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Escape Room and Open Calculation Based on Number (OCN) Method to Measure Emotions in Mathematics Education

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Abstract

Mathematics has been seen as a subject that generates anxiety and rejection on the part of students. Therefore, a new approach will have to be found to replace all the negative connotations that mathematics carries for our students. In this study, students' concerns will be considered, and the open method based on numbers (OCN) will be put into practice. This method is a new way of teaching mathematics that will help students to change their perspective towards mathematics. In addition, an escape room will be implemented along with activities that will be carried out with this methodology. Therefore, we have put into practice a didactic proposal carried out in a class of the subject "Mathematics and its didactics" of the Bilingual Primary Education degree at the Teacher Training College. Their participation was voluntary and anonymous. The results obtained with the intervention have been mostly good and beneficial for the students. Their positive emotions towards mathematics increased. On the other hand, negative emotions towards mathematics mostly decreased.

Keywords

Mathematics Education, Escape Room, OCN, Emotions, Educational Psychology

1. Introduction

Fernández-Martín et al. (2020) reflect in their article that the more traditional teaching methods are becoming obsolete with the passage of time and do not respond to the demands of students. The more society advances, the more changes will occur. In education, there are different methodologies to teach mathematics and other subjects (Jeong, González-Gómez, & Cañada-Cañada, 2021) such as the Escape Room with virtual reality, flipped classroom and numerous other metho-

dologies that make education not lagging. Therefore, in this study, it will implement a mathematical teaching method called open calculation based on number (OCN), created by Jaime Martínez Montero who is a teacher and doctor in Philosophy and Educational Sciences (Díaz-López et al., 2017), together with a virtual Escape Room created with a tool called Modzilla Hubs. The aim is for students to learn mathematics through methods that help them to gain both intrapersonal and interpersonal skills. The OCN helps students to feel more self-confident as there is no single answer, but the answer they give can be correct. In addition, this method proposes that students build their own knowledge (Mendoza Velazco et al., 2020). Moreover, most of these students already at university come with the predisposition that mathematics can be the most difficult subject. Finally, psychological factors will have been taken into account, such as motivation, since, as they say Rodríguez-Rivero et al. (2023), not all teachers are concerned about the lack of motivation of students to learn, and to a greater extent those in the area of mathematics, which is one of the areas in which students are most demotivated. For this reason, this didactic proposal has been carried out in a class at the Teacher Training Faculty in the degree of Bilingual Primary Education, in the subject of Mathematics and its Didactics.

2. Theoretical Framework

2.1. Current (Traditional) Mathematics Education and Its Challenges

Nowadays, traditional teaching–learning methods have become obsolete and do not respond to the demands of today's students, who behave passively and are unmotivated and do not encourage critical thinking (Fernández-Martín et al., 2020). Focusing on mathematics classrooms as a research area may be done for a variety of reasons. One factor could be the unique nature of mathematics; another could be the patterns of interaction and practice between teachers and students in school mathematics that have been retained (Olav Haara et al., 2020). Therefore, they will first focus on traditional teaching and how it has affected the teaching of mathematics. The traditional method is still used because of society's resistance to change (Bracho-López, 2014; Roberts & Geels, 2019). Moreover, traditional educational models have failed to keep pace and habitually use lectures as a medium for content delivery in a classroom. The traditional method of mathematics is a closed method based on numbers, so that the operations are carried out mechanically and the child does not really understand the concepts (Canto López et al., 2022). It seems that traditional ideas about mathematics education and learning have a remarkable capacity to endure. In "Why teach mathematics?" published in 1998, Ernest challenged various misconceptions about how to learn mathematics. Among these were notions that mathematics is unreachable, challenging, and abstract and that understanding it depended on talent (Ernest, 1998). In a traditional mathematics class, the teacher reviews previous content and assignments before demonstrating basic problem solving. This is followed by seatwork that has

students copy the teacher's presentation. In addition to the previous information, mathematics lessons are often taught in a teacher-centered environment where lectures are the norm utilizing traditional methods (Stonewater, 2005; Lessani et al., 2017).

2.2. New Methodologies for Mathematics Learning through Educational Psychology

Nowadays, there are different methodologies to teach mathematics and other subjects (Jeong, González-Gómez, & Cañada-Cañada, 2021; Montero-Izquierdo et al., 2024). In this sense, the use of information and communication technologies (ICTs) has proven to be a useful tool to foster motivation and individual and group participation of students (Gabarda et al., 2017). This methodology refers to the application of game dynamics, mechanics, and frameworks into non-game activities. As a learning technique or tool that brings the dynamics of play into the educational context with the aim of obtaining better academic results from students (Magadán-Díaz & Rivas-García. 2022; Jeong & González-Gómez, 2025). Gamification in education usually aim to improve students' concentration, engagement, performance, and/or decrease students' frustration and demotivation in educational systems (Mostafa, 2020; Lopes et al., 2019; Metwally et al., 2020). Moreover, gamified education may provide a number of benefits to students, e.g., increasing students' motivation (Cózar-Gutiérrez & Sáez-López, 2016; Hallifax et al., 2020), enhancing learning performance (Lo & Hew, 2020; Zainuddin et al., 2020), or improving training processes (Kapp, 2012; Anastasiadis et al., 2018). There is a new method of gamification that is increasing little by little in the new era of digital education, this is the Metaverse. The term Metaverse was invented and first appeared in Neal Stevenson's science fiction novel Snow Crash published in 1992 (Stephenson, 2003) These technologies are persuasive and can influence users' cognition, emotions and behaviors. (Slater et al., 2020). In terms of education, an educational institution can build a campus or a virtual duplicate of its university by building a Metaverse. With its lecture halls, cafeteria areas, and faculty rooms. This enables students, teachers, and other center staff members to interact and communicate in a flexible manner (Moolenaar & Sleegers, 2015; Contreras et al., 2022).

2.3. OCN Methodology for Mathematics Learning

One of the most innovative methodologies of mathematics is the open method based on numbers (or OCN method) is a pedagogical and didactic approach to teaching and learning mathematics inspired by the current of so-called realist mathematics (Yuanita et al., 2018; Van den Heu-vel-Panhuizen & Drijvers, 2020). This method was introduced by Jaime Martínez Montero who is a teacher and doctor in Philosophy and Educational Sciences (Díaz-López et al., 2017; Jeong & González-Gómez, 2022). The OCN is a natural method in which the calculations performed are transparent with respect to the actual manipulations that would be

performed and is a powerful method to improve the mathematics competence (Martinez, 2011). The use of this methodology also contributes to children acquiring important levels of mental arithmetic at an early age; the decomposition and composition of numbers is a constant in this pedagogical practice (Pérez et al., 2018). The first letter, O, corresponds to the term "open" as there is no single way to do the mathematical problems. Each student can solve the problems in their own way. The students can solve these problems in a flexible way according to their development. Also, it is related to their development and mastery of calculus. The C and N indicate that they are "number-based", as opposed to traditional algorithms that are based on numbers. They are digit-based, in the sense that they break down all the digits contained in the number and all of them are treated identically (García & Quirell, 2017; Valero Rodrigo & González Fernández, 2020). In addition, this method proposes that students build their own knowledge (Mendoza Velazco et al., 2020). One of the characteristics of this model is that, unlike what has been done traditionally, mistakes should not be avoided, but rather removed, diagnosed, and acted upon (Mendoza Velazco et al., 2020). Moreover, this new methodology represents an important change in the quantity and quality of children's mathematical achievement (Navarro et al., 2012).

2.4. Cognitive and Affective Domain of OCN Method and Escape Room in Mathematics Education

It's vital to define the term "affective domain" before discussing the implications of the OCN approach and Escape Rooms. This phrase describes a broad spectrum of notions, sentiments, and states of mind that exist outside the purview of cognition (Grootenboer & Marshman, 2016). It is included in Bloom's taxonomy. In summary, the cognitive domain focuses more on critical thinking, the psychomotor domain emphasizes practical, hands-on abilities, and the emotive domain emphasizes collaboration and communication. Students can build a variety of abilities in the learning process, including critical thinking skills and scientific literacy, by utilizing Bloom's taxonomy-oriented learning activities. Activity is defined as all actions taken, whether physical and non-physical (Bloom, 1956; Pujawan et al., 2022). Escape rooms are real-world games where players must find clues, solve puzzles, and complete tasks in one or more rooms to achieve a certain objective within a set period of time so that they can leave the room (Nicholson, 2015; Borrego et al., 2017). There are a great number of studies (Brown et al., 2019; Gómez-Urquiza et al., 2019; Pérez-Vázquez et al., 2019) on the use of escape rooms as a teaching aid in higher education. These studies show that several good feelings are encouraged when participating in an escape room activity. They emphasize the inspiration, curiosity, and enjoyment that students have when solving the suggested puzzles, as well as their value in encouraging cooperative working in a realistic setting. Otherwise, there are negative emotions, especially "nervousness," "frustration" and "worry," which are common, realizing this type of intervention. This kind of intervention are correlated with a combination of positive

and negative emotions.

3. Methods and Materials

This didactic proposal has been carried out with students enrolled in the subject "Mathematics and its Didactics", a compulsory subject of the Bilingual Primary Education Degree. This subject is the first time that undergraduate students are introduced to the field of mathematics didactics. Therefore, different definitions and concepts are worked on, as well as the most relevant theories for the initiation in these specific didactics. For this purpose, the subject is organized into six thematic units, which means a total of 150 hours of work for the student. The subject is structured in the six thematic units, through which the essential characteristics for the teaching/learning of mathematics, the practice of skills and the most relevant teaching/learning methodologies, as well as the history of mathematics, and the main mathematical thoughts are addressed. Consequently, this subject aims to train students on the general understanding of mathematical contents, as well as educational research strategies and disciplines for their subsequent teaching in primary education. In this subject, an active teaching methodology has been carried out, where practical activities based on the OCN method were developed.

3.1. Sample

In this educational proposal, 59 students from the second year of Primary Bilingual Education from the Teacher Training College completed the entire intervention for a whole mathematics session. The entire class took part in this intervention, which was conducted throughout the 2022-2023 academic year. Here, most students are from the baccalaureate of social sciences and humanities (52.54%) as well as in sciences background (42.37%). There are also a small number of students in the arts (3.39%) and technology (1.69%). Because many students have a high level of mathematics, it is not necessary to review some of the most fundamental mathematical concepts.

3.2. Course Contexts

This didactic intervention was carried out in a class in the second year of the Bilingual Primary Education course, in the subject of mathematics and its didactics. in the teacher training college. In this class, students did not know the OCN method. The learning method in the faculty is based on doing different activities in the classroom to reinforce the previous knowledge and the knowledge seen in the class. When the intervention was applied to the class, the method was explained firstly in a large group and then individually the teacher asked each student if they had understood it or they had any doubts about it. An example of the OCN method can be found in **Figure 1**, in which there is no single way of solving the operations. It is a flexible method that does not need a prior indication of how to solve the operation; the different students simply start to solve the operation using the most appropriate numbers that they consider appropriate.

	215+	18
6	221	12
4	225	8
5	230	3
2	232	1
1	**233**	**0**

Figure 1. Example of OCN addition.

3.3. Escape Room (Modzilla Hub)

To start talking about the activity carried out in the classroom, students will first talk about the tool used to carry it out. The tool used is called Mozilla Hub and, as defined by themselves, it is: "the go-to virtual platform for educators, teams, and organizations. Powered by Mozilla, we've designed our platform to make virtual collaboration and learning effortless". The tool offers us a series of resources once we have started our plan (they have three plans, two of them paid and one free). Once we have chosen our plan, we will start to elaborate our map (as shown in **Figure 2**).

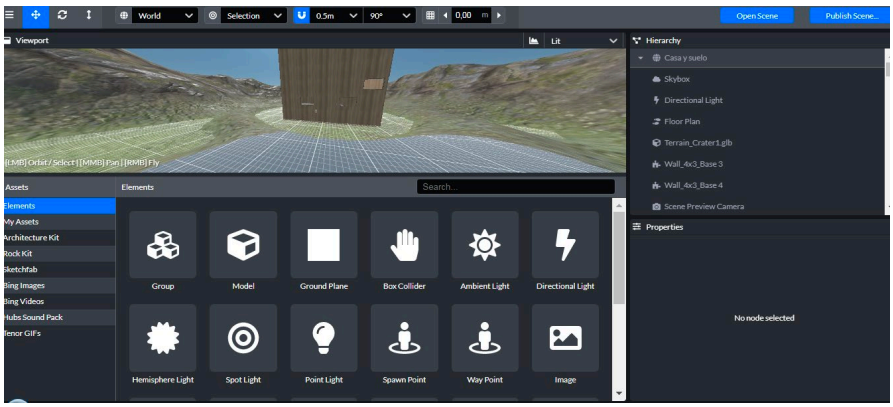

Figure 2. Example of the menu with the available options to design the map and the map on the top left to create it.

There will also be a menu where all the possible accessories to build the map that we want to carry out in the activity will be displayed. Once the map is finished, the users will be able to access the room where it is located. To do this, the users will be provided with a link. Once there, all users have to do is click on "join room" and they will enter the room and start the escape room. When they reach the third and last floor, they will have to find another QR (quick response) code like the one shown in **Figure 3**.

Once the activities have been completed and the QR codes have been found, the students have completed the escape room. The following activities have been chosen from the scratch website. On this page, the users can find many didactic resources to bring to the classroom. The activities consist of different ways of using

the OCN method. In this case, they are going to put in practice: addition, subtraction, multiplication, and division. Here, there is an example of one of the activities of addition. It consists of moving the sticks to one site and then pressing the green arrow to check the OCN process. It will be finished when the right column has a zero in the end. As a clarification, we have decided to put figures of the addition activity, as it is the most visual and one of the most important to understand the OCN method well. However, the rest of the activities follow the same structure and all of them work well. The following data analysis has shown this fact.

Figure 3. Example of QR code hidden in the third floor.

3.4. Data Analysis

At the beginning of the class, the questionnaire was distributed to students (pre-test) and then the same questionnaire was distributed to the participants when the intervention was over. The data collected will help us to see the tendencies of emotions that students have from an age when they have already gone through many mathematics classes (in primary and secondary schools) and we want to see what trend this new methodology adopts. Once the data was collected, a quantitative analysis was carried out. First, it was determined whether these followed a normal distribution, in order to apply parametric statistical tools. In this case, the data was normally distributed. Next, and to evaluate the influence of the intervention, a significance test (t-student) was applied to the variables analyzed (positive and negative emotions) using the average values for each variable previously (pre-test) and after (post-test) the intervention. Finally, a descriptive analysis was implemented to specify the key trends in the existing data. For the statistical analysis of data, both the Jamovi program and the Excel spreadsheet have been used.

4. Results and Discussion

In order to see how the didactic intervention implemented in the classroom has affected the students, we will compare the different emotions that the students had towards mathematics. As mentioned above, the questionnaire is divided into PE

(positive emotion), NE (negative emotion). **Figure 4** shows the evolution of positive emotions towards mathematics before and after the intervention. In all cases, there is an increase in all positive emotions, which allows us to understand that the intervention has been very beneficial for all students.

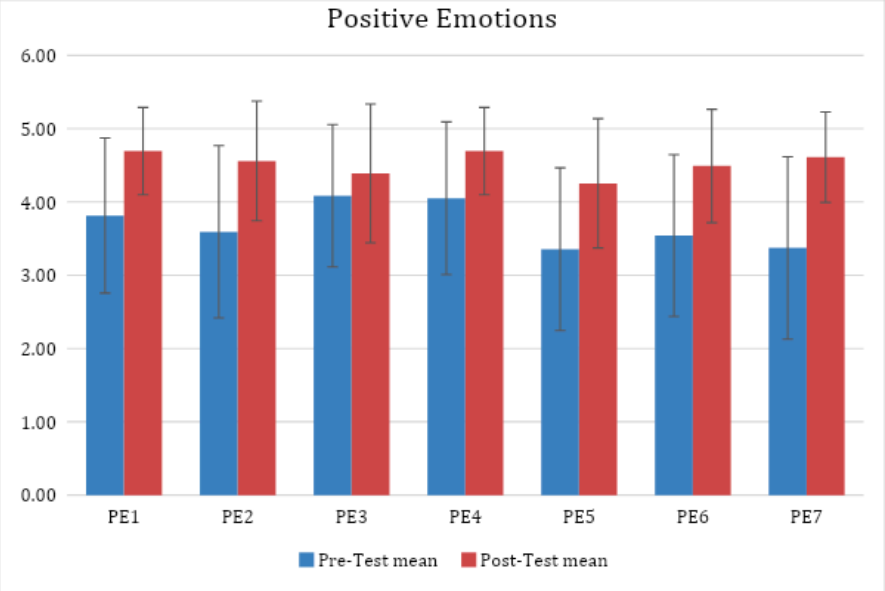

Figure 4. Scores given for the pre- and post-questionnaire representing the positive emotions of the students.

Having all the positive emotions (PE) collected in **Figure 4**, we will also consider the other side of the coin. We are going to analyze all the negative emotions they had before the intervention (pre-test) and how they have evolved once the intervention was developed and concluded in the classroom (post-test). In the first place, it can be clearly seen in **Figure 5**, as in most of them, they decrease except for NE2, with a pre-test value of 3.19 and a post value of 3.25; NE4, with a pre-test value of 1.98 and a post-test value of 2.59 and NE7, although it is hardly noticeable, but it increases by 0.02 (Pre-test of 2.08 and 2.10 in the post-test). These negative emotions refer respectively to nervousness, frustration, and anxiety. Where we can find the biggest difference between their pre- and post-test feelings are in NE1 and NE3. Their values were 1.88 and 0.95 lower than those obtained in the questionnaire prior to the classroom intervention. These negative emotions were uncertainty and worry, respectively.

As can be seen in **Figure 6**, it can clearly see how in most of the positive emotions there have been significant changes, which tells us that this didactic proposal has improved and has produced good feelings at the end. On the other hand, of the negative emotions only three have been significant, which is good because many of their fears have decreased, but more work will be done so that all the negative changes can become significant. Cronbach's alpha is a coefficient that measures the scale of a measure. If the value provided is less than 0.7, the measured scale is said to have a medium-low reliability, and some measured items

should be considered. If the value is above 0.8, it is said to be high, since the closer it is to 1, the more reliable it is. Therefore, we find a 0.852of Cronbach's alpha. This means that our questionnaire has a high reliability and can therefore be used as a reference for further research.

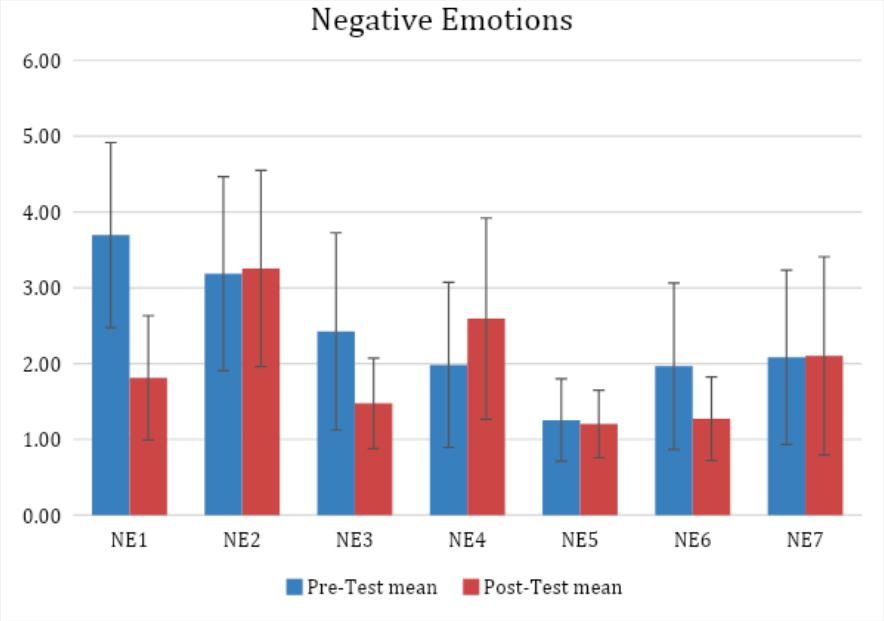

Figure 5. Scores given for the pre- and post-questionnaire representing the negative emotions of the students.

Independent Samples T-Test

		Statistic	df	p		Effect Size
PE1	Student's t	55.772	116	< .001	Cohen's d	10.268
PE2	Student's t	51.855	116	< .001	Cohen's d	0.9547
PE3	Student's t	17.285	116	0.087	Cohen's d	0.3182
PE4	Student's t	41.267	116	< .001	Cohen's d	0.7598
PE5	Student's t	48.641	116	< .001	Cohen's d	0.8956
PE6	Student's t	54.085	116	< .001	Cohen's d	0.9958
PE7	Student's t	68.443	116	< .001	Cohen's d	12.601
NE1	Student's t	-98.257	116	< .001	Cohen's d	-18.091
NE2	Student's t	0.2861	116	0.775	Cohen's d	0.0527
NE3	Student's t	-50.873	116	< .001	Cohen's d	-0.9366
NE4	Student's t	27.278	116	0.007	Cohen's d	0.5022
NE5	Student's t	-0.5548	116	0.580	Cohen's d	-0.1021
NE6	Student's t	-43.435	116	< .001	Cohen's d	-0.7997
NE7	Student's t	0.0747	116	0.941	Cohen's d	0.0138

Note. H_a $\mu_{Post\text{-}test} \neq \mu_{Pre\text{-}test}$

[a] Levene's test is significant ($p < .05$), suggesting a violation of the assumption of equal variances

Figure 6. p-value and effect size analysis on positive and negative emotions items.

As Gómez-Chacón (2000) mentioned, "Emotions play a facilitating/debilitating role in learning and have an impact on students' success/failure. They are conditioned by beliefs about oneself and about mathematics and can be automated and solidified into attitudes and emotions that influence these beliefs." Along with this sentence, it should be mentioned that in this intervention we have been able to see how emotions are present either for good or bad. As they have been able to see in **Figure 4** and **Figure 5** (positive and negative emotions, respectively), they have increased in the case of joy, fun and, on the other hand, have decreased mostly when it comes to negative emotions. This may be due to the fact that in escape rooms, despite being a good tool, some people may feel more overwhelmed or frustrated when they see that they cannot move on to the next level. At first, they thought that positive emotions would not increase as much as they did because we were implementing a new tool in the classroom that the students might find costly or simply boring. Also, being university students and having so many mathematics classes behind them, this type of activity might not be to their liking or general fear due to the insecurities established by the traditional teaching system. On the other hand, negative emotions decreased to a great extent, which was a surprise, as they thought that negative emotions would increase after the activity because we were moving them out of their comfort zone and introducing them to a new teaching methodology. This makes us reflect as teachers that, if the right teaching methods are used, leaving aside the traditional method, and giving way to new innovative methodologies, we can ensure that the new generations of students can learn without being afraid of making mistakes, not only in mathematics but in any subject in which it is proposed. With all the data, we can affirm that the OCN method helps students to a great extent to solve mathematical problems without fear, giving them the necessary autonomy to be able to use it, since it is a flexible and individual method, as any student can adapt it as it suits his/her best. In addition to the OCN method, it is important to highlight the importance of the Escape Room, which is a great tool for them to develop many intrinsic and extrinsic skills, such as teamwork. At the beginning, it is always somewhat costly, as we are using something totally different to what they have learnt throughout their primary school and secondary school years, but once they understand it, they feel more confident and have more fun and above all, which it generates a positive feeling towards mathematics in the students that the traditional method has not been able to achieve and will never be able to achieve. To conclude, these active and innovative methodologies are a great advance and discovery in this century, which does not care about the characteristics of the students and most importantly, does not care that students learn, but only focuses on the students on the day of the exam to release all the knowledge that over time will be erased.

5. Conclusion

In conclusion, the present intervention helps to analyze the positive and negative emotions of the students with respect to mathematics, as well as to see how the

OCN method and Escape Rooms help them to solve problems in a more fun way. This work was carried out in a second year of Primary Bilingual Education from the Teacher Training College during the 2022/2023 academic year. In total, 59 students completed the entire intervention for a whole mathematics session. Questionnaires were passed (pre- and post-test) with different questions that allow us to analyze their emotions about mathematics in a more personal way. The level was adapted to the University level of education, always bearing in mind that as these were new things, they would first have to have a base from which to start, so we made a presentation to put them in context. With the different bases on which we have distributed the questionnaires (PE and NE), the results obtained show that the positive emotions (PE) of the students have increased notably with the intervention of the OCN and Escape Room in the class. Therefore, the students have been able to see that mathematics can generate positive emotions in themselves. On the other hand, the negative feelings (NE) decreased notably, thus conveying that the students, by receiving this mathematics class and refreshing a methodology they already knew through a game such as an escape room. The statistical data for each of the variables that were considered show that the intervention improved the students' emotions towards mathematics and was very useful for them, as they learned a different method to the traditional one for solving the different mathematical operations. The limitations of the intervention are that because we do not have a large sample, since they cannot see how it would be reflected if they had a significant sample to see how mathematics influences and affects students both positively and negatively.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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