MINECRAFT EDUCATION FOR IMPROVING ACADEMIC PERFORMANCE: A COMPARATIVE STUDY IN PRIMARY EDUCATION

MINECRAFT EDUCATION PARA MELHORAR O DESEMPENHO ACADÉMICO: UM ESTUDO COMPARATIVO NO ENSINO BÁSICO

Recebido em: 7 de janeiro de 2025
Aprovado em: 12 de março de 2025
Sistema de Avaliação: Double Blind Review
RCO | a. 17 | v. 1 | p. 52-73 | jan./jun. 2025
DOI: https://doi.org/10.25112/rco.v1.3934

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Revista CONHECIMENTO ONLINE

ISSN: 2176-8501

ABSTRACT

Minecraft Education is a popular construction game that immerses students in interactive virtual environments. By using this tool, students can engage in various learning activities and develop collaborative and problem-solving skills. This study aimed to determine whether incorporating Minecraft Education into the teaching of fractions improved students' learning and grades. A quasi-experimental design was employed, with a control group and an experimental group, involving two groups of primary school students (n = 25). The control group received a fraction learning session using traditional teaching methods, while the experimental group received the same session using Minecraft Education as an educational tool. The results indicated that the experimental group performed better academically on the topic of fractions compared to the control group. Furthermore, students using Minecraft Education demonstrated higher levels of engagement and achieved better marks during the session. The interactive and visual nature of Minecraft Education allowed students to explore abstract fraction concepts in a more tangible and practical way, facilitating deeper and more lasting understanding.

Keywords: Gamification, Educational Innovation, Video Games, Minecraft Education, Primary Education

RESUMO

O Minecraft Education é um jogo de construção popular que permite a imersão em ambientes virtuais interactivos. Através da sua utilização, os alunos podem envolver-se numa variedade de aprendizagens e desenvolver competências de colaboração e de resolução de problemas. O objetivo do estudo era determinar se a incorporação do Minecraft Education no ensino das fracções melhorava a aprendizagem e as notas dos alunos. Para tal, foi realizado um desenho quase-experimental com um grupo de controlo e um grupo experimental, envolvendo dois grupos de alunos do ensino básico (n = 25). Ao primeiro grupo foi proporcionada uma sessão de aprendizagem de fracções utilizando métodos de ensino tradicionais, enquanto ao segundo grupo foi proporcionada a mesma sessão utilizando o Minecraft Education como ferramenta educativa. Os resultados do estudo indicaram que o grupo experimental teve um melhor desempenho académico no tópico das fracções em comparação com o grupo do ensino tradicional. Além disso, os alunos que utilizaram o Minecraft Education demonstraram níveis mais elevados de nota e de envolvimento durante a sessão didática. Por último, a natureza interactiva do Minecraft Education permitiu aos alunos explorar conceitos abstractos de fracções de uma forma mais prática, o que facilitou uma compreensão mais profunda e duradoura.

Palavras-chave: Gamificação, Inovação Educativa, Videojogos, Minecraft Education, Ensino Básico.

ISSN: 2176-8501

1 INTRODUTION

Education is constantly evolving, and in the field of mathematics, educators and curriculum designers are perpetually seeking new strategies and tools to enhance the learning of abstract concepts and stimulate students' interest. In this context, educational technology has played a crucial role by offering more interactive and engaging methods of teaching (Khasawneh, 2024).

Gamification has garnered significant attention in the educational field and is increasingly used as a strategic technique to boost student participation and motivation (Baah et al., 2023; Prieto-Andreu et al., 2022). Its primary goal is to meaningfully engage participants and promote desired behaviors (Hashim et al., 2024). Key features of gamification include the use of points, levels, challenges, rewards, competition, collaboration, immersive narratives, constant feedback, personalization, and other typical game elements. Gamification is applied in various educational contexts to make learning experiences more engaging and rewarding. Well-designed games leverage our strengths, eliminate the fear of failure, and improve our prospects for success. Moreover, they support social cooperation and encourage meaningful civic engagement on a significant scale (Coughlin et al., 2024; Qiao et al., 2023).

An essential aspect of games that should not be overlooked is their innate ability to entertain and amuse. This playful attitude not only increases participation, fosters loyalty, stimulates learning, and communicates uniquely, but also serves as a tool for problem-solving and a means of raising awareness and empowerment (Chen and Yang, 2024).

Today's learners of all ages are immersed in digital stimuli, making it crucial to exploit the educational potential of these resources (Nguyen-Viet and Nguyen-Viet, 2023). Both teachers and students can discover the feasibility of learning in a playful manner, rendering the game-based educational process both entertaining and enjoyable. The appropriate use of technology emerges as the optimal educational tool when infused with a fun and engaging approach (Fernández-Casado, 2022; Galindo, 2019).

In particular, Minecraft Education has emerged as an innovative tool that combines a virtual building environment with educational goals (Galindo-Domínguez, 2019; Nkadimeng and Ankiewicz, 2022). By creating virtual worlds, students can explore and experience mathematical concepts in a practical and engaging way. This tool has demonstrated its potential, particularly in teaching fractions (Plazas-Salazar, 2022). Additionally, Minecraft Education enhances creativity, collaboration, and problem-solving skills, making it both motivating and engaging for students (Bile, 2022; Slattery et al., 2023a; Slattery et al., 2023b). Specifically, Minecraft Education offers a didactic approach to mathematical problem solving. It is a methodology that promotes learning through video games while enhancing various skills and competencies (Herrero et al., 2017).

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The importance of using video games as tools with strong motivational and educational potential in the mathematics learning process is supported by several studies (Hidalgo-Sánchez, 2021; Tablatin et al., 2023; Vázquez and Sevillano, 2022). These investigations highlight the ability of video games to stimulate students' interest and participation in mathematics, underscoring their value in the educational context. Similarly, Jensen and Hanghøj (2020) present a positive view of Minecraft as an effective tool for teaching mathematics. Their results revealed a transformation in students' perspectives regarding their mathematical skills.

The ability to create virtual environments in Minecraft provides a valuable opportunity for exploration, construction, and problem-solving. This tool not only motivates students through challenges but also offers a context conducive to addressing issues related to fractions, thereby enhancing understanding and retention of various mathematical concepts (Mutawa et al., 2023; Narro, 2022). Minecraft enables students to engage in self-directed learning, emphasizing a reinforcement and imitation approach in their educational journey (Sanfélix-Enguídanos, 2023; Tonbuloglu, 2023). As such, it stands out as an exceptional pedagogical tool that promotes teamwork, collaboration, and creativity.

Furthermore, Minecraft's ability to transcend gender barriers and other inequalities is particularly noteworthy (Ahumada, 2021). It also provides a comfortable environment for students with high abilities, autism, and learning disabilities to interact with peers while navigating virtual spaces (Bourdeau et al., 2021).

Fractions are a fundamental topic in mathematics that can be challenging for many students due to their abstract nature. Traditional teaching methods often rely on theoretical and abstract exercises, which may hinder students' understanding and interest (Castro-Rodriguez & Rico, 2017). This raises the question of whether innovative educational methodologies, such as using Minecraft Education, can enhance students' learning and motivation in this specific subject.

Studies have shown that Minecraft can be an effective educational tool, particularly in mathematics. Given the abstract nature of mathematical concepts, Minecraft offers solutions through various interventions, as exemplified by Nkadimeng and Ankiewicz (2022). In this context, even though mathematics itself is not the primary focus, concepts like the union of atoms and the process of generating elements are discussed, engaging students with more abstract and complex ideas than traditional methods typically achieve.

However, the tool is not without limitations. While there is a general consensus that Minecraft Education can provide deeper content understanding and improve academic performance, particularly among students with autism (Gehricke et al., 2022), there are challenges related to the prerequisite

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knowledge of the tool. Prior familiarity is crucial for developing enriching experiences effectively (Edwars et al., 2022; Jensen and Hanghøj, 2020).

Based on these considerations, the purpose of this study was to investigate whether integrating Minecraft Education into the teaching of fractions could enhance student learning outcomes and grades at a school in Spain. The study was guided by the following hypotheses:

a) Causal hypothesis: Integrating Minecraft Education into fraction instruction will lead to improved academic performance and grades among Primary Education students.
b) Intervention hypothesis: Minecraft Education provides the necessary conceptual, instrumental, and procedural elements to enhance academic performance and grades in fraction learning.
c) Action hypothesis: Improvements in academic performance will ensure the sustained and consolidated learning of fractions over the medium and long term.

2 METHODOLOGY

Following Campbell and Stanley's (1963) model, this study employed a quasi-experimental design with a control group, incorporating both pretest and posttest assessments. The primary variables included: (a) the independent variable, which determined participation in practical sessions using Minecraft Education; and (b) the dependent variables, focusing on the learning process of fractions. Participants were randomly assigned to either the treatment group, which involved educational sessions on fractions using Minecraft Education, or the control group.

The sample was selected using a non-probabilistic approach, specifically convenience sampling (Pérez, 2016). The sample naturally consisted of two subgroups drawn from a total of twenty-five students, representing an entire 6th grade Primary Education class.

2.1 PARTICIPANTS

The study participants were students from a school located in the province of Cadiz, Spain. Participation invitations were extended using Microsoft Teams, and data collection was conducted through a survey designed on Google Forms. Prior to gathering responses, participants received comprehensive information about the study's objectives. Measures were taken to ensure the confidentiality and anonymity of all data collected, and informed consent, including parental or guardian authorization for minors, was obtained.

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All data handling adhered to Organic Law 3/2018 of December 5, which governs the Protection of Personal Data and Guarantee of Digital Rights in Spain. The data collection process took place throughout November 2023, with full compliance with parental permissions from the involved families.

The sample for this study comprised 25 6th grade elementary school students, which was considered sufficient for the present research. According to Chou and Feng (2019), in experimental studies with a pretest-posttest design, the sample size does not significantly impact the results. The Experimental Group (EG) consisted of 12 students, while the Control Group (CG) included 13 students. Both groups were ensured to be heterogeneous and similar in terms of age, academic level, and prior knowledge in Mathematics and fractions.

Participants provided demographic information including age, gender, history of grade repetition, and presence of measures for attention to diversity (ACNEAE) in their records. The sample consisted of 18 boys (EG = 9; CG = 9) and 7 girls (EG = 3; CG = 4), all aged between 10 and 11 years. Table 1 details the sociodemographic profile of the participants.

Tabl1 1 Participant's Sociodemographic data

	CG		**EG**			
Variables	n	%	n	%	n	%
Age						
10	24	96	12	92,31	11	91,67
11	1	4	1	7,69	1	8,33
Gender						
Boy	18	72	9	69,23	9	75
Girl	7	28	4	30,77	3	25
Course Repeat						
Promoted	24	96	12	92,31	11	91,67
Not promoted	1	4	1	7,69	1	8,33
ACNEAE						
YES	3	12	2	15,38	1	8,33
NO	22	88	11	84,62	11	91,67

Nota: CG = Control Group; GE = Experimental Group Source: Own Elaboration

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2.2 INSTRUMENTS FOR DATA COLLECTION

Different instruments were used for data collection. The first was a questionnaire prior to the training program, which evaluated the students' level of prior knowledge about fractions; this served to establish the control and experimental groups. The second consisted of a written evaluation after the program, which assessed the students' academic performance on the topic of fractions. In addition, observation logs and video recordings were used during the sessions to capture the level of student participation and engagement in each group.

The main instrument used for both pretest and posttest measures was a self-made scale designed to assess knowledge before and after the intervention. This scale consisted of 8 items, each rated on a four-point Likert scale (1 = inadequate, 2 = elementary, 3 = satisfactory, 4 = excellent), aiming to evaluate general knowledge of fractions. In this study, the scale demonstrated satisfactory reliability with a Cronbach's Alpha coefficient of = .854. The items of the instrument are detailed in Table 2:1 Graphic representation of fractions through coloring and block representation, 2 Reading and writing fractions, 3 Correspondence between decimal numbers and fractions, including the inverse relationship, 4 Comparison of fractions using the signs lesser (<), equal (=), or greater (>), 5 Comparison of decimal numbers using the same signs as in item 4, 6 Focus on fraction equivalence, 7 Operations involving fractions, 8 Representation of a chosen fraction.

Each item was designed to assess specific aspects of fraction knowledge, contributing to the overall evaluation of the intervention's effectiveness.

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Table 2 Pretest and posttest correction rubric.

ÍTEMS	EXCELEN	SATISFACTORY	ELEMENTAL	INADECUATE
1	Color and represent graphically with blocks four fractions, maintaining proportionality.	Color and represent graphically with blocks two fractions, maintaining proportionality.	Color and represent graphically with blocks two fractions, without maintaining proportionality.	Does not color or graphically represent correctly
2	Read and write eight fractions correctly and represent the numerator and denominator.	Read and write eight fractions correctly	Read and write at least two fractions correctly.	Does not read or write correctly
3	Write the exact decimal number of four fractions.	Write the exact decimal number of two fractions	Write the exact decimal number of at least one fraction.	Does not write the decimal number correctly
4	Correctly compares four fractions	Correctly compares two fractions	Compares correctly at least one fraction	Does not compare correctly
5	Correctly compares four decimals	Correctly compares two decimals	Correctly compares at least one decimal place	Does not compare decimals correcly
6	Write four equivalent fractions in the correct form	Write two equivalent fractions in the correct form	Write at least one equivalent fraction correctly	Not spelling correctly
7	Calculates correctly the result of the twelve operations, simplifying the results	Correctly calculates the result of twelve or up to nine operations, simplifying or not simplifying the results.	Correctly calculates the result of six operations, simplifying or not simplifying the results	Does not calculate correctly
8	Represents graphically and fraction correctly	Represents graphically or fraction correctly	Graphically represent the fraction correctly.	Does not represent correctly

Source: Own Elaboration

2.3 PROCEDURES AND MATERIALS

The training program was conducted with both experimental and control groups during the academic year 2023/2024 in the 6th grade of primary education. A total of eight sessions, each lasting 60 minutes, were held over a span of two weeks. The sessions implemented two different approaches: the traditional method and the use of Minecraft Education through computers.

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The training program included eight sessions focused on acquiring knowledge of fractions. During the 1st session, a pretest was conducted where all students took a fractions test, and their results along with the time taken were recorded. Sessions 2 and 3 aimed at familiarizing students with the Minecraft tool. The experimental group (GE) engaged in learning and exploration within an open-world environment using Minecraft Education, facilitating interaction among themselves, while the control group (CG) underwent traditional fractions review sessions. Sessions 4, 5, 6, and 7 involved dividing the class into two heterogeneous groups: CG (13 students) and GE (12 students). The CG remained in their regular classroom where their math teacher taught fractions in a traditional manner across three sessions. Meanwhile, the GE received the same fraction lessons in a computer classroom using Minecraft. This allowed them access to instructional links, review videos, and various tests within an adapted Minecraft world. During the four Minecraft sessions, the activity involved completing an escape room with seven rooms, each aligned with the eight topics to be assessed in the posttest. In the first, fifth, and seventh rooms, students had to solve four exercises to progress to the next room. In the second, third, fourth, and sixth rooms, they faced six exercises (see Figure 1).Finally, in the 8th session, the posttest was administered. All students returned to their respective classrooms for assessment, evaluating the time spent and the knowledge acquired using both methodologies (traditional and Minecraft) in each group (CG and GE).

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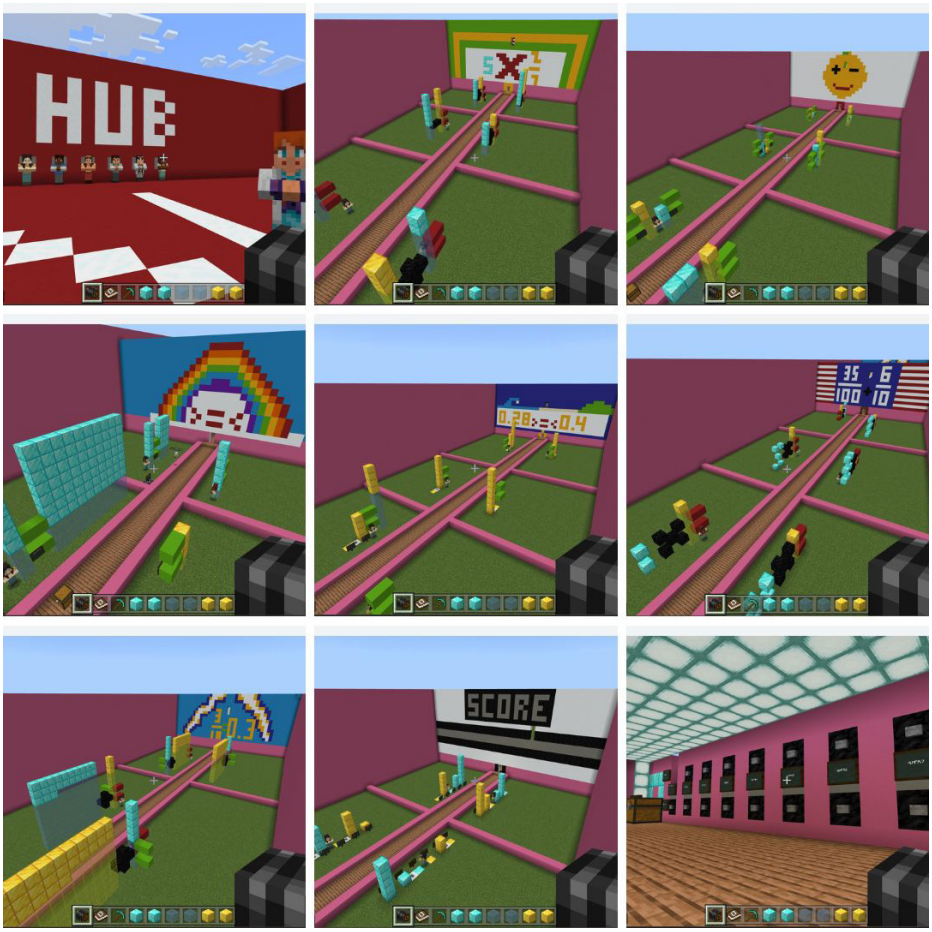
Figure 1 Escape room of the world of fractions in Minecraft Education



Own Elaboration

2.4 DATA ANALYSIS

The data analysis in this study involved using SPSS statistical software, version 25. Initially, fundamental descriptive measures such as means and standard deviations were calculated for the collected data sets. Following this, the t-test was employed to assess differences between groups. Additionally, p-values were computed to determine statistical significance, and Cohen's d-value was used to measure effect size.

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In summary, the analysis included descriptive statistics, t-tests for mean comparisons, calculation of p-values for significance testing, and Cohen's d-value for effect size estimation. These methods were applied to rigorously test the study's hypotheses.

3 RESULTS

The following comparative analysis presents the results of the pretest and posttest in terms of the grades obtained. It is noteworthy that the horizontal axis of the bar graph represents 25 students: the first 13 belong to the CG, while students numbered 14 to 25 (12 students) correspond to the GE (Figure 2).

Regarding the time taken to complete the tests, the following results were obtained: In the pretest, the average time to complete it was 41 minutes, with a range of 26 to 57 minutes overall. Specifically, the CG averaged 46.85 minutes, while the GE averaged 34.67 minutes. In the posttest, the average time to complete it was 30.08 minutes, with a range of 22 to 50 minutes overall. Specifically, the CG averaged 35.38 minutes, while the GE averaged 24.33 minutes. These findings highlight differences in test completion times and performance between the two groups, reflecting the impact of the instructional methodologies used.

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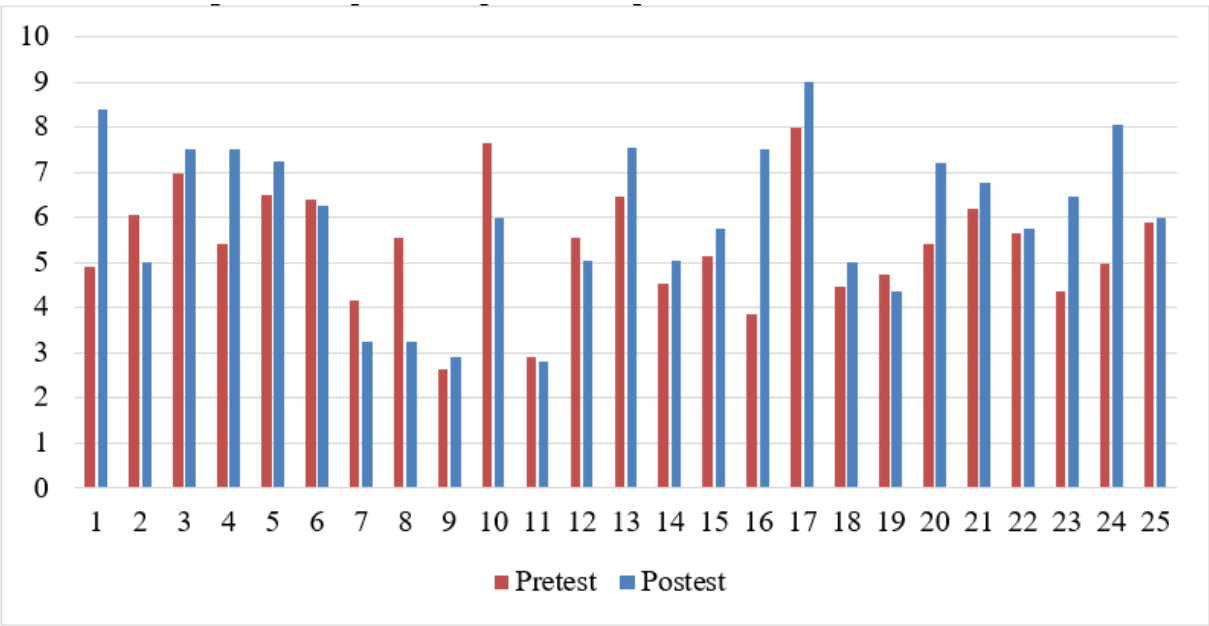
Figure 2 Comparison of pre-test and post-test scores for each student.



Own elaboration

In sum, the data highlight the improvement of the grades in the experimental group after the use of Minecraft Education, with significant differences between the pretest and posttest measures, as well as the improvement of the grades of the experimental group compared to the control group (Table 3). In relation to the initial hypothesis, it can be confirmed, since the mean score of the students has increased (M = 6.408) with respect to the pretest (M = 5.258). However, there are no significant intergroup differences, although the improvement has been substantial in the experimental group.

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Tabla 3 Intra-group and inter-group comparison

Group	n	*M*	SD	*t*	*p*	*d*
Intragroup						
Experimental						
Pretest	12	5,258	1,113	-2,260	.034	.923
Postest	12	6,408	1,366			
Control						
Pretest	13	5,462	1,457	-.166	.869	.065
Postest	13	5,577	2,034			
Intergroup						
Pretest						
Experimental	12	5,258	1,113	.389	.701	.157
Control	13	5,462	1,457			
Postest						
Experimental	12	6,408	1,366	-1,189	.247	.480
Control	13	5,577	2,034			

Source: Own Elaboration

Therefore, the mean scores obtained in the post-test were higher than those in the pre-test for the experimental group (Figure 3), indicating improved academic performance among students using Minecraft Education compared to those following a traditional methodology. Conversely, students in the control group showed a slight increase in post-test scores compared to pre-test scores.

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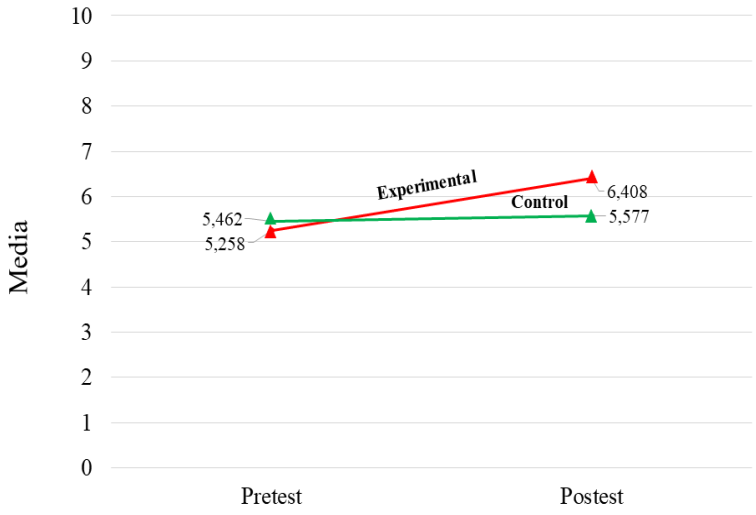
Figura 3 Comparison of control group and experimental group between pre-test and post-test measurements.



Own Elaboration

Analyzing the results by gender, it is notable that the initial group composition is approximately three times more male than female, with 18 males and 7 females. In the control group, males exhibited the highest percentage decrease (30.7%) and increase (30.7%) in their scores. Conversely, females in the control group showed a higher percentage decrease (15.3%) in their scores in the post-test, while the remaining either increased or maintained their scores.

In the experimental group, both males (58.3%) and females (25%) showed improvements in their scores in the post-test measure. Only 8.3% of males either decreased or maintained their scores (Figure 4).

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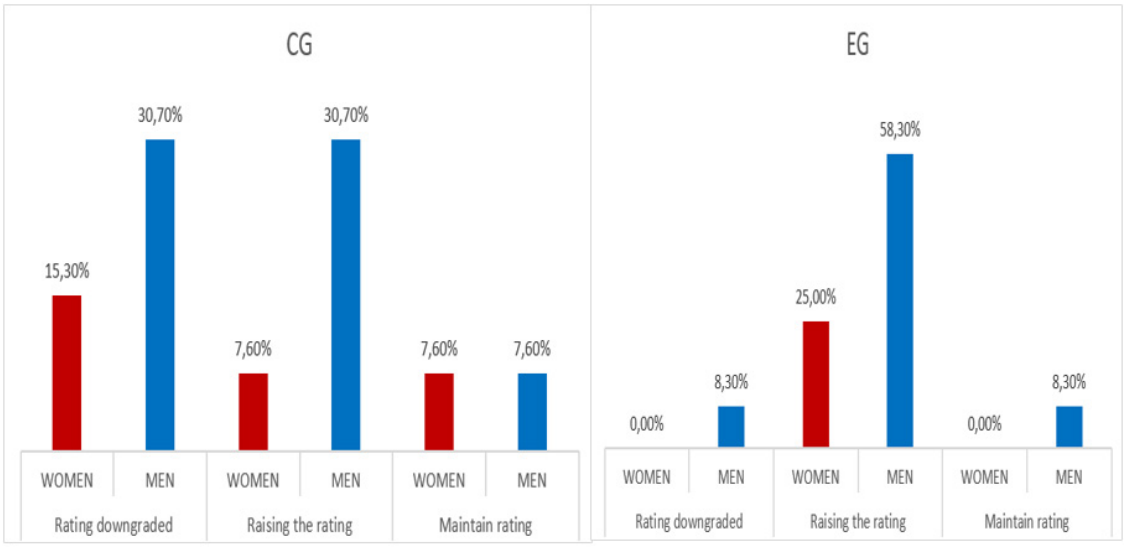
Figura 4 Percentage of students who increase or decrease their GC and GE scores



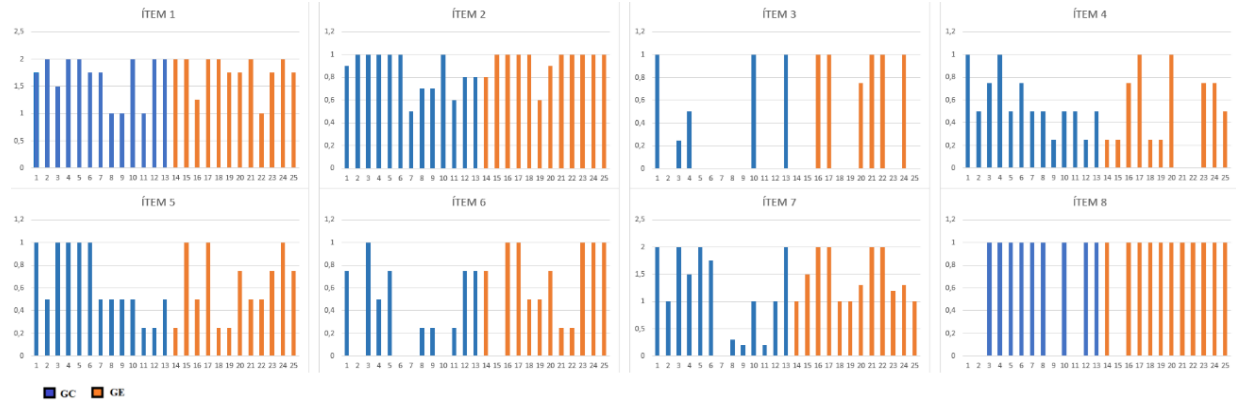
Own Elaboration

Finally, the post-test comparison of all assessed items in both groups is presented (Figure 5). In the first item, there is no significant disparity observed in scores between the CG and the EG. Both groups have six students achieving the maximum score, with all reaching the average score on this item. In the second item, it is notable that the EG has nine students achieving the maximum score, whereas in the CG only six reach this level. Additionally, all participants in both groups achieve the average score on this item, indicating a performance advantage for the EG. Moving to the third item, it is important to highlight that more than twice as many students in the EG (41.67%) achieve the maximum score compared to the CG (23.08%). Furthermore, it is observed that 61.53% (eight students) of the CG do not score on this item, whereas in the EG this percentage is 50% (six students). Therefore, the EG demonstrates superiority in this aspect. In the fourth item, it is noteworthy that in the EG, 50% of the students do not achieve even half of the score. Conversely, in the CG, 11 students (84.61%) reach the average score, while in both groups only two students achieve the maximum score. In the fifth item, among the 13 CG students, all except two achieve the mean score, equivalent to 84.62%. Conversely, in the GE, nine out of 12 students achieve the mean score, representing 75%. Additionally, it is noted that in the CG, 38.46% (five students) attain the maximum score, whereas in the EG this percentage is 25%, with three students achieving this level. Here, the CG demonstrates better results. Moving to the sixth item, it is important to highlight that in the EG, 41.66% of students (five students) achieve the maximum score, while in the CG, only one student (7.69%) accomplishes this. Furthermore, in the GE, only one student (8.33%) does not score, compared to

ISSN: 2176-8501

four students (30.77%) in the CG who do not score. In the seventh item, all students in the EG achieve the average score, reaching 100%. In contrast, in the CG, four students (30.77%) fall below the average score, including one student scoring 0. Finally, in the eighth item, it is notable that all participants achieve the maximum score, except for four students in the CG (30.77%) and one student in the EG (8.33%). In this comparison, the EG demonstrates higher achievement overall

Figura 5 Comparison of the eight items in the post-test between CG and GE



Own Elaboration

4 DISCUSSION AND CONCLUSION

The study aimed to evaluate whether integrating Minecraft Education into fraction instruction would enhance student learning and academic performance. Based on the hypothesis that incorporating Minecraft would improve academic outcomes, the research yielded positive results supporting the effectiveness of this approach.

In the comparative analysis between the pre-test and post-test, students exhibited variability in performance during the pre-test, reflecting diverse levels of understanding of fraction concepts prior to the intervention. Specifically, in the post-test, some students demonstrated improvements in their grades compared to the pre-test, indicating progress in learning fractions. This suggests that the use of Minecraft Education positively impacted student learning outcomes in this study.

With regard to the data analysis, it stands out that within the CG, eight students experienced a decrease in their grades from the pretest to the posttest, representing 61.53% of the total. In contrast, in the GE, only one of the students recorded a decrease in grade, equivalent to 8.33%. This finding supports Bile's (2022) and Slattery et al.'s (2023) claim about the creative, motivational and educational capacity

ISSN: 2176-8501

of virtual environments such as Minecraft. In addition, among the CG students, four students were identified as failing, compared to the GE, where only one student did so. These results suggest that the use of virtual environments, in the context of Minecraft, can have a positive impact on the retention and understanding of mathematical concepts (Mutawa et al., 2023), especially in solving problems related to fractions.

In the context of analyzing the time taken to complete the tests, there appears to be a slight decrease in the time required, suggesting greater efficiency in solving fraction exercises after the intervention. What is notable, considering the earlier findings, is that both groups experienced a similar reduction in time, but the GE showed improved results compared to the CG. This outcome reinforces the notion that integrating video games into mathematics instruction can not only expedite problem-solving skills but also lead to significant enhancements in academic performance (Hidalgo-Sánchez, 2021; Tablatin et al., 2023; Vázquez and Sevillano, 2022).

Regarding the results by gender, despite there being more men than women in the sample, a similar percentage of men increased and decreased their grades between the pre-test and the post-test, whereas more women showed a decrease in their grades. Conversely, an equal percentage of men and women approximately maintained their grades. In the GE, none of the women experienced a decrease or maintenance in their grades; all of them showed improvement. The majority of men also increased their grades, with only one showing a decrease and one maintaining their grades. These findings align with previous research, such as Ahumada (2021), which suggests that using Minecraft can effectively address gender barriers, inequalities, and learning challenges in a virtual environment while promoting interaction among classmates.

In comparing all assessed items in the post-test between both groups, the Control Group (CG) shows improvement in academic performance across most items, except for the first item where the difference is not significant enough to evaluate, and the fourth and fifth items where the CG performs better. It is noteworthy that on these two items, the probability of correct answers is nearly 50%, suggesting that the CG's better performance could be attributed to chance. These findings indicate that the intervention involving the creation of virtual worlds has positively influenced the academic performance of the CG, particularly in teaching mathematical concepts related to fractions (Plazas-Salazar, 2022).

Based on the results obtained, it can be concluded that the implementation of Minecraft Education as an innovative educational method to teach fractions to sixth-grade primary school students was highly effective, achieving the intended objective and confirming the established hypothesis. Students showed significant improvement in their understanding of fractions following the educational

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intervention, highlighting the potential of this approach to enhance mathematical learning. Furthermore, gamification and the use of virtual environments such as Minecraft Education were found to increase student engagement (Baah et al., 2023; Hashim et al., 2024; Prieto-Andreu et al., 2022). These factors contributed to more meaningful and interactive learning experiences, enabling students to develop mathematical skills more effectively (Khasawneh, 2024).

All findings suggest that the didactic session on fractions had a positive impact on students' learning. It is relevant to note that individual improvement may vary, and additional factors, such as active participation in the class, could have influenced the results. However, the ability to explore and experiment with mathematical concepts in a hands-on and engaging way in virtual environments, as highlighted in the literature (Jensen and Hanghøj, 2020; Slattery et al., 2023a; Slattery et al., 2023b), was beneficial and was reflected in improved performance on most of the items assessed.

In relation to the identified limitations, it is essential to acknowledge that the quasi-experimental study was conducted with a small sample size, potentially limiting the generalizability of the findings. A possible enhancement could involve including more diverse comparison groups, thereby enlarging the sample size and providing a more comprehensive representation in terms of participant numbers and gender balance.

For future research, it is recommended to expand beyond the topic of fractions and explore other relevant areas of mathematical knowledge pertinent to sixth-grade primary school students.

Furthermore, the observed lack of improvement in the first item in the experimental group presents an area of interest for future investigation or adjustments in the implementation of the intervention. The superior results of the control group on items four and five may indicate the effectiveness of specific aspects of traditional teaching methods in those particular subjects. These insights underscore the importance of considering innovative approaches, such as the creation of virtual worlds, to enhance mathematics learning, particularly in specific domains like fractions.

Overall, this research underscores the significance of adopting innovative pedagogical approaches in teaching mathematics, particularly in challenging topics such as fractions. The integration of educational technologies like Minecraft Education offers students a more interactive and practical learning experience, thereby enhancing their academic performance and comprehension of mathematical concepts.

In conclusion, this comparative study between traditional fraction instruction and the innovative use of Minecraft Education has evidenced the effectiveness and promise of the latter approach. The findings advocate for the integration of innovative educational methods and digital technologies in classrooms to enhance mathematics instruction and foster engaged, meaningful learning among students.

ISSN: 2176-8501

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