within rich contexts. We argue that because students have had this rich context, they can make inferences of that process of learning across contexts. Broker-

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figures can leverage anchored experiences that were conceptually rich and help re-contextualize them through metacognitive brokering.

A third implication is that by crossing boundaries between the formal and informal, and bridging the two, we have introduced a methodology for overcoming groupthink arising from enculturation. The way around groupthink is to engage in boundary crossing interactions in which members are constantly in dialogue with other communities (Brown and Duguid 1991; Wenger 2000). 21st century learning requires developing dispositions of adaptability in thinking and we see this as inter-relating learning across contexts.

It should be acknowledged that schools have introduced innovations in attempts to make learning less de-contextualized. If one describes this phenomenon as schools' unique practice, without referencing the yardsticks of the disciplinary communities, an argument might be made that schools help students develop a lens of seeing meanings peculiar to schools' practices. Construed in this way, there are indeed overlaps with disciplinary communities, but the two are not identical.

An inherent assumption of this paper is that schools remain as bastions for formal learning of disciplinary understandings. We acknowledge literature that has focused on either the formal or informal, while identifying a dearth of studies, which attempt to capitalize on both (Barron 2006). Our approach is one of mitigating limitations of schools by putting the tacit, social-collective, and informal back through technological means.

One of the case studies presented have appropriated technology within an established curricular framework differently to bridge formal and informal

learning. The rationale for using technology to augment the geography classroom in the first case study relates to how Singapore's mostly urbanized topography and landscape does not provide adequate opportunities for students to develop intuitive understandings of geography.

For instance, unless students in Singapore have first travelled overseas, they are unable to develop first-hand, embodied understandings of hydrology. Thus, geographical concepts taught in the formal curriculum represent *post-hoc* depictions, founded upon the assumption of a corpus of *tacit* prior intuition about landscape evolution – the formal *post-hoc* instruction of concepts should ideally build upon the tacit intuitions, resulting in novice geographers developing expertise as they come to understand the formal processes undergirding their childhood intuitions. While this assumption may be valid in many countries, it is our argument that it does not hold in Singapore; thus, with no foundational intuition upon which to build, the formal instruction in geography classrooms remains an abstract house of cards, with consequent implications for (the lack of) enduring understandings.

By working within the limitations of school structures in this way, outcomes of formal learning are not undermined. Rather, by leveraging the intuitions developed from the novice geographers' collaborative experimentations in *Second Life*, the amount of time spent on formal content instruction can be reduced and spaces for authentic learning can be created by letting students mess around and manipulate the environment in order to develop embodied understandings.

The use of technology is less emphasized in the second case study. Observations of how students interact and learn in bowling even as they critique each others'

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performance through video recordings can be leveraged upon, and such learning opportunities expanded through the use of collaborative and social media platforms.

Consistent with other studies conducted by some authors of this paper (Author 2011b; Author 2010), well designed social media can provide learners with the tools to perform regulatory roles with peers, engage in goal-setting, and establish bridges by transferring goal-setting from sporting domains to academic performances. We recognize that more in-depth case examples need to be observed in future studies to fully understand how technology facilitates rich authentic learning in informal contexts – including sports and co-curricular activities – in order to facilitate bridges to formal learning.

There are other technological platforms, such as game-based learning and fictive worlds like *Quest Atlantis*, *Second Life,* and *World of Warcraft*, which may be useful to augment de-contextualized learning (Barab et al. 2005; Brown and Adler 2008; Chee 2001, 2010; Jan, Chee, and Tan 2010; Thomas and Brown 2009). The potential of these worlds lie in leveraging its contextual affordances to bring the tacit back into the learning process. However, the success of these learning environments depend on supporting curriculum and pedagogy, and through teachers who capitalize on the inter-relationships between students' engagement in challenging tasks and their consequent social interactions.

Consistent with Vygotsky's (1978) position that learners, teachers, and the learning environment are in continual dialectic interplay, this dialogic nature obliges the development of a fluency in students to monitor their own learning.

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Our research has shown that rich experiences in which students have opportunities to experiment, tinker, and hypothesize can be productively leveraged as anchored experiences to enable re-contextualization, and to address weaknesses in other perceived contexts. Cognition and metacognition occur naturally when learners' actions have consequences to themselves and to others.

Informal learning is generally characterized by outcomes which are emergent; seldom are specific outcomes or closures determinable at the outset. There are seldom direct trajectories which might be traced from the intended scrutiny to an outcome of learning. In other words, learning outcomes in informal contexts are not prescribed from the beginning, thus, even through students are engaging in inquiry, they may not be engaging in what might be easily recognized as productive inquiry or learning.

However, when principles of informal learning are leveraged to create authentic learning experiences in formal settings, activities inspired by informal learning are put in place to augment the de-contextualized learning that characterizes so many formal classrooms; these include activities which foreground participatory experimentation and learning as part of community-membership. Teachers might thus begin to use more dialogic modes of pedagogy and instruction that emphasize interactions between formal and informal learning spaces. Teachers and parents must also be alert to teachable moments through which meanings are built.

In this paper, we have noted that the schooling system comprises more than just the formal curriculum. Particularly in the context of the Singapore education system, there is a formal component comprising classroom learning as well as an informal component that focuses on CCAs. It is our argument that the informal

can be leveraged to facilitate formal-and-informal dialectics through which

authentic learning occurs.

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Appendix 1 – Typical interview questions from the reported intervention

Case study 1

1.   During our lessons in the virtual world, one of the activities that you took part in was to work with your team-mates to form your own drainage basin. Now, let's look at this topographical map. Where is the drainage basin on this map?

2.   What clues in the map did you use to help you determine the watershed?

3.   Here's another map, this time of a different part of the world. Your task – for the next five minutes – is to predict how the form and shape of the drainage basin will evolve over time.

4.   What are some of the criteria that you applied when formulating your prediction?

Case study 2

1.   Do you set challenging goals for bowling?

2.   If you make a mistake, how do you avoid repeating it?

3.   How well do you know your strengths and weaknesses?

4.   Do you think that your peers, coaches, or parents could affect your performance?

   • If yes, by whom? Please elaborate on it.

   • If no, what could influence your performance?

5.   Do you find in-class learning can be useful for your bowling practices or vice versa?