Results of an exploratory study conducted with 118 elementary-school students

Transforming Education with Minecraft

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Abstract

Minecraft is currently the second most popular video game of all time, with more than 100,000,000 copies sold worldwide. Schools in many countries, including the United States of America and Sweden, have decided to integrate the game into their standardized curricula. It is also used in other countries to teach children science, urban planning, and languages. In Montreal, several schools have joined Mission 375, a contest associated with the city's 375th anniversary celebration. The aim is to get students to use Minecraft to reproduce detailed historic Montreal sites and events.

The increasing application of this video game for educational purposes has attracted research attention. The main goals of this exploratory study were to identify the uses, benefits, and challenges of supported integration of Minecraft into classrooms for teaching and learning purposes. Participants comprised 118 students attending third to sixth grade of a French-language school in the Greater Montreal (Canada) Area during the 2016–2017 school year. Data were collected with ten instruments: (1) surveys; (2) semi-directed interviews outside of game time; (3) short individual interviews during game time; (4) group discussions with students throughout the Minecraft gameplay sessions; (5) observations and analysis of supervised gameplay videos; (6) observations and analysis of think aloud protocol videos collected during supervised gameplay; (7) individual interviews with teachers and moderators during supervised gameplay sessions; (8) tracking of students' progress across the game levels; (9) a weekly diary by the Minecraft moderator; and (10) "digital footprints" (i.e., student-generated Minecraft products).

This project gave students an opportunity to learn through supported educational use of Minecraft. A specific pedagogical Minecraft program was designed for this project. It contains 30 tasks divided into 10 progressive levels that advance from the simplest to the hardest task. This approach allowed developing a number of learning skills, including motivation, computer programming, basic informatics skills, and peer collaboration. This report presents the background, research method, and results, including the many benefits for students of using Minecraft at school.

1. INTRODUCTION

Should parents and educators be worried about a study called "Transforming schools with Minecraft?" Their concerns might be justified when one considers that Minecraft is the second most popular video game of all time, with over 100,000,000 copies sold (Figure 1). The fears that surround this game may have arisen from the widely held views that video games are harmful for children, that they cause household conflicts, that they inspire violence, and so on. Parents and educators alike have these fears, which may be well founded. What parent has never asked their child to turn off a video game, having been disturbed by content that they felt was inappropriate? Moreover, both the media and researchers have suggested that overuse of video games can hinder child development. However, few are aware of the enormous potential of supported, purposeful, and educational use of Minecraft for children's learning.

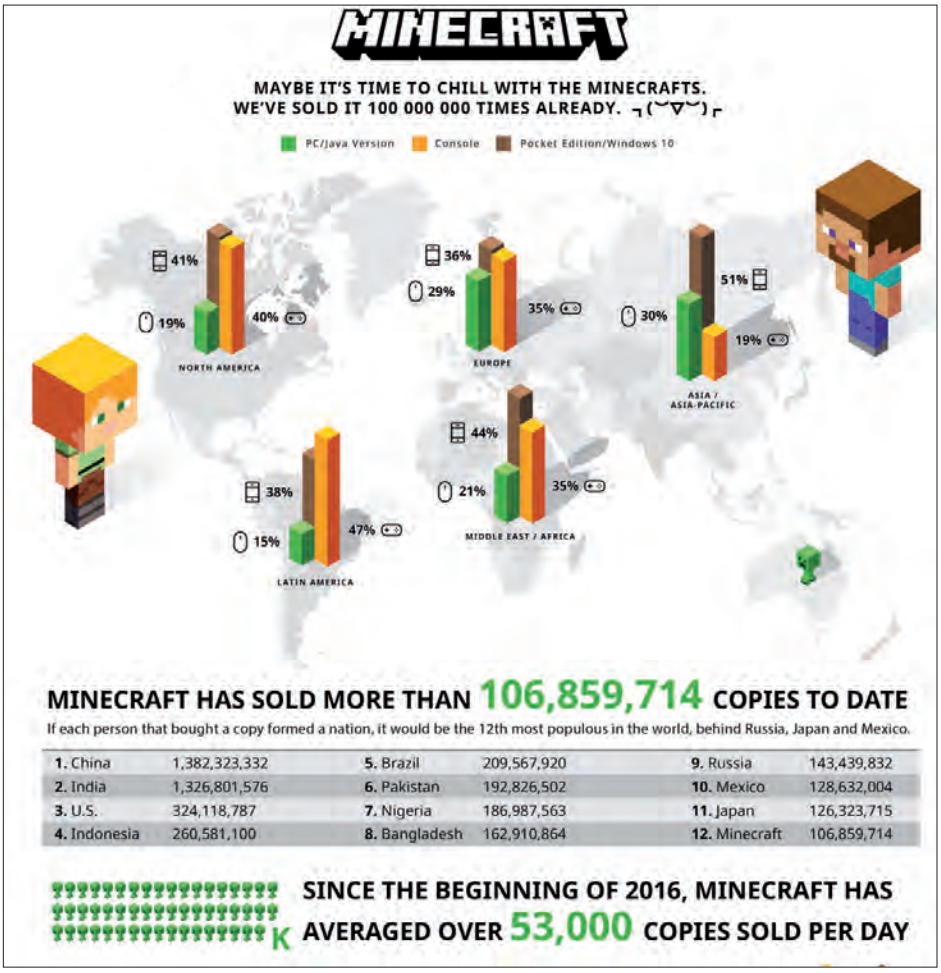

Figure 1 – Schematic Illustration of Minecraft Sales.

An educational version of Minecraft has been available since the fall of 2016, and it is rapidly catching on at schools. For example, since 2013, American and Swedish schools have been integrating Minecraft into their curricula. Other countries have used Minecraft to teach science, urban planning, and to some extent, languages. In Montreal, many schools have joined Mission 375, a contest associated with the city's 375th anniversary celebration. The aim is to get students to use Minecraft to reproduce detailed historic sites and events in Montreal. Many educational applications and experiences can also be found on various online forums. We therefore felt it was relevant to conduct an empirical study of the educational use of Minecraft in order to assess the potential for learning and to understand the impact on young learners.

Given the popularity of Minecraft, we adopted an exploratory research design. The research objectives were to: (a) highlight the main uses of Minecraft in a school setting; (b) identify the benefits of using Minecraft at school; and (c) determine the challenges in using Minecraft at school.

This report is organized into seven sections. After the introduction (Section 1), a review of the literature on the use of Minecraft at school (Section 2) is presented. This is followed by the methods (Section 3), the results (Section 4), conclusions (Section 5), and some recommendations for using Minecraft at school (Section 6). The references are listed in Section 7.

2. MINECRAFT AND EDUCATION

Minecraft could be considered an online, updated version of the classic Lego building blocks. Lego blocks are connected and assembled to create a practically limitless variety of structures. The same is true for Minecraft, except that instead of handling building blocks, users operate in a virtual world, using pixelated cubes. The main limitation for both Lego and Minecraft is the user's imagination. Minecraft gives users the additional advantage of being able to play safely with water, earth, fire, trees, and other natural elements. Expanding on this compelling concept, an educational version of the video game was released late in 2016.

To design the new educational version, Microsoft and Mojang AB sought the input of experienced teachers so that it would help students acquire and develop key learning aptitudes. Creativity, student engagement, and collaboration between users are just some of the aptitudes that can be developed through gameplay. These benefits provide the educational utility of the game and help explain its surging popularity.

This trend raises a few questions. What are the main findings on the educational uses of Minecraft? Can students learn effectively by playing it? Does it provide positive stimulation? Are there any barriers to using this type of video game at school?

All these questions have theoretical and practical implications, and they all stem from a single key question: why focus on the use of video games at school? The simple answer is that the usefulness of educational games has long been validated by numerous studies. Logically, therefore, digital games should be examined as well. This becomes even more apparent when one realizes that video games are the world's leading cultural industry. However, it has not always been easy to use games, and especially video games, in class, even though empirical studies have demonstrated that they can provide environments that encourage certain types of learning, and they can have positive "cognitive, affective, and psychomotor" effects on players.

When a highly engaged player enters the flow state, the circumstances are extremely favourable for learning. The player's high engagement allows full immersion in the online environment. The player is then more open to learning through the interactions, discoveries, and experiences during the game. High engagement also limits distractions, loss of motivation, and misunderstanding of content, all negative factors for learning. Thus, gamers are free to discover and to cognitively focus on the task at hand. In addition, video games help students acquire the 21st-century skills

that they will need in their future careers and lives. The development of these skills becomes even more vital when considering that almost 15% of Québec students drop out of school without a diploma or qualifications. According to Morgan (2015), Minecraft puts some of these skills to use in addition to developing core aptitudes such as digital literacy, after only six months of gameplay.

One of the major benefits of using video games for learning is the great enjoyment it entails, a critical condition for learning. At school, Minecraft can not only help students develop problem-solving and teamwork skills, it can increase their motivation as well. This is the main finding by Méndez, Arrieta, Dios, Encinas, and Quieruga-Dios (2016), who analyzed video game use by architecture students. Furthermore, according to Callaghan (2016), the educational use of Minecraft fosters conditions that are beneficial for learning, and particularly for engagement, collaboration, and creativity. In addition, Minecraft boosts motivation through the use of creativity to improve problem-solving skills. Some authors feel that Minecraft would also be beneficial for teachers, because it allows designing creative projects for students. Others claim that Minecraft has an "immense" impact on education because it encourages learning through play, creation, and cooperation in class.

For all these reasons, growing numbers of schools have been using Minecraft to complement traditional teaching practices. Craft the World is another, earlier sandbox strategy game that allows users to draw from a community stockpile of information and resources and that encourages the use of several informal learning areas. MinecraftEdu, the first educational version of Minecraft, has been shown to stimulate students' interest in science and the use of information and communication technologies (ICT) in class.

Minecraft's potential has also been tapped for purposes such as architectural projects, as demonstrated by Magnussen and Elming (2015), who described the Minecraft-based remodeling of Copenhagen neighbourhoods by students in collaboration with city authorities.

Other studies argue that Minecraft's creative features allow users to learn about technology, teamwork, and engineering. So, besides exercising their creativity, users can inhabit a virtual environment to learn about and use concepts that are more difficult to understand in real life.

To further illustrate Minecraft's educational potential, positive outcomes have been observed in other educational contexts. For instance, studies have shown significant positive impacts on students with autism spectrum disorder (ASD), with improved collaboration and social connectivity. Because the game has no specific objectives, ASD students can immerse themselves in their own personal narrative, allowing them to create and explore. Moreover, there is an online network dedicated to Minecraft play by ASD users, which opens the door to new social interactions.

3. METHODOLOGY

This section presents the research methods. In accordance with the Publication Manual of the American Psychological Association, it includes information about the participants (3.1), data collection tools (3.2), and data analysis strategies (3.3) used in this study.

3.1 Participants

A total of 118 elementary school students (63 girls: 53.4%; 55 boys: 46.4%) participated in this study. All students were aged from 9 to 12 years, with a mean age of 11.3 years. All participants were enrolled in French-speaking elementary schools in the Greater Montreal Area in the province of Québec, Canada. The schools were located in areas where the poverty index fluctuated between 7 and 10 (where 10 = the lowest socioeconomic standing). Students were recruited on a volunteer basis, with the consent of their parents and the schools. Data were collected during the 2016–2017 school year.

3.2 Data Collection Tools

Ten data collection tools were used in this study:

1. Research surveys (n = 4) completed by all students (n = 118)
2. Semi-directed interviews outside of game time (n = 6 X 30 minutes)
3. Short individual interviews (n = 118 X 5 minutes) during game time
4. Group discussions with students during the Minecraft gaming sessions (n = 3)
5. Observations and analysis of supervised gameplay videos (n = 6 X 75 minutes)
6. Observations and analysis of think aloud protocol videos (n = 3 X 30 minutes) collected during supervised gameplay
7. Individual interviews with teachers and moderators during supervised gameplay sessions (n = 6)
8. Tracking of students' advancement through the game levels
9. A weekly diary by the Minecraft moderator (n = 17)
10. "Digital footprints," or student-generated Minecraft products (see section 4.3)

3.3 Data Analysis Strategies

Surveys were used to collect both quantitative and qualitative data derived from Likert responses and open-ended questions. Accordingly, a mixed-method data analysis approach was used. The quantitative data analysis was used to produce and analyze the descriptive statistics using SPSS 23 and the online survey application Survey Monkey. These preliminary data were then validated and expanded with a qualitative analysis of the responses to the open-ended survey questions using QDA Miner. This consisted of a content analysis with semi-open coding of students' responses concerning the main study objectives (use, benefits, and challenges).

The interview data were analyzed based on the protocols developed by L'Écuyer (1990) and Miles and Huberman (2003). A content analysis approach was adopted, using QDA Miner.

3.4 Methodological Strengths and Shortcomings

One of the main strengths of this study is the unique methodological approach. The combination of data collected from surveys, interviews, think aloud protocols, journals, tracking of student progress, and digital footprints allows substantial data triangulation and validation. This variety of methods provides a deeper analysis and interpretation of results. However, certain shortcomings must be considered. First, the use of student perceptions is a limitation that was offset, at least partially, by the large number of participants and the variety of data collection methods, including observations and analysis of video recordings. To reduce this methodological bias, responses by different types of participants were systematically compared and differences were highlighted as appropriate.

Another shortcoming concerns the non-random selection of participants. The study sample does not necessarily represent the target population (elementary school students in the Greater Montreal Area). It would have been practically impossible to generate a random, representative sample, mainly due to logistical constraints. Therefore, convenience sampling was used to recruit volunteer participants. The only requirement for participating was to attend the supervised Minecraft gaming sessions.

4. RESULTS

The main study findings are presented below with respect to the research objectives, which were to:

(a) Highlight the main uses of Minecraft at school

(b) Identify the benefits of using Minecraft at school

(c) Pinpoint challenges of using Minecraft at school.

First, the setting for the supervised gameplay is described. Photos and screenshots of student-generated products are then presented to illustrate the gameplay experience. Finally, the most salient educational outcomes of the supervised use of Minecraft in class are presented.

To guide the students' use of Minecraft, an educational Minecraft program, Become the Minecraft Master, was created specifically for this research project (Figure 2). Briefly, this program includes 30 educational tasks that call upon various skills and competencies. They are grouped into 10 levels that progress from the simplest to the most complex (Figure 3). This presentation allows students to progressively discover Minecraft and advance toward full mastery by the end of the program. For example, students began by personalizing their user interface. In the second level, they explored the game. Eventually, they learned to master the digital environment along with the gaming tasks. This progressive structure was designed to help students understand and control the digital environment.

Figure 2 – *Become the Minecraft* Master School Program.

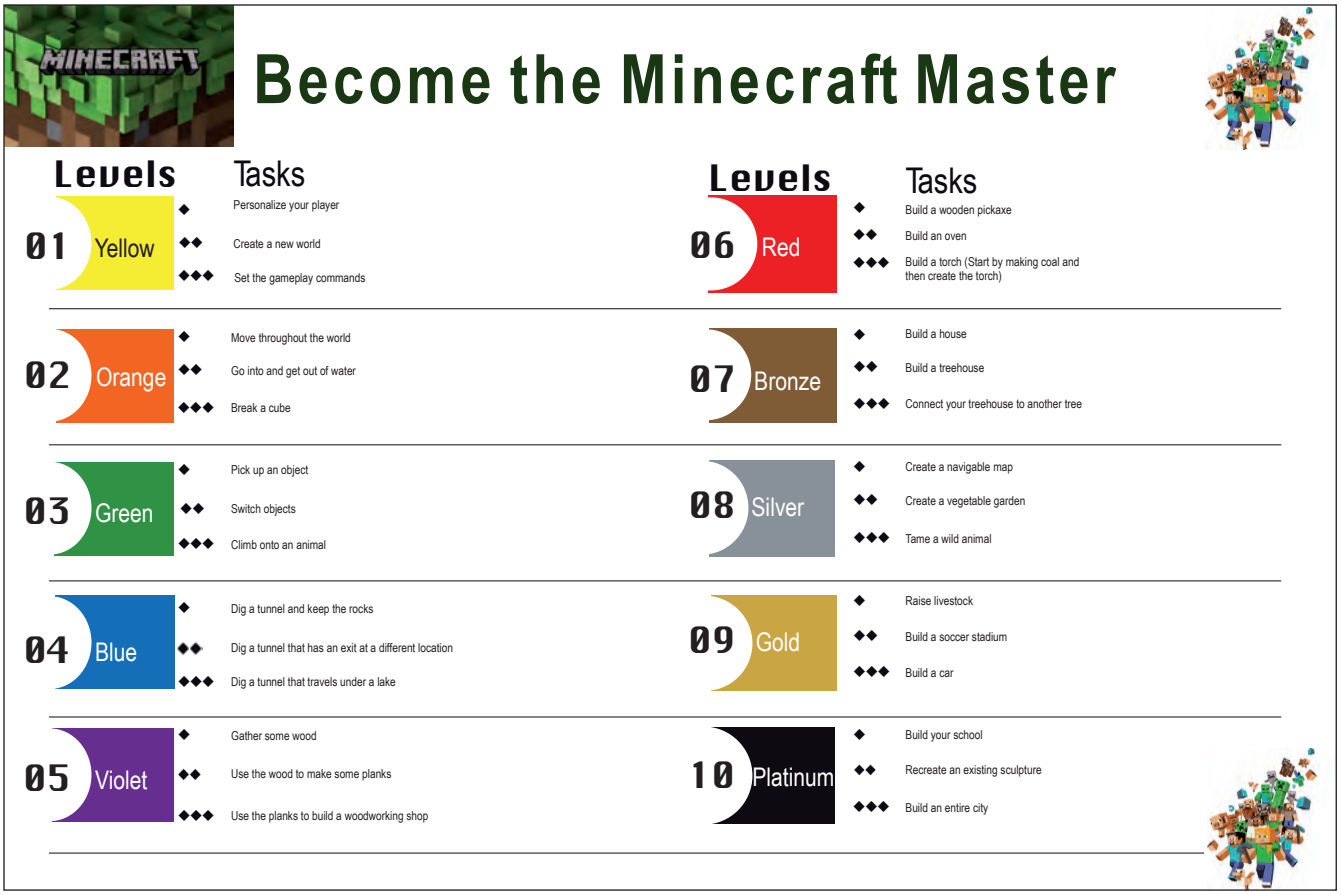

Figure 3 – Minecraft Master Levels.

To encourage students to advance through the levels, colour-coded levels were introduced during gameplay. For example, after completing level one, students could move up to a level called Minecraft Master Level 1 Yellow and eventually advance up to the 10th level, Minecraft Master Level 10 Platinum. In addition, because each level contains three different tasks, the moderator (a Minecraft expert) validated each completed task with a Minecraft Graduation Certificate (Figure 4). Students had to collect 30 graduation certificates to become a certified Minecraft Master.

Level Completion Certificate

Minecraf Master

Student Name:_____

Levels

01 Yellow ◆ ◆ ◆	
02 Orange ◆ ◆ ◆	
03 Green ◆ ◆ ◆	
04 Blue ◆ ◆ ◆	
05 Violet ◆ ◆ ◆	
06 Red ◆ ◆ ◆	
07 Bronze ◆ ◆ ◆	
08 Silver ◆ ◆ ◆	
09 Gold ◆ ◆ ◆	
10 Platinum ◆ ◆ ◆	

Figure 4 – *Become the Minecraft* Master Level Certificate of Completion.

To help promote student engagement, students were awarded Minecraft Master wristbands once they successfully completed a level. It is important to note that, like the certificates, the moderator also distributed the wristbands. Upon validation, students received a wristband featuring the name and colour of the level as well as some game visuals (Figures 5 and 6). The wristbands provided tangible extrinsic motivation for the students to engage in gameplay and to achieve as many levels as possible.

Figure 5 – A Student Displaying Various Minecraft Master Level Wristbands.

Figure 6 – Students Posing with their Minecraft Master Level Wristbands.

In the sessions, students were offered a choice of gameplay styles. They could participate in the "creative" mode, with access to all the objects. Alternatively, they could opt for the "survival" mode, where they had to design and build their own objects to progress in the game and to survive and thrive in a given environment.

As the gaming session progressed, students who achieved the Minecraft Master level could access additional, more difficult levels. These Minecraft Pro levels required completing significantly more complex tasks (Figure 7). Students also received certificates for these upper levels after six or eight weeks of participation.

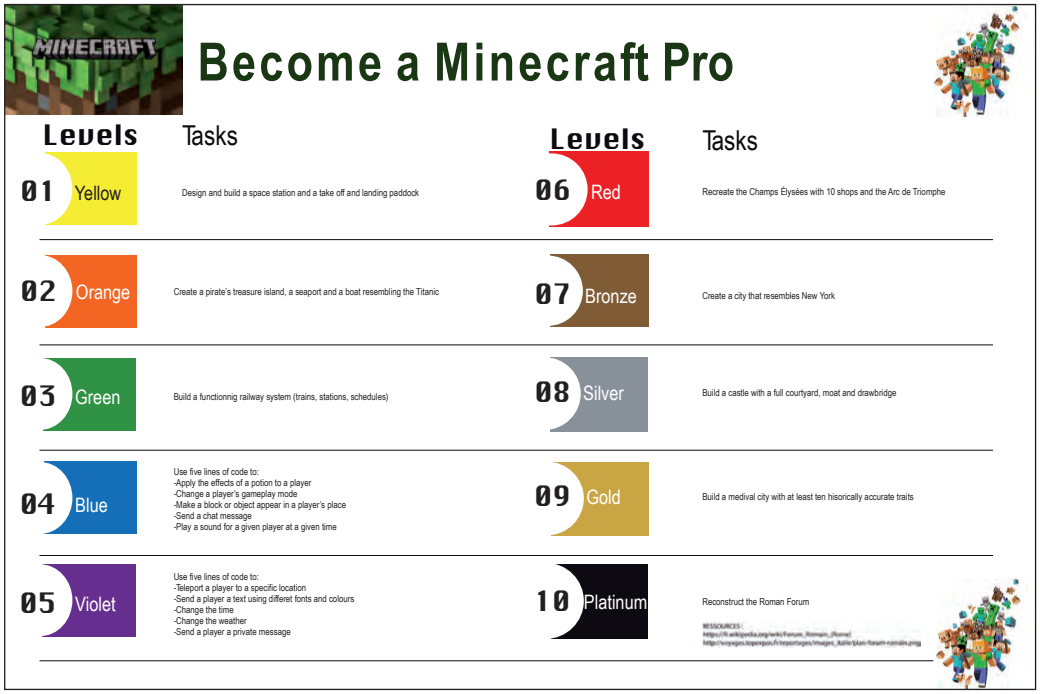

Figure 7 – Minecraft Pro Levels.

Figure 8 – Presentation of the Minecraft Pro Certificates.

Figure 9 – Example of a Minecraft Pro Certificate

We must underscore the moderator's essential role in this study. The journal of his interactions with students provided useful contextual corroboration for his observations.

Several screenshots were taken during the gameplay sessions. Based on Jaillet and Larose's (2009) concept of digital footprints, we felt it important to present these as results to demonstrate the students' proficiency, creativity, engagement, and motivation as well as the complexity of the structures they designed and built. For example, they built impressive houses (Figures 10 and 11), a soccer stadium (Figure 12), a space ship (Figure 13), a railroad track to the Titanic (Figure 14), and the Titanic itself (Figures 15 and 16).

Figure 10 – House 1 Created by Elementary Students.

Figure 11 – A House on the Water Created by Elementary Students.

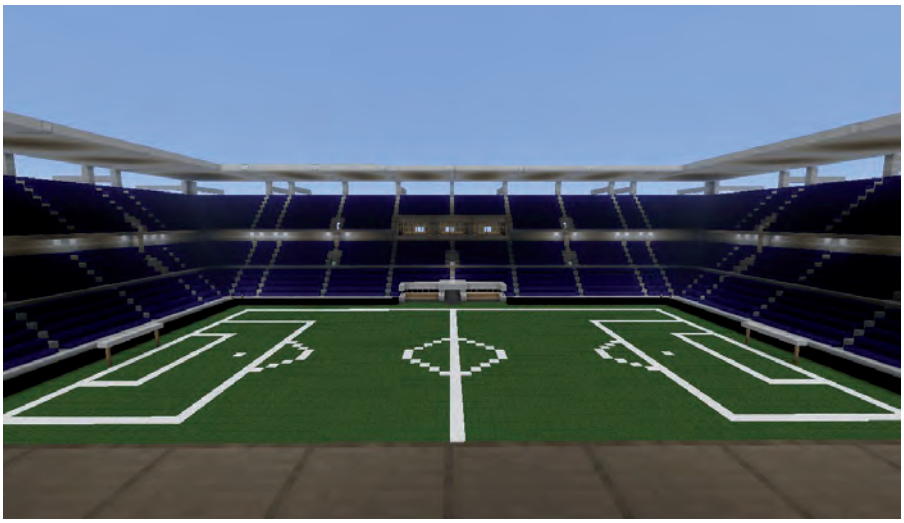

Figure 12 – A Soccer Stadium Created by Elementary Students.

Figure 13 – A Student Building a Spaceship.

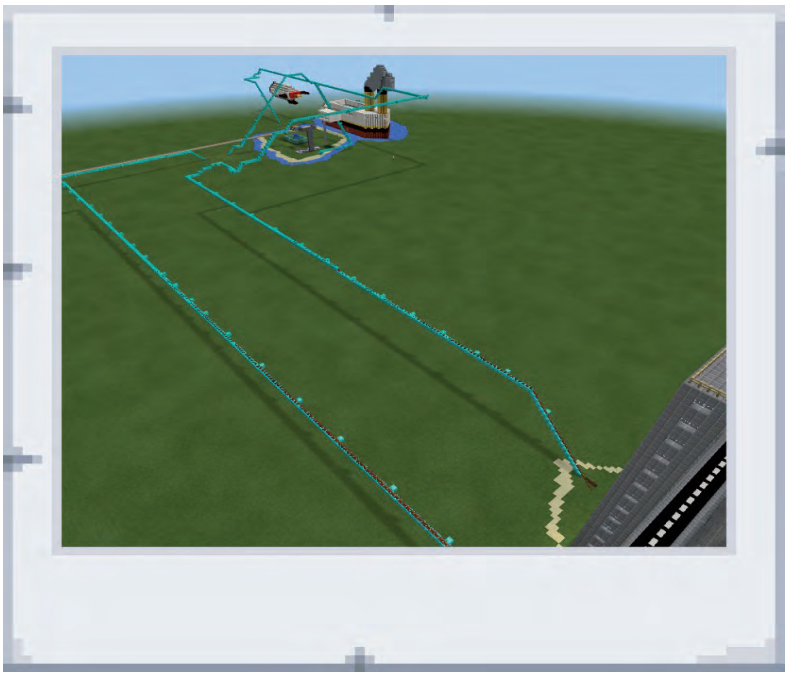

Figure 14 – A Railroad Leading to the Titanic.

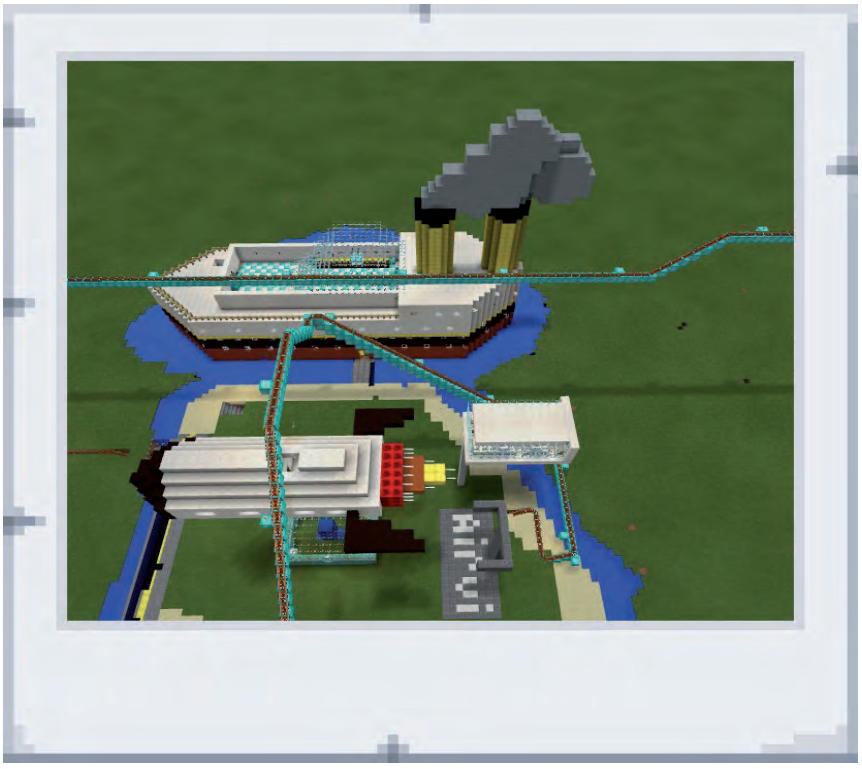

Figure 15 – A Reproduction of the Titanic Created by Students.

Figure 16 – A Reproduction of the Titanic Created by Students.

The study results highlight the many educational benefits of using Minecraft in class. The main benefits of using Minecraft for learning are listed below, and are discussed subsequently:

1. Increased overall motivation toward school
2. Better communication and information technology skills
3. Increased creativity
4. Increased feelings of academic self-efficacy
5. Creation of a positive learning environment
6. Improved reading skills
7. Improved writing skills
8. Development of autonomy
9. Increased collaboration between students (many students chose to work in groups)
10. Students developed a propensity to help each other troubleshoot gameplay issues.
11. Improved computer programming and computational logic skills (more advanced levels required basic programming skills.)
12. Improved problem-solving skills
13. Improved informational research competencies (some tasks required students to independently research specific information.)
14. Development of various math-related skills (perimeter, volume, calculation, required resources, counting)

15. Better understanding of scientific concepts (e.g., students had to identify certain elements in order to start a fire, or they had to understand basic agricultural concepts to accomplish certain tasks.)
16. Increased perseverance in the face of adversity (students met several challenges throughout gameplay, in addition to repeating certain tasks to improve their productions.)
17. Better understanding of history (especially when recreating historically accurate structures and sites)
18. Improved ability to follow directions
19. Greater self-esteem at school
20. Improved oral communication skills
21. Improved ability to generate high-quality products
22. Improved social skills
23. Improved English language skills (students were mainly French-speaking)
24. Improved organizational skills
25. Better inductive and deductive reasoning.

4.1 Motivational Benefits for Students

The results of the variety of data collection methods used in this study indicate that playing Minecraft at school has a significant impact on student motivation. Among several outcomes that demonstrate this point, the most striking might be an email that one student's father sent to a school principal. The father says that even though school had been out for quite some time, his daughter wanted to go back so she could play Minecraft. In addition, although participation in the Minecraft project was voluntary and the sessions were held after school, the moderator reported very few absences in his detailed record of attendance. In his opinion, the students were "very motivated"[1] and showed "lots of interest in the Minecraft activity." He also pointed out that, "It's an optional activity, and they come to school because they want to." One school principal even had to turn some students away due to high demand for places in the program.

Results on the survey responses indicate that 77.1% of students found playing Minecraft at school "extremely" fun. This trend was supported by the student interviews:

– "It isn't real. It's cool. We can build things."
– "I like building cities."

1 Quotes are translated from the original French.

- "I like being able to construct things."
- "Minecraft, compared to the other cubic games, is really the most interesting game."
- "I like creating, making houses, pools, and all that."
- "I like playing Minecraft a lot."
- Minecraft is "fun, and at the same time, it's educational."
- "We have fun when we play, but when we have fun, we learn things."

4.2 A Highly Beneficial, Level-Based Structure

Overall, students followed the proposed structural levels throughout the duration of the activity. They also progressed quickly: some advanced to more difficult levels after only a few sessions (almost 19% of students). The moderator confirmed this trend at the fourth session: "Almost all the students are advancing through the levels, and at least half the class has passed level 7, while many have finished level 9."

Game mastery came rapidly for most students: after only a single session, even novice students could move, select tools, throw them, and so on. According to the moderator, even in the first session, "Everyone has now understood how Minecraft works. All the students know how to move, break down, retrieve, and select blocks." It noteworthy that the levels were not all easy, and that student success depended on perseverance and teamwork: "The levels are pretty hard for me, since I had never tried" (student). The built-in level structure also required students to read and follow directions, giving them practice in some key methodological skills for academic success.

4.3 Many academic impacts

The results also provide insights into how Minecraft scaffolded student independence and autonomy, as indicated by the students themselves: "You can build at your own pace. You decide what you build, and that's what I like."

Student collaboration and mutual support were also apparent during the sessions: all students reported helping at least someone, and 90% said that they had played in teams. The moderator also stressed the importance of collaboration, suggesting that the "good co-operation between the youngsters" allowed for "faster advancement through the levels," "probably because they have other, more expert students to help them." This demonstrates effective co-operation between students, which allows creating a positive learning environment and the development of social skills. The interview results also revealed that Minecraft nurtures qualities

such as collaboration, teamwork, and helping others. When students were asked what they did when a problem occurred during gameplay, many of their responses underscored the importance of teamwork:

- "I ask friends who are better at playing than I am."
- "I'm learning how to be part of a team."
- "Teamwork is more fun."
- "[others] help me a lot, so I can learn more things."
- "In Minecraft, we're more together, we're tighter, and we work much better in teams than on other projects."
- "When I have a problem, I usually try to find the solution by asking my friends what they think about it."
- "Working in a team is easy. Being alone, it won't be easy."
- "I ask my friend for help."
- "I ask a friend [who is sitting] next to me, and then he helps me."

Based on students' statements, the potential for having fun during gameplay was determinant for the positive interactions observed between the children: "It's like a playground, only it's virtual."

The results also revealed that the structured Minecraft system greatly increased students' feelings of self-efficacy and self-esteem: "It feels like I'm a pro, and they ask me questions that I know [the answers to]" (student). Students also improved their oral communication skills: "We learn how to communicate with each other better" (student). Furthermore, Minecraft encourage creativity. The students designed several online environments and proposed new types of building structures, both showing impressive quality and ingenuity: "The students are quite creative" (moderator). This creativity appeared to stem, at least partially, from their competitive nature: "We see more and more creativity due to the competition between these groups" (moderator).

The students particularly enjoyed having to reconstruct a model of their own school (a required task), as demonstrated by the survey results. They also appreciated the inherently creative nature of Minecraft, according to the interviews:

- "Imagination has no limits."
- "I like building things. I'm really good at it. I have a lot of imagination in that."
- "I'm learning to make objects, to build objects." "You can do what you want."

- "We can put whatever we imagine."
- "We can build what we want. We can invent what we want, create things, like inventing something that doesn't really exist."
- "We can create things."
- "We can build lots of stuff."
- "There's really no limit to what we can do."

Students were also able to develop information search skills, particularly when they had to find out how to advance through the levels. They also improved their problem-solving skills: "Going through the levels taught them to read and understand written instructions" (moderator). In the interviews, students said that playing Minecraft at school made them "really think" to solve problems. For example, at one point, to advance to another level, students had to find a way to gather some coal: "To get coal, you need to solve a problem" (student).

The analysis results also indicated that the game required students to follow logical sequences involving the use of inductive and deductive mathematical reasoning. The moderator corroborated this finding: "I also insist on having them understand the logical sequence of the levels. Like, for example, we make them build a shop before an oven because you need to have a shop before you can build an oven."

One of the more popular tasks required students to learn basic agricultural and farming notions such as crop tending and livestock rearing (Figure 17): "Like plants, what we need to make them grow" (student).

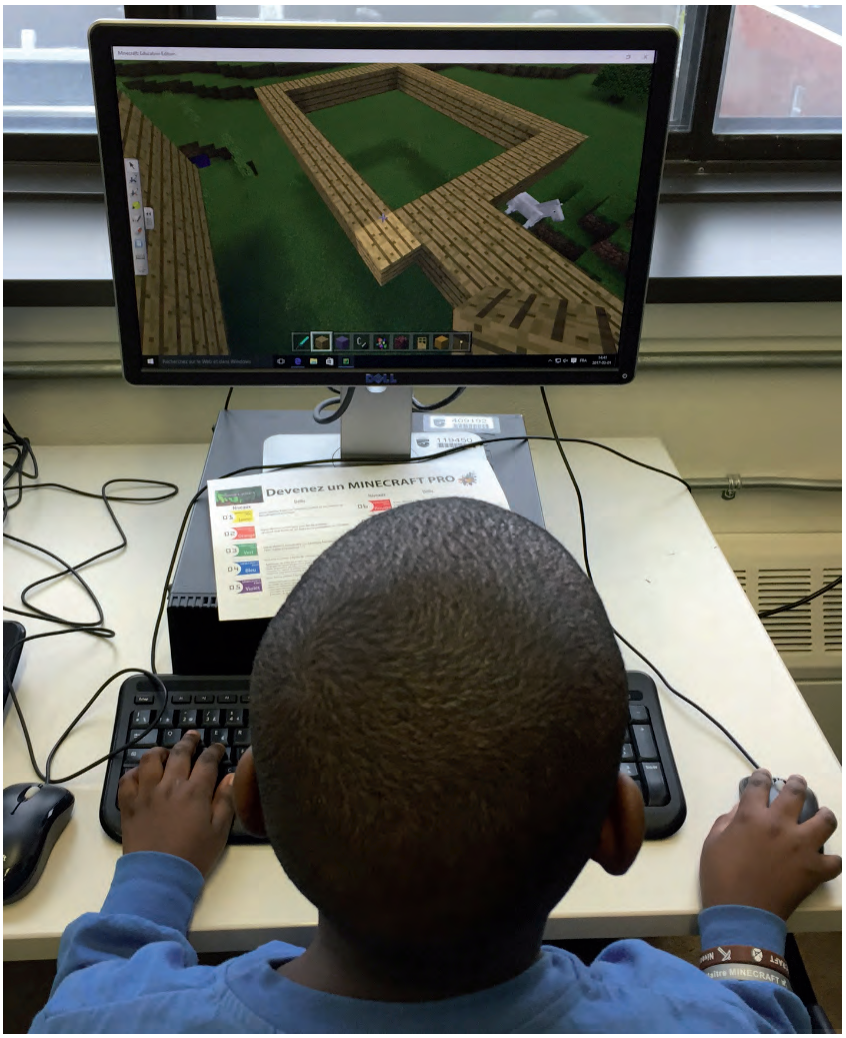

Figure 17 – A Student Building a Livestock Pen.

Participation in the Minecraft afterschool program also helped students develop their ability to navigate their surroundings, improve their sense of direction, and learn basic scientific and engineering concepts. For example, students had to use maps to find the elements they needed to start a fire. They also had to figure out how a train works in order to accomplish certain tasks.

In the students' opinion, the scaffolded gameplay environment required them not only to use the Internet as a search tool, but also to apply themselves in their quest for answers: "To do things, you can't go fast. You need to think and concentrate to do things in Minecraft." In addition, according to the moderator, students who were initially unable to complete a task developed independent research skills in order to gather "information from online encyclopaedias, YouTube, or websites like Minecraft Wiki," a Wikipedia dedicated to Minecraft. Furthermore, as supported by the observations and analysis of the videotaped sessions, both students and the

moderator used YouTube to troubleshoot gameplay issues. In addition, the responses in the student interviews corroborated the moderator's initial observations and the videotapes:

- "I go online, I write 'how to build a fort in Minecraft,' I click on 'Enter,' and it shows me. Then I go back to Minecraft and I do it."
- "I go on YouTube to see how to build it."
- "Last time, I went on YouTube and I built a house."

The group observations and individual interviews also indicated that Minecraft required the students to focus on their writing, for instance, when they had to create signs. Good writing skills were also required when the students had to name their finished buildings and neighbourhoods. Additionally, the students often communicated with classmates in writing, as evidenced by the interviews: "We practice our writing, our French grammar." Interestingly, the students, who were generally French-speaking, improved their English as well: many of the online resources were available in English only (Figure 18). Again, the student interviews support this finding: "Knowing English was important […] to know what the name of the block meant."

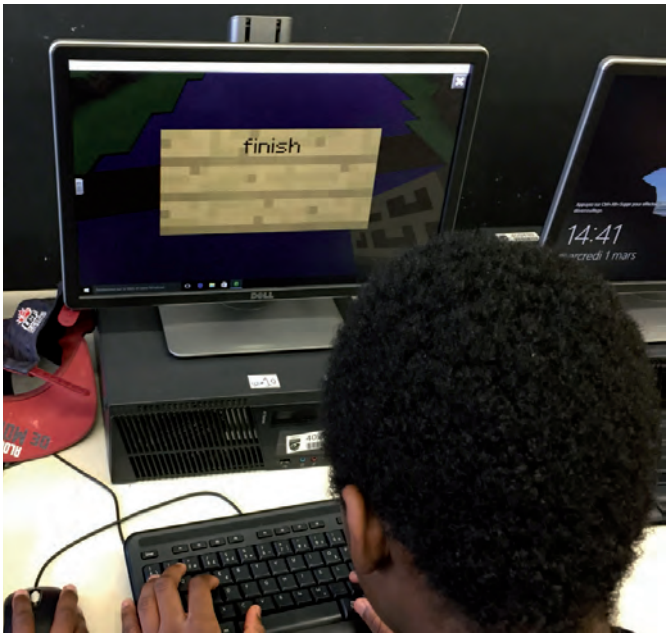

Figure 18 – A Student Writing in English while Using Minecraft.

The results also indicate that Minecraft required the players to persevere in difficult situations: "Perseverance […] their progression is constant" (moderator). This result was confirmed by the videotapes, which showed students starting certain levels over repeatedly.

The survey results showed that as the students played Minecraft, they learned about mathematics (e.g., surface area, perimeter), informatics, and geography. These results are supported by the interviews:

- "It teaches me to count well, because to build you need to count well, because in Minecraft you need to have even-numbered buildings. There are also odd-numbered buildings, but those are harder."
- "I'm learning mathematics, also geography, volume, and the measurements to know how many blocks to put."
- "Mathematics, if, for example, we say: make a third of the house this colour."
- "I have to calculate the exact number of blocks I need."

Students, both girls and boys, developed information and communications technology (ITC) skills as well as computer programming and computational logic skills during gameplay. This was largely thanks to the lines of code that can be applied throughout the game (Figures 19 and 20). In fact, almost 80% of students said that they used code to advance to a higher level. This trend is reinforced by excerpts from the student interviews in which they reported using programming to: "teleport, how to switch the day and the night, how to add or take away the bad guys." This aspect is of interest because it demonstrates that Minecraft can be used to teach students how to code. The significance of this finding cannot be understated, especially in light of the importance of coding and computer programming for today's students (see Karsenti & Bugmann, 2017).

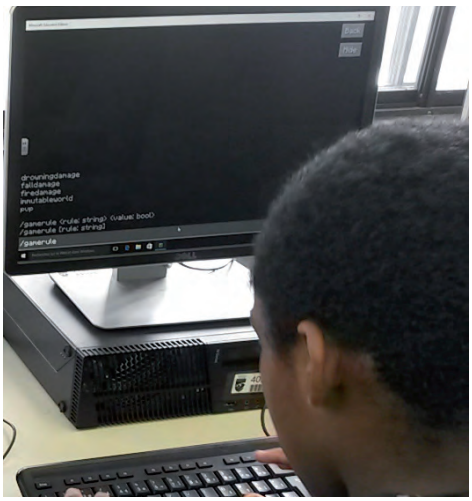

Figure 19 – A Student Learning Computer Programming while Using Minecraft.

2 At June 6, 2017.

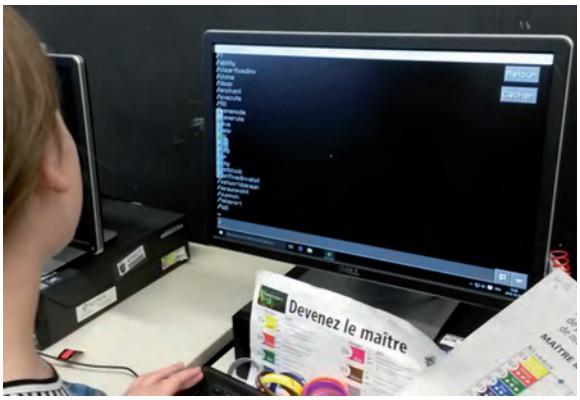

Figure 20 – A Student Learning Computer Programming while Using Minecraft.

Another benefit of using Minecraft at school is that students can use it to learn about history, especially at the Minecraft Pro level, where they create environments based on historic events and geographic sites (e.g., the construction of the Eiffel Tower, the sinking of the Titanic, events held at the Roman Coliseum).

Finally, the moderator proposed that Minecraft could be used at school to produce a range of learning outcomes: "What goes up must come down, so it demonstrates gravity. They don't even notice that they're learning these kinds of things, but later on in life they'll say to themselves: 'Oh yes, that was obvious.'"

4.4 Some Challenges Remain

Some noteworthy challenges came up during the study that merit discussion. As with many, if not all, uses of modern technology, technical problems occurred without warning. Albeit rarely, it sometimes happened that computer workstations got disconnected from the game during gameplay. It is therefore important to ensure that computers meet gameplay specifications before they are used, thereby minimizing the occurrence of such events. In addition, one must keep in mind that access to the educational edition of Minecraft (Minecraft Education Edition) requires a Microsoft Office 365 account. These accounts are free for educational institutions, learners, and teachers. However, a single-user annual subscription to the Minecraft Education Edition game costs 5 USD (6.73 CAD).[2]

Despite these potential barriers, the students made noticeable progress overall on their gameplay competencies, as seen in the videos, including the novice students. It is also important to note that the moderator or teacher should be able to answer students' questions about the game, and they should have at least minimal mastery of gameplay and basic computer skills in order to ensure student success.

5. CONCLUSION

This study of 118 student students attending two Québec elementary schools demonstrated that supported, educational, and purposeful use of Minecraft can significantly benefit student learning. Notably, this gameplay project enabled the students to engage not only with the game, but with the pedagogical content as well. By completing up to 10 increasingly complex levels, they developed several competencies across a wide variety of fields. A gaming approach therefore appears to be relevant and applicable, not only in Québec and Canada, but around the world. In fact, innovative countries such as Sweden have already integrated Minecraft into school curricula.

A total of 25 benefits of the pedagogical use of Minecraft were identified in this exploratory study. This number was most probably limited by the short study duration (6 to 8 sessions) and the small number of participants, and it would be reasonable to expect several more benefits to be identified in future studies. The use of Minecraft in an afterschool program acted to stimulate and sustain student engagement, which alone provides a strong argument for the program's success. This conclusion was supported by the wild enthusiasm of the students, "all [of whom] asked to continue next year" (moderator).

We must also point out that, in this study, Minecraft was used in a planned, supported, and purposeful manner. This type of structure must be maintained is real pedagogical goals are to be achieved. A video game such as Minecraft, which offers significant pedagogical benefits, will not be effective in the absence of structure. Without these boundaries, students might not want to stop playing, and they might avoid many potential learning opportunities. It is for these reasons that the internal (difficulty levels) and external (presence of a moderator) structures were built into this afterschool program.

Finally, it goes without saying that a critical balance should be struck between the use of video games and other activities. There is a big difference between obsessive gaming and using games as exceptional teaching and learning tools, with yet undefined potential. Both parents and educators are responsible for overseeing the use of videogames like Minecraft to ensure that they provide appropriate support for learning and the development of technology skills. This will allow students to benefit from the full educational potential of this incredible game and others like it.

6. RECOMMENDATIONS

Based on the results, we may propose the following recommendations:

1. Schools should strive to create opportunities for students to play supported and purposeful versions of Minecraft, along with appropriate Minecraft activities.
2. The success of an educational activity is directly dependent on the presence of a qualified, competent moderator.
3. The presence of progressive levels drives student engagement and motivation.
4. The use of levels and tasks should scaffold the learning of specific skills and the development of key competencies.
5. For program success, it is essential to ensure that the school's computer resources meet the requirements of the Minecraft program.
6. It is important to adopt an open approach that allows students to evolve as the game progresses, with freedom of gameplay.
7. Students should be allowed to develop independent solutions to problems they encounter in Minecraft.
8. Collaboration and teamwork in gameplay should be encouraged.
9. Student creations should be valued.
10. A reward system should be considered to boost and sustain motivation.
11. Students should be encouraged to create supplemental levels with new proposed tasks to accomplish.
12. Proper oral communication between students during gameplay should be expected.
13. Students should be required to explain their learning, so that they become aware of their progress.
14. Students should be reminded that Minecraft is a game and that games are supposed to be fun.

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