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PROFESSIONAL LEARNING IN THE MAKERSPACE: EMBODIMENT OF THE TEACHING EFFECTIVENESS FRAMEWORK

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Makerspaces have recently entered educational discussions as a way to develop the problem solving, collaboration, creativity, and digital skills needed for the 21st century. But there is an added affordance – makerspaces as powerful learning environments for teachers, as delineated in the Teacher Effectiveness Framework (TEF), (2009). Inherent in the design of makerspaces are opportunities for teacher collaboration and valuable feedback through multiple iterative learning designs, as well as long-term reflection and application of learning. This article describes a primary school's makerspace journey 1.0, and the opportunities it provided for teachers to apply what they were learning from the TEF.

Keywords: Makerspace; Teaching Effectiveness Framework; STEM; Design Thinking

INTRODUCTION

Current scholars in education suggest school makerspaces hold potential as environments for deep student understanding and knowledge building (Martin, 2015; Vossoughi and Bevan, 2014). What has not been so readily acknowledged is the makerspace as learning environment for teachers. In prototyping a makerspace in a K-3 school in Canmore, one of the surprises that

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emerged was how the makerspace impacted teacher thinking about designing, assessing, communicating, and collaborating for learning. At the time the makerspace was initiated, this school was involved in a multi-year project with the Galileo Educational Network in implementing the Teaching Effectiveness Framework (TEF) (2009) to enable learning environments in which all learners, including teachers, thrive. This paper details this school's initial foray into makerspace as learning environment and how the work conducted there enabled connections to the TEF.

WHAT IS THE TEACHING EFFECTIVENESS FRAMEWORK?

In partnership with other agencies, the Canadian Educational Association (CEA) commissioned Friesen (2009) to author the Teaching Effectiveness Framework (2009). Based on current research and "what it means to teach and learn in increasingly networked, technology-rich, digital classrooms" (Friesen, 2009, p. 3), the document presents five principles of effective teaching practice. These include 1) intentional design for learning, 2) provision for student opportunities in worthwhile interdisciplinary work, 3) assessment as a seamless part of learning, 4) opportunities to build a variety of relationships while building knowledge, and 5) teacher opportunity to develop and improve practice with colleagues (Friesen, 2009). Included as part of the framework, he Effective Teaching Practices Rubric (ETPF) offers formative feedback in relation to teacher effectiveness.

MAKERSPACES AS EDUCATIONAL LEARNING ENVIRONMENTS

Makerspaces in schools have grown out of the maker movement (Dougherty, 2012) where making activities are primarily found in adult, out-of-school spaces (Martin, 2015). Halverson and Sheridan (2014) define the maker movement as "the growing number of people who are engaged in the creative production of artifacts in their daily lives and who find physical and digital forums to share their processes and products with others" (p. 496).

Educational makerspaces are in part linked to Papert's theory of constructionism (1986), which "involves two intertwined types of construction: the construction of knowledge in the context of building personally meaningful artifacts" (Kafai and Resnick, 1996, p. 1). Having the ability to physically make, test, analyse, rethink, remake, and retest, as often as needed allows for deep learning on student's terms. Educational makerspaces encourage students to tinker with objects and ideas in order to develop significant conceptual understanding.

BUILDING MAKERSPACE PEDAGOGY

As part of final requirements for her MEd degree (2014), and before beginning the work in the makerspace, Becker, who led the first iteration, researched extensively in the areas of constructionism (Kafai and Resnick, 1996; Stager, 2013), the Reggio Emilia approach (Thornton and Burnton, 2005), and design thinking (Gow, 2012; Kafai and Resnick, 1996). From her research, she developed a list of desirable elements that would lend themselves to a makerspace environment. Becker, in guiding teachers, impressed upon them that work in the makerspace is 1) iterative, 2) real world problem based, 3) collaborative, 4) interdisciplinary, 5) process driven, 6) well documented, and 7) non-linear. In designing and collaborating in the makerspace with staff, these elemental ideas were kept in the forefront, but not just for students. Becker wanted teachers to see the makerspace as a place of learning for themselves, where they were encouraged to take risks, and make adjustments throughout their learning process.

THREE MAKERSPACE CASE STUDIES

In introducing the makerspace concept to the school, free tinkering was offered at lunchtime, but Becker felt that adding design tasks that connected to curriculum topics was another important way to demonstrate the potential of the space. The following are examples of curricular projects conducted within the school makerspace.

Grade 3 Bridge Building

Friesen (2009) states that today learning opportunities need to be "thoughtfully and intentionally designed to engage students both academically and intellectually" (p. 4). With grade 3 classes, introducing the makerspace concept involved a redesign of a traditional bridge building unit. Previously, the teachers had used an activity booklet, where the students conducted specific teacher selected "experiments" followed by a written record of their conceptual thinking based on the experiment results. When Becker suggested that teachers present a design challenge in which students build bridges that could hold at least 10 kg, reaction was sceptical that their students would be capable of this task. The teaching team wanted to continue to use the booklet before going to the makerspace, to ensure that the curricular outcomes listed in the program of studies were covered. With some negotiation, the traditional booklet approach was abandoned.

The Effective Teaching Practices Rubric (ETPR) found in the TEF states learning experiences should "engage the students in doing work that require[s] distinct ways of thinking and acting in the world that particular disciplines embody" (Friesen, 2009, p. 7). In the makerspace, teachers came to see that students' acting as structural engineers was an important part of the learning process. As well, guest speakers, videos, and print materials were selected not just to introduce scientific content, but also to familiarize students with the work of bridge builders, so that they could imagine themselves in that role. Before stepping into the makerspace, students met in collaborative teams, sketched ideas, selected a design, and then drew up blueprints.

While building, and as part of the assessment design, each engineering team used an iPad to photograph problems they experienced in the building process, followed by a photo record of how those particular problems were addressed. Students also completed a written reflection after each building session. Initially, teachers found that the reflections were superficial, at best. As part of the iterative nature of makerspace work, Becker suggested to teachers that rather than write about what they did as engineers-in-training, students should focus on problems they encountered and how they addressed them. This resulted in richer student reflections, not only in terms of understanding the scientific concepts involved in building with materials, but also in working through collaborative difficulties, and keying in on the habits of mind required of bridge builders.

When the bridge building work was completed, Wuitschik unintentionally forgot to photograph her students' finished products. In professional dialogue, she articulated that "forgetting" demonstrated for her how the focus in the makerspace had shifted to process, as opposed to finished product. This move from assessment of artefact to assessment for learning allowed her to see her students learning needs and strengths in new ways.

As conceptual misunderstandings arose in the makerspace, teachers took it upon themselves to address those in class, at point of need, and often through demonstrations. This connects to the ETPR (Friesen, 2009) descriptor which states that teachers ". . . help students to learn how, when and why to use different strategies and technologies that provide hints, clues, or other feedback as the students' work progresses rather than at the end" (p. 11). It became evident that the original booklet design did not address the individual learning needs of students, but rather satisfied the curriculum and reporting needs of teachers.

Grade 2 Magnet Play

The makerspace became a place to ask important questions about teaching and learning. As Friesen (2009) states, “The teacher works in collaboration with others to design robust learning tasks and obtain feedback about instructional planning from colleagues and mentors” (p. 12). Based on suggestions from Gabrielson (2013), teachers planned sessions for purposeful play with magnets to address key scientific concepts. Students were then given the task of designing a game that incorporated magnets.

While the children worked on game ideas, the classroom teacher conducted individual performance assessments with each student based on three main curricular outcomes. O’Connell was surprised to see that, even given ample time to play, some students had not internalized the key magnetic concepts. In reflecting on past practice, she came to the realization that traditional assessment methods that she had used consistently in the classroom were flawed. Working in the makerspace gave her time to watch her students and observe how they learned, promoting opportunities for discussion about teaching pedagogy, student learning, and authentic assessment. Questions that arose included, How can conceptual learning be scaffolded in the makerspace? Should small group direct teaching be part of this magnet work? Would debriefing and in-depth class discussion have strengthened conceptual ideas? Why did some children have great difficulty with conceptual understanding, yet demonstrate the ability to create innovative, thoughtful games? As a result of these and additional questions that surfaced, several important changes will be incorporated in the next design iteration with magnets including small group scaffolding built in to the design, a visit by the local toy store owner to learn about the characteristics of an excellent toy in order to develop toy design criteria, and adjustments to assessment practices.

The design of makerspaces and the iterative work that happens in the process often changes the relationship between teachers and children, allowing for many natural dialogical opportunities. As students played with magnets and designed and developed their own games, teachers were able to freely engage with individuals to ". . . extend learning, stimulate discussion, pose questions, provoke thinking, suggest resources and help students determine their next learning steps" (Friesen, 2009, p. 11) . Teachers were able to see that the makerspace provided more opportunities for formative feedback that was timely and tailor made to each student.

Grade 1 Town Build

The interdisciplinary grade one makerspace activity involved combining outcomes from science, social studies, and language arts. As part of social studies, students were asked to reflect on their community of Canmore, what they liked about it, and what they thought was needed to make it better. Though many children suggested physical ideas, such as a movie theatre, others spoke to the notion of making the town a more caring place. Work in the makerspace included building a 3-D map of the town, so that the students could "see" its layout. Brainstorming a list of their favourite buildings, students were given a photo of one and asked to recreate the building using Lego blocks. This connected to the science outcomes of constructing model buildings and comparing them for similarities and differences. Buildings were placed on a giant paper map in the library. It was amazing to see how "emotionally and intellectually invested in the work" (Friesen, 2009, p. 10), students became in seeing their town come to life. For example, after the Safeway store was placed, students of their own volition added parking spaces, and shopping carts, "because people will need those for their groceries." The map, which was displayed in the learning commons, became a centre of interest for all students in the school. They loved to search out and recognize their favourite buildings, getting a sense of its location in relation to the rest of the town. Again the makerspace became a place for teachers to ask questions, such as Should some free play with Lego happen first for those students who have not used the material and find it challenging? Should students receive direct instruction as to how to make their walls stronger? How do we assess in an interdisciplinary environment? Not only did teachers think about their students in new ways, they also thought about their teaching practice.

CONCLUSION AND NEXT STEPS

Though this was the first iteration of this makerspace, it is evident from teacher discussion and comments that their work connected immediately to the TEF. As further evidence, when the Galileo Educational Network called for teachers to share a project within their school district that conveyed the principles embodied within the TEF, all three were presented as exemplars. Based on this initial study, it would appear that inherent in the design of makerspaces is the opportunity to develop principles of teacher effectiveness.

However, this is not to say that creating a school makerspace is without challenges. Becker was hired in a consulting role to lead the development of this project. Having a designated leader on staff with the pedagogical background in makerspaces who guides this work and continues to move the staff forward is critical to its success. Having the funds, expertise, and staff available may make this a challenge.

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