Stem Education and The Learning of Mathematics in Vulnerable Populations

Educación Stem y el aprendizaje de las matemáticas en poblaciones vulnerables

Educação Stem E Aprendizagem De Matemática Em Populações Vulneráveis

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Abstract

Introduction: This article is the product of a classroom experiment developed by UNIMINUTO in the ninth-grade of the Educational Institution Simón Bolivar in "La Nohora" neighborhood of the Villavicencio – Colombia; this project was executed during 2017 and 2018.

Problem: The problem is the low academic performance of students in mathematics, in addition to multiple possible adverse situations they face as a vulnerable population.

Objective: The objective is to have a positive impact on the academic performance of the students.

Methodology: In the development of the strategy, STEM education was used to support the learning of math; six sessions were carried out within the students' own classroom. The students solved challenges by programming robots.

Results: Completing each challenge had an important attitudinal impact on the students; their perceived joy and satisfaction were an unexpected result. A previous knowledge test was carried out at the beginning; at the end of the sessions, a formative test was also performed. Afterwards, the results of both tests were compared to evidence improvements in the students' mathematical skills.

Conclusions: It was possible to provide the target population with an alternative to understand issues mistakenly considered difficult and to propose important playful and didactic moments in cognitive development.

Originality: This article shows an educational innovation that the team of researchers will continue to apply through new projects that allow financing the purchase of equipment and the logistics of the workshops.

Limitations: Lack of strategic alliances that allow financing more meetings with students and the acquisition of more robots.

Keywords: Educational Robotics, STEM Education, Math learning, Robots and Math.

Resumen

Introducción: Este artículo es producto de una experiencia de aula desarrollada por UNIMINUTO en el noveno grado de la Institución Educativa Simón Bolívar en el barrio "La Nohora" de Villavicencio - Colombia, este proyecto se ejecutó durante 2017 y 2018.

Problema: El problema es el bajo rendimiento académico de los estudiantes en matemáticas, además de las múltiples posibles situaciones adversas que enfrentan como población vulnerable.

Objetivo: El objetivo es tener un impacto positivo en el rendimiento académico de los estudiantes.

Metodología: En el desarrollo de la estrategia, se utilizó la educación STEM para apoyar el aprendizaje de las matemáticas a través de seis sesiones que se llevaron a cabo en su propia aula. Los estudiantes resolvieron retos programando robots.

Resultados: Completar cada desafío tuvo un impacto actitudinal importante en los estudiantes, su alegría y satisfacción fue un resultado inesperado. Se realizó una prueba de conocimientos previa al inicio y al final de las sesiones también se aplicó una prueba formativa. Posteriormente, se compararon los resultados de ambas pruebas para evidenciar mejoras en las habilidades matemáticas de los estudiantes.

Conclusiones: Se logró brindar a la población objetivo una alternativa para comprender temas erróneamente considerados difíciles y proponer importantes momentos lúdicos y didácticos en el desarrollo cognitivo.

Palabras clave: Robótica educativa, Educación STEM, Aprendizaje de las matemáticas, Robótica y matemáticas.

Resumo

Introdução: Este artigo é o produto de uma experiência em sala de aula desenvolvida pela UNIMINUTO no nono ano da Instituição Educacional Simón Bolívar no bairro "La Nohora" de Villavicencio - Colômbia, este projeto foi realizado durante os anos de 2017 e 2018.

Problema: O problema é o baixo desempenho acadêmico dos alunos em matemática, além das múltiplas possíveis situações adversas que eles enfrentam como população vulnerável.

Objetivo: O objetivo é ter um impacto positivo no desempenho acadêmico do aluno.

Metodologia: No desenvolvimento da estratégia, a educação STEM foi utilizada para apoiar a aprendizagem da matemática através de seis sessões que foram realizadas na própria sala de aula. Os alunos resolveram desafios programando robôs.

Resultados: A conclusão de cada desafio teve um impacto atitudinal significativo nos alunos, sua alegria e satisfação foi um resultado inesperado. Foi realizado um teste de conhecimento antes do início e no final das sessões também foi aplicado um teste de treinamento. Posteriormente, os resultados de ambos os testes foram comparados para mostrar melhorias nas habilidades matemáticas dos alunos.

Conclusões: Foi possível oferecer à população-alvo uma alternativa para compreender temas erroneamente considerados difíceis e propor momentos lúdicos e didáticos importantes no desenvolvimento cognitivo.

Palavras-chave: Robótica educacional, educação STEM, aprendizagem matemática, robótica e matemática.

1. INTRODUCTION

For this work, multiple theoretical and pedagogical references related to the topic proposed in this research were considered. Regarding the pedagogical strategy, appropriate references were reviewed; these were an important tool in the execution of this project.

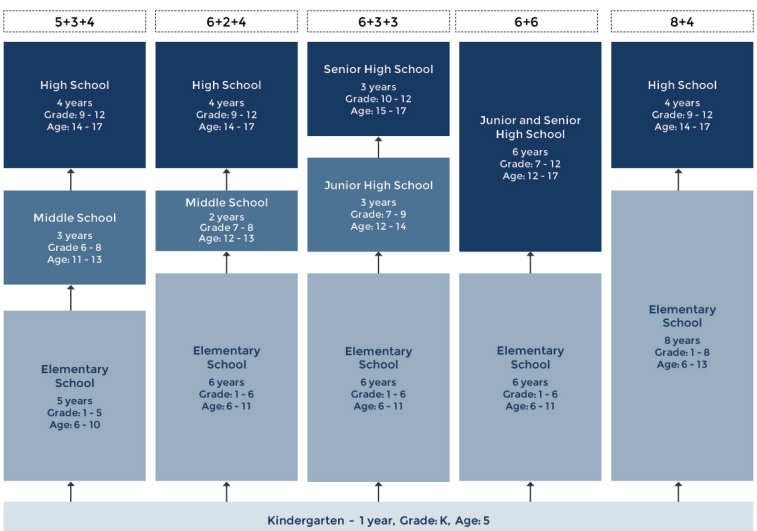

Figure 1. Common K-12 education models
Source: [1].

Some strategies used by other countries were studied, one of them is "The P21 Framework for 21st Century Learning", that was developed by "The Partnership for 21st Century Learning", to place 21st century readiness at the center of K-12 education in the United States. The United States Department of Homeland Security has determined, on K-12 Education (Fig. 1), that students begin formal education between the ages of 5 and 6 [2]. In general, elementary, and middle school grades from kindergarten through grade 12 (K-12) are required to attend college. The P21 Framework defines and illustrates the learning and innovation skills: Critical thinking, Communication, Collaboration and Creativity (4Cs); which provide knowledge, experience and underpin support systems that students need to be successful in work, life and citizenship [3]. The importance of 12th grade and the impact it has on academic achievement is highlighted here. In Colombia, secondary education is completed at the end of grade 11.

The search for novel pedagogical strategies related to the work that was carried out, led the team to focus on education in science, technology, engineering, and mathematics (STEM). According to [4], STEM Education is a discipline based on the integration of disciplinary knowledge into a new whole. STEM Education aims to increase the number of people with skills in the disciplinary knowledge that allow them to develop skills applicable in their daily and academic lives, emphasizing training for work [5]. The Carnegie Mellon Robotics Academy studies how teachers use robots in classrooms to teach Computer Science, Science, Technology, Engineering, and Mathematics (CS -STEM) [6].

As Colombia is still a developing country, this research was primarily carried out in universities or in the few research centers that exist in the country [7][8]. It is especially noteworthy that STEM Education is an issue that is gaining strength in the classrooms of Colombia; however, it is due to the initiatives of teachers, and not to institutional or governmental approaches, as has been done in other countries. The subject treated by this article is mainly pedagogical, since a training process was carried out. However, in each challenge within the classroom, the use of a robot was essential, which necessarily leads to the search for technological foundations. In the same way, one of the main references in terms of STEM Education and the use of robotics as an instrument or tool for teaching, is the *Parque Científico de Innovación Social* (PCIS) which is a service platform that integrates actors and resources from various institutions, articulating agents of the Science, Technology and Innovation System, with the communities of the most vulnerable territories in Colombia, to develop projects based on social innovation with a comprehensive development approach [9] [10, p. 57].

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Universidad Cooperativa de Colombia

The STEM Robotics Program was created by *PCIS*, based on the methodology developed by the School of Robotics at Carnegie Mellon University [11]. Social innovation is a new solution to a problem or need of a community, this solution can be a product, a service, a practice or a management model that meets the following: it is characterized by being more efficient than the existing solution, is generated in a participatory way between the community and researchers, is sustainable, scalable and can generate permanent changes in society [9] [10, p. 32]. Using social innovation and previous work done by the *PCIS*, the researchers theoretically base the project on STEM Education and educational robotics as a pedagogical strategy. It is important to note that the *PCIS* operates in Bogotá - Colombia and that the work presented here was carried out in the city of Villavicencio, located approximately 80 km from the country's capital.

To identify the problem that gave rise to this article, the work team met with the *Centro de Educación para el Desarrollo (CED)* of the *Corporación Universitaria Minuto de Dios (UNIMINUTO),* which made it known that part of the younger population of *La Nohora* neighborhood in Villavicencio, were frequently exposed to distractors that prevented them from focusing their attention on activities that are productive for them, in addition to having difficulties in appropriating math skills. Worse still, some of these distractors could potentially evolve into more complex problems such as drug addiction and even crime. Thus, the need arose to find alternatives so that young people could use their time appropriately while practicing 4C skills and refining their knowledge in mathematics and problem solving [12].

The project arises from a workshop carried out by the *CED* in 2017, in which the problems found in the different practice centers of the institution were socialized. One of the problems found was the low academic performance in terms of mathematical competencies of the young people of the population. This community is in Villavicencio and has been classified as a vulnerable community due to its multiple problems. One of the possible causes of the problem identified in the student population occurs with the consumption of alcohol and psychoactive or hallucinogenic substances, which leads to the neighborhood becoming a space for the problems that can seriously affect people's psychosocial development, as well as their academic performance [13]. This is how the team of researchers attending the workshop became interested in the problem raised and the initial idea of cooperation was proposed to mitigate and respond to the situation.

2. RESEARCH BACKGROUND

In the introduction, it has been explained how skills related to STEM Education have gained importance in universities, in pedagogy research groups and even in schools and colleges with students in basic education, as is the case in the work presented here. Educational robotics is presented as a motivating, innovative strategy that attracts the child and youth population, since it involves a high component of technological development with which the population feels comfortable and where the levels of curiosity manage to focus the attention of people.

Table 1. Research background.

Title	Topic area	Results
Liquid-handling LEGO robots and experiments for STEM education and research [14].	Biology, Natural science.	• Development of LEGO -based pipetting robots that handle volumes of liquid. • The application can be in science and chemical experiments for education and research. • These activities were tested with elementary, middle, and high school students. • The publication includes instructions for construction and experimentation.
LEGO MindStorms: Not Just for K-12 Anymore [15].	Computer science	• Using the robot for college level courses such as operating systems, introduction to programming. • The development of laboratory exercises to illustrate and explore computer science concepts.
Physical visualization of math concepts using LEGO Mindstorms [16].	Educational robotics.	• Educational robotics for the teaching of advanced mathematics such as the physical visualization of metrics (Euclidean, Taxi and Infinity), and the convergence of the Cauchy sequence, using a LEGO Mindstorms NXT mobile robot. • Applied to a group of graduate students who provided good feedback on this type of educational activity. • Students were encouraged to use mathematical concepts in interdisciplinary problems and encouraged to understand their functionality and application in the real world.
PiBot: An open low-cost robotic platform with camera for STEM education [17].	STEM education	• This article presents a robotics platform, PiBot, developed to improve robotics teaching. • The processor is the Raspberry Pi 3 controller board, and an infrastructure written in Python language was implemented so that the student can use this camera as the main sensor of the robotic platform. • Higher level commands provided to improve learning outcome for beginners.
A systematic review of studies on educational robotics [18].	Educational robotics, K-12 education.	• The studies were classified into five themes: general effectiveness of educational robotics, learning and transfer skills of students, creativity and motivation, diversity and broadening the participation and professional development of teachers.

Source: Own work

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Universidad Cooperativa de Colombia

Table 1 shows a list of the works with the greatest international impact and that support this article from the point of view of the state of the art. All the related works have the use of technological elements in common, such as robots to work on topics related to mathematics, physics and technology, and the results presented positively impacted the students.

In Colombia there are initiatives to encourage young people's interest in science and technology. As part of these strategies, there is one called *Todo es ciencia*, a program of the Ministry of Sciences, Technology, and Innovation. In 2019, a work was published that compiled science fiction stories, whose typical audience is young people, with the main objective being to demystify the scientific and technological work of the country [19]. Another important strategy with a long history in the country is the *Programa Ondas*, whose main objective is to carry out science, technology and innovation projects from basic and secondary education institutions, with the support of universities and private companies [20].

In the *Orinoquía* region there are some initiatives that work with robots in the classroom as an innovative aspect. The *ROVOFIC* initiative, which is a robotics school and an enterprise that is part of *ParqueSoft Meta*, whose objective is that children and young people of different ages learn to program using robotics and 3D printing. In this way, they develop skills such as concentration, teamwork and proposing dynamic solutions in a playful way, solving conflicts, and overcoming challenges [21]. Likewise, in some universities in the country, similar studies have been carried out in which robotics plays an important role in solving community problems and the learning of mathematics, such as the one presented by [22] [23] [24]. On the other hand, own work of this article presented this work in a research event in which the publication of a conference article with partial results of the project was achieved [25].

3. MATERIALS AND METHODS

This process began with the application of the praxeological approach, which seeks to confront the reality of the young and solve the need of the community in general [13]; all this, through a deliberation on how to approach this process of strengthening and reinforcing skills in mathematics, looking for an alternative to generate a teaching-learning process in said community. Thus, from this need, the educational robotics project was born, whose work team was made up of members of the neighborhood, teachers and staff of the *Simón Bolívar* educational institution and the project researchers of to the *UNIMINUTO*.

As a result of the study carried out by the *CED* from *UNIMINUTO*, it was determined that the target population were young people between 14 and 16 years old, ninth-grade students of basic secondary education of the *Simón Bolívar* Educational Institution of *La Nohora* neighborhood, whom, because of their level of schooling, had met the prior knowledge necessary to operate the robots with which the project for teaching mathematics was developed. The Educational Institution does not have a systems room, and the conditions of vulnerability of *La Nohora* community have already manifested themselves; therefore, for some of the students it was their first experience using computers and even more so robots, which injected motivation and expectation of the environment prior to the beginning of the sessions. According to [26], and referring to the location of the *La Nohora* neighborhood: "... it is eleven kilometers from *Villavicencio*, on the road that goes to *Acacías*. It was founded in 1999 with the arrival of 160 families who were displaced from *Guaviare*, *Mapiripán* and *Puerto Alvira*. In 2001, there were approximately 480 families settled in this place because more displaced and vulnerable people from *Villavicencio* settled there". To contextualize the reader about the geographic location of the community, it is georeferenced at the following coordinates: Latitude 4° 4' 46.94 "N and Longitude 73° 41' 47.75" W. In addition, it is evident in this way that the community is located near Villavicencio and that social problems are close to the entities that can possibly solve them.

Considering the specific case and the characteristics of the population, a strategy was proposed in which the solution to the problem posed was taken to the community, as opposed to attempting to independently study the problem prior to offering a possible solution. this guarantees the active participation of the population as the main actors in the situation to be resolved. The phases contemplated by the praxeological approach, based on four moments (Seeing, Judging, Acting and Creative Feedbacking), were applied. Regarding the "Seeing" phase, visits were made and the neighborhood's problem was identified directly with the community [27]; also, the most pertinent topics to be addressed in the mathematics reinforcement sessions were defined. Then, the process of "Judging" was carried out with the group of teachers, students, parents, and with the community in general; defining together (co-investigating with the community) the actions to be developed. Work was done on the creation of learning guides for working with the students, approached from praxeology and validated as appropriate training instruments, according to the main objective of the project [28].

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Universidad Cooperativa de Colombia

Table 2. Themes And Guides.

Guide	Thematic	Summary
Sessions 1 - 2	First degree equations.	• Relate the wheel perimeter through the measurement of the lengths travelled for the robot. • Create geometric paths with the robot.
Sessions 3 - 4	Proportionality	• Relationship between lengths. • Program trajectories using movement duration time.
Sessions 5 - 6	Speed	• Use lengths and times to determine the speed of the tours. • Use a sensor to avoid obstacles.

Source: Own work

In total, three work learning guides were built, which were developed at the rate of one guide for every two educational robotics sessions. The topics addressed in the robotics sessions were based on the information collected through a diagnostic test carried out on the students under study. After an analysis in which mathematics teachers from both the educational institution and *UNIMINUTO* were involved, the topics listed in Table 2 were chosen and they were distributed among the six work sessions; one of these sessions for the development of soft skills and the other five for direct work with the robot, for a total of 20 direct hours of work with the tool. Each of the guides was developed considering the praxeological approach and STEM Education.

Considering that positive emotional and attitudinal results were evidenced in the students who participated in this experience, an interview was done as the main instrument to identify and quantify these qualitative results. The interview was conducted with the students during and at the end of the process to tangibly show the results that were considered unexpected [29]. Due to the direct influence of the *PCIS*, the team of researchers organized the planning of the project using the *Ruta de Innovación Social* as a basis, because of its investigative, pedagogical, and social innovation nature.

Ruta de Innovación Social

The *Ruta de Innovación Social* is a methodology to generate social innovations with the communities. The route is made up of two great moments described textually below [30]:

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Universidad Cooperativa de Colombia

A. Big Challenge 1

- Enlisting: the frame of reference of the situation to be improved, the allies and the resources that will be used in the design of the new solution are defined.
- Understanding: the situation to be improved is structured, identifying the interest groups, traditional knowledge, and the variables around a central problem.
- Analyzing: traditional knowledge is validated and complemented against technical and technological knowledge, collecting evidence on the relationships between the identified variables. At this time, solutions already created in other contexts for similar problems are also identified.
- Creating: corresponds to the process of ideation and co-creation of the new solution with the community, which generate prototypes to be validated. It is necessary to clarify that in the phases of Understanding, Analyzing and Creating, a dialogue of knowledge is developed between the community (traditional knowledge) and the researchers (scientific knowledge).
- Implementing: it is the execution and validation of the prototypes developed with the community.

B. Big Challenge 2

- Packaging: allows structuring the solution co-created with the community as a social technology, which helps convey the whole set of previously validated knowledge, practices, methods, and instruments to other communities.
- Scaling: the appropriation of social technology by communities other than the co-creator of the process is sought, adapting it to different contexts, thus increasing the number of people benefited.

Prior to the execution of the educational robotics workshops, the learning guides used for the development of the class sessions were created. These sessions were carried out at the *Simón Bolívar* Educational Institution; periodically giving feedback, which corresponds to the creative feedback contemplated by the praxeological approach. All this helps to determine the level of acceptance by the students, considering the principles of teamwork, since the actions that were carried out were collaborative.

e-ISSN 2357-6014 / Vol. 18, no. 1 / january-april 2022 / Bogotá D.C., Colombia
Universidad Cooperativa de Colombia

Materials and Equipment

The work sessions were based on STEM Education and the praxeological approach. It was necessary to have a technological package made up of NXT LEGO robots (Figure 2) and a specialized software for programming [31], in addition to the corresponding audiovisual aid and the necessary computer equipment that was supplied by UNIMINUTO.

Figure 2. LEGO *NXT robot* [32].

This technological equipment made the teaching-learning process innovative and allowed students to assess the applicability of mathematics in exercises and practical challenges. It should be taken into account that technology advances by leaps and bounds and that education is one of the sciences that benefits enormously from it, allowing technology to enter into the classroom as a didactic tool, without restriction of any kind [33]. The robot was programmed using the LEGO MINDSTORMS EV3 software. This visual programming software is free and easy to use and can also be downloaded from the official LEGO website.

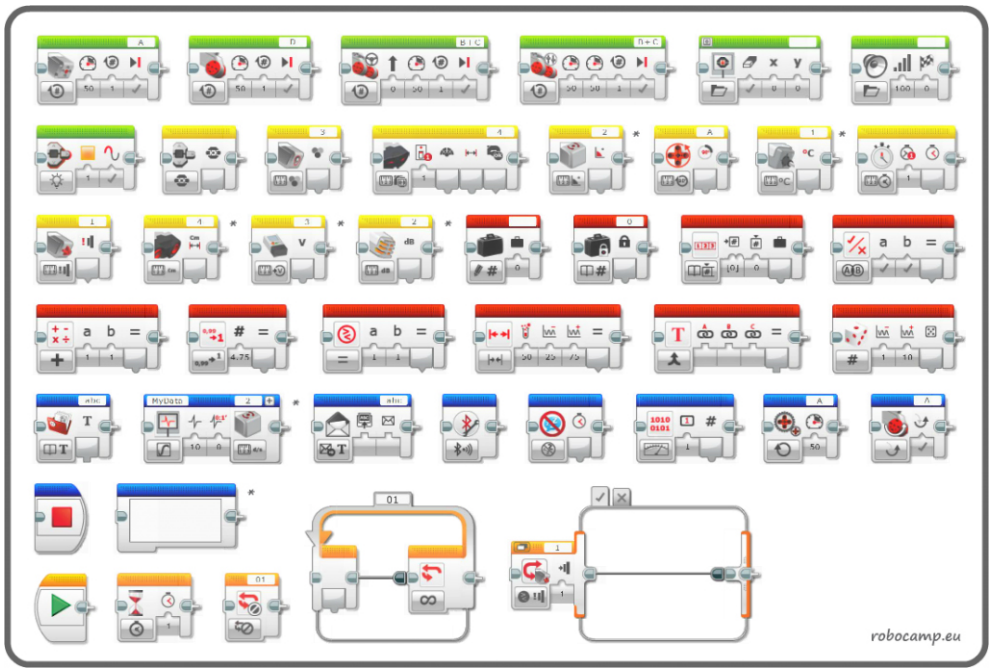


Figure 3. LEGO *robot programming block* [31].

Visual programming allows the user to create programs with the logical organization of blocks, which each block performing a specific action [34]. The programming of the robot is carried out through action blocks, classified in the colors green, orange, yellow, red, and blue. Within each of these categories there are blocks of different shapes (Figure 3) according to their function [34] [35]. Below is a brief description of the functional blocks of the program:

- Green blocks control the rotations of the robot's motors, images, sounds and lights.
- Orange blocks control the flow of the program. All programs start with a start block.
- The yellow blocks are used for reading the data obtained by the color sensor, infrared sensor, and the touch sensor, among others.
- Red blocks allow you to work with data, that is, to write and read variables, to compare values and much more.
- The blue blocks allow you to work with files, Bluetooth connections, among others.

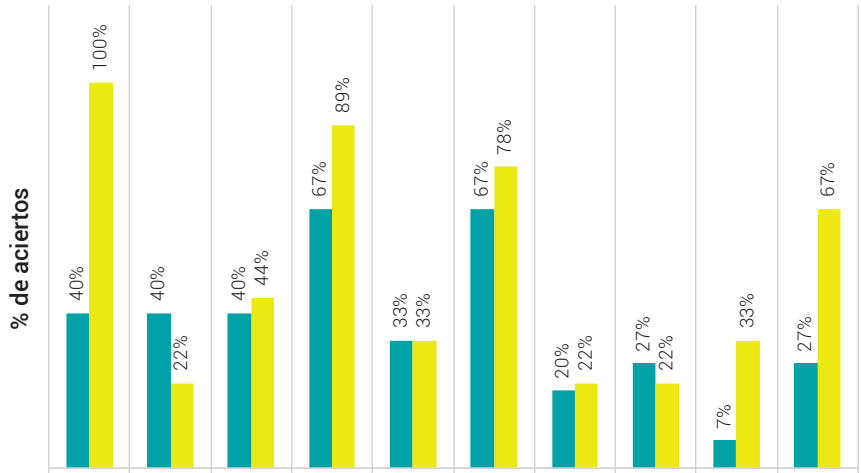
e-ISSN 2357-6014 / Vol. 18, no. 1 / january-april 2022 / Bogotá D.C., Colombia
Universidad Cooperativa de Colombia

4. RESULTS

Once the work sessions with the students were carried out, it was possible to show qualitative and quantitative results. These results were analyzed and socialized with the main actors of the project. After this stage, the research team proposed to objectively evaluate the implemented strategy for which, based on interviews and a SWOT instrument, a general vision of the initiative was obtained by interviewing academic peers and the main actors of the project.

Quantitative results

Through the application of an evaluation of previous knowledge, the students underwent an initial diagnosis with which they sought to achieve two things: the first, to identify their weaknesses in terms of the topics investigated, and the second, to obtain the baseline to work on educational robotics sessions.



	1	2	3	4	5	6	7	8	9	10
Diagnóstico	40%	40%	40%	67%	33%	67%	20%	27%	7%	27%
Salida	100%	22%	44%	89%	33%	78%	22%	22%	33%	67%

Figure 4. Comparison of hits (Diagnosis and Output).
Source: Own work

At the end of the educational robotics sessions, a second evaluation was applied to the students and a significant improvement was evidenced; despite the little time dedicated to the sessions. It is necessary to clarify that the topics covered in the exit evaluation, and even some of the questions, coincide with those of the diagnostic test. The reason for the above is because the process was executed only in 20 hours of effective classroom work, slightly limiting the possibility of dealing with more complex

topics. The results of the diagnostic tests and their formative evaluation can be compared in Figure 4. It is observed that the percentage of correct answers increased in questions 1, 3, 4, 6, 7, 9 and 10 (7 of 10 questions), in questions 2 and 8 there was no progress and in question 5 the change was not significant. With this, it could be deduced that regarding the number of hits, there was progress for 70%, there was no change in 20% and there was confusion in 10%.

In relation to the topics developed with the sessions and taking into account that the questions were formulated according to the themes proposed according to the ninth-grade curriculum, Table 3 shows the results analyzed according to each of the suggested topics.

Table 3. Hits by topics.

Topic	Question number	Diagnosis	Formative evaluation
First degree equations	1, 2, 3	40%	56%
Polygon perimeters	4, 6	67%	83%
Applications of first degree equations	5, 7, 8	27%	26%
Circumference perimeter	9, 10	17%	50%

Source: The autors.

Qualitative results

Active participation on the student population was observed in the sessions. They solved the exercises assuming the roles indicated for each of the learning guides and worked as a team to solve the challenges proposed. A great ability to work collaboratively was evidenced.

Figure 5. Teamwork.
Source: Own work

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Universidad Cooperativa de Colombia

Figure 5 shows one of the groups analyzing the challenge presented in the session and organizing the roles of each of the members. It should be noted that the initiative generated, as is normal, an environment of healthy competition in the work sessions, where each group wanted to complete the challenge before the other teams. This implicit challenge was generated spontaneously during the work sessions and fostered a learning environment full of interest, leadership initiatives and solidarity work, which would hardly have been achieved if it had been planned. The level of satisfaction of the students who managed to finish the challenge before their peers was indescribable, so much so that it motivated everyone involved to continue with their work [29]. That situation motivated the other teams to complete the challenge even with the support of those who had already completed it, showing a great level of empathy and pedagogical interest.

These emotional reactions ended up motivating the team of teachers to continue bringing meaningful learning moments, but also moments of joy to the students. A special emphasis is placed on the fact that these types of results, although not easy to quantify, are highly relevant and significant since the emotional impact achieved on the population maintains the interest of students and spreads very quickly throughout the participants and indirectly in the families or close circle of each of the directly impacted elements of the population.

Another of the skills strengthened by this work was the leadership capacity of the students, highlighted when expressing ideas and in public speaking. This skill allows them to enrich discussion through real arguments and with the seriousness that situations warrant. It is worth highlighting the participation of the students in the graduation ceremony, where they expressed the satisfaction of the process and the joy of being able to complete each stage, thus demonstrating their capacity for expression and leadership, overcoming the fear of expressing ideas in front of a large audience and to those with higher training and intellectual maturity.

Project evaluation

The first stage of the project concluded at the closing ceremony of the educational robotics workshops, where special recognition was made to the participants and the work with the students was concluded. The next step corresponded to the evaluation of the results obtained. Therefore, it became necessary to ask questions to the main interest group about the project, but not before going to peer evaluators to validate the results obtained and the instruments and strategies used. Through work sessions with the community and using guided interviews, an evaluation of the level of success

of the project was obtained. Through this exercise, a SWOT matrix was built with the contributions of the participants of the evaluation sessions. The analysis that was carried out in conjunction with the researchers allowed the analysis of the information provided by the participants of the evaluation process, and later, some strategies were proposed that are listed below:

- Articulate the methodology applied with the curricula of educational institutions, taking the competencies stipulated by the Ministry of National Education as a fundamental reference.
- Increase each of the sessions to an hourly intensity of 40 hours, for the development of the workshop course "Robotics for strengthening basic skills in mathematics." This is due to the time limitation evidenced in the information collected.
- Strengthen the interdisciplinarity of the research professors' team, because it is necessary for the work group to be made up of psychologists, social workers, and engineers, due to the multidisciplinary complexity of the project.
- Continue with the research training of own work about topics related to the development of software, computing, educational robotics, automation, mathematics, psychology, pedagogy, and social work.
- The methodology requires implementing an evaluation phase of the academic follow-up of students and impact measurement.
- Train the teachers designated by the educational institution in such a way that the implemented strategies can be applied under the same methodology in their classrooms.
- Search for support strategies for teachers from their classrooms to mainstream the knowledge acquired in the educational robotics classes with the curriculum of the educational institution for the mathematics courses.
- Maintain permanent communication with the mathematics teachers of the institution under study to evaluate the learning acquired by the students.

Currently, own work of this project are working on the formulation of a global strategy that could potentially impact a larger population. The exercise of evaluation of what has been carried out allows each of the comments of the project participants to be considered and improve the proposal based on them.

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5. DISCUSSION AND CONCLUSIONS

This work has represented an experience of applying praxeology and STEM Education, allowing to establish a reflection about the way in which a transformation of the human being and his community can be achieved, based on best practices in mathematics teaching; in this case, using robots. Thus, it managed to contribute to a community in response to a need for education. The emotional and attitudinal aspect of the students was not considered in the initial planning of the research since the focus was to improve the academic performance. During the project, there was the satisfaction of observing euphoric moments of joy, companionship, empathy, and assertiveness in the students that were surely were transmitted to their close social circle (family, friends, etc.); that had a direct impact on the main people involved in the development of this project.

Despite the short time dedicated to the educational robotics sessions focused on learning mathematics (20 hours), it was possible to show that the group of students improved in the topics questioned through the STEM Education and the praxis, which allows the researchers to propose new strategies and alliances with educational institutions where the time of dedication is increased and the limitation in terms of technological resources can be overcome. This improvement in the ninth-grade test group has also helped conclude that the work carried out can be replicated in different populations and under different contexts.

Considering this case related to young people in the ninth-grade, and of a community of the characteristics described, having contact with technological tools and being able to manipulate and control them can make a difference in the personal goals of each of the beneficiaries and that is, without a doubt, the most important achievement of this research; to inspire the participants. In this project, the *Ruta de Innovación Social* was followed, in this way it was possible, between the community and researchers, to design and package the solution through a process of evaluation and feedback to be replicated in other communities. One of those packaged elements is a book which describes the project experience and shows the most precise way to apply this same strategy in other communities, thus promoting the union between the community and the institution of higher education to improve educational practices, transform lives and try to solve problems in the environment of the students that are the target of this study.

Faced with the state of the art consulted, it is important to mention that most of the related works have been carried out in colleges and university facilities. So, bringing the technological solution to vulnerable communities is an important aspect and one that had a positive impact on the study population. The interaction of the students

with the robots in their own space generated all kinds of unexpected results, as well as stimulating the children's creativity, curiosity, and interest in the study of disciplines related to engineering. Each of the results obtained and how they contributed to the community in general were analyzed. In a strategic way, the team of researchers provided a space for the same beneficiary community of the initiative, to suggest possible new strategies and express the needs that they currently have and that UNIMINUTO would be able, based on projects of this same nature, to help nurture and continue generating a positive impact on the communities of Villavicencio and the entire region.

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