Revista Criterios - 31 (1) Enero-Junio 2024 Rev. Criterios - pp. 68-82
ISSN: 0121-8670, ISSN Electrónico: 2256-1161
https://doi.org/10.31948/revcriterios
Universidad Mariana, San Juan de Pasto, Nariño, Colombia.

Britabot: experiences with the Educational Robotics Seedbed

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To reference this article / Cómo citar este artículo / Para citar este artigo: Palma-Polo, J. M., Coral-Vargas. M. O., & Zuleta-Medina, A. (2024). Britabot: Experiences with the Educational Robotics Seedbed. *Revista Criterios, 31*(1), 68-82. https://doi.org/10.31948/rc.v31i1.3854

Reception date: March 21, 2023
Review date: June 02, 2023
Approval date: November 11, 2023

Abstract

This article presents the journey and experiences after the implementation of the Educational Robotics Workshop supported by Science and Technology 'Britabot' in a private rural educational institution in the city of San Juan de Pasto. There was an experimental group of 28 students, from the fifth grade of elementary school to the eleventh grade of high school, between 10 and 18 years old, and two teachers assigned to the school, to whom a training strategy was applied to strengthen their skills and competencies, through the use of the STEAM approach and tools and elements of educational robotics, which allowed them to guide their learning through constructivism and the development of a curriculum guide previously designed for the fulfillment of the objectives of the project. The qualitative research modality was used within a critical social approach applied in action research.

Keywords: education; educational robotics; research seedbed; STEAM competencies.

Article result of the research entitled: "BRITABOT": Educational Robotics Seedbed supported in Science and Technology to contribute to the skills of students from Colegio Musical Británico.

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Britabot: experiencias con el Semillero de Educación Robótica

Resumen

En este artículo se presenta el recorrido y las experiencias vividas tras la implementación del Semillero de Robótica Educativa apoyado en Ciencia y Tecnología 'Britabot' en una institución educativa privada rural de la ciudad de San Juan de Pasto. Se contó con un grupo experimental de 28 estudiantes, de los grados quinto de primaria hasta grado once de media académica, entre los 10 y 18 años de edad, y 2 profesores adscritos al Colegio Musical Británico, a quienes se aplicó una estrategia formativa para el fortalecimiento de sus habilidades y competencias, mediante el uso del enfoque STEAM a través de herramientas y elementos propios de la Robótica Educativa, que les permitieron orientar su aprendizaje por medio del constructivismo y el desarrollo de una guía curricular previamente diseñada para el cumplimiento de los objetivos del proyecto. Se usó la modalidad de investigación cualitativa, dentro de un enfoque crítico social aplicado en la investigación acción.

Palabras clave: educación; robótica educativa; semillero de investigación; competencias STEAM.

Britabot: experiências com o Semillero de Robótica Educacional

Resumo

Este artigo apresenta a jornada e as experiências após a implementação do Núcleo de Robótica Educacional apoiada pela Ciência e Tecnologia 'Britabot' em uma instituição educacional rural privada na cidade de San Juan de Pasto. Contou-se com a participação de um grupo experimental de 28 alunos do quinto ano do ensino fundamental ao décimo primeiro ano do ensino médio, entre 10 e 18 anos de idade, e dois professores designados para a escola, aos quais foi aplicada uma estratégia de treinamento para fortalecer suas habilidades e competências, por meio do uso da abordagem STEAM e de ferramentas e elementos da robótica educacional, o que lhes permitiu orientar seu aprendizado por meio do construtivismo e do desenvolvimento de um guia curricular previamente elaborado para o cumprimento dos objetivos do projeto. A modalidade de pesquisa qualitativa foi utilizada dentro de uma abordagem social crítica aplicada na pesquisa-ação.

Palavras-chave: educação; robótica educacional; núcleo de pesquisa; competências STEAM.

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Introduction

Since the publication of the document produced by the European Parliament, in which the STEAM (Science, Technology, Engineering, Arts, and Mathematics) domain was identified as one of the key competences for teaching and learning of 21st century citizens, this approach has become relevant in educational environments as it allows the use of advanced technologies in relation to science education and the development of a set of competences, including digital competences, as a pillar of today's society.

Educational robotics, as the core of STEAM skills training, is one of the bets in education that the best institutions in the world have considered as a tool to improve the quality of education (Romero-Rodríguez et al., 2014) and strengthen the teaching processes of skills inherent to technological development and others related to curricular areas such as physics, mathematics, English, mechanics, and other subjects.

The search for a comprehensive education, in which the structuring of knowledge and the development of skills and competencies converge, is one of the most important missions of any basic educational institution, since the construction of knowledge is essential to function in a globalized world, in a competitive environment where students must secure their vision of the future and their life project.

From this need, and with a critical look at the constant transformation of this technological society, digital skills become relevant as a dynamic element of multiple opportunities; therefore, from the educational institutions, it is important to consider a transformation of curricular processes within a research framework focused on the development of these skills and knowledge from an early age.

One of the bets is the inclusion of educational robotics; in this learning framework, STEAM competencies enhance the teaching processes, since the study of this science contributes significantly to the achievement of the objectives, as it is part of an educational offer that generates motivation, since it is developed in a dynamic pedagogical design of constructivism, the use and creation of 'technofacts' and the construction of knowledge in a collaborative environment.

Within educational institutions, the pandemic forced teachers and students to broaden their knowledge of digital tools. This process led many students to face challenges in solving problems with the use of technology, while teachers understood the need for updating in order to provide a better educational service oriented to the needs of today's society, something that had already been proposed in the framework of teacher competencies in ICT (Organización de las Naciones Unidas para la Educación, la Ciencia y la Cultura [UNESCO], 2023).

This conjugation of needs and opportunities is intertwined with the continuing advances in science and technology, which may seem distant to many. Perez (2002, cited in Carneiro (2021) argues that "humanity is at a 'tipping point' of unprecedented technological change" (p. 15). The world is advancing at an accelerated pace; therefore, the generation of the competencies and skills required by this new world scenario, where science and technology are the basis for future exercises and developments, becomes a latent need.

The Colegio Musical Británico, as well as other institutions, lacks a comprehensive education in science and technology; therefore, it needs to rethink its academic processes in order to scale its education towards one that integrates diverse competencies and values the application of educational robotics as a means of learning.

Consequently, in the backwardness that exists from the curricular and pedagogical practices, it is important to look for alternatives that boots the processes of educational transformation, in addition to the generation of computer skills in students, because after having already traveled a path where they reached the new presentiality with skills that they acquired as autodidacts, it would be a mistake to return to the old training paradigm in science and technology, where the experiences of computer science are reduced to learning office automation and a few commercial programs, mainly.

In this back and forth of ideas, the proposal arises to implement a research seedbed that, from the level of elementary education, can

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contribute to the strengthening of computer skills from the STEAM approach. For this reason, the use of educational robotics as a valuable resource to promote new learning that, linked to a curricular structure of the seedbed, strengthens the knowledge in science and technology, applying them in the solution of environmental problems and in the curricular development of the areas related to these skills such as English, mathematics, physics, among others, has been appropriated as a pillar of the seedbed. The fact of choosing what reality offers as didactic material makes it a useful resource with a transforming application in the learning process.

Theories

Background check

Atlas.ti helps uncover information with intuitive search tools that allow us to capture words, phrases, or fragments on a massive scale to perform basic analysis tasks until you reach the depths of your research. Once the program has analyzed the recurrence of the concepts contained in the documents, it produces a cloud of initial words, from which a manual debugging process is carried out, eliminating expressions, connectors and others without semantic value, to finally leave a semantic construction in accordance with the nature of the research.

Figure 1

Cloud of words generated by Atlas.ti

This word cloud allowed the creation of the initial codes for the analysis of the documents focused on research seedlings and educational robotics. The most relevant studies are presented below.

At the international level, although most of the initiatives for the creation of robotics incubators are based at universities, it was found that several of them are oriented towards the creation of robotics clubs in high schools, as in the case of the New York Institute of Technology and the College of Engineering & Computers Sciences. Together, they implemented the 'Computer Club' in Hempstead High Schools, where they worked with the ETIC Research Robot for Student Engagement & Learning Activities, a robot created by Dr. Michael Nizich that could be remotely programmed by students through the Zoom platform due to the pandemic. With the robot and without prior knowledge of programming, they were able to generate skills in critical thinking, conflict resolution, and innovative design, all through the STEAM methodology. This background is important for

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the research because it allows understanding how it is possible to work with STEM (Science, Technology, Engineering and Mathematics) through remote programming processes to generate the skills and competencies of this learning methodology.

Next, at the national level, a pedagogical experience was found with the research seedbed 'Innovantes Natos', supported by educational robotics at the Colegio Las Américas in the city of Bogotá, led by Diana Noy, computer science teacher, and Yesid Rodríguez, automated design teacher.

In addition, this seedbed, born in 2013 as a strategy to take advantage of free time against the student day and construction of extracurricular project in the application of new technologies in education, began with the participation of students in grades ten and eleven of high school, with the firm purpose of proposing technological solutions to real problems of their environment, through the appropriation of tools that bring them closer to areas of knowledge such as electronics, computer science, mechanics, and design, all mediated by the STEAM methodology, which brings together the areas of the common core.

In 2019, the seedbed set out to learn the basic operation of commercial robots for work purposes with mobility and recycled materials. In 2021, it planned to produce robots that simulate human sensations and aspects. This seedbed has continuously participated in various district and university competitions, and its work has been recognized by the Instituto para la Investigación Educativa y el Desarrollo Pedagógico (IDEP).

For this research process, this background was vital and important, since its vision of linking educational processes with solutions to environmental problems, thereby generating critical and reflective social thinking, was aligned as an essential part in the development of the proposed objectives.

Another important precedent in this line was found at the 'Gustavo Rojas Pinilla' School in Bogotá D.C., with its 'Robotic Strong' research seed group, led by Carlos Mario Caycedo Villalobos, a degree in electronics. This seed group began as a class project to build and move three animals. This project was promoted by the Science and Physics department of the tenth grade, which was later joined by the Information Technology teacher to contribute to the Mechanics and Electronics department, resulting in the construction of an animatronic toucan. With this construction they participated in 'Bogota Robotics 2013', a moment that gave shape to the seedbed as such.

Similarly, a regional precedent is 'CatiNar', which offers children, adolescents, and adults the opportunity to learn how to use different tools such as drones, 3D printers, virtual reality, even common electrical tools, through specialized workshops published on its official website and social networks, in order to convene digital entrepreneurs and other population eager for knowledge in technological and digital tools.

The presence of this type of space in the locality has made it possible to strengthen the research project not only through feedback with the CatiNar consultants, but also through the exchange of experiences based on the learning of technological tools that are part of the core of the studies with the research participants of the seedbed.

All these references followed a relevant path in the categorization of a large number of recent documents related to the research project *Britabot: Educational Robotics Seedbed supported by Science and Technology* and thus contribute to the skills of the students of the Colegio Musical Británico. This information was prioritized due to its thematic richness, and the qualitative data software Atlas.ti was considered as the main reference.

Seedbeds as a source of educational transformation

The seedbeds are one of the innovative strategies implemented from the primary school level to initiate research training in students. These training spaces contribute to the improvement of the research and innovation indicators of both students and teachers; therefore, there is a clear need for their implementation, since, in addition to strengthening the research processes, they support the teaching processes through the transversality of the areas involved and the impact on the curricular processes in which they are immersed, as a new component within the training strategies. Rodríguez et al. (2019) emphasize the need for research training as part of the overall training process

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of any professional, since one learns to do research only by doing research, and not as part of a course or subject. In the proposal, these authors highlight the initiative of research seedbeds as a contribution to the training of professionals.

Historically, seedbeds have their genesis in universities, where they have been sustained for many years; but, over time, these processes have migrated towards the basic level, since it is understood that investigative processes must forge their foundations in the school stage, which is when the foundations of university academic work and, later, professional work are laid.

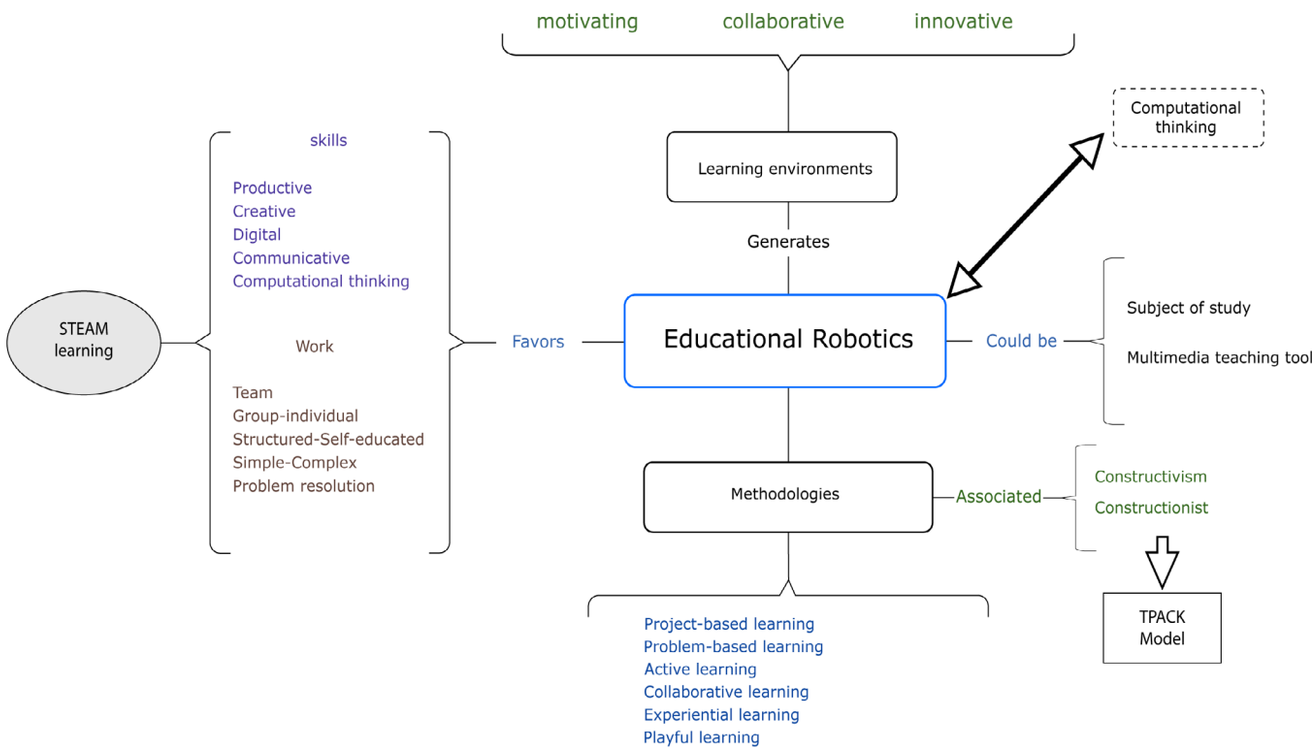
Educational robotics

González-Fernández et al. (2021) highlight the benefits in terms of the development of communication skills, teamwork, creativity, and problem solving, factors that are strengthened thanks to the dynamism of the approach with which the process is approached, since teaching based on Learning Project-based (PBL), in collaborative, meaningful and playful learning, fosters interest and leads the student to an education of enjoyment and not of obligation.

Using educational robotics tools as a didactic instrument for learning creates a guide for solving environmental problems with multidisciplinary solutions, which activates the cognitive and social processes related to meaningful learning, germinating in the acquisition of technological and scientific knowledge.

Figure 2

Learning methodologies and their interaction with the teaching of educational robotics



Source: González-Fernández et al. (2021).

In Figure 2 it can be seen that educational robotics creates an entire scaffolding for learning through active methodologies that allow the student to build skills and competencies through exercises derived from the study and application of new technologies in education.

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Methodology

The research is framed in the social-critical paradigm, within a social-critical approach applied to action research, because through the learning experiences obtained, a line of interpretation of the states of progress of each member of the group was drawn, which has a subjective value, since it seeks to bring each person to the threshold of his or her knowledge, which can go beyond the curricular proposal that is based on it.

In addition, the critical social approach leads the student to achieve a critical and self-reflective consciousness, considering his initial context in relation to the final one, as well as the problems of his environment, to which solutions have been given through the investigative processes.

Finally, action research becomes a key aspect for the success of the research project, since it directly addresses the problem, improving educational practices, their understanding and the implementation of new strategies in education.

Another important aspect within the research was the STEAM approach with the use of PBL work, a strategy that, together with the curricular proposal, collaborates in the development of the phases of the action research paradigm, based on the methodology of Suárez (2002). In the **first phase**, a diagnosis of the state of the research work to be carried out within the educational institution was prepared. After characterizing the students, their knowledge, the resources, the work team, among others, in the **second phase**, the search for the educational strategy that best adapts to the results of the seed producers was established, considering a series of theoretical references to support the work of implementing the strategy. In the third phase, the planning sheet for the implementation of the Educational Robotics Seedbed was created as a working strategy, integrating the curriculum proposal with all the aspects necessary for its development. Finally, group work was initiated through sessions that allowed the completion of the research with the evaluation of the application of the training strategy and the qualitative analysis of the results of the educational process using the data analysis software Atlas.ti. The data collected were tabulated in skill evaluation matrices, data obtained through the direct observation method.

The working group consisted of students from the Robotics Seedbed. Below are some aspects that were considered for the development of the research:

- Specific thematic focus: By including members of the Robotics Seedbed, it is ensured that the participants have a particular interest and affinity for the research topic; this guarantees their motivation and commitment to the project's goal of promoting skills in robotics and technology.
- Relevance to the seedbed: The research is closely aligned with the goals and focus of the robotics seedbed. Participants are already familiar with the context, resources and goals, which facilitates the implementation of research activities and understanding of their importance.
- Use of internal resources: By using the members of the seedbed as a work unit, the internal resources of the educational institution are used. This may include the knowledge and experience of teachers and tutors, as well as access to the facilities and equipment needed to carry out the research.
- Creating a Learning Community: Involving seedbed members in the research creates an active and participatory learning community. Students collaborate on research, share their knowledge and experiences, and work together to achieve project goals.
- Development of competencies and skills: Participation in research provides an opportunity to develop and apply competencies and skills in robotics and technology. Through active practice and real-world problem solving, students can improve their understanding and acquire skills in these areas.

Thus, the selection of the members of the Robotics Seedbed as a working unit guarantees greater thematic affinity, greater commitment, and greater relevance for the project. This contributes to more effective research and to the development of skills and competencies in robotics and technology among the students involved in the seedbed.

At the end of the cycle of training work with the seedbed, it was considered useful to apply a questionnaire within a semi-structured

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interview with some of the agents involved in this space, to know their vision of the developments carried out.

The interview consisted of a different number of questions applied to representatives of the seedbed: students, seedbed teachers, parents, and the rector of the educational institution. The number of representatives to whom the interview was applied can be seen in Table 1.

Table 1

Number of people interviewed according to their role in the seedbed

Categories	Num. of representatives
Rector	1
Teachers of the seedbed	2
Students of the seedbed	7
Parents of the seedbed	2

The importance of knowing all points of view allowed us to analyze the opinions, suggestions, and other aspects of the work of the Educational Robotics Seedbed from different perspectives to arrive at pertinent conclusions and recommendations.

Results

Looking for a change that would affect the education of the educational community, the educational robotics seedbed based on science and technology 'Britabot' was implemented in the year 2022. The name of the seedbed was thought of in the place of work: Colegio Musical Británico.

The selection of the age group was due to certain characteristics of the school population and the minimum competencies for the exercise of the seedbed; therefore, it was established between the ages of 10 and 18; however, teachers up to 45 years were later allowed to join. However, the main focus for entering the seedbed was always motivation, because you can only learn if there is interest from the child and, of course, from the adult.

The seedbed began the implementation phase with an internally developed curriculum that covered all the basic aspects of the practice. It included topics, objectives, work plans, methodology, materials needed, learning areas, and other key elements. In addition, it serves as the main guide, covering more than 90% of the aspects necessary to guide the learning process of the seedbed participants.

The process originated from postgraduate research work; it was carried out within the qualitative paradigm, through the action research methodology. Three phases were considered in the process:

- Characterize the students who are part of the seedbed and their previous skills in educational robotics.
- Design an educational strategy to promote the skills of the students of the Colegio Musical Británico through an educational robotics incubator.
- Evaluate the impact of the educational strategy designed to develop the skills of the students of the Colegio Musical Británico through an educational robotics incubator.

During the introductory phase, the characterization of the student population made it possible to collect socio-demographic data and prior knowledge, which made it possible to understand the potential, social, economic, and knowledge barriers that could affect their process.

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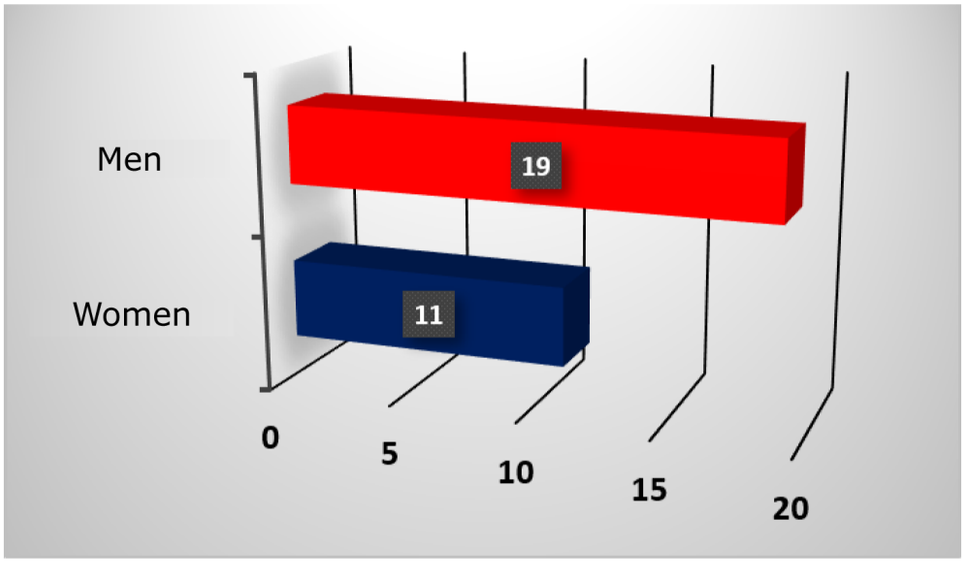
Figure 3

Classification by gender

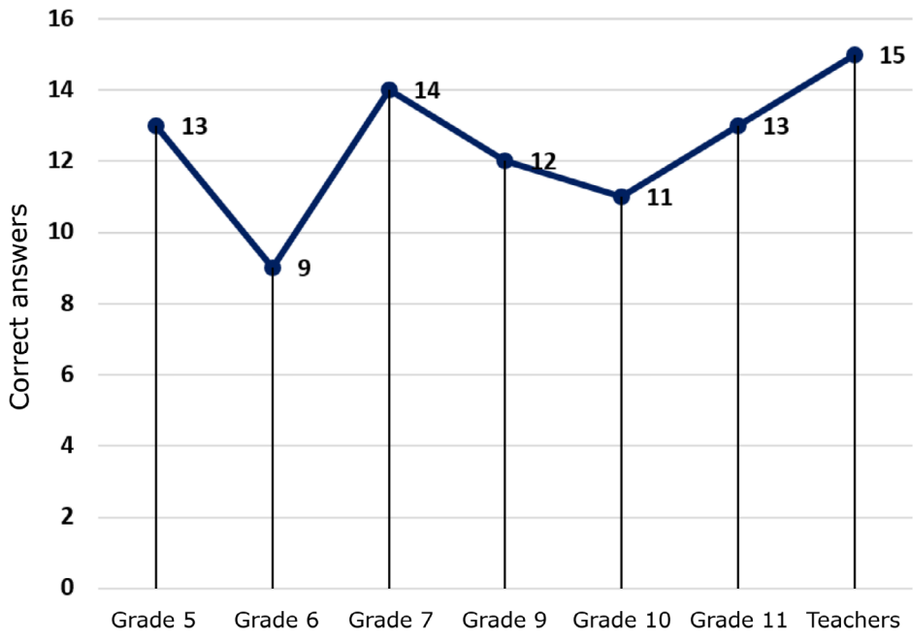


Note: Number of the students of the seedbed classified by gender in the 2022 school year.

From Figure 3, it can be concluded that the marked interest in studying scientific topics was predominantly among the male gender; however, in practice, it was observed that women performed better in the training process.

Figure 4

Results of the prior knowledge diagnostic test



After applying the diagnostic test consisting of fifteen questions on topics related to educational robotics, it can be seen in Figure 4 that the results were positive, since only a small group of students were below average, while the others had extensive knowledge of the basics to begin the learning process.

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The STEAM route

With the previous indicators and other additional ones used to characterize the population, the learning process began with the STEAM approach, based on the Educational Robotics and Informatics curriculum proposal created for this purpose. In this way, it started with a group of 30 students, with an intensity of three hours per week as part of extracurricular work, that is, outside the usual school day. In this space, different topics were worked on, starting with psychomotor exploration activities to quickly move on to other systematic learning and structuring exercises: block programming, circuit design, working with Arduino, 3D design, and printing, among others.

The activities were recorded in a digital magazine that can be seen at the following link: http://colegiomusicalbritanico.edu.co/Britabot/mobile/index.html

Each session was developed within PBL to allow work based on compliance objectives; in each one, an evaluation was carried out through a matrix that included nine parameters evaluated according to the fulfillment of certain skills (see Table 2).

Table 2

Table of student skills

Code	Skill name	Skill description
Skill 1	Colaboration and oral comunication	There is direct communication among the students that make up the research group, in addition to the interaction with the project tutors.
Skill 2	Networking and collaborative work	Collaborative work was carried out through small intervention groups, where students got together and made the invention of a technological artifact and the exhibition of their work.
Skill 3	Agility and adaptability	There is evidence of interest in being part of the management of these science and technology-based topics, in addition to their adaptation, previous perceptions, and agility to solve questions.
Skill 4	Self-confidence	Self-confidence is observed in the execution of tasks, trusting in themselves for the resolution of activities and group participation.
Skill 5	Empathy and global vision	They were empathetic with their peers, respecting each other's thinking and contribution to the group activity; they are able to include their thinking and receive the thinking of others in the realization of the activity.
Skill 6	Autonomy and self-control	Based on the initial conception of the activities they developed, it was observed that they fully comply with the activities through their previous knowledge.
Skill 7	Capacity for initiative	They demonstrate initiative in the creation and development of the activity
Skill 8	Creativity and imagination	They make use of creativity and imagination in the invention of technological prototypes
Skill 9	Critical thinking	They can think critically and make an appraisal of the topics that are presented to them.

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Results of the route

The development of the methodology and the pedagogical and curricular proposal for the teaching of educational robotics allowed the achievement of the proposed objectives.

Autonomous participation in the seedbed was considered essential; therefore, each student's interest in the topics of the course not only allowed for the acquisition of knowledge, but also guaranteed regular attendance at the sessions.

In one year, 27 work sessions were held, with an attendance rate of 78%; during this year, there were five forced desertions, three dues to withdrawal from the educational institution and two dues to personal situations. There were also six dropouts due to lack of motivation and six admissions after the start date. At the end of the course, 24 students were certified as having completed the training process of the Educational Robotics Seminar, which represents 80% of those who participated from the beginning of the course.

After tabulating the skills matrix, in accordance with the development of all the topics of the Robotics and Educational Informatics curriculum proposal, Table 3 shows the following results:

Table 3

Table of student skills results

	Average									
Months	**Skill 1**	**Skill 2**	**Skill 3**	**Skill 4**	**Skill 5**	**Skill 6**	**Skill 7**	**Skill 8**	**Skill 9**	**Total**
March	15,80	19,40	17,20	17,40	20,80	17,80	16,40	20,20	15,60	160,60
April	11,00	20,33	15,67	14,67	21,33	11,67	10,33	15,33	0,33	120,67
May	18,25	20,75	14,50	12,75	21,75	11,00	10,50	14,25	14,25	138,00
June	17,00	19,50	17,00	14,00	23,50	13,50	12,50	13,00	19,50	149,50
July	11,00	15,33	14,33	8,67	19,67	15,67	13,67	15,67	13,33	127,33
August	12,00	16,33	16,00	13,00	17,67	12,00	10,00	16,00	11,33	124,33
September	9,00	11,00	13,67	6,67	19,00	11,67	10,67	12,33	3,67	97,67
October	12,67	15,00	14,00	13,33	20,00	17,33	13,00	18,33	12,33	136,00
November	17,00	6,00	22,00	13,00	23,00	22,00	12,00	13,00	17,00	145,00
Average	13,75	15,96	16,04	12,61	20,75	14,74	12,12	15,35	11,93	133,23

Table 3 shows the average of the 24 students in relation to the total number of skills developed during each month. These results allow us to draw the following conclusions:

- The skills they developed the most after the seedbed process were: empathy, global vision, agility, adaptability, network collaboration, collaborative work, creativity, and imagination.
- During the first trimester, the results were generally higher than the others. This is due to the fact that the initial topics based on more practical, manual content were best received by the students, while in the other quarters the programming processes, circuit design, and 'technofacts' required more specific skills such as logic, computational thinking, and others that were developed more slowly.
- In this first cycle of beginners, 62% of the skills in the matrix were developed in the students who completed the course.

Revista Criterios - 31 (1) Enero-Junio 2024 Rev. Criterios - pp. 68-82
ISSN: 0121-8670, ISSN Electrónico: 2256-1161
https://doi.org/10.31948/rexcriterios
Universidad Mariana, San Juan de Pasto, Nariño, Colombia.

- After the training with the proposed curriculum design, it is observed that the topics Introduction to Sensors and Arduino Programming were the topics that caused the most difficulty to the students, which is reflected in the month of September with the lowest score at the level of assessment of the skills compliance matrix.

Since one of the objectives set from the beginning was to participate in events to stimulate the seedbed and its results, in August we registered for the Torneo Nacional Ruta STEM 2022 of the Ministerio de Tecnologías de la Información y las Comunicaciones de Colombia -MinTIC- for the application of educational projects focused on the STEM methodology.

After the evaluation of the project, it advanced to the departmental phase among five finalists, where the seedbed was the departmental representative in the tournament. In the national phase, the project was ranked among the 20 best out of 312 proposals. In the capital of the country, the seedbed was presented and some of the work carried out, as follows: three Arduino projects were set by two student speakers and a tutor of the seedbed, projects that were selected among the twelve best in the country, generating several awards and prizes for the work done with educational robotics.

Seedbed publications

If you wish to access all the contents of the digital magazine, please visit the following link: http://colegiomusicalbritanico.edu.co/Britabot/mobile/index.html

On the website there is a space dedicated exclusively to the seedbed, as one of the extracurricular projects of the educational institution, because although it was developed with the encouragement of the tutors, it would not have been possible without the school and its support. We invite you to get to know this space in the following link: http://colegiomusicalbritanico.edu.co/semillero22.html

The feeling of pride after representing this region in a national event and being able to bring this recognition, which postulates Nariño as a territory where advanced learning spaces in science and technology are built, was recognized by media such as the program 'Vive la Mañana' and the CNC channel (regional channel), where the seedbed was a special guest to share some of their work, the call for MinTIC and achievements.

Thanks to the national recognition obtained by the project, media such as Página 10, with more than 60,000 followers, published the achievement of the seedbed as one of the news to highlight. The publication can be found at the following link: https://pagina10.com/web/semillero-de-robotica-del-colegio-musical-britanico-de-pasto-gano-reconocimiento-nacional/

Finally, this achievement also invited to make a multimedia publication for the community of the educational institution and the general public, which was uploaded to YouTube as part of the repository of this project. This publication can be accessed through the following link: https://youtu.be/DT8LIZvCWgI

Discussion

There are several positive opinions and studies on the effectiveness of the STEAM approach as a methodology applied to elementary and middle school students, which suggest that the interdisciplinary study combined with real-world application provides several strengths to the approach that are different from the use of traditional teaching and learning techniques. These statements are also found in the study conducted by Li et al. (2020), who found that students who worked with STEAM methodology had better appropriation of concepts, learning application capacity, and interest in the fields involved, which is consistent with the result of the present research, since there was evidence of an increase in the development of STEAM approach skills as an effect of applying this methodology, skills such as computational thinking, teamwork, creativity, and innovation, among others.

Other research using this approach also demonstrated these and other skills developed in Britabot; one of them, from the New York Institute of Technology and the College of Engineering & Computers Sciences with the implementation of robotics clubs in high schools in Hempstead, who worked with ETIC Research Robot for Student Engagement & Learning Activities, a robot created by Ph.D. Michael Nizich and could be programmed remotely by students through the Zoom platform who, despite the pandemic and

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without prior knowledge of coding, were able to generate skills in critical thinking, conflict resolution, and innovative design, all through STEAM methodology.

In the study of the seedbed 'Innovantes Natos' of the Colegio Las Américas in the city of Bogotá, the researchers applied this approach to solving environmental problems with the use of technology through mechanics, computer science, electronics, and design, all mediated by STEAM, which earned them honorary positions before the Instituto para la Investigación Educativa y el Desarrollo Pedagógico, demonstrating that the correct incorporation of this approach allows them to achieve visible results, such as those found in this research.

The result of the application of the STEAM approach in Britabot led the seedbed to participate in the STEAM 2022 Tournament of the MinTIC, a tournament that seeks projects that incorporate science, technology, engineering, art, and mathematics. In this field, the proposal and work of the seedbed placed it as one of the twelve best projects in Colombia.

These learning outcomes are in line with the objectives of MinTIC and the Ministerio de Educación Nacional (MEN), which are: to contribute to the development of 21st century skills such as critical and computational thinking, creativity and problem solving through the use and appropriation of science and technology. To advance this purpose, the creation of a bank of eligible teachers from the public and private sectors was sought, with the purpose of training them in the STEAM educational approach and thus linking them to the transformation of educational practice through the application of new methodologies.

The MinTIC and MEN strategy is consistent with LaCosse et al. (2021), who found that the effectiveness of the STEM approach is highly dependent on the teacher's ability to effectively integrate STEM disciplines in the classroom and the student's ability to transfer what they have learned to new situations.

In summary, although there is several evidence and studies on the effectiveness and strengths of the STEAM approach as an active methodology in generating new learning applied to the context, such effectiveness is only possible if teachers are trained and motivated by a change in educational paradigm and who also promote training adapted to the current learning needs of students.

Conclusions

After conducting a survey with the application of characterization sheets to the population under study, high school students belonging to socioeconomic strata 1, 2, and 3, classified as low, medium-low, and medium, respectively, presented previous knowledge on the topics of educational robotics, technology, and innovation, which suggests that their level of perception and appropriation of the topics was of previous access. However, it was also evident that students with fewer resources find it difficult to access advanced technological content, thus eliminating a possible ideological bias in relation to those with better resources and opportunities.

The objective of the project was to improve the skills of the student members of the seedbed through the use of educational robotics. This objective was achieved thanks to the incorporation of the Educational Robotics Seedbed based on Science and Technology; in addition, these spaces for creating and modeling knowledge allowed the improvement of competencies and skills guided by active methodologies.

Three teachers from the educational institution were included as participants in the formative process of this study, who used this space for updating and transforming their academic curricula in the classroom. The results of the surveys applied to them showed that the teaching-learning process of the seedbed has generated changes in educational practice, leaving a marked interest and motivation to include technological topics and practices, as well as the incorporation of new pedagogical strategies based on active methodologies.

After analyzing the evaluation matrices in parallel with the activities developed, it became clear that educational robotics, as an educational axis from the use of STEAM competencies, managed to incorporate topics from academic areas such as science, mathematics, and technology, areas included in the projects developed as part of the proposed curriculum guide. The use and application of multidisciplinary contents allowed the students of the seedbed to improve their academic level

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in regular classes, thanks to the incentives and exposure to knowledge during it. Also, the application of the students' learning and competencies, visible in the scientific projects of the institution, was considered. The above proves that the educational robotics training process had a positive impact on the academics of the project participants in the different areas involved in the work.

Likewise, after analyzing the evaluation matrices of skills and assessment of the deliverable products, the work demonstrated that the student of the seedbed managed to build his/her learning mediated by basic notions of topics related to educational robotics, adopting the pedagogical approach of constructivism through teamwork, social interaction, and assertive communication to meet each of the educational challenges proposed in the seedbed.

The results of the seedbed in terms of results and competencies generated showed that the application of the previously designed educational strategy 'Curriculum Guide' was effective in the development of the class sessions thanks to the organization of topics, objectives, physical and methodological resources, execution time, and expected learning.

The data obtained from this research process was fundamental to conclude that STEAM competencies allow the development of dimensions of this approach, such as obtaining and processing information, computational thinking, logical thinking, systemic thinking, and the problem-solving process developed through applications such as Scratch, MBlock, MBot Simulator, TinkerCad, and the Arduino platform, through various programming languages.

After developing the curriculum guide proposed within the STEAM approach and participating in the STEM 2022 Route, it was found that the knowledge scheme applied in the tournament allowed the Educational Robotics Seedbed supported in Science and Technology 'Britabot' to achieve regional and national recognition, being selected as one of the twelve best projects in the country, thanks to the promotion of 21st century skills in its educational activities.

The creation and publication of the digital magazine, hosted on the institutional website, as a strategy for socializing the educational proposal, generated a greater dissemination of the practices, achievements, and recognitions of the Educational Robotics Seedbed and represented a greater welcome for the year 2023 at the beginning of a new stage with the seedbed, demonstrating that the exposure of the activities and merits of this learning space was of interest to the internal and external educational community.

After the completion of the work cycle, it was possible to observe in several students, the motivation and interest to continue with technological studies as a professional option, leaving as an example the choice of electronic engineering by an eleventh-grade student, the acquisition of a programming kit by a fifth-grade student and the interest in programming by a sixth-grade student, which, as part of the sample group, are visible representations of the scope of the study and the effectiveness of the training proposal of the seedbed.

It can be concluded that the use of constructivism as part of the active learning methodologies used in this project allows students to access knowledge in a dynamic and motivating way, promoting better attitudes and performance.

Recommendations

After the formation of the working team of the Educational Robotics Seedbed supported by Science and Technology, its work and recognitions, parents, directors of the institution and students, requested to continue this training process during the next school year. Therefore, it is requested to include in the budget of the educational institution the purchase of electronic, digital, and intelligent materials and devices for the future development of the practices of the Educational Robotics Seedbed.

Seek agreements with public and private entities that promote work with educational robotics and the application of science and technology for the development of science, technology, and innovation projects.

Invite the entire faculty of the Colegio Musical Británico to become part of the Educational Robotics Seedbed to gain new knowledge on topics related to educational robotics, generate new educational practices, and transform their academic curricula.

Continue to look for training calls and skills in educational robotics from government or

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private entities so that seedbed students can strengthen their knowledge and obtain technological resources for work within the Colegio Musical Británico.

Seek the incorporation of the Educational Robotics Seedbed supported by Science and Technology in the Fundación Red Colombiana de Semilleros de Investigación (RedCOLSI).

Conflict of interest

The authors of this article declare that they have no conflicts of interest and have not received any funding for the work presented.

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Contribution

All authors participated in the preparation of the manuscript, read it, and approved it.