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Exploring Maker Cultures and Pedagogies to Bridge the Gaps for Students with Special Needs

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Abstract. Through this ethnographic study, the researchers investigate the efficacy of using "makerspace" pedagogies with students who are identified as having special needs. These pedagogies include the transferable skills and global competencies as outlined by the Ontario Ministry of education. The research questions address how teachers view changes in his/her special education students' behaviour and learning based on their participation in maker-related activities, including, but not limited to coding, programmable robots, and circuits, in the classroom. Teachers were supported through professional development by our STEAM 3D Maker Team at the Faculty of Education and then subsequent visits made to each of 20 different schools investigated how maker pedagogies were being employed. Qualitative data was collected in the form of digital video and audio recordings, photographs, observational field notes, and individual and focus group interviews. The data suggest that the use of maker pedagogies can facilitate a number of improved outcomes for students with exceptionalities, including confidence and perseverance, engagement and motivation, self-regulation, collaborative skills, and increased academic achievement.

1. Introduction

Comprised of individuals with an interest in engineering, the arts, or those with a curiosity and a desire to create, the "maker movement" encompasses people from all walks of life who take pleasure in the design, production, and sharing of physical or digital artifacts[13][19]. This movement has inspired the construction of makerspaces worldwide, where people of all ages and levels of expertise gather to bring their ideas to fruition, often with the help of coding, fabrication, and other commonly regarded "maker tools [12][28]. Infusing these technologies into the traditional crafting and construction activities undertaken by youth promotes the development of skills typically associated with science, technology, engineering, the arts and mathematics, also referred to as STEAM education [7]. Furthermore, by becoming producers, rather than solely consumers, of technological products, youth become creative, proficient problem-solvers [5][12].

Although schools have been slow to utilize digital technologies [16], integrating making and maker pedagogies into the classroom could facilitate the growth of modern knowledge and skills [5][12]. Derived from makerspace practices, these pedagogies embrace a more flexible approach to learning by encouraging students to tackle projects they are passionate about with the tools and processes of their choosing [6][28]. In doing so, this approach promotes inquiry-based learning, critical thinking, problem-solving, collaboration, perseverance [16][19], and the global competencies identified by the

Ontario Ministry of Education (2017b). Making can also function as a bridge between creativity and curricular content for students who struggle in traditional classrooms [1][6].

Given the affordances of making and the recent trend towards adopting maker pedagogies in schools, there is a continued need for research into best practices for education. To that end, this study sought to gain insight into the value of maker pedagogies for learning, particularly with students that are often disadvantaged by traditional methods. Approximately a year after providing targeted professional development, an infusion of resources, and ongoing support to establish makerspaces in 20 school boards across Ontario, Canada, we asked teachers, school support staff, and administrators to describe the impact of these pedagogies on their students with exceptionalities and their overall classroom learning environment. The questions guiding this research asked:

1. How do elementary school teachers believe that maker pedagogies impact students with exceptionalities?
2. How has the shift towards the adoption of maker pedagogies impacted their classroom learning environment?

2. Literature Review

In contrast to traditional instructionist teaching methods, maker pedagogies have emerged from a combination of student-centred, inquiry-based approaches. Constructionism is credited as the primary inspiration behind the maker movement due to its emphasis on experimentation, problem-solving, and fabrication [13]. Working with tools and materials to design, create, and share products of learning enables students to develop and reinforce conceptual understandings [15], particularly when the learning is personally relevant [27].

Maker pedagogies employ a framework of "low floors, high ceilings, and wide walls" that create an inclusive environment for learning. Proposed by Papert (1980) and later expanded upon by Resnick and Silverman (2005) [27], the "low floors" in making refer to the careful selection of tools and strategies that allow for participation without prior experience, while the "high ceilings" provide space for complex, sophisticated projects. The addition of "wide walls" ensures that the making process is flexible and accommodating, allowing students to pursue varied interests [27].The inherently collaborative nature of the maker movement promotes teamwork and communication, encouraging students to take on various participation and leadership roles [2][28]. Finally, making can be implemented across the curriculum to support a balanced, integrated approach to education [11][28]. A focus on the arts in making has prompted the shift from STEM towards STEAM education, allowing students to express their learning in creative and personally meaningful ways [12], while drawing on fundamental mathematics, engineering, science, and technological principles [5]. This versatility, in conjunction with the focus on student-centred, inquiry-based learning, allows maker pedagogies to support education across all ages and abilities.

Ontario's dedication to inclusive and equitable education means that classrooms have become diverse learning spaces, promoting academic growth and success among diverse student populations [21]. Teachers must become skilled differentiators, with the ability to provide targeted, personalized instruction for students with various communication, behavioural, intellectual, and physical exceptionalities [22]. Narrowing the achievement gap that separates students with exceptionalities from their peers requires developmentally appropriate skills and strategies that can be difficult to facilitate in instructive contexts [9]. Additionally, a lack of self-confidence and academic self-efficacy in exceptional students contributes to less effort invested in class [18]. However, curricular programs that are hands-on and participatory [10][18] facilitate the development of appropriate skills and strategies [9], and integrating multimodal tools to enhance students' engagement and ability for self-expression [10][16] can help address these challenges.

Makerspace pedagogies offer teachers a unique approach to reaching their students while also accounting for the growing needs of today's learners. The Ontario Ministry of Education (2017b) [23] defines transferable skills through a global competencies framework, which includes: critical thinking, innovation and creativity, self-directed learning, collaboration, communication, and citizenship. Through the integration of these skills in the classroom, educators better prepare students to be able to make more meaningful connections between what is learned in the classroom and students' personal life experiences [8][3]. These skills extend past the traditionally utilized 'soft skills' and are more industry-relevant, offering opportunities for wider connections to be made to the community at large [17][29][25][20]. Overall, these competencies encourage teachers to think past simply quantifying and assessing students' retention abilities, and to explore what information they are constructing to add to the greater knowledge community [29].

Research has identified that maker pedagogies can benefit students with diverse learning needs [14]. Engaging in self-directed, hands-on, exploratory activities, such as coding programmable robots, can help reduce behavioural issues and increase students' motivation to learn [26], while the emphasis on personally relevant projects promotes engagement [1][14], creativity [30], global competencies, and fluency in curricular content [16]. The "low floor" provides numerous entry points for students with diverse needs and abilities [30], and the failure-positivity of the maker movement encourages students who traditionally struggle in instructivist learning contexts to persevere through challenges, both in and out of the classroom [16].

3. Methodology

3.1. Participants

The participants in this study came from 20 school boards across Ontario. The assortment of elementary schools was comprised of a representative sample of English, French, public, and Catholic boards. Each school selected three teachers to work in interdisciplinary, cross-curricular teams to promote, observe, and evaluate the impact of makerspaces and maker pedagogies on their school communities and students. These teachers ranged in position, with participants coming from primary, junior, and intermediate divisions, as well as some teacher librarians (TL) and special education resource teachers (SERT). Each school was afforded support and professional development opportunities from the research team during the implementation of their new makerspaces, tools, and activities.

3.2. Setting

This study took place in three main locations: a research lab at a university in Southern Ontario, the respective schools that were participating in the study, and online through social networking platforms, including TeachOntario in the first year of the study, and Twitter during the second. Initial professional development (PD) sessions were held at the university, where participants and other stakeholders in the project, including administrators, Ontario Ministry of Education representatives, and STEM/STEAM coordinators for the school boards, were exposed to a variety of maker technologies, and pedagogies. Once these PD sessions concluded, the research continued at their host institutions, where participants took on-site, real time video and photos of their students and spaces as they developed. The research team also visited the schools to conduct additional PD, take notes, photos, and videos, as well as conduct additional interviews. Participants were invited to participate in and contribute to an online Professional Learning Network (PLN) on TeachOntario, where they had access to a Science consultant as well as the research team. There was limited uptake with this platform, so in the second year of the project the research team shifted the PLN onto Twitter, where participants were encouraged to use #makeON to ensure that all interested stakeholders could easily locate the tweets as they were shared.

3.3. Data Collection & Analysis

A mixed methods approach was used for this study – primarily qualitative case study practices, with each case consisting of a different school. Quantitative data was collected in the form of online questionnaires completed individually by the participants. In order to better understand teacher participants' experiences and learning, qualitative, ethnographic case study techniques were used. Data collection included a variety of quantitative and qualitative measures. Pre- and post-interviews were conducted with each participant team to gauge their growth and development of their perspectives over the course of the study. This allowed the research team to gain a more holistic view to the experiences and expectations of the participants. Surveys were completed at the beginning and the conclusion of the project. The interviews were conducted halfway through the school year as well as at the final research team visit, usually occurring during the school's makerfaire. Digital video and audio recordings were taken both at the research laboratory and the host schools during the professional development sessions as well as during the research team visits and interviews. Additionally, members of the research team created field notes and observational notes to supplement the photos and videos.

In order to complete analysis of the data, several layers of thematic coding were used as well as triangulation techniques. Interviews were transcribed and the transcriptions followed traditional coding protocols [31] as they related to the research questions. These codes were compared across the cases so that repetitive and overlapping patterns could be identified [4].

4. Findings

At the midpoint of the study, 11 of the 20 participating school boards had sufficient data to analyze. We consider these school boards to be representative of our larger sample, given their distribution across rural and urban cities in Ontario. Participants provided insight into their experiences with maker pedagogies in their schools, including their perceptions of the impact of making on their students with exceptionalities, and their interpretation of how these pedagogies have impacted their overall classroom context.

5. Perceptions of Impact on Students with Exceptionalities

Achievement and subject expertise. Several participating teachers expressed that maker pedagogies offered alternative ways for their students to demonstrate their understanding of curricular content and develop global competencies. After observing a student with a learning disability excel using virtual reality, one vice-principal noted, "if that child just used paper and pencil, two things: one, we may not get that level of thinking out of that child, and two, he wouldn't be in a position where he is the expert in front of his peers."

Another participant identified that making primed students for participation in more traditional learning activities. Describing a first-grade student who often has trouble at the beginning of each school day, one teacher mentioned, "the building and making time, the quiet time when he's thinking and building and carrying on from yesterday, it's just enough to get into that learning brain."

Confidence and perseverance. Participants also noted that the self-directed learning and failure-positivity emphasized by maker pedagogies encouraged students to persevere through challenges and perceived setbacks in unprecedented ways. One teacher expressed, "that whole perseverance piece is showing up with the makerspace and with kids that you maybe don't expect, like some of my [students with exceptionalities] … they're proud of themselves." Making encourages experimentation and iteration, providing students with multiple opportunities to achieve success.

Self-regulation. Over half of the participating schools described the positive impact that making has had on their students' abilities to concentrate and self-regulate. Engaging students in the hands-on construction of physical or digital artifacts allowed students from one school to "focus in and be calm and to regulate again." Several teachers corroborated the role of making in enhancing focus, and one mentioned that their students had requested a "makerspace corner" for this very purpose: "they are focused on what they're doing. Maybe if they're knitting or something, it's amazing … I always have the stuff out, the kids can go do something when they want to calm down."

Other teachers indicated that maker pedagogies encouraged students to pursue projects they were passionate about, which helped to reduce the incidence of discipline issues that were prevalent in traditional classroom instruction. Exemplifying this, one teacher shared:

> When you have something they're interested in, you don't have those problems. I have a little boy in Phys. Ed., and there's always an issue in behaviour. … One night we had a practice and I said, 'where is he?' He's in the corner engaged, building a robot, and it's completely different from when I saw him in the gym class because it was something he liked and he had something to do with his hands.

Despite the tendency of students with behavioural exceptionalities to struggle in classrooms that require students to remain seated and work quietly, maker pedagogies create a context for passion-driven, student-centred, hands-on work that can captivate students' concentration and focus unbridled energy.

Collaboration and leadership. Making encourages students to collaborate and share from the very beginning of the design process, and the "low floors, high ceilings, and wide walls" [27] promote collaboration across the academic spectrum. After observing the implementation of maker pedagogies in their school, a vice-principal explained that making facilitated “new learning partnerships that may not have existed in traditional classrooms.” Another teacher noted that “there is a lot of higher level thinking and problem-solving that is required [in making], so we do have some students who would struggle with that, [but] the collaboration helps.”

Teachers also described unexpected displays of leadership. Assessing the impact of maker pedagogies on their school, one principal explained that “students who have difficulty accessing the curriculum in traditional ways suddenly blossomed into leaders in the classroom environment.” Despite many of the participants initially being unfamiliar with maker culture, embracing these pedagogies enabled their exceptional students to not only succeed in their own learning, but to become active partners and leaders in the classroom.

Engagement and passion for learning. Participating schools ubiquitously identified an increase in classroom engagement among their students with exceptionalities. Noting that the use of digital tools was new for her school, one teacher described her students as “more willing to focus on the one task … rather than get bored of something and walk around the class.” Others mentioned that their students became so passionate about making that they were reluctant to disengage at the end of the school day.

Teachers explained that this was most evident among their students that were typically unmotivated by classroom activities. One student, described by his teachers as having “low engagement, struggles with reading, fine motor skills, et cetera,” had taken the initiative to create an apology letter to his teacher using a coding platform called Scratch Junior. Another participant explained,

> There have been a few students in my class who traditionally aren’t overly motivated, who don’t usually achieve a high rate when it comes to pencil and paper work, and some of them really love the opportunities to explore and to make.

Despite being disengaged by traditional learning activities, the student-centred learning and authentic practices espoused by maker pedagogies encouraged students with diverse interests and abilities to be engaged in the learning process.

6. Impact on Classroom Learning Environment

In addition to the individual impacts of maker pedagogies on their students with exceptionalities, participants identified aspects of their overall classroom context that had changed as a result of this project. By adopting an inquiry-based, student-centred, passion-driven perspective, teachers found that maker pedagogies alleviated the rigidity required by traditional learning environments, providing more opportunities for students to succeed. Several participants noted a shift in how they assess students’ learning, with one teacher describing the role of oral communication in the learning process: “being able to express yourself orally, that’s a huge improvement. For the kids who don’t usually like to talk, they’ll talk your ear off when they’re doing these things.” Another participant observed that making was a natural extension for traditional activities, “it’s great that it’s been there in the classroom. When they’re finished their work or need a bit of supplemental working, they’re invited to work independently on their projects.”

Establishing a dedicated makerspace, be it an entire room or simply a corner of the classroom, enabled students to extend their understanding of the concepts they were learning through more traditional methods or to pursue individual passion projects, thereby enriching their learning in other ways.

7. Educational Implications

Our research has shown that before these maker pedagogies can be effectively employed in the classroom, teachers need to participate in relevant professional development. The major implications resulting from this study were teachers' perceptions of the impact on students with exceptionalities and the effect that these teaching methods have on the classroom learning environment.

This study has emphasized that students, particularly those who are identified as having exceptionalities, benefit from the use of interest-driven, inquiry-based maker pedagogies. The educators involved in this study noted that the greater flexibility of this type of teaching had a substantial impact on their students. Teachers shifted away from the rigidity of formal lesson plans, as they observed their students becoming leaders of their learning by remixing tasks to account for their individual needs and goals. Ultimately, maker pedagogies encourage students to take ownership of their learning in a way that is both supported by the curriculum as well as the classroom teacher.

By leveraging the maker technologies and pedagogies available in the classroom, teachers are able to expose their students to novel ways to approach their learning. Students are better able to tackle complex tasks using a variety of global competencies as well as the maker tools that they are presented with. Maker pedagogies encourage teachers to critically assess their current practice and reimagine it in a way that encourages their students to be producers of knowledge and content, rather than passive consumers of it.

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