Promoting Students' Interest in Learning Through Play in a Makerspace

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Abstract: Makerspaces have been increasingly popular in education to achieve interest-driven creation and learning. In this paper, we describe background of makerspace, uncover its advantages in stimulating intrinsic motivations and natural curiosity of learners, and propose a framework to operationalize makerspace. We target to investigate learning affordances, contextual conditions (e.g., community-building mechanisms, infrastructural settings), dos and don'ts around the development of such ground-up initiative in Singapore. Our assumption is that such design of learning environments and/or pedagogies could be avenue to promote and optimise "interest", "creation" and/or "habit" in learning

Keywords: Makerspace, student-centred learning, playful learning, interest-driven, intrinsic motivation

1. Introduction

In Singapore, students are evaluated with regularly administrated, standardized tests. Schools are also appraised based on how well their students have performed based on these extrinsic goals and expectations. With these evaluative practices in place, schools are understood as a place where students compete to acquire as much knowledge as possible. Rather than developing proactive learners, Torrance (2007) and Sadler (2007) caution that these "assessment for learning" practices not only deter learning, but also promote learning as "criteria compliance in pursuit of grades" (Torrance, 2007).

While Singapore has been consistently among the top ranking countries of International evaluation studies, Government leaders recognize and acknowledge the apparent lack of thinking skills and creativity among students (Tan and Gopinathan, 2000). Education evaluation practices remain characterized by high-stakes and standardized testing notwithstanding the rhetoric of education reforms to promote active learners with a creative and critical thinking culture within schools (Tan & Gopinathan, 2000; Tan, 2001).

Because of the emphasis on the extrinsic goals and expectations of the school, the intrinsic motivations and natural curiosity of children may have been extinguished inadvertently (Honey and Kanter, 2013). Research-based evidence, however has found that this natural interest to learn could be rekindled by designing learning environments that are supportive (Honey & Kanter, 2013).

A makerspace could be an entry point for learning in an informal context, supporting meaningful learning and engaging student interest. This underlying motivation applies equally well to the structuring and design of any system, be it mechanical, institutional, or social. In this respect, the concept of a makerspace poses interesting challenges to the design of schooling: What if, instead of training our students to grow up to become helpless consumers of knowledge (in all its forms), we could nurture in them the spirit of intellectual curiosity, a thirst for understanding, equipped with an extensive 'toolbox' of intellectual devices with which to create a better world for themselves? Here, the vision recalls the ideals of education as articulated by critical sociologists of education (see, e.g., Freire, 1970/2000; Giroux, 1983; Marcuse, 1964/1991; Young, 1971), and located within more contemporary critiques of the neoliberal standardised 'consumer' model of education (Apple, 2001; Klees, 2008; McGregor, 2009; Olssen, 2004; Pick & Taylor, 2009).

This paper proposes that a makerspace as an avenue for students to establish their interests, to regain their individual agency, and to possess the knowledge, skills, and means to accomplish their designs. In next sections, we will start with the background of maker movement and introduce how the makerspace has been employed in education in recent years. Then we elaborate on the characteristics of a makerspace in the sense of interest-driven creation and propose a framework to operationalising a sample makerspace. Finally, we suggest our future developments in advancing makerspaces in Singapore schools.

2. A Makerspace as a learning environment to promote and optimise interest and creation in learning

2.1 Background of the Maker movement

The roots of the contemporary movement may be traced back to German hacker groups such as the Chaos Computer Club (CCC) (Maxigas, 2012), fused with American hacker (Thomas, 2002) and maker culture (Anderson, 2012). The driving philosophy of the movement of these grassroots networks is driven by a “Do-It-Yourself ethic” that is self-directed, hands-on, with flexible goals (Schrock, 2014; Gauntlett, 2011) that is a result from a shared interest in making, generally employing democratic rather than “top down” organizational practices (Schrock, 2014).

In typical implementations, makerspaces consist of both traditional and digital media, tending towards open or minimally guided exploration with a focus on student authorship of ideas. These spaces encourage experimentation that entails a positive experience that “arouses curiosity, strengthens initiative, and sets up desires and purposes” (Dewey, 1938). Its approach is a student-centered, project-based learning style that stems from the pedagogical tradition of learning by making and through apprenticeship (Maker Media, 2013). Learners may respond to design prompts requiring them to make objects with particular functionalities, or to solve a practical challenge. Using the design method, learners analyze problem contexts, creatively generate prototype solutions to these problems, then iteratively improve on prototypes until a satisfactory solution is reached. The task is a deeply cognitive one, often requiring makers to continually evaluate the system of components during cycles of ‘de-bugging’ when their designs almost inevitably fail to work initially.

2.2 Makerspaces in Education

Makerspaces can create an engaging and empowering learning experience for all students. Making enriches the educational experience of students who do not learn effectively in a mainstream curriculum, or who are motivated by different interests, developing skills such as curiosity, creativity, and the ability to learn on one’s own (Cavallo, et al., 2004). Its highly collaborative environment allows students’ interest to be connected, both in and out of school, by identifying, developing and sharing broad framework of projects and kits (Kalil, 2013). Makers engage collaborate and give guidance to peers. They are open to sharing and exhibition, instead of competition. These interactions create new opportunities for different learning experiences (Dougherty, 2013).

Makerspaces allow educators to experiment with different pedagogical approaches, to counteract education in schools that is characterized by rote learning, standardization, high-stakes testing and the narrowing of school curriculum (Baker, et. al. 2010; Rose, 2010). These alternative approaches include scientific inquiry and the everyday, “thinking with our hands,” and authentic learning by participating in real life scenarios.

In recent times, literature in the international context (e.g., Honey & Kanter, 2013; Dougherty, 2013) point to makerspaces as ideal learning context to build up on intrinsic motivation. In this view, makerspaces offer advantages over conventional learning activities (e.g., Bennett & Monahan, 2013; Petrich, et al., 2013) because:

- Conventional classroom activities are often constrained within the boundaries of teacher –centred instruction, content knowledge, and exams. Activities in makerspaces, give students the opportunity to design and make objects of their own initiative. This provides the opportunity for students to express their own intentions through making.
- Through makerspaces' emphasis on the iterative design, appreciating failure as a means of feedback for improvement, and the benefits of play, we anticipate that the activity structures of makerspaces may afford the creation of new learner identities that conventional classrooms fail to develop. For instance, makerspaces eschew the prospect of making as a means to attain an extrinsic goal, but instead, that making is an intrinsic goal in itself.

3. Building interest in Makerspaces through play and tinkering

3.1 The Makerspace as an informal learning space

Because learning in formal classroom setting emphasize routine tasks and instructions, the motivations of a learner lean towards extrinsic factors (Saonsone & Harackiewicz, 2000).

Research has found that informal learning environments often are instrumental for sustained science learning of individuals (National research council, 2009). Informal contexts such as hobbies, non-curricular activities and summer programs can afford enriching experiences that can set interest in a subject. If such moments of situational interests are further reinforced, they can open up extended pathways of learning through intrinsic motivation (Quinn & Bell, 2013).

3.2 The role of intrinsic motivation in a makerspace

Similarly, one of the first theorists to use the precise term ‘intrinsic motivation’ - Hunt, wrote that humans find being at the helm of one’s environment to be inherently motivating (Hunt, 1961; 1965). Likewise Bruner (1961, 1966) suggested that the contextualization of learning was instrumental in generating students’ interest of the larger world outside of their classrooms – and this was done by demonstrating to students the relevance and utility of skills that were taught.

There is also evidence that students derive high levels of intrinsic motivation and learning efficacy when they are faced with topics that they are most interested in. Asher (1981) Asher, Hymel, & Wigfield (1978) for instance, established that students' capacity to remember was highly correlated with past measures of their interest in the topics. In comparable fashion, Anderson, Shirey, Wilson, and Fielding (1987) demonstrated that grade-school children's memory for sentences was better predicted the interest value of the sentences.

Considering the above theoretical frameworks, it appears that makerspace draws on the earlier concepts – in enabling applied learning as the emphasis on doing and making, in an authentic learning environment. By capitalizing on and catering to students’ varying abilities and interests, the makerspace paves opportunities for them to design and create objects based on their interests, with an emphasis on authorship of ideas. In doing so, students develop skills and competencies that go beyond routine cognitive tasks, such as the ability to critically seek and synthesize information, the ability to create and innovate, and the ability to self-direct one’s learning (Dede, 2010).

3.3 Learning through play and tinkering

It has been argued that instructive teaching that is routine and repetitive in nature becomes a chore to learners (Hidi, 1995) and that interest and motivation levels could be increased if learning tasks were more like play and recreational activities (Shernoff, et al., 1999). Lepper & Cordova (1992) also reported a series of studies that demonstrated enjoyable and making learning fun resulted in increased interest and learning.

The concept of experimental play is an integral aspect of the maker movement. The central notion is that makers experiment and play to better understand the functions of that object. Through experimentation and play, they explore what they can do and learn as they explore (Dougherty, 2013).

We situate this understanding within the extant literature on the importance of play, to locate and trace evidence of learning through students’ participation in a makerspace – as an informal learning environment designed for tinkering and making. To do so, we will draw on the work of Vygotsky (1978), Holzman (2009), Goldberg (2009), Piaget (1973) and Papert (1980).

Insights on play were first advanced by Lev Vygotsky (1978) in the early twentieth century. At the core of Vygotsky’s Cultural-Historical theory is the idea that interactions between children and their social environment nurture children’s development. These interactions involve the people around them, cultural artifacts, such as books or toys, along with culturally specific practices, in the classroom, at home or on the playground. Children construct their own meanings, knowledge, skills and attitudes based on these interactions. “A child’s greatest achievements are possible in play, achievements that tomorrow will become her basic level of real action and morality.” (Vygotsky, 1978) As a result of play, the learner will develop skills, interest and a sense of purpose (Vygotsky, 2004).

The concept of play has been explored in experimental schools to understand the kinds of learning environment and performance postures it affords (Holzman, 2009). Opportunities were created to emphasize performance and students take on roles of writers, scientists, historians, test artists, mathematicians, and so on. Games were created to help learning and visitors and itinerant participants were asked to join in to give freely their expertise, ideas (Holzman, 1997). Holzman (2009) observed that through play students and teachers leant to “speak other languages”. Students had studied the theoretical significance and practical importance of the various roles they had taken on from performing as mathematicians, scientists, biologists. Similarly, Goldberg (2009) saw that to play "car shop," children might talk about the nature of the repair, who will play the owner of the car, who will act as the receptionist, and who will play the mechanic. Such play planning serves as the precursor to reflective thinking. The basis of learning is through play and discovery – “to understand is to discover, or reconstruct by rediscovery, and such conditions must be complied with if future individuals are to be formed who are capable of production and creativity and not simply repetition” (Piaget, 1973).

In a makerspace, the concept of play and tinkering is emphasized, as opposed to a routine following of instructions, as seen in formal classroom settings. Tinkering is a playful style of designing and making, where one is constantly experimenting, exploring new ideas in the process of creating something. Tinkering draws on constructionist theories of pedagogy (Papert & Harel, 1991); often identified as an important theory of learning within the maker movement. Tinkering affords an expansive view of learning. Constructionism emphasizes discovery, inquiry, and constructing knowledge by engaging with materials. Through tinkering, learners understand a particular subject, through iterative design and testing, especially in seeing how the artifacts change over time. Tinkering emphasizes the iterative approach, where “mistakes” or “failed” attempts pave the way for new ideas. This is an important process in making, where a range of solutions can be derived by field of possibilities. These principles are central to the development of tinkering within the maker movement context.

4. Operationalizing of A Makerspace

To operationalize our makerspace, we have adapted Stanford University’s d.school problem-framing framework to generate activities, as outlined by Bennett & Monahan (2013). (See figure 3.2) (IDEO, n.d.).

This framework helps educators to first consider the setting, to set the design problem in a context that can be understood by the learner. Similar activities have been carried out by the New York Hall of Science Design Lab and they have found that thinking about the setting of the problem has deeply engaged participants in problem-solving. As participants contextualize the problem, they will start to ideate and begin brainstorming for solutions to solve the problem. Research has shown that actively engaging students in design projects can help them develop deep analytical understanding of the knowledge and principles of a domain that will support the mastery of self- guided inquiry skills that are difficult to teach (Crismond, 2001; Johnsey, 1993; Roth, 1995). At the same time, this design- based framework serves to promote engagement and allow for multiple points of entry into STEM learning in an informal context that is the makerspace.

Sample Activity: Singapore’s Jubilee Celebration activity

Think about something you could build for Singapore’s Jubilee celebration that would make people proud. How would you use an LED and/or a motor in the city to make your creation do something to spread pride in Singapore? Using the materials below, to build models with circuits to add to Singapore’s Jubilee celebrations. Materials: cardboard boxes, index cards, aluminum foil strips, binder clips, paper clips, markers, scissors, watch batteries, motors, LEDs and any other items that you can find easily.

Figure 1: The goal of the activity is defined by the learner, promoting a sense of agency

Designing the activity

Generating Authentic Design Problems Think of a subject and encourage students think about the characteristics and problems they might encounter in such situations/settings	
Settings (places or situations that students might encounter or be interested in) Example: Local park	**Characters** (at least 3 – 6 characters who might be part of this setting) Example: Animals, Parents, kids, pets
Potential Problems (at least four problems to solve in this setting) Example: Litter, habitat disruption, animal behavior, safety of equipment	**STEM Concepts and BIG Ideas** (Ideas that need to wrestle with to solve this problem) Example: Interdependence of organisms; life cycle, failure in structures

Figure 2: This chart to help teachers plan for activities that would meet their content goal (Bennett & Monahan, 2013)

5. Conclusion and Future Work

In this paper, we describe background of makerspace, uncover its advantages in stimulating intrinsic motivations and natural curiosity of learners, and propose a framework to operationalize the makerspace as a site to nurture interest-driven creation and learning. Our objective of this development tranche is to establish makerspace in Low Progress Learner (LPL) context; and to generate guidance and rules to build makerspaces that can be applicable and replicable to more school contexts in Singapore. We target to investigate learning affordances, contextual conditions (e.g., community-building mechanisms, infrastructural settings), dos and don'ts around the development of such ground-up initiative in education. Specialized to address learning needs for students afforded by makerspaces, we need to identify how learning activities shape students' pro-STEM attitudes, such as acquiring personal context for STEM, motivation for learning STEM, enjoyment of STEM experiences, acceptance of scientific enquiry as a way of thought, as well as developing interest in pursuing a STEM related career.

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