

Minecraft's Implementation and Impact on Education

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Abstract. Minecraft is a popular sandbox video game that offers freedom of creation and collaboration. Its unique qualities are benefiting education. This paper aims to analyze the impact of Minecraft on education and its current application status. The study analyzed features of Minecraft that encourage players' creativity or help improve their skills before stating a number of detailed examples to connect the game and education through the concept of gamification. The study found that aspects like multiplayer mode, creating and destroying blocks, and ease of use contribute to the unique advantages of Minecraft in education. This research will help inform educators about how they can use the game to improve the efficiency and quality of the specific subject they teach. Future research can also be based on this study to find more advanced methods and use cases as well as judge other games' potential to benefit education.

1 Introduction

Minecraft is a global hit that has sold more than 300 million units (Parrish, 2023). It has an impact on people across different academic fields, age groups, regions, and cultures. Not only is the game a commercially successful product, but it has also raised researchers' interest in recent years due to its freedom of creation and diverse demography. Many have been studying the game's nature that attracts such a number of players and creates a phenomenal culture, and some have tried to expand its usage from entertainment to beneficial aspects such as education along with the growing popularity of gamification. The game has been implemented in science and literature classes and has seen advantages over traditional methods of teaching (Pusey, 2015; Callaghan, 2016; Cipollone, 2014). For Instance, Megan Pusey explored the usage of the game in Earth Science, concluding the effectiveness of implementation in this subject.

However, studies currently mainly focus on theoretical or single-case research that may provide limited or even one-sided information. For such reason, this study's goal is to present both a theoretical analysis of the advantages of Minecraft on education and gather several case studies on different levels of students by previous researchers to reinforce the theory that the game is suitable and sometimes better, for education compared with traditional teaching.

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This study first analyzes the concept of game-based learning with regard to Minecraft then finds potential links between them and gives some examples. Afterwards, the study summarizes and analyzes the design, purpose, and results of a number of case studies. Finally, the study is concluded by establishing connections between the case studies stated and the analytical research to further prove the main argument.

2 Minecraft as an educational tool

Gamification or Game-based Learning---The act of applying game elements like achievements and scores to aspects of education has long been used in various fields of education (Groh, 2012). According to previous studies, games' unique features of rapid feedback, freedom to fail, progression, storytelling, and more aid players in learning knowledge more effectively (Stott, 2013).

Minecraft has been seen as an educational game by many educators and researchers. It allows collaboration by having multiplayer mode; it also provides tools like a chalkboard and camera for easy assessment and instruction (Park, 2018). The fundamental mechanisms of the game encourage creativity by allowing the creation, modification, and destruction of anything in a world. Beyond that, the game has a unique crafting system which enables the player to explore item recipes and craft basic or advanced tools, blocks, armour, and weapons in the inventory or crafting table. This forces players to self-experiment or research online to survive, which practices information literacy (Groh, 2012). The world generation algorithm of the game gives players a nearly infinite range to build and explore, and it usually boosts their interest in finding new things (Bebbington, 2014).

In Minecraft, complicated mechanisms interconnect with each other in various ways, which ultimately resembles different fields of the real world, such as Biology, Ecology, Physics, Chemistry, Geology, and Geography (Tornqvist, 2014). And because of the game's sandbox nature, it sparks player creations in different forms related to the fields stated above. For instance, the concept of Ecology and preservation was implemented by a map called Skyblock – a World only consists of several blocks of land and a tree. The player must properly manage wood, stones, grass blocks, water, and other resources, otherwise, the game can't proceed.

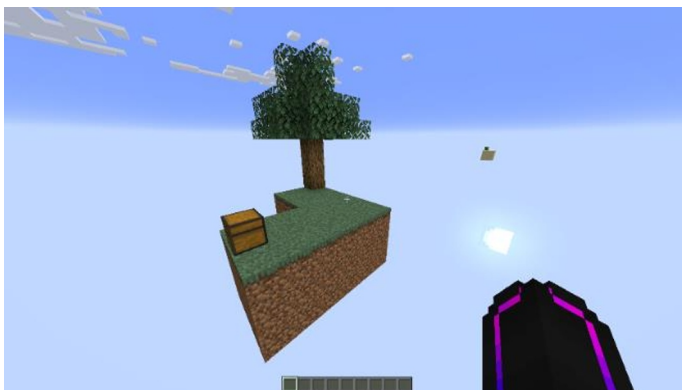


Fig. 1. Skyblock (Sammyuri, 2022)

As Figure 1 shows, Skyblock's main island is only made of grass block, a tree, and a chest with ice and a bucket of lava inside. The player has to chop down the tree by hand and then collect as much as saplings as he or she can before planting them with gaps in the grass. In order to get cobblestone, another useful item in the game, a T-shaped hole must be dug to put the ice and lava in a specific spot to generate stones.

As, an example for Geology, a typical Minecraft world generator creates a number of biomes, from desert to forest to extreme hill and ocean -all resemble real-world geological scenes (Short, 2012). Thus, players can learn about this subject during gameplay.



Fig. 2. Cherry Blossom on a hill (Sammyuri, 2022)

The scene in Figure 2 shows a cherry blossom on a hill. With the help of a mod called Iris and a shader called Complementary Shaders, the look of the game can be as realistic as the image shown. This can immerse the player to increase their engagement.

On top of the aspects stated, Minecraft features more technical mechanisms, including 1. Redstone: it resembles real computer circuits by mixing on and off of Redstone signal and 16 levels of signal strength to replicate binary and hexadecimal systems, thus creating basic logic gate circuits and, later, more complex ones, 2. Commands: because Minecraft the game is written by a programming language called Java, all the commands that control aspects of the game are also in Java syntax, but more abstract, and 3. Mods: This also needs to be in Java in order to function with the game, and it requires real programming experience to get into. They are beneficial for practising engineering skills (Kelly, 2015; Ekaputra, 2013).



Fig. 3. A Functioning Minecraft inside Minecraft itself (Sammyuri, 2022)

Take the Working Minecraft inside Minecraft in Figure 3 for example the build has an 8kb program memory, 256b extra RAM, hardware acceleration unit, 6kb graphic memory, graphic processor, 96 by 64 pixel screen, and a controller. The Minecraft program inside the machine was written on URCL, an Assembly-like language close to the physical hardware, and the world instance is running on a custom self-host server that optimizes the performance. All the components are replicas of basic, low-level hardware in the real world with near-physical programs to function as a computer. This demonstrates the understanding one needs

to finish the project and potentially how much a regular person can gain from Minecraft if he or she digs deeper

3 Minecraft case studies

The following study presents researchers' different studies on Minecraft's real-world use in education and analyzes them in detail to further prove the point that the game has educational benefits.

Minecraft in the Science classroom

This is a study by Megan Pusey and Grant Pusey (Pusey, 2015). The study took place in two Perth metropolitan schools, in which students in three science classes ranging from 13 to 14 years old got to use Minecraft Educational Edition as part of the class.

The ICT department provides a computer to host the Minecraft server software in order to allow multiple students and teachers to connect to the same world. Students can access the world within their schools' Intranet, but not over the Internet outside of the schools.

Low-to-medium performance laptops were provided to students to run MinecraftEdu. Students can install the game by running a program in the shared student folder and following the step-by-step instructions. As observed, students had no problem installing the game within 5 to 10 minutes and the game ran smoothly on their laptops. Because the game works best with a keyboard and an external mouse, students were encouraged to take an external mouse to the classroom. Most students followed while some of them still used touchpads to play the game.

To best fit the primary feature of Minecraft, a Year 8 Earth Science program implementing both Minecraft and traditional teaching elements was designed. Lessons in the program are 1. Introduction to MinecraftEdu, 2. Find and Classify, 3. Scientific Inquiry Skills, 4. Stratigraphy, 5. Quiz Maze, 6. Design and Build.

The first lesson was designed to help students, especially those who have less experience in video games, learn how to properly interact with the game as well as each other. The lesson primarily used an in-built world without needing much modification and teacher instruction. Students felt positive in the tutorial world.

Worlds in Minecraft can be outputted as a folder or single file, which can then be imported to another computer or back to the game once needed. This allows teachers to create the world and share it with others. For instance, a world for the fourth lesson of the program was created by a teacher, which can then be saved and imported later for similar lessons with little to no modification. Teachers can also download worlds online and make changes to better suit their classes.

During the program, students were required to dig up dirt to identify earth layers, find evidence of their age, build the shelters with knowledge about rocks' characteristics, build cell structures, and use signposts to label the components and describe their functions.

Throughout the program, nearly all students felt excited learning science lessons with Minecraft and had higher engagement than usual. Parents express a positive attitude toward the teaching method. Students were surveyed before and after the program, and they had more positive feelings toward science, Earth Science, and ICTs afterwards than before the program. Most of the students enjoy using Minecraft during lessons, and 94% of students agree or strongly agree with using MinecraftEdu again. According to the open-ended questions, students generally like the different ways to teach science, and believe they have more knowledge than using only textbooks. They like to play around and like the feeling that people are together.

However, some students dislike the lack of freedom to build whatever they want or have had little experience with Minecraft or the device they're using, resulting in negative feedback.

4 Minecraft in project-based learning

Noelene Callaghan conducted a study on 168 students in a secondary school to investigate the use of Minecraft in learning spaces by monitoring and analysing students' in-game behaviour during lessons. Students were surveyed on whether they had experience in Minecraft before the program. Two separated groups researched are 1. Year 7 TAS class, 2. Minecraft Club. The former had 3 75-minute sessions in 3 weeks while the second group accessed Minecraft 1.5 hours per week in a term. All the students logged in using the usernames and passwords given. For the year 7 TAS class, they were required to design their ideal houses using CAD software and then check the validity of their designs. Students can communicate and collaborate on one project with others and take screenshots or record videos to later blog their experiences.

During sessions, teachers who have had experience in Minecraft observe the students with an observation framework while other researchers use TechSmith Snagit to observe students through the Internet. The researchers focused on students' communication, collaboration, and engagement, as well as how they connect sub-tasks and create authentic learning environments.

In order to analyze a large amount of information, researchers implemented a strategy which comprehensively incorporates information gathered from predefined learning material, two worlds, class observation, survey, and student text communication and blogs. The study also considered both teacher's and researchers' opinions, which reduces bias.

According to the survey, 68% of the students in groups have experience in Minecraft, and most of them tend to build and have fun rather than mine or hunt during gameplay while nobody sees grieving as a purpose. Some major differences have been found between the year 7 TAS class and the Minecraft Club: 1. Students from Minecraft Club tend to add their personality to the builds instead of strictly following the rules. 2. The club's students share equal responsibilities for a task whereas groups in the TAS class heavily rely on 1 or 2 key people's lead to complete the tasks. 3. club members didn't worry about malicious playing activities while class students seemed to care about whether someone was going to grieve. 4. club members used some extent of text chat, but class students didn't at all. No one encountered issues installing, running, logging in, or navigating around in Minecraft. Most students think it is beneficial to use MinecraftEdu as part of their lesson, but not many people refer to the architectural aspects.

When playing the game, students were observed to collaborate and communicate with others: people in the class form bigger groups to finish the same project whereas club members tend to have smaller groups. Students showed skills like creating and evaluating in the sessions, which implies that the game helps develop and perfect these skills. Both students and teachers agree that Minecraft did an important job of instilling knowledge. Students showed engagement while in the game, which helped them to be more productive, and they were more likely to interact with teachers, which strengthened their relationships.

Finally, the study concluded that games like Minecraft could assist in teaching people with different learning abilities and improve cognitive capabilities.

5 Literary concepts in minecraft

Written by Maria et al, the study was about teaching literary concepts with the help of Minecraft (Cipollone, 2014). The study's purpose is to demonstrate how students can better express their creativity through the game. It primarily focuses on a group of 20 high schoolers in the Northeastern United States. The teacher surveyed the 20 students prior and found out that only 1 of them had experience in Minecraft before. The study was separated into 6 weeks,

in which students were required to explore the concepts of characterization and plot, and then create an interesting story in Minecraft.

First, a server was hosted for students' creations and instructor observation. The instructor divided students into 5 groups and then helped them get familiarized with the game before giving an optional prompt to them to spark creativity. Two options for shooting the story video were given: 1. Using a screen capturing software Bandicam to record the story. 2. Record the video with an actual camera.

A group of 4 female students chose to act in person instead of creating videos for reasons such as boredom with the game. The author of the study recognized the situation and concluded that popular games don't guarantee student interest.

Before the class began, students had to brainstorm the plot outside of the classroom and then go to the computer lab to create the scenes. The first group's result is "A Burning Passion": A person called Joseph has the curse that all of the people he loves will be burned to death. The video starts with him looking at his parent's graves and being afraid of burning his uncle which causes Joseph to refuse to live with him, and then a lightning bolt strikes. This shows the protagonist's internal conflict and struggle in such an extreme environment, demonstrating students' understanding of the complex personality in a literature work as well as their handling of Minecraft as a visualization tool to express emotional tension. The second group features a video called "The Hole": Roy is restrained by his family since he believes there is a rabbit only he can see telling him to dig holes everywhere, which results in a huge underground world under his house. When he gets into a verbal fight with the rabbit, the rabbit says that it's actually himself, with a deviated mind. The third group has a less complete work "The Flesh-Eating Predator": Kelly and her two friends try to join a party but accidentally go into a creepy house. The owner of the house murdered three of them.

The researchers concluded that students demonstrated experimentation with character traits and development, which is different from the traditional method that sparks less creativity, and that a new style of teaching that focuses on exploration, collaboration, and production skills should be employed.

6 Discussion

The case studies stated above show that, in many cases, Minecraft encourages creativity, acting like a platform for students to collaborate, and communicate with each other at relatively low cost. The nature of the game generally raises students' interest in the subject they are studying and usually adds something extra to the fixed course content. It is simple and requires a short time to set up, and it's intuitive, which means educators and students with no experience of the game can easily learn to navigate and interact with it. Its world save feature allows the sharing of different worlds with unique purposes circulating the educational field. This reduces educators' effort to manually build a world suiting their needs, rather, with minimum customization, a world from external sources can already meet the curriculum. This game's pixelated, square-blocked world allows high customization and modification and can be used in diverse contexts such as creating machinima, designing houses, building cell structures, exploring earth layers, and more. However, current researches primarily focus on Minecraft's basic mechanisms' use in education instead of diving deeper into more technical and challenging parts. For example, currently, no case study has been conducted to research the effect of the Redstone mechanism on engineering fields, nor has any study about commands or Mods in software development or computer Science. The author recommends future research to pay more attention to those fields, given plenty of content creators are featuring the kind of content, many being valuable study subjects. Research can also be around the demography of Minecraft the game and engineering fields to grasp the potential relationship between these two in order to explore detailed

features of players of Minecraft, which helps determine what educational field or student personalities this game is best suited to. Beyond Redstone, commands, and plugins, other aspects of the game can be analyzed in depth. These include the world generation algorithm, the villager trading system, item farms, the mob generation algorithm, accessibility features such as voiceovers and subtitles, and the different communities that have formed around self-hosted servers (such as 2b2t and Hypixel), as well as multiple play modes such as survival, hardcore, and creative. Through those advanced features, future works can explore the game's application in STEM, especially how to foster students' programming and engineering skills.

7 Conclusion

This study identified core elements of game-based learning and its several applications in Minecraft including multiplayer mode, chalkboard, camera, world creation, generation, and sharing, crafting, and Redstone, and has found the game's connection with other fields through two shared worlds and an auto-generated arbitrary world. The study also summarized three different real case studies of Minecraft's educational use in various ages in both the United States and Australia. Results in these studies show that using Minecraft as an educational tool helps raise students' interests and engagement. The game doesn't require high-end hardware, is easy to get familiar with, and is intuitive to operate for most educators and students at or above middle school. Students like the multiplayer feature which allows them to connect and collaborate with others, increasing their efficiency. They also mostly appreciate they can build, destroy, and film whatever they want despite some complaining of limited freedom compared to actual gaming. This also results in a more convenient and less costly field-study-like experience, which sparks creativity. The author suggests expanding the usage of Minecraft from general, literal fields to both broader areas and more specialized STEM subjects through its advanced features. The boost in creativity will surely benefit education as a whole.

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