



Using Minecraft for Mathematics Instruction

Introduction

Minecraft Education is an open-world, game-based learning platform designed for classroom use. It provides a transformative way to engage students in subjects across the curriculum in a social and immersive digital environment (Moilanen et al., 2020). It is based on the popular video game Minecraft, and includes features tailored specifically to educators, such as allowing teachers to manage in-game activities, integrate lesson plans, and create controlled and safe learning environments.

This paper examines the effectiveness of Minecraft Education as a tool for delivering mathematics instruction, particularly in, but not limited to, the domain of geometry and spatial mathematics.

Context: Teaching Mathematics in Minecraft Education

The Minecraft world is composed of blocks, each representing a cubic meter in the game's scale. This fundamental structure lends itself exceptionally well to teaching mathematics, specifically geometry and spatial reasoning. For instance, educators can guide students to construct and manipulate geometric structures, fostering understanding of geometric concepts (Kervin et al., 2016).

The natural process of building within Minecraft involves calculating volumes, areas, and perimeters, enhancing the learners' ability to think in three dimensions. This virtual construction mirrors the physical construction of objects, providing an engaging and intuitive means of learning math (Richardson, 2018). Furthermore, Minecraft Education's interactive lessons and teacher guides equip educators with the resources to design specific mathematical challenges. For instance, tasks might include designing a house with a given floor area or creating a farm with a specific perimeter.



Impact of Minecraft Education on Mathematical Outcomes

The use of Minecraft Education in mathematics has shown a positive impact on students' mathematical outcomes. This is demonstrated in both their conceptual understanding and problem-solving skills, as well as their attitudes and engagement towards the subject.

Several studies highlight improved mathematical understanding when Minecraft is integrated into learning experiences. An et al. (2016) found that students demonstrated improved understanding of mathematical concepts, particularly fractions and geometry, after participating in Minecraft-based lessons. These findings suggest that the immersive and interactive nature of Minecraft facilitates students' understanding of abstract mathematical concepts.

Furthermore, Minecraft's open-world structure fosters problem-solving and strategic thinking skills, essential for mathematics learning (Kharbach, 2012). When students are engaged in tasks such as constructing buildings or managing resources, they are effectively problem-solving within a mathematical context.

The motivational factor of Minecraft Education cannot be overlooked. The game-based approach can increase students' interest and engagement in mathematics (Cheung & Slavin, 2013). Engaged students are more likely to actively participate in their learning, leading to improved mathematical outcomes.

Value of Geometric Learning and Spatial Mathematics with Minecraft

Spatial reasoning skills, an integral part of geometric learning, have been associated with success in mathematics and science domains (Uttal et al., 2013). Minecraft Education allows students to engage in spatial mathematics in a tangible way. By immersing themselves in a virtual world, students can manipulate and navigate through geometric spaces, thereby strengthening their spatial reasoning skills.

A study by Kafai and Burke (2013) showed that students who used Minecraft as a tool for learning demonstrated improved spatial reasoning skills. This improvement was attributed to the process of navigating a three-dimensional world, manipulating geometric shapes, and understanding spatial relationships. Minecraft Education extends this spatial engagement further by providing lesson plans and activities specifically tailored for math instruction.

Additionally, the game-based nature of Minecraft motivates learners to engage in problem-solving tasks that involve mathematical concepts, leading to deeper learning (Squire, 2011).

Harnessing Number Concepts in Minecraft Education

In addition to geometry, Minecraft Education is a potent tool for exploring number concepts, aiding in the development of number sense. This aspect of mathematics understanding refers



to the ability to intuitively work with numbers, including their relationships, operations, magnitudes, and representations (Berch, 2005).

Minecraft Education naturally involves the use of numbers and counting. For instance, collecting and using resources involves understanding of quantity and basic arithmetic. When crafting items, students need to consider how many resources they have, how many are required, and how many will be left afterwards.

More advanced tasks can involve ratios, fractions, and proportions. For example, students can design structures based on specific proportions, or carry out tasks that involve distributing resources evenly among a certain number of characters or locations (Hwang et al., 2019). These interactive activities provide students with practical, hands-on experience with number concepts.

Exploring Symmetry through Minecraft Education

Symmetry is another mathematical concept that is naturally embedded within the Minecraft Education environment. Minecraft offers a virtual sandbox where students can experiment with line symmetry (reflection), rotational symmetry, and translational symmetry (repetition), thus promoting understanding of these key geometric concepts (Falloon, 2019).

Students can design symmetrical structures or patterns, reflecting on how different shapes can be rotated, flipped, or translated while maintaining their fundamental identity. These tasks provide a highly visual and interactive way of exploring symmetry, which research has shown to be effective for learning this concept (Battista, 1990).

Moreover, Minecraft's environment encourages students to spot symmetry in the world around them and understand its role in design and aesthetics. Such activities not only bolster mathematical understanding but also foster creativity and critical thinking skills.

Fraction Learning within Minecraft Education

Minecraft Education also provides rich opportunities for fraction learning. Understanding fractions and fraction operations is a fundamental aspect of mathematical literacy, yet it is often challenging for many students to grasp (Siegler et al., 2010).

In Minecraft, students can experience fractions in an intuitive, concrete manner. For instance, the game environment comprises blocks that students can use to visually represent fractions. They could take a whole block as one whole unit, and then use smaller blocks or divided sections of a block to represent fractional parts.

Fractional concepts can also be explored through resource management and crafting tasks. Students might need to divide resources into equal parts, identify what fraction of their total resources a certain amount represents, or carry out tasks that involve fractional operations. For example, students could be asked to share a certain number of resources equally among



characters, or to calculate what fraction of their total resources would be used in crafting an item (An, 2018).

This contextual, hands-on exploration of fractions can help students develop a deeper understanding of fractional concepts and operations. It allows students to see the practical applications of fractions, providing an authentic learning experience that can enhance their mathematical literacy.

Problem-Solving Mathematics with Minecraft Education

One of the main strengths of Minecraft Education in the mathematics classroom lies in its ability to foster problem-solving skills. The game naturally encourages students to think strategically, analyze situations, and devise solutions - all crucial aspects of mathematical problem-solving.

Students in Minecraft are often placed in situations that require them to figure out how to use their resources most effectively. For instance, they may need to calculate how many blocks they need to build a structure of a certain size, determine the most efficient way to gather resources, or plan out a design that meets specific constraints (An et al., 2016). These tasks require mathematical thinking and problem-solving skills, and the immersive nature of the game helps students see the relevance and application of these skills in a tangible context.

Minecraft Education further enhances problem-solving by allowing teachers to design challenges and activities that target specific mathematical skills or concepts. The game's flexible environment can accommodate a wide range of problem types and difficulty levels, making it adaptable to different learning needs and objectives (Hauge, 2014).

In addition, Minecraft encourages collaborative problem-solving. Students can work together on projects or challenges, promoting the development of collaborative skills as well as deeper mathematical understanding. Research has shown that collaborative problem-solving can lead to higher achievement in mathematics (Roseth et al., 2008).

Effective Implementation of Minecraft Education for Mathematics Instruction

While Minecraft Education holds significant potential as a tool for mathematics instruction, its effectiveness relies on thoughtful implementation. There are several key factors that educators must consider when introducing Minecraft into the classroom.

Alignment with Curriculum: First and foremost, the Minecraft activities should align with the learning objectives and the curriculum standards (Kenny et al., 2016). This ensures that the



game is not just a fun diversion, but an effective tool that reinforces and enhances the mathematics instruction.

Incorporation of Pedagogical Strategies: Minecraft should be implemented in a manner that complements effective pedagogical strategies. For instance, problem-based learning, inquiry-based learning, and collaborative learning can all be effectively facilitated within Minecraft (Wu et al., 2013).

Providing Guidance and Support: While Minecraft's open-ended nature encourages exploration, students may need guidance to connect their gameplay with mathematical concepts (Crompton et al., 2017). Teachers should be prepared to provide scaffolding, offer hints, or ask probing questions to help students make these connections.

Assessing Learning: Assessment should be an integral part of the Minecraft-based lessons. Given the game's interactive nature, assessment might look different than in a traditional math class. Teachers may need to assess students' in-game creations, observe their problem-solving process, or provide in-game challenges that serve as assessments (Kearney et al., 2019).

Professional Development: Lastly, teachers may require professional development to become comfortable with Minecraft and understand how to use it effectively for mathematics instruction. This might involve technical training as well as exploration of pedagogical strategies for game-based learning (Hamari et al., 2016).

By considering these factors, educators can ensure that the integration of Minecraft Education into the classroom maximizes the benefits for students' mathematics learning.

Conclusion: Adoption of Minecraft Education for Mathematics Education

Minecraft Education offers a unique and engaging way of teaching mathematics that aligns with research on effective learning. By introducing mathematical concepts through interactive, hands-on tasks in a familiar and engaging environment, it can enhance students' spatial reasoning skills and their overall understanding of math.

Incorporating Minecraft Education into a curriculum is an innovative way to approach mathematics instruction. This approach not only resonates with today's digital native learners but also aligns with the best teaching practices, which advocate active, student-centered learning (Prensky, 2001).

Given its significant potential to foster understanding mathematical concepts and improve spatial reasoning skills, Minecraft Education should be considered as a tool for mathematics education by teachers and educators globally.



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