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Teaching with Sandbox Games: Minecraft, Game-Based Learning, and 21st Century Competencies

Enseigner avec les jeux Sandbox: Minecraft, l'apprentissage par le jeu et les compétences du 21e siècle

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Abstract

In this paper, the findings of a research study, working with 12 educators in a large urban school board in Ontario using Minecraft for 21st century competency development, are presented. A number of pedagogical moves teachers made to support 21st century learning through communication and collaboration, both in the classroom and in the game world, are identified along with three approaches to play, directed/ guided, scaffolded, and open, that represented critical thinking and creativity/innovation. This study argues that while an open, exploratory sandbox game such as Minecraft can meaningfully aid students in the development of 21st century competencies, it is in fact teachers' decisions around how the game will be used in the classroom that determines whether or not 21st century competency development is supported.

Keywords: Digital game-based learning; 21st century competencies; Pedagogy; Minecraft

Résumé

Dans cet article, nous présentons les résultats d'une étude de recherche menée auprès de douze éducateurs d'une grande commission scolaire urbaine de l'Ontario qui utilisent Minecraft pour le développement des compétences du 21e siècle. Nous identifions un certain nombre de mesures pédagogiques prises par les enseignants pour soutenir l'apprentissage du 21e siècle par la communication et la collaboration, à la fois dans la salle de classe et dans l'univers du jeu, ainsi que trois approches du jeu, dirigé/guidé, échafaudé et ouvert, qui représentent la pensée critique et la créativité/innovation. Nous soutenons que si un jeu de *sandbox* ouvert et exploratoire tel que Minecraft peut aider de manière significative les élèves à développer les compétences du 21e siècle, ce sont en fait

les décisions des enseignants sur la manière dont le jeu sera utilisé en classe qui déterminent si le développement des compétences du 21e siècle est soutenu ou non.

Mots-clés : Apprentissage par le jeu numérique ; compétences du 21e siècle ; pédagogie ; Minecraft

Introduction

School boards across Canada have taken an interest in student 21st century competency development. Broadly defined, 21st century competencies refer to the skills required to be successful in our increasingly interconnected globalized knowledge economy. While 21st century competency models vary (Dede, 2009; Voogt et al., 2011), they typically include elements of creativity, innovation and entrepreneurship, critical thinking, collaboration, communication, character building, culture and ethical citizenship, and computer and digital technologies (Canadians for 21st Century Learning and Innovation, 2012). In Ontario, the province in which this study was conducted, 21st century competencies do not appear in the curriculum, but rather, are promoted in a policy document (Ontario Ministry of Education, 2016) which champions four competencies: critical thinking, requiring students to "acquire, process, interpret, rationalize, and critically analyze large volumes of often conflicting information to the point of making an informed decision and taking action in a timely fashion" (p. 12); communication, which refers to listening paired with effective communication using a wide variety of modes (e.g., oral and written) and tools; collaboration, meaning adopting the role as content producers, while demonstrating the capacity to learn alongside others; and creativity and innovation, developing new ideas to solve problems, and carrying them to fruition (Ontario Ministry of Education, 2016). A number of school boards have also begun to develop their own 21st century competency frameworks which involve some combination of these skills (Durham Catholic District School Board, 2020; Ottawa Carleton District School Board, 2020; York Region District School Board, 2018).[1]

While interest in 21st century competencies remains high, policy makers and educational researchers have long argued that intensive support for professional development is urgently required for the wider modeling, uptake, and board-wide sharing of innovative pedagogies and practices that can amplify the opportunities provided by digital technologies for 21st century learning (Hargreaves & Fullan, 2012; Thumlert et al., 2018). This is especially important given that the Ontario Ministry of Education (2014) has identified "invest[ment] in innovative teaching practices and instructional methods enabled by technology" (p. 6) as a key priority area, echoed in 2016 as a call for "transformations in pedagogical practice, new learning partnerships, enhanced use of digital tools and resources, and physical and virtual spaces designed to support [the] learning [required] to ensure students' development of 21st century competencies" (p. 23). Relatedly, research demonstrates that digital games are an effective tool for leveraging the development of 21st century competencies in young people (Barab &

[1] While it lies outside of the scope of this article to provide a detailed critique, we do acknowledge here the limitations of 21st century competency frameworks. In many respects, competency frameworks are inherently capitalist. They adhere to a competitive individualistic logic, in their focus on developing skilled workers without any regard for establishing a communitarian ethos (Tan et al., 2015; Kivunja, 2014). As a result, schooling is reduced to skill development in support of capitalist ends, rather than the cultivation of well-rounded human beings.

Dede, 2007; Romero et al., 2015; Steinkuehler, 2007). Research on the use of digital games in education supports their positive impact on student learning (Hébert et al., 2018; Jenson & de Castell, 2011; Jenson et al., 2016; Kirriemuir & Mcfarlane, 2007; Muehrer et al., 2012; Pivec & Pivec, 2008). However, little research has been conducted on the pedagogical practices teachers can employ for digital game-based learning (DGBL) (Hébert & Jenson, 2019) and on those, specifically, that support 21st century learning.

In this paper, findings of a research study, working with 12 educators in a large urban school board in Ontario, are presented. The aim of the study was to better understand both the pedagogical moves teachers made to support 21st century competency development and teacher views of Minecraft as a means of supporting 21st century learning. The questions that guided this study were the following: 1) in what ways did teachers approach 21st century competency development through Minecraft? and 2) how did they conceive of Minecraft as a tool for collaboration, communication, critical thinking, creativity, and innovation? We begin with a review of the literature on DGBL and 21st century competencies and digital game-based learning and pedagogies, before detailing the study and outlining its findings.

Literature Review

Minecraft and Digital Game-Based Learning for 21st Century Competency Development

DGBL has been said to support the development of 21st century competencies in players, including critical thinking (Gentile et al., 2019; Hussein et al., 2019; Tung, 2019), collaboration and communication (Checa-Romero & Pascual Gómez, 2018; Hämäläinen & Oksanen, 2012; Leemkuil et al., 2003), and creativity and innovation (Hsiao et al., 2014; Ott & Pozzi, 2012). When it comes to digital games and 21st century competencies, it is important to note that not all games are designed equal. Digital games that are used in educational settings commonly adopt behaviourist or cognitivist approaches to learning, focusing on rote memorization or drill and practice of basic facts and/or skills (Egenfeldt-Nielsen, 2006; Hanghoj, 2008; Squire, 2011), approaches that are largely antithetical to 21st century competency building.

Minecraft is a first-person, multiplayer sandbox game originally created by Mojang studios (Mojang, 2020) and now owned by Microsoft (Microsoft, 2020a). Minecraft allows players to design virtual environments as their avatar moves along a grid, gathering, placing, and constructing 3D objects (Callaghan, 2016). The game can be played individually or with multiple players, using a number of modes, the two most popular being survival where players must maintain their health to survive, and creative which allows players unfettered access to goods. In 2016, Microsoft released Minecraft: Education Edition, targeted at teachers in the inclusion of classroom controls and a variety of resources such as lesson plans and assessment tools (Microsoft, 2020b).

Unlike drill-and-practice games, Minecraft is explicitly marketed as a tool for cultivating 21st century skill development with Microsoft claiming that the game "helps prepare students for the future workplace, building skills like collaboration, critical thinking and systems thinking," particularly as

students navigate the "open learning environment," which "gives [them] the freedom to experiment, encouraging self-expression and problem-solving" (Microsoft, 2020c).[2] In many ways, the structure of Minecraft might lend itself to 21st century competency building; it is seemingly devoid of an objective and does not come with an accompanying instructional manual (Apperley, 2015; Simon & Wershler, 2018); its open-endedness, and users' subsequent reliance on the player community, calls for both collaboration and communication as players devise and share tips and tutorials and creativity, as players produce modifications that ultimately "transform[] the game environment" (Cipollone et al., 2014, p. 4).

As Minecraft has been touted "one of the most widely played and popular video games of all time" (Simon & Wershler, 2018), it is not surprising that the scholarly community has taken interest in the game. Looking specifically at 21st century competency development through the use of Minecraft, Morgan (2015) examined how the game fostered the cultivation of 21st century skills in youth who regularly played at home. Using player self-reports about who they communicated with about gameplay, and whether or not they created, problem solved, designed, and made decisions while playing, Morgan concluded that the amount of time players spent on the Minecraft platform was directly correlated with levels of design, decision making, and planning, meaning the more time spent, the deeper the player was engaged with these processes. Morgan also found that the multiplayer platform specifically enabled players to solve problems collaboratively and offered opportunities to use critical thinking skills. Similarly, working with 10 and 11 year-olds at an after-school club, Bailey (2016) investigated how students communicated with one another while engaged in gameplay. Focusing on songs as a form of collaboration and creativity, Bailey's work sheds light on the importance of evaluating student play in situ, or beyond the virtual game environment, in order to gain a holistic understanding of how students are not only interacting with one another, but also building meaning. Voiskounsky et al. (2017), looking at young adults, contrasted creativity of players who used Minecraft individually with those in pairs, measuring the number of ideas that players used during construction as evidence of creativity. Findings suggested that players had more ideas, and thus were more creative, when working individually. While one might raise questions about the methodology here, evaluating creativity quantitatively rather than qualitatively, the study importantly disrupts the notion that one element of 21st century competency development, creativity, is necessarily supported by another, in this case, collaboration. In the next section, we shift to DGBL and pedagogy.

Digital Game-Based Learning and Pedagogies

Very little has been written about DGBL and pedagogy. As argued elsewhere (Hébert & Jenson, 2019) in the literature on DGBL, the classroom teacher is regularly positioned outside of the learning process, with students acquiring understanding through direct interaction with the game. Congruously, support for teachers around DGBL often centres on establishing familiarity with the game, identifying theories of learning inherent within the game, or recognizing the manner in which the game supports

[2] How specifically these competencies might be developed by playing Minecraft will of course vary depending on the definition of 21st century competencies one references.

learning in particular subject areas rather than on specific pedagogical strategies (e.g. Becker, 2017; McNeil, 2018). Only a handful of studies have explored the specific ways in which teachers might approach teaching with digital games, including requisite competencies (Nousiainen et al., 2018), various roles adopted by the classroom teacher in facilitating DGBL (Marklund & Taylor, 2015), and best practices for supporting DGBL in classroom spaces (Hanghoj, 2008). A few attempts have also been made to articulate a pedagogical framework for DGBL (Denham, 2019; Foster, 2012; Shah & Foster, 2015), including our own digital game-based pedagogies framework (Hébert & Jenson, 2019), which represented some of the successful approaches to DGBL we witnessed through classroom observations and conversations with teachers.

With respect to research around Minecraft in classrooms, Pusey and Pusey (2015) evaluated the effectiveness of Minecraft as a tool for teaching science in three year 8 classes in Perth, Australia using a standardized curriculum. Results of a student survey and teacher observations demonstrated that using Minecraft increased student interest in ICT and engagement in science classes. In a similar study, Callaghan (2016) examined the use of Minecraft to support project-based learning among students at a high school in Sydney, Australia. Survey results indicated that Minecraft enabled collaboration among students and enhanced engagement, the development of cognitive skills, and students' production of authentic tasks. For Callaghan, the teacher's role in using Minecraft to support learning in the classroom was relegated to verifying student work had been completed properly; otherwise, the teacher "had no impact on how engaged students were with Minecraft Edu or their ability to direct their own learning or work collaboratively as this occurred automatically" (p. 258). However, it is noted that this framing ignores the work of the classroom teacher, both in constructing meaningful lessons for 21st century learning and engaging in pedagogical decisions such as whether or not the students will work together within, or outside of, the game platform. For example, authentic task creation was lauded by Callaghan, as students "turn[ed] their semester long [project-based learning unit] of researching and investigating the design elements of a process of designing their dream home…into an actual architectural structure in Minecraft" (p. 253), but attributed to Minecraft, rather than innovative planning on behalf of the educator. Finally, focusing a bit more explicitly on the classroom teacher, Cipollone et al. (2014) conducted a case study on an English teacher's use of Minecraft to foster learning of literacy concepts. They concluded that Minecraft provided a space for students to engage creatively with a literature unit and that Minecraft supports constructivist learning, which promoted knowledge building through exploration and experimentation. Notably, the authors stressed that how the game was implemented, including instructional strategies teachers employ, plays a crucial role in supporting creative learning through Minecraft.

The Study

Workshop

For this project, we worked closely with our research partner, a large urban school board in the Greater Toronto Area. The board has adopted a rather comprehensive policy for empowering modern learners, which includes a 21st century competency framework, centring on collaboration, communication, problem solving and critical thinking, creativity and innovation, global citizenship, and learning to learn (Peel District School Board, 2016). The board was interested in teacher professional development around 21st century competencies and digital games and decided upon Minecraft as the game of focus.

The professional development workshop was framed by a production pedagogies approach (Thumlert et al., 2015) where participants engage with or perform a task before they have a comprehensive understanding of it. Performance before competency "signals a 'short cut' to participative agency, a circumventing (by other means) of traditional suppositions that state that 'basic' literacy rudiments must be meted out and mastered before actors can truly think or design, perform or take part in common" (Thumlert et al., 2015, p. 799). This means moving away from a more didactic instructional approach, leading potential players step-by-step through game mechanics, toward open-ended exploratory play. Utilizing production pedagogies in a teacher-focused professional development session enables modeling of the play-based process, demonstrating that teachers need not be experts at specific games before introducing them into their classrooms, and that they can learn about the game alongside their students.

The single-day workshop was hosted at the board office. After a brief introduction to Minecraft, led by one of our collaborators from the board, teacher participants were divided into small groups and given a series of mini challenges to complete in Minecraft: create a sustainable house, an innovative roller coaster, or an underwater filtration system. A student "expert" attended this part of the session and circulated to answer questions, provide general guidance, and to chat with groups about his own experience as a student using Minecraft in the classroom. At the end of this part of the session, participants were given the opportunity to share what they had completed with the large group.

Following structured play with Minecraft, participants were provided a short introduction to DGBL, which included the authors' digital game-based pedagogies framework (Hébert & Jenson, 2019). A brief review of 21st century competencies was also provided, and the six board-based competencies named and described, with particular emphasis on the four Ministry of Education endorsed competencies. A free-flowing conversation followed regarding assessment of student learning through Minecraft before educators were divided into small groups to devise short curriculum units for their individual classes. For context, it is important to note that while all Ontario teachers use the same curriculum documents, teachers are given autonomy regarding how to take up curriculum in the classroom, and classes work at different paces. Rather than provide teachers with a packaged unit to "deliver" to their students, we offered time and space for imagining and thinking through ways in which

the game might be used to support learning in specific classrooms, according to the needs of particular students.

Participants

Fifteen educators attended the workshop, recruited directly by our partner board. Of these educators, one was a librarian/teacher dyad who would be working with the same group of students, and another, a librarian who would be collaborating with a classroom teacher who did not attend the workshop and who did not wish to participate in interviews. In total, 12 teachers from 11 classrooms were involved in the study, including one teacher-librarian. Teacher experience ranged from 3 to more than 15 years and teachers were from a mix of rural and urban schools. For purposes of clarity, we refer throughout this paper to 11 educators, grouping the participating dyad together as they shared the same classroom and teaching responsibilities.

Data Collection and Analysis

Data collection consisted of in-class observations of teaching, photos and videos of classroom activity, fieldnotes based on the observations, and interviews with teachers. Regarding observations, in total we visited each classroom four times, two prior to and two after the professional development (PD) workshop. The two visits prior to PD were designed to get a general understanding of classroom dynamics and participants' pedagogies. Post-PD day observations documented how participant teachers framed and made use of Minecraft as a 21st century learning object. Each interview was about 30 minutes in length. For the purposes of this paper, we report on educator responses to the questions around 21st century competencies, specifically, how 21st century competencies are developed through the use of Minecraft in the classroom. Data was coded using open-ended, thematic coding (Braun & Clarke, 2006; Clarke & Braun, 2017), with attention to the 21st century competencies: collaboration and communication, critical thinking, and creativity and innovation. In the next section we shift to our findings.

Findings

Collaboration and Communication

Based on the authors' observations, it appeared that all classroom teachers elected for the students to play Minecraft in multiplayer mode, thus creating the possibility for students to work together to complete learning tasks in the same game world. During observations, while often told that students were working together, it was not always clear what specifically students were doing to collaborate within the virtual world of the game; that said, students were not limited to collaborating within Minecraft. Conceiving of the learning environment as extending beyond the game and into the physical classroom, in 3 of the 11 classrooms visited, students were assigned a project that required in-person, collaborative group work; one or two group members worked in Minecraft, while other group members completed different facets of the project: taking notes, composing a presentation, and/or filling out other forms related to the assignment. It was clear that students were working together toward a

common learning goal. Collaboration was also encouraged through proximity, as in all 11 classrooms, the classroom was arranged such that students sat together in groups. This arrangement also aided in facilitating communication. In many instances, students were observed engaging in conversations about their learning, asking questions of one another as they moved through the game, or explaining what they were building and why. Communication was explicitly evident in two classes where students were required to deliver presentations about what they had constructed in their worlds, and in two other classes where students were preparing to give presentations.

Finally, during our classroom visits, two teachers expressed concerns around students being destructive in multiplayer mode, undoing the work of others by tearing down structures, or moving things around. This objectionable behaviour precipitated whole class conversations about respectful, collaborative gameplay. For example, Kathy's class composed a Minecraft agreement; students were required to "show kindness and understanding ([recognizing that] everyone has different experience levels and confidence)," engage in "cooperative teamwork (listen, divide work, ask questions, leadership not ownership," and demonstrate "respect (for yourself, others, and learning…including taking risks" (see Figure 1). Kelly's class produced a document outlining what collaboration to support learning in Minecraft should look like; collaboration referred to "shar[ing] ideas [and] knowledge" and engaging in "effective communication." Actionable steps students could take to communicate well were also listed: "[divide] work (plan)," "work together [on] big projects [to] save time," and "be encourag[ing]" (see Figure 2).

Figure 1

Minecraft Agreement

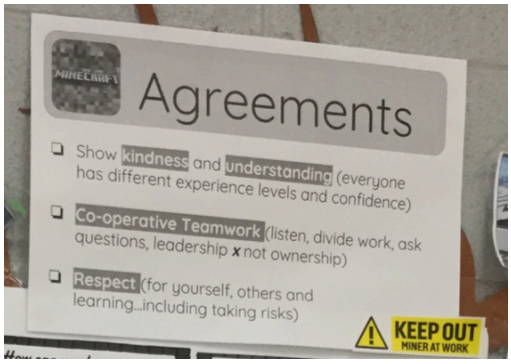
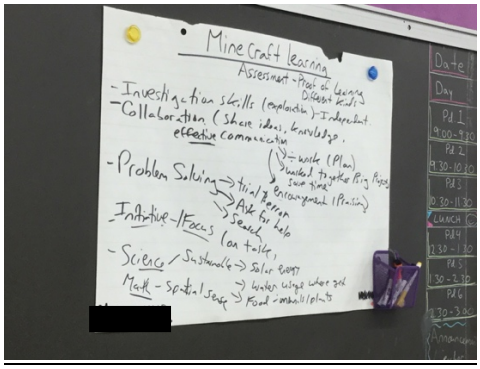


Figure 2

Making Minecraft Learning Explicit



Teacher Perceptions: Minecraft as Supporting Communication and Collaboration

In the interviews, when asked how 21st century competencies are developed through the use of Minecraft in the classroom, 10 of 11 educators spoke of collaboration. For some, collaboration was attributed to the structure of the game, insofar as the game provided space for students to "develop collective intelligence and to co-construct meaning, becoming creators of content as well as consumers" (Ontario Ministry of Education, 2016, p. 13). Kelly, for instance, described Minecraft as kind of "virtual maker space, where students are collaborating,…building together….[and] communicating while they do it." Marc noted that the game was structured around collaboration, inviting "people to come in and join to help create something." But for others, the elements of collaboration they called attention to could be attributed to the pedagogical decisions they made around how the game would be used to support learning in the classroom. For example, for Kate communication was crucial for project completion and she stressed that students need to "listen to other people's ideas when [they] are building something….If you had students going off completely building on their own and not reflecting with other students, their products were not as successful." Sue stressed that working in teams requires an acknowledgement of each member's strengths and necessitates conversations around what is feasible for a project. She said, "not everybody in the classroom…has the same skill set or [operates at the] same level. That really [required] them to sort of collaborate if they wanted to be successful… Some got a little too extravagant with their [Minecraft] structure, but the collaboration part [helped] keep their self-regulation in check."

Meaningful Learning Activities: Critical Thinking and Creativity/Innovation

Supporting student engagement in critical thinking and creativity/innovation through Minecraft was most clearly represented through the types of learning tasks teachers offered for students. All 11 educators who participated in the study were able to create meaningful learning activities, and only one relied exclusively on one of the activities offered to teachers during the workshop. Based on observations, the lessons teachers designed were classified as supporting one of three types of play: directed/guided, scaffolded, or open. These types of play are viewed as supportive of the critical thinking, creativity, and innovation elements of 21st century competency development and, accordingly,

open play, the one requiring the highest level of student autonomy, and directed/guided play requiring the least amount of critical thinking, creativity, and innovation.

The authors were not present for all of the lessons the teachers delivered around Minecraft, and therefore, cannot speak to all of the learning tasks developed. Based on observations of two classroom periods, three teachers (Kyle, Devin, and Sally) offered lessons that exclusively supported directed/guided play, four scaffolded play (Kelly, Tina, Claire, and Marc), and two open-ended play (Pabla and Saran). Two teachers (Kathy and Lance) provided lessons that fostered both directed and open-ended play.

Directed/Guided Play

Directed/guided play involved learning tasks that are more closed than open. These tasks narrowly focused on the development of a specific skill or deepening student understanding of a singular concept; the range of responses students produced were typically restricted, and production was constrained by a specific set of criteria. In this study, directed/guided play in Minecraft was evidenced by teachers' use of Minecraft to support learning of mathematical concepts through application, using critical, creative and innovating thinking to work with number lines, shapes, surface area, prisms, or ratios.

In Sally's class, for example, students began their work on surface area using physical 3D blocks, expanding surface area by adding and subsequently counting blocks in their structure (see Figure 3). Minecraft was introduced as a means for creating more sophisticated structures; students were tasked with producing a shelter with a flat roof, a pyramid, or any two additional structures with surface areas of $25m^2$ and 50 m^2. In Kathy's classroom, students also started the lesson outside of the digital platform. Working with operational sense, students used mathematical terms to explain an image projected onto the board from Minecraft before writing a math sentence about the image and plotting it on a number line (see Figures 4 & 5). Students then used Minecraft to create an amphitheater, explaining how they would arrange the seats, constructing a multiplication sentence, and plotting the sentence on a number line.

In other instances, students began to use Minecraft after a short introductory lesson. Kyle's students, learning about volume, were asked to create two shelter prisms, one where the volume of the shelter was numerically greater than its surface area, and a second where it was smaller. The period ended with a discussion about what students noticed in creating these objects, the challenges they encountered, and how these observations might be useful in the real world. In Devin's class, learning centred on Cartesian coordinates (see Figure 6). Students had to follow a set of directions to produce a Cartesian plane in Minecraft: use 35 blocks in all four directions, place a black block as the axis and a yellow block in every fifth position, and in quadrant one, put a black box in a number of different spots, before filling in the shape to create a triangle.

Figure 3

Students use 3D Blocks to Learn about Surface Area

Figure 4

Students Create a Number Line

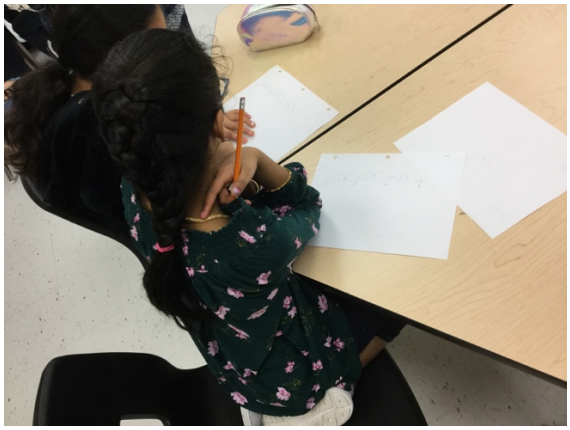


Figure 5

Minecraft Task: Explaining an Image Using Mathematical Concepts

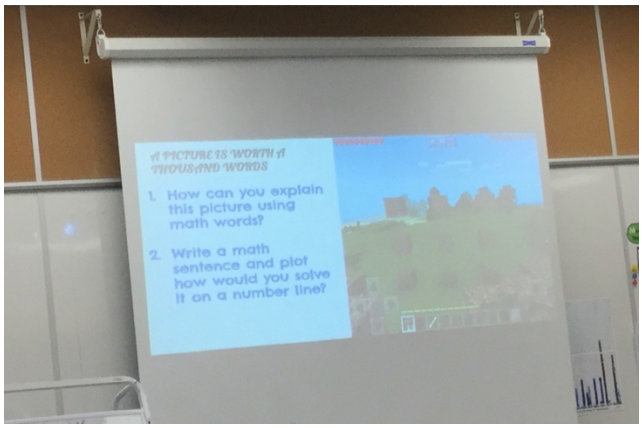
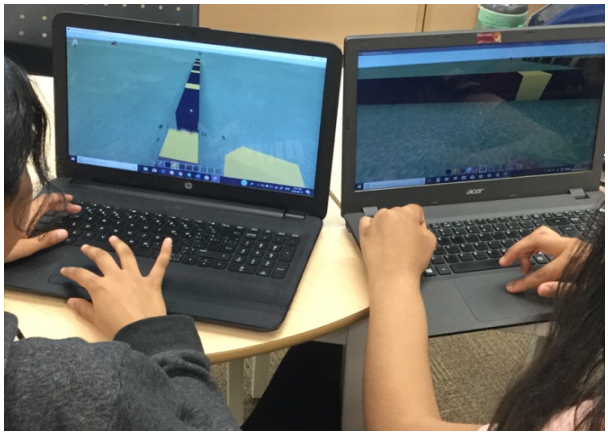


Figure 6

Students Create a Cartesian Plane



Scaffolded Play

Scaffolded play was represented by learning tasks that were more open-ended, involved multiple concepts, and allowed for more creativity/innovation, problem-solving and critical thinking; students engaged in design and project management, "acquir[ing], process[ing], interpret[ing], rationaliz[ing], and critically analyz[ing]" information (Ontario Ministry of Education, 2016, p. 13), and developed new and unique ways of solving problems. In Minecraft, in this study, students created a sustainable house, a natural disaster, a rollercoaster, a garden, and a parking lot. One teacher, Marc, offered two distinct lessons that nicely captured scaffolded play.

In Marc's first lesson, students were told that the parent council was asking students to come up with a proposal that would respond to a lack of parking in the current lot. Students were instructed to develop a design, determine how the design would increase the number of available spots, structure a budget for the proposed work, and decide on a timeline. The period started with a short lesson and overview of the task. The class then traveled out to the parking lot to complete measurements (see Figure 7) before returning to the classroom to conduct research and design their parking lot in Minecraft (see Figures 9 & 10). Roles were selected by group members and multiple devices were in operation in each group as students worked in pairs on each task. Marc stopped the lesson at one point to scaffold learning a bit, discussing the financial burden of constructing a multi-story parking garage. At the end of the period, students were asked to present their plans to the group.

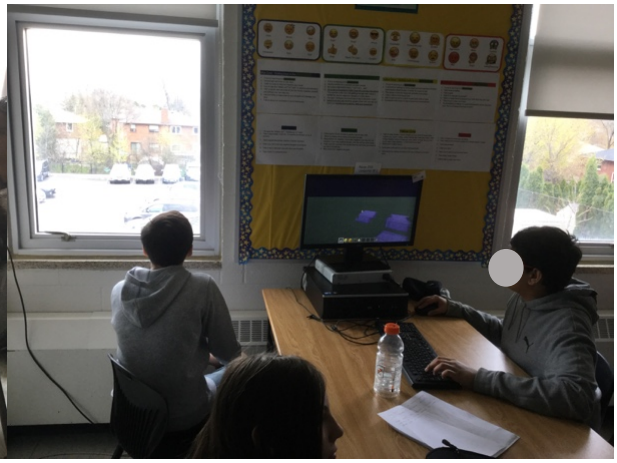
In Marc's second lesson, students were also assigned an inquiry-based task, challenged with devising a proposal that would provide grey water to water the garden next to the school. Students went outside to measure and take photos of the garden space (see Figure 8) and were instructed to pay attention to how water would be collected and transported to different parts of the garden, how plants might be organized to make the garden more efficient, and to consider how plots are planted. They then designed the garden using Minecraft (see Figures 9 & 10). Once again, pairs took on different tasks, with some students preparing the presentation while others built the garden in the game.

Figures 7 and 8

Students Complete Measurements of the Parking Lot and Community Garden Plot


Figures 9 and 10

Students Design New Parking Lot Infrastructure Using Minecraft

Figures 11 and 12

Students Create New Community Garden Plot on Minecraft

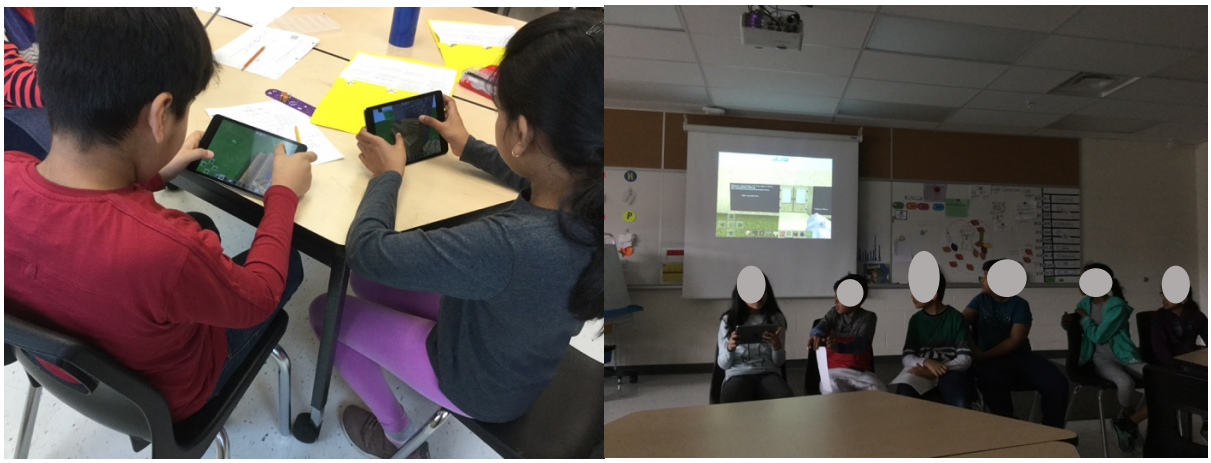

Open Play

In more open-ended learning environments, students were given quite a bit of freedom and flexibility over how they would demonstrate their understanding. Learning tasks required quite a bit from students in terms of critical thinking, creativity, and innovation, as little guidance was provided by educators through frameworks and templates. In this study, open play was apparent as students were asked to build a city, create Indigenous and settler communities as they would appear in Canada the 1700 and 1800s, and construct biomes.

The tail end of open play lessons in Kathy's class were observed. Using screencast, a projector, and an iPad, students gave tours of the biomes they had created in their Minecraft world. Groups discussed vegetation and animals that live in these spaces, and the impact of human involvement (e.g., global warming, pollution, deforestation) (see Figures 13 & 14). In Lance's class, students were instructed to transform their extant Minecraft desert biomes in order to make them more biodiverse. Lance led the students through a short discussion of biomes and ecosystems, before students were instructed to research and add plants to the digital environment. For this assignment, students compiled a set of field notes based on their research about specific plants. They exchanged facts for plants (e.g., a student presents five facts to the teacher about orchids, receives five orchids to place in their Minecraft world), and were rewarded for presenting more complex over simplistic information (e.g., what types of insects pollinate the plant, rather than how many leaves it had). Lance reminded students that they should place plants in the digital environment with attention to the types of conditions they require to thrive (e.g., trilliums require shade) (see Figures 16 and 17).

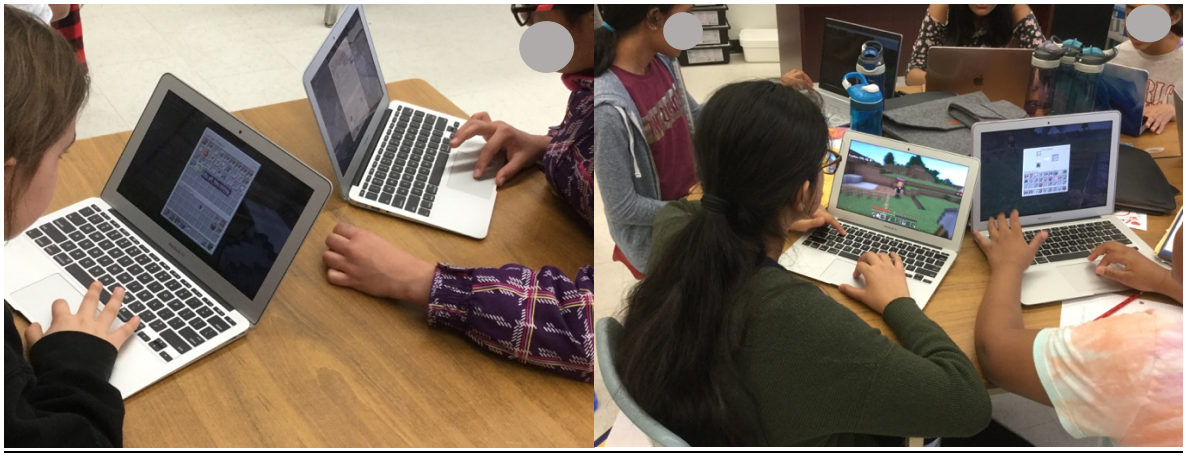
Figures 13 and 14

Students Design Amphitheaters and Present Biomes to the Class



Figures 15 and 16

Students Work to Make Their Biomes Biodiverse



Teacher Perceptions: Minecraft as Supporting Critical Thinking, Creativity and Innovation.

During interviews, six teachers identified the game as a means of fostering critical thinking and creativity and innovation. For Pabla, Minecraft calls for a transference of skills from classroom learning to the digital game environment, and this learning process involves creativity and innovation: "they have to be innovative to try and transfer their learning from the textbook of the research they did for Minecraft [to the game]. As they are integrating their knowledge, they're going to try to demonstrate it through creative[ity] and innovat[ion]." For all of the other educators who spoke of critical thinking, creativity and/or innovation, these elements were reflected not so much in the game itself, but in the learning activities they had created for students. For Kelly, creativity and critical thinking appeared in students' selection of materials: "In this project particularly, there's been a lot of critical thinking. They had to think about what materials they were going to build with in order to sustain their natural disaster, and that required a lot of thought." While we did not witness this specific lesson in our observations, Devin explained an assignment he had designed around a problem, "you know, I say 'I would like you guys to build a city that is themed ergonomic.' Minecraft allows them to be as creative as they can be and still follow within some sort of framework, which creates individuals [who] can think critically and they can be creative in those designs, which is what we want to create for [the] future generation's work force." For Claire, problem-solving was built into scaffolding, as students worked in groups to "solve the problems on their own without assistance." Lance saw the potential to use the game as a means of developing critical thinking skills in students, but stressed that, "Minecraft itself is just a tool. I think it's the teachers or the professionals who create the assignments [that] connects to the 21st century competencies."

Discussion

The authors' observations shed light on three crucial components of supporting collaboration and communication through the use of digital games in classrooms. First, playing in multiplayer mode alone

does not elicit collaboration. It is the role of the classroom teacher to design collaborative learning tasks for students to complete within games. Second, supporting meaningful, collaborative learning through Minecraft for these teachers, and in digital game-based learning more broadly, does not always necessitate 1:1 device use and need not take place within the virtual world of the game. This is important when considering that lack of access to devices is frequently cited as a barrier to integrating digital games into the classroom (Hébert et al., 2021). Third, observations made clear that asking students to work together does not automatically mean successful collaboration and communication, as students require scaffolding and guidance. Developing a set of guidelines with and alongside students regarding in/appropriate collaboration and communication is a crucial part of 21st century education.

For critical thinking, creativity, and innovation, all teachers involved in the study were able to create meaningful learning activities for students around the use of Minecraft, represented through three tiers or types of play: directed/guided play, scaffolded play, and open play. The tasks teachers assigned did vary, as did the level of critical thinking, creativity, and innovation that was fostered. For us, this again demonstrates that it is the teacher who supports 21st century learning.

Finally, what the interviews made clear was that teachers identified collaboration as the primary 21st century competency developed through the use of Minecraft in the classroom and were able to point both to game features and teacher-made pedagogical decisions that supported this 21st century learning in the classroom. While critical thinking, creativity, and innovation was identified by fewer teachers as a means of supporting 21st century competency development, teachers again were able to highlight how the decisions they made regarding how specifically to use the game made competency development possible.

Conclusion

This study demonstrated that, with the guidance offered in the workshop, all of the teachers in the study were able to design lessons using Minecraft that supported 21st century competency development. This is no small feat and, arguably, can be attributed to the affordances of Minecraft as a platform – its open world, builder interface allows teachers to customize learning experiences for students that can be both structured and unstructured. What was clear, throughout the study, was that the role of the classroom teacher, both in facilitating collaboration and communication and in designing learning tasks that support critical thinking, creativity, and innovation, cannot be understated.

For many teachers, teaching with digital games will require a re-imagining of their role, as they shift from a deliverer of curriculum to participant in a collaborative learning environment (Beavis & O'Mara, 2010). Teachers will need support in scaffolding collaboration and communication and in designing learning tasks that require more student autonomy, and higher levels of flexibility with respect to how students can demonstrate what they know. For example, and as previously pointed out, collaboration and communication can be modelled through class agreements and discussions, the division of labour in group work, knowledge sharing, and presenting work to the whole class and creativity, critical thinking, and innovation in designing student-driven, inquiry projects. In this study,

the authors observed teachers willing to share their know-how of Minecraft but also learn from more accomplished students in their classes, especially those who created opportunities for open-ended play.

While outside the purview of this paper, not all practices teachers engaged in were supportive of 21st century competency development. Quite a few instances where teachers employed teacher-directed pedagogical practices rather than student-centred techniques, were observed. The former fosters student dependence on the teacher, who corrects mistakes and responds to student questions with concrete answers. In contrast, student-centered techniques position students as responsible for their own learning, with teachers directing them to resources or aiding them with the problem-solving process. Another challenge that was observed with rather open-ended learning environments was that it can be easy for students to get off task, with a number turning away from their assignment to engage in online games or card tricks or goofing around with others. This is where the incorporation of other digital game-based pedagogies practices such as appropriate lesson pacing and clear expectations (Hébert & Jenson, 2019) are important.

That said, what was clear is that Minecraft provided an open, exploratory platform for teachers to support their students in experimentation, creativity, collaboration, and other 21st century skills that continue to be emphasized in curricula in Canada, and in Ontario in particular. For the teachers in this study, Minecraft was a world in which they could invite their students to experiment and play, even as some students tested the boundaries of appropriate behavior. What we hope this study of a short-term game-focused professional development session reveals is the power and impact of research-informed PD on teaching. That all the participants in this study were able to successfully carry out a Minecraft unit and then speak at some length about how it modelled pedagogically for them a 21st century framework speaks also to the potentiality of an open world game like Minecraft for supporting learning.

References

Apperley, T. (2015). Glitch sorting: Minecraft, curation and the postdigital. In D. M. Berry & M. Dieter (Eds.), *Postdigital Aesthetics* (pp. 232–244). Palgrave Macmillan.

Bailey, C. (2016). Free the sheep: Improvised song and performance in and around a minecraft community. *Literacy*, *50*(2), 62–71. https://doi.org/10.1111/lit.12076

Barab, S., & Dede, C. (2007). Games and immersive participatory simulations for science education: An emerging type of curricula. *Journal of Science Education and Technology*, *16*(1), 1–3. https://doi.org/10.1007/s10956-007-9043-9

Beavis, C., & O'Mara, Jo. (2010). Computer games-Pushing at the boundaries of literacy. *Australian Journal of Language and Literacy*, *33*(1), 65–76.

Becker, K. (2017). *Choosing and using digital games in the classroom: A practical guide*. Springer.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Callaghan, N. (2016). Investigating the role of Minecraft in educational learning environments. *Educational Media International*, *53*(4), 244–260. https://doi.org/10.1080/09523987.2016.1254877

Canadians for 21st Century Learning and Innovation. (2012). *Shifting Minds: A 21st Century Vision for Public Education for Canada*. http://www.c21canada.org/wp-content/uploads/2012/11/Shifting-Minds-Revised.pdf

Checa-Romero, M., & Pascual Gómez, I. (2018). Minecraft and machinima in action: development of creativity in the classroom. *Technology, Pedagogy and Education*, *27*(5), 625–637. https://doi.org/10.1080/1475939X.2018.1537933

Cipollone, M., Schifter, C. C., & Moffat, R. A. (2014). Minecraft as a creative tool: A case study. *International Journal of Game-Based Learning*, *4*(2), 1–14. https://doi.org/10.4018/ijgbl.2014040101

Clarke, V., & Braun, V. (2017). Thematic analysis. *Journal of Positive Psychology*, *12*(3), 297–298. https://doi.org/10.1080/17439760.2016.1262613

Dede, C. (2009). *Comparing Frameworks for "21st Century Skills."* http://www.watertown.k12.ma.us/dept/ed_tech/research/pdf/ChrisDede.pdf

Denham, A. R. (2019). Using the PCaRD digital game-based learning model of instruction in the middle school mathematics classroom: A case study. *British Journal of Educational Technology*, *50*(1), 415-427. https://doi.org/10.1111/bjet.12582

Durham Catholic District School Board. (2020). *21st Century Learning*. https://www.dcdsb.ca/en/programs-services/21st-Century-Learning.aspx

Egenfeldt-Nielsen, S. (2006). Overview of research on the educational use of video games. *Nordic Journal of Digital Literacy*, *1*(3), 184–213. https://doi.org/10.1353/dia.2006.0003

Foster, A. (2012). Assessing learning games for school content: The TPACK-PCaRD framework and methodology. In D. Ifenthaler, D. Eseryel, & X. Ge (Eds.), *Assessment in Game-Based Learning: Foundations, Innovations, and Perspectives* (pp. 201–215). Springer. https://doi.org/10.1007/978-1-4614-3546-4

Gentile, M., Città, G., Perna, S., Signa, A., Dal Grande, V., Ottaviano, S., La Guardia, D., & Allegra, M. (2019). The role of disposition to critical thinking in digital game-based learning. *International Journal of Serious Games*, *6*(3), 51–63. https://doi.org/10.17083/ijsg.v6i3.316

Hämäläinen, R., & Oksanen, K. (2012). Challenge of supporting vocational learning: Empowering collaboration in a scripted 3D game - How does teachers' real-time orchestration make a difference? *Computers and Education*, *59*(2), 281–293. https://doi.org/10.1016/j.compedu.2012.01.002

Hanghoj, T. (2008). *Playful knowledge: An explorative study of educational gaming.*

Hargreaves, A., & Fullan, M. (2012). *Professional capital: Transforming teaching in every school*. Teachers College Press.

Hébert, C., & Jenson, J. (2019). Digital game-based pedagogy: Developing teaching strategies for game-based learning. *Journal of Interactive Technology and Pedagogy*, *15*.

Hébert, C., Jenson, J., & Fong, K. (2018). Challenges with Measuring Learning through Digital Gameplay in K-12 Classrooms. *Media and Communication*, *6*(2), 112–125. https://doi.org/10.17645/mac.v6i2.1366

Hébert, C., Jenson, J., & Terzopoulos, T. (2021). "Access to technology is the major challenge": Teacher perspectives on barriers to DGBL in K-12 classrooms. *E-Learning and Digital Media*. https://doi.org/10.1177/2042753021995315

Hsiao, H. S., Chang, C. S., Lin, C. Y., & Hu, P. M. (2014). Development of children's creativity and manual skills within digital game-based learning environment. *Journal of Computer Assisted Learning*, *30*(4), 377–395. https://doi.org/10.1111/jcal.12057

Hussein, M. H., Ow, S. H., Cheong, L. S., & Thong, M. K. (2019). A Digital Game-Based Learning Method to Improve Students' Critical Thinking Skills in Elementary Science. *IEEE Access*, *7*, 96309–96318. https://doi.org/10.1109/ACCESS.2019.2929089

Jenson, J., & de Castell, S. (2011). Girls@Play. *Feminist Media Studies*, *11*(2), 167–179.

Jenson, J., Hébert, C., & Khayatt, D. (2016). *Playing to learn: Evaluating the impact of teacher support for the use of videogames in grade 7 and 8 classrooms*.

Kirriemuir, J., & Mcfarlane, A. (2007). *Literature review in games and learning*.

Kivunja, C. (2014). Do You Want Your Students to Be Job-Ready with 21st Century Skills? Change Pedagogies: A Pedagogical Paradigm Shift from Vygotskyian Social Constructivism to Critical Thinking, Problem Solving and Siemens' Digital Connectivism. *International Journal of Higher Education*, *3*(3), 81–91. https://doi.org/10.5430/ijhe.v3n3p81

Leemkuil, H., de Jong, T., de Hoog, R., & Christoph, N. (2003). KM QUEST: A collaborative Internet-based simulation game. *Simulation and Gaming*, *34*(1), 89–111. https://doi.org/10.1177/1046878102250605

Marklund, B. B., & Taylor, A. A. (2015). Teachers' many roles in game-based learning projects. *European Conference on Games Based Learning*, 359–367.

McNeil, L. (2018). Introducing teachers to digital game–enhanced pedagogy: Successes and challenges in a graduate course. *TESOL Journal*, *9*(3), 580–584. https://doi.org/10.1002/tesj.383

Microsoft. (2020a). *Minecraft*. https://www.minecraft.net/en-us/

Microsoft. (2020b). *Minecraft Education Edition*. https://education.minecraft.net/how-it-works/what-is-minecraft

Microsoft. (2020c). *Why Minecraft?* https://education.minecraft.net/how-it-works/why-minecraft#21st-century-skills

Mojang. (2020). *Mojang Studios Game*. https://www.mojang.com/games/

Morgan, M. L. (2015). *21St Century Skills Through Multiplayer Game Play* (Issue May). New England College.

Muehrer, R., Jenson, J., Friedberg, J., & Husain, N. (2012). Challenges and opportunities: using a science-based video game in secondary school settings. *Cultural Studies of Science Education*, *7*(4), 783–805. http://link.springer.com/10.1007/s11422-012-9409-z

Nousiainen, T., Kangas, M., Rikala, J., & Vesisenaho, M. (2018). Teacher competencies in game-based pedagogy. *Teaching and Teacher Education*, *74*, 85-97. https://doi.org/10.1016/j.tate.2018.04.012

Ontario Ministry of Education. (2014). *Achieving Excellence* (Issue April). http://www.edu.gov.on.ca/eng/about/renewedVision.pdf

Ontario Ministry of Education. (2016). *21 Century Competencies*. http://www.edugains.ca/resources21CL/About21stCentury/21CL_21stCenturyCompetencies.pdf

Ott, M., & Pozzi, F. (2012). Digital games as creativity enablers for children. *Behaviour and Information Technology*, *31*(10), 1011–1019. https://doi.org/10.1080/0144929X.2010.526148

Ottawa Carleton District School Board. (2020). *Exit Outcomes*. https://ocdsb.ca/elementary/classroom/Exit Outcomes

Peel District School Board. (2016). *Empowering Modern Learners*. http://www.peelschools.org/aboutus/21stcentury/Documents/Empowering Modern Learners - 12 page Nov 8.pdf

Pivec, M., & Pivec, P. (2008). *Games in Schools*. http://www.paulpivec.com/Games_in_Schools.pdf

Pusey, M., & Pusey, G. (2015). Using minecraft in the science classroom. *International Journal of Innovation in Science and Mathematics Education*, *23*(3), 22–34.

Romero, M., Usart, M., & Ott, M. (2015). Can serious games contribute to developing and sustaining 21st century skills? *Games and Culture*, *10*(2), 148–177. https://doi.org/10.1177/1555412014548919

Shah, M., & Foster, A. (2015). Developing and assessing teachers' knowledge of game-based learning. *Technology and Teacher Education*, *23*(2), 241–267.

Simon, B., & Wershler, D. (2018). Childhood's end (Or, we have never been modern, except in minecraft). *Cultural Politics*, *14*(3), 289–303. https://doi.org/10.1215/17432197-7093310

Squire, K. (2011). *Video games and learning: Teaching and participatory culture in the digital age*. Teachers College Press.

Steinkuehler, C. (2007). Massively multiplayer online gaming as a constellation of literacy practices. *E-Learning*, *4*(3), 297–318.

Tan, C., Chua, C. S. K., & Goh, O. (2015). Rethinking the Framework for 21st-Century Education: Toward a Communitarian Conception. *Educational Forum*, *79*(3), 307–320. https://doi.org/10.1080/00131725.2015.1037511

Thumlert, K., de Castell, S., & Jenson, J. (2015). Short Cuts and Extended Techniques: Rethinking relations between technology and educational theory. *Educational Philosophy and Theory*, *47*(8), 786–803. https://doi.org/10.1080/00131857.2014.901163

Thumlert, K., Owston, R., & Malhotra, T. (2018). Transforming school culture through inquiry-driven learning and iPads. *Journal of Professional Capital and Community*. https://doi.org/10.1108/JPCC-09-2017-0020

Tung, R. (2019). *Can digital game based learning develop critical thinking skills in secondary school learners using standards based grading* [Vancouver Island University]. https://doi.org/10.1017/CBO9781107415324.004

Voiskounsky, A. E., Yermolova, T. D., Yagolkovskiy, S. R., & Khromova, V. M. (2017). Creativity in online gaming: Individual and dyadic performance in Minecraft. *Psychology in Russia: State of the Art*, *10*(4), 144–161. https://doi.org/10.11621/pir.2017.0413

Voogt, J., Dede, C., & Erstad, O. (2011). *21st century learning*. http://www2.curtin.edu.au/edusummit/local/docs/6_EDUsummIT_2011_21st_century_learning.pdf

York Region District School Board. (2018). *Modern Learning Strategy*. https://www.yrdsb.ca/AboutUs/BIPSA/Documents/Modern-Learning-Strategy.pdf

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