VEXCODE VR: A Virtual Tool as Support in the Teaching of Analytical Geometry

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Abstract

Virtual Educational Robotics (VER) leverages virtual platforms where students can design, build, program, and operate robots, offering an alternative to traditional educational robotics that relies on physical kits. This study evaluates the impact of VEXcode VR, a web-based platform developed by VEX Robotics, as an educational tool to improve the learning of Analytical Geometry in secondary education in Mexico. The objective of integrating VEXcode VR is to facilitate the understanding of geometric concepts through interactive simulations, replacing traditional Cartesian plane representations with dynamic digital environments. A quasi-experimental research design was employed, comparing an experimental group utilizing VEXcode VR with a control group following conventional methods. Pre- and post-test assessments showed that the experimental group scored on average 6.46 points higher than the control group (out of 50), corresponding to an 18.2% difference. Statistical analysis (Welch's t-test: $t = 2.615$, $df \approx 45$, $p = 0.012$) indicated that this improvement was significant, with a moderate-to-large effect size (Cohen's $d = 0.72$). These findings suggest that VEXcode VR enhances mathematical comprehension, engagement, and academic performance, supporting its integration into STEM education to foster more effective and interactive learning experiences.

Keywords: ICT, Educational Robotics, Virtual Educational Robotics, Constructionism, Virtual Education.

1 Introduction

The COVID-19 pandemic caused an unprecedented disruption in education, affecting nearly 1.6 billion students in over 190 countries [1, 2]. As a result, schools had to rapidly transition to remote or online learning, increasing the reliance on Information and Communication Technology (ICT) tools to maintain educational continuity [2]. This shift also impacted the field of Educational Robotics (ER), traditionally dependent on physical kits such as LEGO, VEX, and MECCANO, which became impractical in remote settings [3, 9].

To address this limitation, Virtual Educational Robotics (VER) emerged as an alternative, allowing students to design, build, and program robots in virtual environments. One of the most widely adopted platforms for this purpose is VEXcode VR, a web-based educational tool developed by VEX Robotics [10-12]. This platform provides students with a simulation-based learning environment where they can manipulate virtual robots, explore mathematical concepts, and develop programming skills without requiring physical hardware.

This study investigates the effectiveness of VEXcode VR in enhancing the learning of Analytical Geometry in secondary education in Mexico. The objective is to determine whether integrating this virtual robotics tool into classroom instruction improves students' understanding and performance in key mathematical topics compared to traditional teaching methods. To evaluate this, a quasi-experimental study was conducted, comparing a control group using conventional teaching strategies with an experimental group utilizing VEXcode VR for problem-solving and geometric visualization.

The results of this research provide insights into how virtual robotics can bridge the gap between traditional and technology-enhanced learning, particularly in STEM education. By analyzing students' academic performance and engagement, this study aims to demonstrate the potential of VEXcode VR as a powerful tool for fostering a more interactive and effective learning experience.

2 Virtual Educational Robotics

Virtual educational robotics combines robotic technology with digital environments to enhance learning in various subjects, especially Analytical Geometry. Through tools like Virtual Reality (VR) and Augmented Reality (AR), students can interact with geometric figures in an immersive way, making it easier to understand abstract concepts that traditional methods often struggle to convey [13, 14].

Integrating robotics into digital learning environments has proven to improve student engagement, develop critical thinking, and strengthen problem-solving skills [A3] [A4] [15, 16]. Specifically, in mathematics education, virtual robotics allows students to interact with three-dimensional models and explore geometric concepts more dynamically and practically [17].

Recent studies highlight that this methodology promotes active and collaborative learning. Thanks to virtual platforms, students can experience real-world applications of geometry, leading to more meaningful learning [18]. Additionally, these tools have been particularly useful in expanding educational access to communities with limited resources, where physical robotics kits are not always available [19].

Virtual educational robotics has become a key resource in teaching Analytical Geometry. Some of its most notable applications include:

- 3D Visualization: Virtual environments allow students to manipulate geometric figures in three dimensions, enhancing their spatial reasoning skills [14, 18].
- Interactive Simulations: Digital platforms enable students to explore geometric problems applied to architecture, engineering, and other disciplines [16, 20].
- Collaborative Learning: Many virtual robotics tools support teamwork, where students work together to solve challenges and improve their communication skills[15].

Despite its many benefits, virtual educational robotics faces some obstacles:

- Technology Access: Not all schools have the infrastructure needed to support virtual reality platforms or online simulations [19].
- Teacher Training: For these resources to be effectively utilized, teachers need specialized training in using educational technologies [17].
- Student Adaptation: While some students quickly adapt to digital learning environments, others may struggle with the transition from traditional to interactive, technology-driven methods [18].

As technology advances, new opportunities emerge for virtual robotics in education. Some key trends include:

1. Personalized Learning: The integration of Artificial Intelligence (AI) will allow activities to be tailored to each student's needs [13].
2. Increased Use of Augmented Reality: This technology will facilitate interaction with geometric models overlaid onto the real world, enriching the learning experience [16].
3. Expansion to Other Disciplines: While educational robotics currently focuses on STEM, its potential extends to the humanities and social sciences [20].

By overcoming current challenges and continuing to innovate in its implementation, virtual educational robotics could transform the teaching of Analytical Geometry and many other fields of knowledge [15].

3 Problem Outline

México has obtained below-average results in national tests such as PLANEA and international assessments like PISA in the areas of Mathematics and Science for high school students (15-17 years). These results stem from issues within the National Education System [13] [21].

According to data from the National Institute for the Evaluation of Education (INEE) in 2018, the learning assessment (PLANEA) was conducted at four measurement levels. In the areas of Language and Communication, as well as Mathematics, Level 1 (L1) is the lowest, and Level 4 (L4) is the highest. In the evaluation of students in the final year of secondary education, it was found that 66.2% of students achieved Level L1, which represents the lowest level of achievement on the scale, in the mathematics area [14] [22].

In 2018, the Organization for Economic Cooperation and Development (OECD) carried out the Program for International Student Assessment (PISA), a standardized test that assessed the area of Mathematics. Mexico scored 409 points in this evaluation, which is 80 points below the average of OECD member countries [15] [23].

Hence, there is a need for virtual educational robotics tools (VER) to improve the teaching and learning processes in mathematics for secondary education in Mexico. However, due to the restrictions imposed by the COVID-19 pandemic, these tools, which involve manipulating physical components and teamwork, could not be used. Therefore, the use of virtual VER tools can help address the issue of limited access to physical devices and facilitate learning in STEM areas. The following challenges are proposed to address in this work:

- Design educational strategies using the VEXcode VR educational platform as a teaching and learning tool.
- Implement the virtual educational robotics tool VEXcode VR in the teaching and learning process for selected topics in analytical geometry.
- Quantify the impact of using the VEXcode VR platform on the achievement of learning outcomes in specific topics of analytical geometry, measuring basic learning statistics such as median, range, and mean.

In the following sections, a series of experiments are proposed to test the impact of employing virtual educational robotics tools on the teaching and learning process for selected topics in Analytical Geometry in Mexican secondary education.

4 Methods

4.1 Research Approach

The research focuses on evaluating the effectiveness of Virtual Extended Reality (VER) in building mathematics learning and specific topics in Analytical Geometry at the secondary education level. The chosen approach was quantitative, allowing for hypothesis testing through numerical measurement and statistical analysis of the collected data. Data were obtained through surveys and experiments, enabling the generalization of findings from the research [16] [24].

4.2 Scope of the Research

The research has a descriptive scope that allowed for describing the characteristics of the learning outcomes and the opinion of students from a secondary education level group when using the VEXcode VR tool during their Analytical Geometry classes. The descriptive scope of the research refers to the type of investigation that aims to describe or understand a specific phenomenon without attempting to explain or predict it [16] [24].

4.3 Design

The research design was quasi-experimental. In quasi-experimental designs, subjects are not matched or randomly assigned to groups, but instead, they are placed in pre-existing complete groups [16] [24]. The process included participant selection, the administration of a pretest, an educational intervention with differentiated methodologies for the experimental and control groups, and a post-test to measure learning outcomes. Additionally, a perception survey was conducted to gather students' opinions on the use of virtual educational robotics. The methodological process is illustrated in Figure 1.

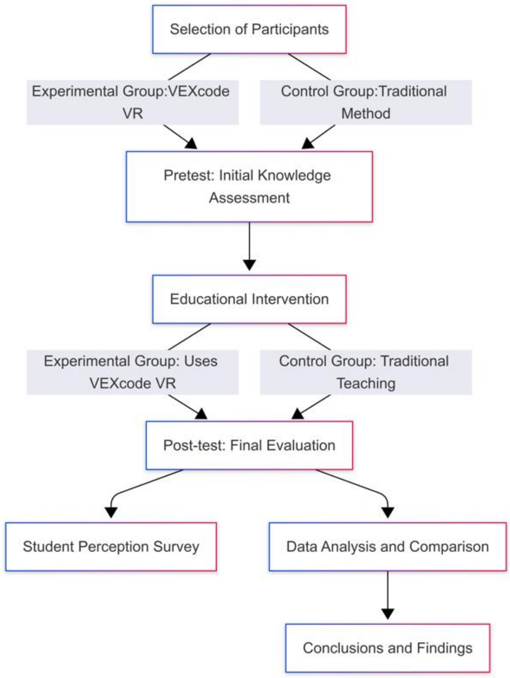

Figure 1: Methodological process followed in this study, illustrating the steps from participant selection to data analysis.

Data were obtained through surveys and experiments that allowed for generalizing the findings obtained in the research.

The study used a combination of standardized tests and Likert-scale questionnaires to collect data on the effect of using the RE tool on the learning of Analytical Geometry.

A standardized test based on the National Education System's literature was administered to measure the participant's level of knowledge on the topic before starting the experimentation (Figure 2). A diagnostic test consisting of 10 multiple-choice questions was used to assess the participants' knowledge of specific topics of Analytical Geometry.

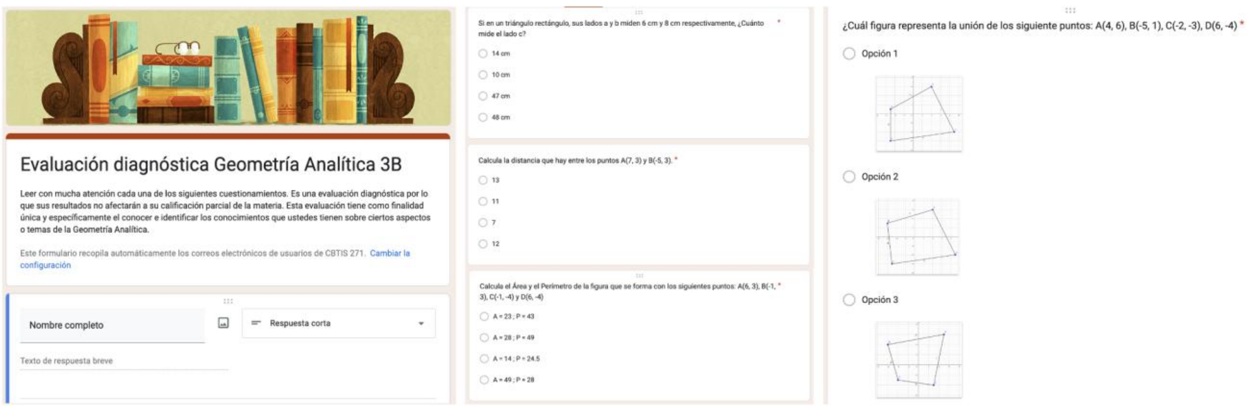

Figure 2: Standardized diagnostic test - pretest.

To measure the impact of using the RE tool on the learning of Analytical Geometry, an instrument was designed with 7 multiple-choice exercises that covered the topics covered during the experimentation. This final test was also based on a standardized test (Figure 3).

To assess students' opinions on the use of the VEXcode VR platform in their educational process, a Likert scale questionnaire (Figure 3) was utilized. It covered topics such as ICT proficiency, the benefits of ICT use in the classroom, and opinions on the use of VEXcode VR.

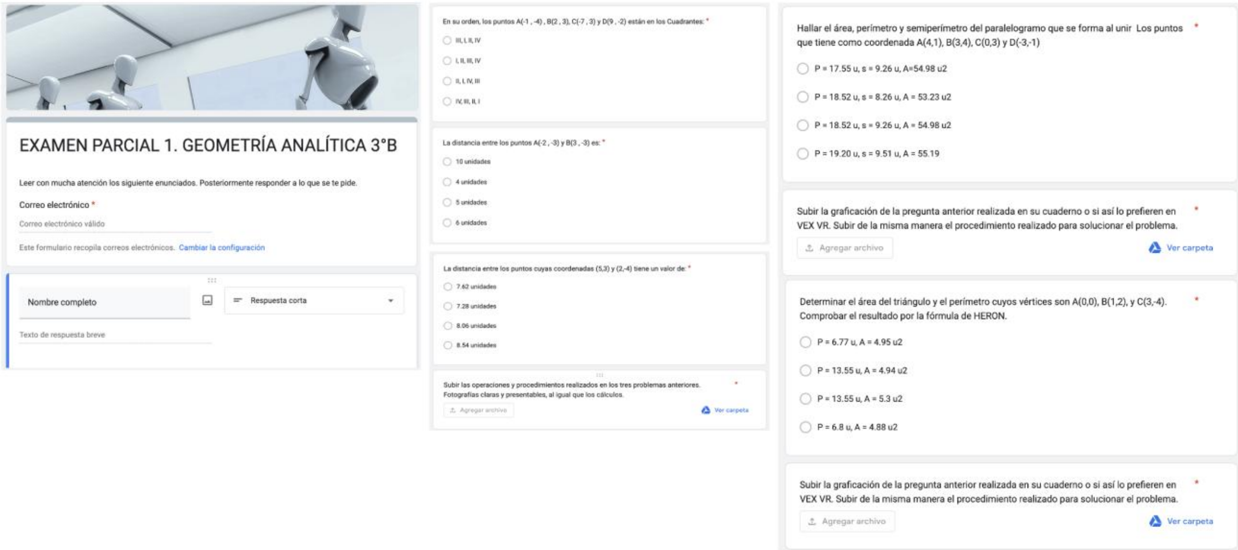

Figure 3: Final standardized test - post-test.

Both groups were trained in VER to ensure equality of situations. After the training, a theoretical class on Analytic Geometry was conducted in both groups using the teaching and learning strategies commonly employed by the teacher (Figure 4). Subsequently, the theoretical knowledge was applied to solve problem-type exercises and to graph the different figures involved in solving the problems.

Figure 4: Evidence of the development of selected topics in Analytic Geometry in video classes.

In the control group, traditional means such as virtual Cartesian planes and websites where manual drawing is possible were used. In contrast, the experimental group utilized the VEXcode VR platform to graph the figures and assist in solving the presented problems (Figure 5). Therefore, in the experimental group, traditional means were not employed, and only the VER tool was used to address the exercises.

Figure 5: Evidence of the training in Virtual Educational Robotics using VEXcode VR.

It is important to highlight that the VEXcode VR platform was selected for the experimentation due to its features such as being free, having technical support, extensive documentation, and suitable robots and simulation environments for the development of specific topics in Analytical Geometry.

Table 1: Experimentation process.

Activity	Control group	Experimental group
Diagnostic evaluation	Online diagnostic exam administration	Online diagnostic exam administration
Training in VER	Virtual classes on RE and VER, platform usage	Virtual classes on RE and VER, platform usage
Topic 1: Rectangular coordinate system	Classic strategy	Classic strategy
Topic 2: Distance between two points in the plane	Classic strategy	Classic strategy
Topic 3: Area of a polygon in terms of the coordinates of its vertices	Classic strategy	VER strategy
Evaluation of learning outcomes	Administration of virtual non-standardized tests.	Administration of virtual non-standardized tests.

The complete research process (See Table 1) included determining prior knowledge (pretest), training both groups in the VEXcode VR platform, delivering the topics in class, using the VER platform in the experimental group, measuring final learning outcomes (post-test), and finally, administering a questionnaire to gather opinions. This process was carried out over four weeks. During those four weeks, each group had four 50-minute sessions per week, following the current curriculum of the General Directorate of Industrial Technological Education.

4.4 Research Context

The experiment was carried out at a Public Institution of Higher Education (CBTIS 271) located in Ciudad Victoria, Tamaulipas, Mexico. CBTIS No. 271 is situated within the TECNOTAM Science and Technology Park on the outskirts of the city and is surrounded by educational and research centers. The institution has 550 students dispersed in 21 groups, ranging from 25 to 35 students each. It offers three technical careers focused on science and engineering, including programming, mechatronics, and plastics transformation. This institution is renowned in the region for its high academic standards since its establishment in 2010. As a result, students who enroll in the institution are generally those who are interested in studying engineering and have above-average grades compared to national averages.

4.5 Research Participants

For the experimentation, two groups of third-semester students (aged 16-17) from the Technical Programming program were selected, with each group consisting of 26 students. One group was assigned as the control group, while the other served as the experimental group. In the control group, the class was conducted in a normal manner following the usual procedures and instructions of the subject's main instructor. The experimental group, on the other hand, implemented the use of VER as part of the teaching and learning process to address selected topics in Analytical Geometry. Table 2 presents the gender characteristics of the selected groups for the research.

Table 2: Gender Characteristics of the Study Groups.

	Males	Females	Total
Control group	17	9	26
Experimental group	18	8	26
Total	**35**	**17**	**52**

3.6 Procedure for Data Analysis

The data analysis procedure began with coding and assigning numerical values to the responses obtained from the diagnostic tests (pretest), final tests (post-test), and an opinion questionnaire in Microsoft Excel. Next, IBM SPSS 25 was used to generate tables and graphs, as well as to calculate descriptive statistics. These included measures of central tendency (mean, median, and mode) and measures of variability (range, standard deviation, and variance), which facilitated the identification of patterns, trends, and outliers and guided further analyses [16].

In addition to descriptive statistics, supplementary tests were conducted to assess the significance and magnitude of the differences observed between the control and experimental groups. Specifically, an independent-samples **Welch's t-test** was performed to determine whether the post-test mean scores differed statistically; this test was chosen because it does not assume equal variances and is therefore more robust when sample sizes or variances differ across groups. Meanwhile, **Cohen's d** was used to quantify the effect size. This approach not only confirmed whether any differences were unlikely to be due to chance but also provided insight into the practical relevance of the intervention.

5 Results

This section presents the findings obtained throughout the research. First, it reviews the results of the diagnostic tests (pretest) administered to both groups, alongside descriptive statistics and bar charts illustrating key responses. Next, it details the posttest (partial final exam) outcomes for both groups, highlighting the impact on academic performance in selected Analytical Geometry topics when using the VEXcode VR platform. These results underwent further statistical scrutiny through Welch's t-test chosen for its robustness to unequal variances revealing a statistically significant improvement in the experimental group. Additionally, Cohen's d was computed to gauge the practical relevance of this difference. Finally, this section examines students' opinions regarding the inclusion of the VEXcode VR platform in Analytical Geometry classes, covering four categories: ICT proficiency, benefits of using ICT tools in the classroom, views on platform implementation, and ease of use for completing schoolwork.

5.1 Diagnosis of the Control Group

This section presents the diagnosis of the control group through a diagnostic test consisting of 10 questions on topics related to order of operations, algebra, geometry, trigonometry, shapes, figures, and formulas. Table 3 shows that the group obtained an average score of 6.5769 out of a total of 10 points available, indicating that the majority of the group is above the passing level (6 points). The standard deviation was 1.8585, suggesting that the scores obtained are close to the mean, with no outliers far from it. The score range was 7 points, with a minimum score of 2 and a maximum score of 9.

Table 3: Scores obtained in the diagnostic test by the control group.

	N	Range	Minimum	Maximum	Mean	Standard Deviation	Variance
Score obtained in the diagnostic exam:	26	7.00	2.00	9.00	6.5769	1.85845	3.454
N valid (per list)	26						

According to Figure 6, it can be observed that 8 students obtained a score of 7, which is the most frequent, while 2 students obtained a score of 2, which is the least frequent. The diagnostic test was based on the bibliography of the Analytical Geometry course, which was the subject taught during the experimentation.

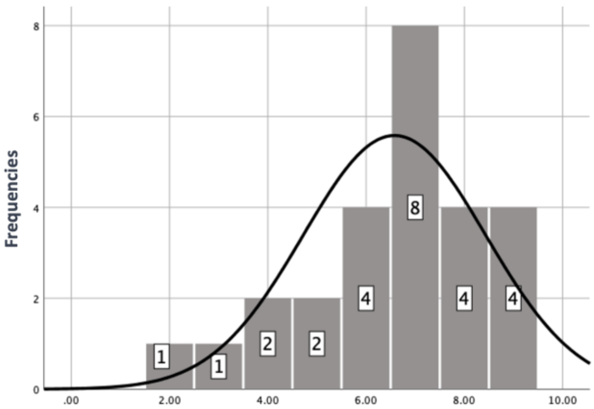

Figure 6: Scores obtained in the diagnostic test for the control group.

The topics covered in the test included order of operations, Algebra, geometric figures, and their formulas, as well as knowledge of Geometry and Trigonometry, with Trigonometry being the most important area of prior knowledge. The statistics of the response frequencies to the questions related to these topics are presented. Overall, it can be observed that there is a specific lack of knowledge in Geometry and Trigonometry in the control group (See Figure 7).

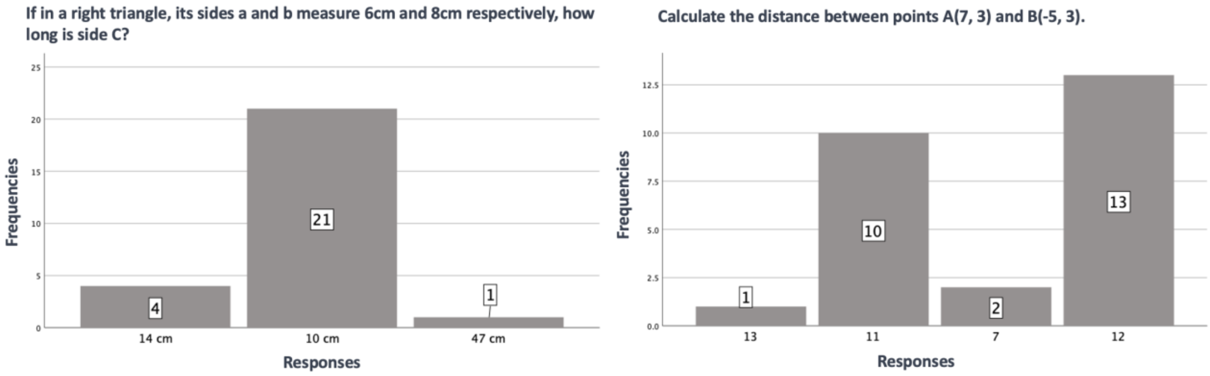

Figure 7: Frequencies of the responses to questions 1 and 2 in Geometry and Trigonometry in the control group.

5.2 Diagnostic Assessment for the Control Group

This section presents the diagnostic assessment results for the experimental group in the study of Analytical Geometry. The results shown in Table 4 indicate that the average score obtained in the diagnostic test was 5.9643, slightly lower than that of the control group (6.57). The standard deviation was 1.83, indicating that the scores obtained by the students in the experimental group were closer to the mean. Additionally, the variance was 3.369.

Table 4: Scores obtained in the diagnostic test for the experimental group.

	N	Range	Minimum	Maximum	Mean	Standard Deviation	Variance
Scores obtained from the diagnostic exam.	26	7.00	2.00	9.00	5.9643	1.83550	3.369
N valid (per list)	26						

It is mentioned that in the experimental group, responses were obtained from 28 students in the Google Forms survey, but two of them stopped attending virtual classes and submitting the scheduled assignments and activities. Additionally, Figure 8 presents the frequency histogram of the scores obtained in the diagnostic test, where it can be observed that the most frequent score was 7, like the control group.

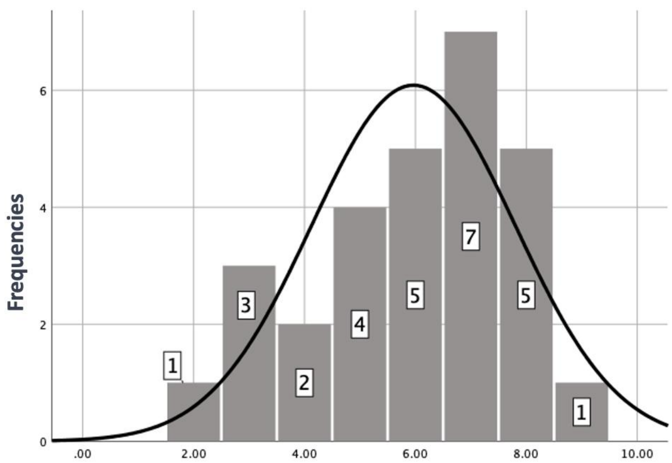

Figure 8: Scores obtained in the diagnostic test for the experimental group.

In addition, questions were asked regarding the knowledge of Geometry and Trigonometry in the experimental group, and the following results were obtained (See Figure 9): in question 1, 68% of the group answered correctly; in question 2, 57% selected the correct answer, and in the last question, 53% answered correctly. Despite the mean score of the experimental group being below the passing grade, the results show that in terms of knowledge about the topic of interest, the experimental group performed better than the control group.

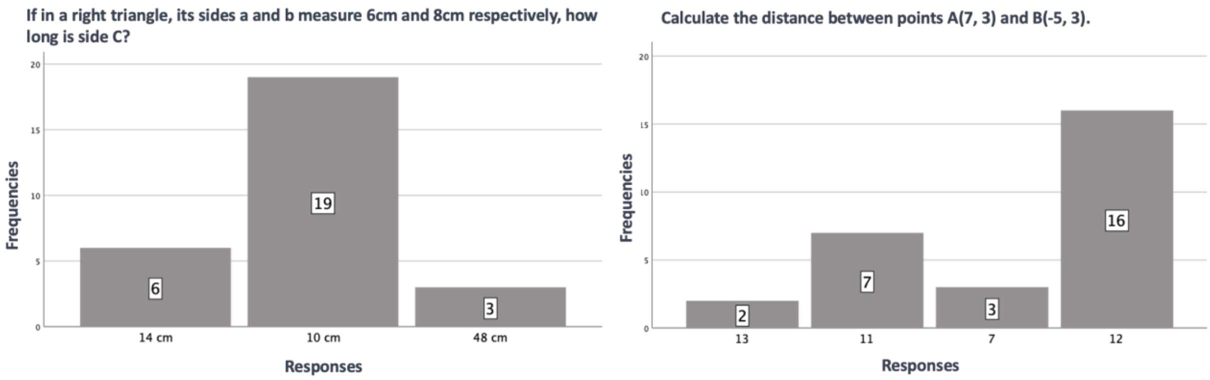

Figure 9: Frequencies of the responses to questions 1 (68%) and 2 (57%) in Geometry and Trigonometry in the experimental group.

5.3 Partial Final Evaluation of the Control Group

This section presents the evaluation of the knowledge acquired by the control group on the topic of Analytical Geometry through a partial final exam. The exam consisted of 7 questions related to the topics covered in class and was administered in a traditional manner to the control group, while the experimental group used the VEXcode VR platform to develop the topics.

The results of the partial final evaluation for the control group were analyzed using descriptive statistics. According to Table 5, the mean score obtained was 35.4616 out of a maximum of 50 points, indicating that the majority of the group was above the passing grade of 30 points. The standard deviation was 10.226, indicating that the distribution of scores was not close to the mean, and a variance of 104.578 was observed. The range of scores obtained was from 6 to 50.

Table 5: Scores obtained in the partial final exam (post-test) for the control group.

	N	Range	Minimum	Maximum	Mean	Standard Deviation	Variance
Scores obtained in the partial exam (post-test)	26	44.00	6.00	50.00	35.4615	10.22636	104.578
N valid (per list)	26						

The histogram of the scores obtained in the post-test evaluation of the control group (Figure 10) showed that the most frequent score was 45 points, occurring 7 times, which corresponds to 27% of the group. The majority of the scores were below the normal curve, except for the score of 6 and the score of 45.

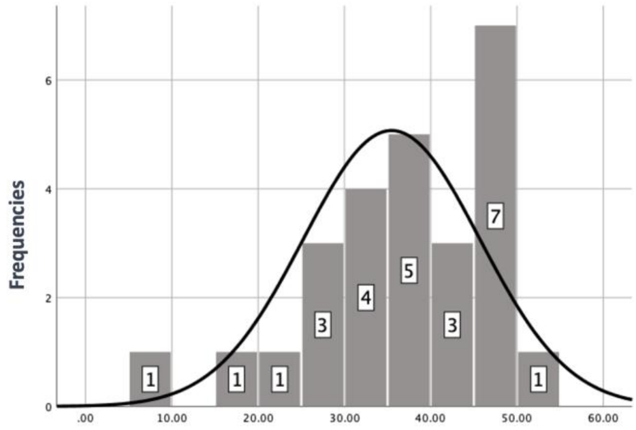

Figure 10: Scores obtained in the final partial test (post-test) for the control group.

Three key questions were identified regarding the knowledge acquired in the selected topic of the subject (See Figure 11). In the first question, 39% of the group answered correctly, while 35% of the group selected an incorrect answer. In the second question, 62% of the group selected the correct answer, while 38% of the group selected incorrect answers. In the third question, only 39% of the group selected the correct answer.

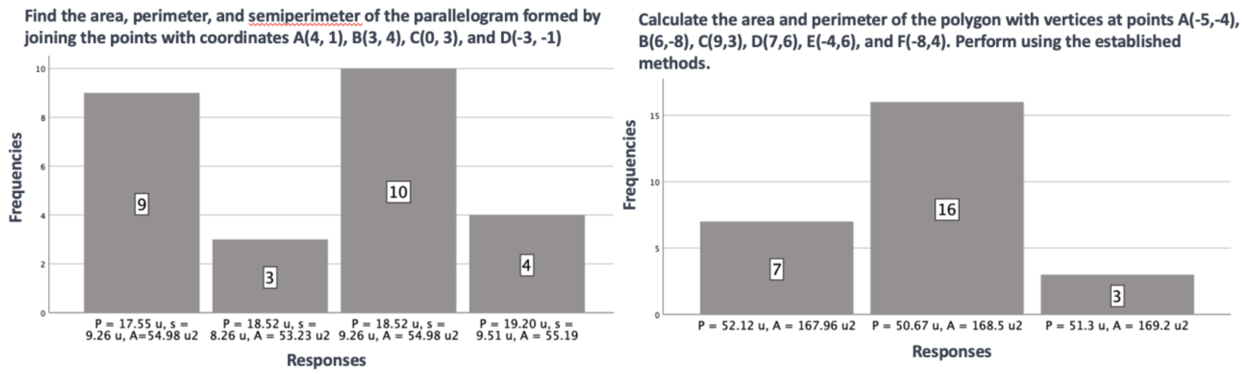

Figure 11: Frequencies of the responses regarding the inquiries (left) 1 about the area, perimeter, and semi perimeter, and (right) inquiry 2 about the area, perimeter, and semi perimeter of figures graphed by traditional method on a Cartesian plane in the control group.

In summary, the final partial evaluation of the control group revealed that the majority of students achieved a score above the passing grade in the subject of Analytical Geometry. However, there was a distribution of scores that deviated from the mean, and areas for improvement were identified in the knowledge acquired in three specific inquiries.

5.4 Final Partial Evaluation of the Experimental Group

In this section, the final partial evaluation conducted on the experimental group is presented, where a post-test was administered to assess the understanding of Analytical Geometry concepts developed through the VEXcode VR platform. As shown in Table 6, it can be observed that the experimental group achieved a mean score of 41.92321, which was 6.46171 points higher than the control group. Furthermore, the standard deviation was 7.36436, indicating that the distribution of scores was closer to the mean compared to the control group.

Table 6: Scores obtained in the final partial test (post-test) for the experimental group.

	N	Range	Minimum	Maximum	Mean	Standard Deviation	Variance
Score obtained in the partial exam (post-test)	26	24.00	26.00	50.00	41.9231	7.36436	54.234
N valid (per list)	26						

Regarding the range of scores, it was 24 points in the experimental group, while it was 44 points in the control group. Figure 12 shows that 54% of students in the experimental group achieved a score above 45 points.

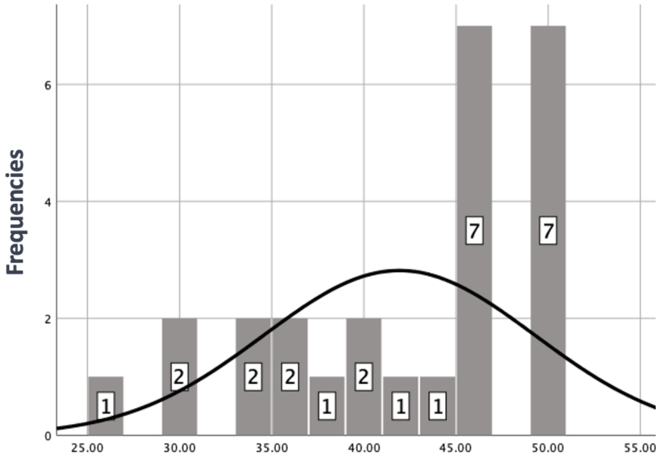

Figure 12: Scores obtained in the final partial test (post-test) by the experimental group.

Regarding the key questions in the posttest (Figure 13), there was a positive difference in the number of correct answers compared to the control group. These results indicate that the experimental group demonstrated a better understanding of the content covered in the subject and using the VEXcode VR platform for completing class assignments.

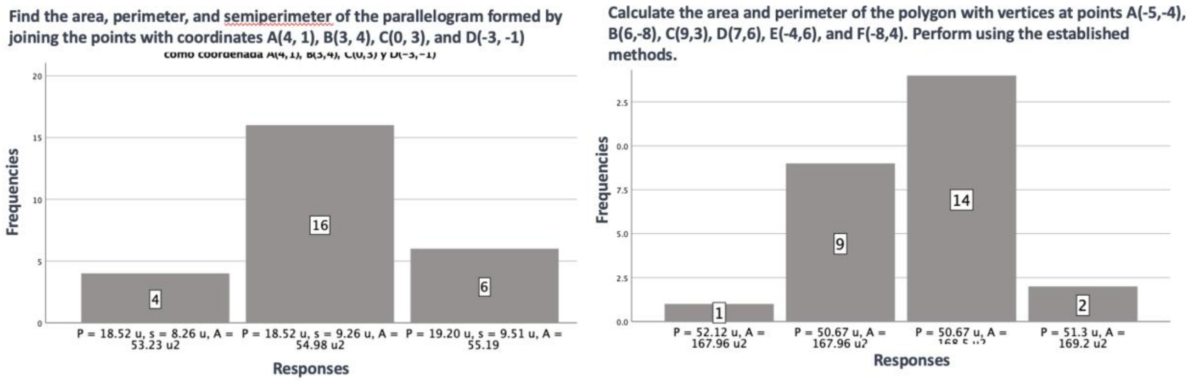

Figure 13: Frequency of responses for the inquiries (left) 1 regarding area, perimeter, and semi-perimeter, and (right) inquiry 2 regarding area, perimeter, and semi-perimeter of figures graphed using the traditional method on a Cartesian plane in the experimental group.

5.5 Statistical Analysis of the Post-Test Results: Welch's t-Test and Cohen's d

Following the descriptive comparison of post-test outcomes, a further statistical assessment was conducted to determine whether the observed difference in mean scores between the experimental and control groups was statistically significant, and to evaluate the practical relevance of that difference. An independent-samples Welch's t-test was applied chosen for its robustness when group variances are not assumed to be equal, and Cohen's d was computed to estimate the effect size.

Welch's t-Test. Using the means and standard deviations reported for each group (Tables 5 and 6), the experimental group's average post-test score (41.9231) was approximately 6.46 points higher than that of the control group (35.4615) on a 50-point scale. The Welch's t-test indicated that this difference was statistically significant (p<0.05p < 0.05p<0.05), suggesting that the higher performance in the experimental group is unlikely due to chance alone.

Cohen's d. To measure the magnitude of this difference, Cohen's d was calculated. The resulting value (d≈0.72d \approx. 0.72d≈0.72) corresponds to a moderate-to-large effect size, highlighting the practical significance of the intervention. In other words, the use of VEXcode VR for learning Analytical Geometry did not merely produce a statistically detectible difference, but one that is educationally meaningful as well.

Overall, these findings reinforce the descriptive results indicating that the experimental group benefited from the use of the VEXcode VR platform, both in terms of average performance and consistency of scores. The statistical evidence further supports the conclusion that VEXcode VR may substantially enhance students' understanding and application of Analytical Geometry concepts.

5.6 Students' Opinion on the Implementation of VEXcode VR in the Classroom

In this section, the results obtained from a Likert scale questionnaire are presented to assess students' opinions on the implementation of VEXcode VR in the classroom for selected topics in Analytical Geometry. Overall (see Figure 14), it was found that 53.57% of students consider themselves to have a moderate proficiency in using technological devices and platforms, while 28.57% strongly agree that ICT tools greatly support the educational process in the classroom. Regarding the use of the VEXcode VR platform, 50% of students have a neutral opinion, while 32% agree that its use supports various activities in the educational process.

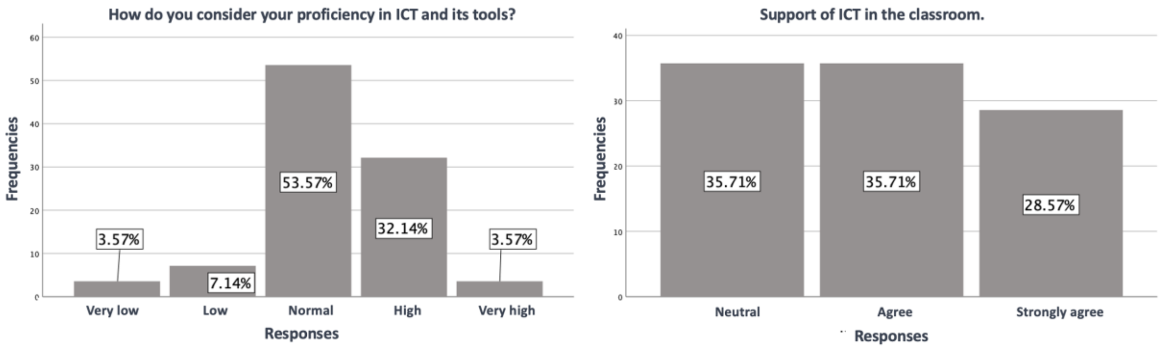

Figure 14: Scores obtained in (left) level of mastery of ICT devices by students and (right) students' opinion on the support provided by ICT tools in the classroom in the experimental group.

Regarding the motivation and interest of students in using the platform, 50% of the group reported feeling motivated and interested when using it. Finally, 53.57% of the students have no positive or negative opinion about the ease of use of the platform, while 32.14% found it easy to use (See Figure 15).

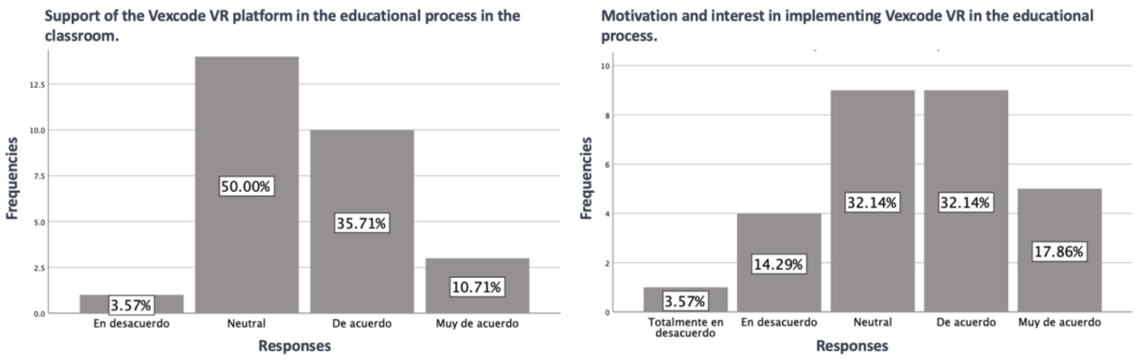

Figure 15: Scores obtained for (left) students' opinion on the support provided by the VEXcode VR platform in the educational process within the classroom, and (right) students' opinion on the motivation and interest to learn math topics and do schoolwork when using the VEXcode VR platform in the experimental group.

Overall, these results indicate that students have a positive opinion about the implementation of VEXcode VR in the classroom, although there is a significant percentage that remains neutral in some evaluated aspects (Figure 16).

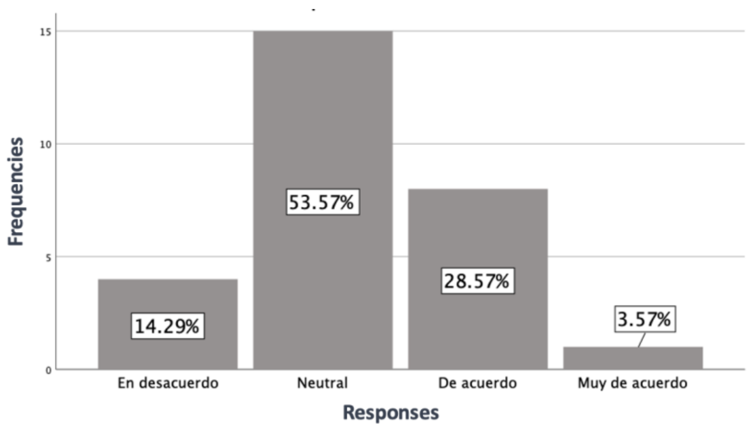

Figure 16: Students' opinion about the ease of using VEXcode VR for carrying out Mathematics school activities in the experimental group.

6 Conclusions and Future Work

The findings of this research demonstrate the effectiveness of integrating VEXcode VR into the teaching of Analytical Geometry. Although the control group initially exhibited a slightly higher mean score on the diagnostic exam, the experimental group's post-test performance ultimately surpassed that of the control by an average of 6.46 points (approximately 18.2% on a 50-point scale). Further statistical analysis using Welch's t-test revealed that this difference was significant, and Cohen's d (0.72) indicated a moderate-to-large effect size, underscoring the practical importance of the intervention.

A didactic strategy was designed whereby students used a VEXcode VR mobile robot to plot figures based on given coordinates in the Cartesian plane. This approach supported conceptual understanding and application of Analytical Geometry topics more effectively than traditional strategies. Consequently, it is concluded that VEXcode VR shows clear potential for enhancing student learning in mathematics and other STEM domains.

Looking ahead, several avenues for future work emerge:

Longer-Term Studies. - Implementing the platform over a semester or an entire academic year would allow a more in-depth exploration of how sustained use influences learning gains and student engagement.

Broader Educational Levels. - Evaluating VEXcode VR at primary and secondary levels could confirm whether the platform's block-based approach effectively supports younger learners in developing problem-solving and computational thinking skills.

Exploration of Other Platforms. - Investigating additional visual programming environments would help determine which tools are best suited for particular STEM topics, thus broadening the range of pedagogical resources available to educators.

Through these steps, this research aims to contribute to the continuous improvement of mathematics education and to validate the broader impact of VEXcode VR and similar tools on student development in STEM fields.

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Appendix (if necessary)

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