International Journal of Innovative Research and Scientific Studies, 8(12) 2025, pages: 118-124

IJIRSS
International Journal of Innovative Research & Scientific Studies

ISSN: 2617-6548

URL: www.ijirss.com

The vision of science, technology, and innovation among children and adolescents in Córdoba, Colombia

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Abstract

The socioeconomic development of nations depends on advances in science, technology, and innovation. It is in this context that a society that values and constructs favorable meanings around these elements manages to remain at the forefront of an increasingly globalized world. This study aims to analyze the perceptions of science, technology, and innovation held by children and adolescents enrolled in school in three municipalities of Córdoba, Colombia. An exploratory-interpretive study with a qualitative approach and phenomenological-hermeneutic design was conducted. 32 participants participated in focus groups. The results yielded significant constructs around science as a principle of knowledge, technology as a medium between what is learned and what is lived; and innovation as a space for projecting and transforming the future. The constructs developed by children and adolescents are influenced by the characteristics of the social, ethnic, and school environment in which they operate. This should be considered in future research and the development of educational plans that allow for a practical and consistent approach to STEM.

Keywords: Adolescents, Children, Innovation, Perceptions, Science, Technology.

DOI: 10.53894/ijirss.v8i12.11022
Funding: This research was funded by the Colombian General Royalties System, which was approved with the (Grant Number: BPIN 2021000100256).
History: Received: 17 October 2025 / **Revised:** 10 November 2025 / **Accepted:** 14 November 2025 / **Published:** 5 December 2025

Competing Interests: The authors declare that they have no competing interests.
Authors' Contributions: All authors contributed equally to the conception and design of the study. All authors have read and agreed to the published version of the manuscript.
Transparency: The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.
Acknowledgments: "The authors would like to thank the University of Córdoba, Colombia, for the administrative and academic support received during the study. They would also like to thank the children and adolescents who participated in the research."
Publisher: Innovative Research Publishing

1. Introduction

Science, technology and innovation significantly influence different areas of daily life, such as the economic, social and cultural to the extent that they impact within the orbit of education, comprehensive training and the generation of new knowledge. Despite its strategic importance, institutional efforts are insufficient within the context of accessibility, relevance and use by the population, and needs are also highlighted regarding the participation of technology within educational curricula in order to effectively address the problems and challenges that arise as a result of technological transformation [1].

As a result, some populations are deprived of access to science, technology, and innovation (STI), a reason that creates profound inequalities in the generation, dissemination, and appropriation of scientific knowledge. Thus, conditions and ways of life are perpetuated within the framework of poor, unequal, and developed societies with a limited approach to human rights. Given this situation, technological literacy is conceived as a fundamental pillar for addressing the challenges and transformations that modern societies are undergoing [2].

During the last decades there has been an increase in studies on the level of scientific literacy and the promotion of scientific and technological vocation in the search to understand opinions, expectations and concerns of students regarding science and technology, which makes it possible to characterize the reciprocal influences between individuals and social groups, allowing to guide the educational process from the perspective of an integral formation, critical thinking and in articulation with social needs. Similarly, some recent research reaffirms that scientific training should be enhanced from early childhood, since this stage of life is the one that offers greater opportunities to develop future skills and abilities in the critical analysis of reality, citizenship and human development [3-5].

At the national level, gaps in access to technology are reflected in dispersed rural populations, according to the Ministry of Science, Technology and Innovation of Colombia, 69% of the resources for science, technology and innovation activities (ACTI) and 66% of the funded research projects are concentrated in Bogotá (capital of Colombia) and in the departments of Antioquia and Valle del Cauca [6]. By virtue of this, it is necessary to promote access to science with the aim of providing tools that solve the particularities of each territory, as well as the achievement and construction of free, informed citizens with the capacity for scientific production.

Under this panorama, questions arise about the factors underlying the low academic productivity in territories other than the main urban centers of the country; especially where ethnic communities or socially disadvantaged groups settle. The explanation of this phenomenon is stated from the institutional disarticulation that is observed for the development and strengthening of human capacities both in the university and in the school, as well as the little support and value that has been given to scientific literacy from an early age, where in addition it is possible to incorporate the original everyday and technological knowledge for the improvement and satisfaction of needs, which before on the contrary, begin to generate feelings of apathy, distrust, disinterest and little credibility in the management of the respective public policies in the territories [7].

In relation to science and technology, each person is understood as a key actor in its use and articulation with the particularities of their territory, which is why it is necessary to approach the study of science, technology and innovation from the perceptions of children and adolescents (NNA), from the perspective of understanding their concept of science and how they use the tools to do science; which implies questions and reflections on what scientific knowledge is and the articulation between the elements of science, technology and innovation (STeI). Consequently, this research is developed with the purpose of analyzing the perceptions of science, technology and innovation held by children and adolescents enrolled in three municipalities in Córdoba, Colombia.

2. Materials and Methods

An exploratory interpretive study was conducted with a qualitative approach and phenomenological-hermeneutic design, which allowed for the analysis of the participants' sociocultural perceptions.

The participating population was 32 boys, girls and adolescents enrolled in grades 5, 6, 7 and 8, distributed and located in the urban and rural areas of 10 Educational Institutions in the Municipalities of San Andrés de Sotavento (4), Tuchín (4) and Chinú (2) in the department of Córdoba, Colombia. A convenience sampling was carried out aligned with the inclusion criteria: i) have the informed consent of the parents, ii) be formally enrolled in one of the 10 educational institutions that were part of the BPIN 2021000100256 project, executed by the University of Córdoba, iii) Maintain a representative proportionality between men and women for each focus group.

Data was collected through focus groups comprised of eight students (four men and four women). These groups also used drawing as a knowledge production technique. The group interviews were recorded, transcribed, and processed using Atlas ti software.

The information was analyzed using Bardin's content analysis technique [8] which pre-establishes three key moments: i) pre-analysis, in which the in-depth reading of the social representations constructed in the workshops and focus groups took place; ii) analysis, consisting of an exploratory phase which yielded categories and subcategories of analysis that were structured into conceptual and contextual units; iii) interpretation that was carried out based on the theoretical elements to comprehensively understand the analytical axis.

This research study guaranteed the confidentiality of the participants, as well as their anonymous participation, declared as research with minimal risk and with the use of informed consent completed by the participants' legal representatives. The project always guaranteed the ethical principles of the Declaration of Helsinki, such as autonomy, beneficence, non-maleficence, and justice. Furthermore, the macro-research from which the results are derived was approved by the Research Committee of the University of Córdoba for submission to the General Royalties System of

Colombia. This review guaranteed the review of all ethical, technical, and conceptual guidelines, obtaining approval for its implementation under code No. 2021000100256.

3. Results

Through a hermeneutic analysis process, the perceptions of science, technology, and innovation constructed by school-aged children and adolescents in three municipalities in the department of Córdoba, Colombia, were identified. The results are not presented as isolated notions, but rather as a network of meanings structured through experiences in the school environment, as well as in daily practices and projections for the future. The findings were organized into three categories: science as a foundation of knowledge; technology as a mediator between what is learned and what is experienced; and innovation as a horizon of transformation.

3.1. Science: Starting Point of Knowledge

The first category, "Science: Starting Point of Knowledge," shows that participants construct perceptions based on the plurality of meanings surrounding science. Their constructions reflect attempts at social appropriation of the concept from different perspectives. However, students demonstrated a clear and objective cohesion in viewing it as an element interacting with other constructions and linked to everyday life.

While much of the perception of science was from an analogical perspective, as participants approached a broader and more inclusive conceptualization of science, including more technical and objective language, it was common to approach it from specific areas such as the natural sciences, as can be seen in the following narratives:

"It is a body of knowledge obtained through practice and study that is responsible for explaining what happens in our environment." (NNAJ 8th grade, Tuchín).

"Science is the knowledge that a person has." (NNAJ 8th grade, Tuchín).

"Science is a body of systematic, verifiable knowledge that studies, explains, and predicts natural phenomena." (7th grade NNAJ, Tuchín).

"Science is everything that arises from what we study in the natural sciences, because that's where we talk about science the most." (NNAJ of 9th grade, Chinú).

From another perspective, it was established that some students view science as an organized, planned, and rigorous process that allows them to address reality, solve problems, and seek new knowledge. This view is shaped by the praxeological premise, which incorporates methods and methodologies that allow for the acquisition of knowledge associated with research, or as something obtained through the application of the scientific method, as expressed in the following narratives:

"For me, science is scientific research and experimentation." (5th grade children, Chinú).

"Science is when you do experiments in a laboratory, when you do something new so that when you invent it, no one else will say anything about it." (7th grade children, Tuchín).

"Try to conduct experiments, provide answers to questions, and provide an understanding of each element." (7th-grade children, Tuchín).

Based on the above, drawing techniques were applied to identify some key elements through which each participant showed the way in which they visualize and construct their perceptions about science, based on their experience. Each illustrative element is related in Table 1.

Table 1.
Perceptions about science.

Element used to represent the meaning of science	Description	Frequency with which it is included in images and drawings
Laboratory utensils	Erlenmeyer flask with liquids or substances	20
	Flat-bottomed flask with liquids or substances	8
	Test tube	7
	Test tubes with liquids or substances	5
	Beaker glass	1
	Rack with test tubes	2
	Microscope	3
	Lighter	3
	Table with laboratory elements on it	10
	DNA chain	1
	Atoms	5
Place where science is developed	Laboratory or closed space	13
	Outdoor space (outdoors or surrounded by nature)	4
	No location is specified	11
Who develops science	Scientist	5
	Scientist	2
	female children and adolescents	3
	Male NNA	2
	No subject is reflected	16
Scientist's clothing	White coat	8
	School uniform	1
	Goggles	5
Action and/or attitude of the person carrying out the scientific activity	Conducting experiments	4
	Observation	3
	Smiling	1
Words and/or legends incorporated into the drawing	Experimentation, explanation, matter, observation, identification	1
Other Symbols and Elements	Light bulb	2
	Magnifying glass	5
	Book	1

Source: Prepared by the authors based on the analysis of drawings created by the study participants.

Each element expresses a traditional scientific construct linked to experimentation. The allusion to laboratory materials and/or equipment, such as the Erlenmeyer flask, was the most frequently used resource in the symbolic approach to science.

The predominance of laboratory tools and utensils as symbols of science stems from the teaching of natural sciences, biology, and chemistry, where these tools are required to perform laboratory practices. In this sense, participants define the discussed concept based on the sensorial exposure accumulated during their school years, whether through direct contact or through images regularly shared in textbooks, school presentations, or teacher-led activities in the classroom or laboratory.

When investigating the place where science is conducted, a tendency to situate it within laboratories or other enclosed spaces became evident, a finding that underscores the idea that science is perceived as strictly associated with laboratories. This can be a limiting factor for students who lack such a space within their institutions and, as a result, perceive themselves as distant from science or the scientific method.

3.1.1. Technology: Between What is Learned and What is Lived

The results obtained in the second category indicate that technology, like science, is rooted in the traditional conception of current societies, although it is perceived by children and adolescents as a construct not alien to their reality. For them, technology constitutes a process situated in the circle of transformation, usefulness and response to contextual problems, as can be seen reflected in their narratives:

"For me, technology is a process of changing or transforming something new and giving it a function. Technology can also be used to solve problems." (8th grade children, San Andrés de Sotavento).

"Technology is the set of knowledge and tools used." (Children, 5th grade, Tuchín).

"Technology refers to the application of scientific and practical knowledge to solve and satisfy human needs." (7th grade children, Chinú)

In this order of ideas, some of the children and adolescents conceive technology as the end of a process, that is, they attribute significant characteristics to the product, which are clearly expressed in visions of technology as an artefact,

apparatus or technological device, updated and efficient, produced from the ideation of man and related to the perception of its response to the needs of human populations:

"They are technological devices; they are becoming more advanced and efficient every day in their operation, like the computer, which is a technological device that has advanced in its technology." (8th grade children, Chinú).

"Thanks to technology, humans have invented cars for convenience, so that human beings can get around." (NNAJ, 7th grade, Tuchín).

"Technology is a technological device that helps us develop our minds and reach our potential." (8th grade children, Chinú)

"Technology is based on good things, that's why we have phones, televisions, etc." (5th grade students, San Andrés de Sotavento).

"Technology has revolutionized the entire world, such as the internet, computers, etc." (8th grade children, Tuchín).

Likewise, the perception of technology is not separate from innovation. Consequently, and according to participants' responses, it is represented as a means of social communication or an element of research and scientific appropriation, leading to a creative parallel where unique ideas are materialized while pre-existing elements are perfected. Similarly, technology as an innovation facilitates the daily lives of children and adolescents within their communities, making it a transformative and relevant tool within their communities:

"Technology is when they use social media to research. We live surrounded by technology sites, and we can create them and make inventions that don't exist yet, yet are technological." (6th grade children, Tuchín).

"Technology is the science that seeks to bring new innovations to society and transform new changes into our lives." (8th grade children, Chinú).

"Technology makes our daily lives easier, makes everything simpler. We no longer have to wait in lines to get a document; we can download and print them from home." (8th grade children, San Andrés de Sotavento).

3.1.2. Innovation as a Horizon of Transformation

In terms of innovation, the results show similarities between some of the concepts developed by the participants. In this sense, some children and adolescents explain that innovation is improving an existing product or process to transform it into a more effective response to human needs:

"For me, it would be recreating something new or perhaps improving something that already exists. That helps us a lot to innovate or create new things in our minds." (6th-grade children, San Andrés de Sotavento)

"For me, innovation is like improving something that already exists. For example, cell phones were just things that were only used for making calls. Then they innovated, and they improved them to what we know today ." (Children, 5th grade, San Andrés de Sotavento).

For their own purposes, some of the participants establish an intrinsic relationship between innovation and research, technology and science. This social construction is denoted in some of the notions expressed by the children and adolescents:

> " *Innovation is something in science that allows one thing to be changed into something new and perfect. Science allows for innovation." (Children, 5th grade, Tuchín).*
>
> *"These are new ideas being implemented around the world; they're also implementations that help technology and scientists. They can also generate something new throughout the country and our reservation." (8th grade children, Tuchín).*

Based on the above, it can be highlighted that each child or adolescent maintains a conceptual connection that associates significant elements such as technology, science, and innovation. Similarly, they connect these aspects from their perspective and cultural context . Based on the above, it is vital to recognize the conceptual construct that revolves around the transformative nature of innovation and its connection with human action, an action and principle that improves living conditions:

> *"It's a series of transformations that occur through human action, for example the Industrial Revolution." (8th grade children, Tuchín).*
>
> *"For me, innovation is anything we as people can create, such as a cell phone that can be charged with a solar panel, not using electricity, but solar energy." (6th-grade children, San Andrés de Sotavento)* .

Some narratives demonstrate the construction of meanings in relation to historical events as exemplary models of great importance, such as the Industrial Revolution. This is an indicator that reveals the influence of the phenomenon based on the content learned in school, with the understanding that milestones such as this were processes of social, political, economic, and cultural transformation, which drastically influenced the evolution of modern societies.

This appreciation is strengthened by analyzing the notion of innovation, which marks a before and after, an example of this is the modification of instruments and tools for cooking food, highlighting that in the past cooking was done in artisanal stoves whose main fuel was firewood, but that, thanks to innovation, currently This activity can be carried out in a stove, which also highlights the ability to improve an everyday procedure that was carried out within the family context:

> *"For me, innovation means creating new things. Our ancestors cooked over firewood, but over time, that custom was lost with the advent of technology. Many people now cook on stoves."* (8th grade children, Tuchín).

4. Discussion

Children and adolescents' perceptions of science are stereotyped by typical representations of laboratories, equipment, clothing, intelligent men, and to a lesser extent, comprehensive constructions are evident that include knowledge appropriation processes and open science. These results are similar to a Beijing study [9] with a minority population that maintains the status quo of science and the personnel that develops it, showing the need to reorient public policies that promote access to science for all, especially encouraging innovative classroom processes where lectures and practical applications of science are minimized [10].

For its part, the study by Serje Gutiérrez, et al. [11] debates the importance of fostering favorable attitudes in relation to the elements of science and research, considering an established relationship between attitude and age, highlighting that students present less favorable behaviors towards training in science than other members of the academic community. In this sense, it is evident that there is a need to approach science and research from the notion of social and open science that transcends the traditionalist concept that underlies the perceptions of the participants.

In addition to the above, Flores Espejo [12] warns that there is currently a process of distortion of the nature of science, where much of it is attributed to teachers in charge of the scientific education of children and adolescents. For this reason, there is a need to transform pedagogical practices that promote a renewed vision of science, so that students become familiar with this concept and manage to improve scientific and argumentative skills [13] and promote scientific careers [14]. By virtue of this, the results of the present study show that the construction of perceptions about science and research is linked to the prevalence of technical concepts, adding to the efforts to bring the school and the curricular contents closer to scientific education.

Despite the above, for Quevedo-Pinzón and Franco-Avellaneda [15] the prevalence recorded by some teachers on the concept of science as an infallible or strictly exact method, limits the implementation of public policies of open and social sciences. Faced with this, knowledge continues to be conceived as a product, based on the imaginary that students manage to appropriate technology and science when they learn content, which substantially distances the process of social appropriation and the construction of skills or scientific thinking from purely social and cultural scenarios.

The findings of this study showed a porosity of meanings regarding STI, from the rigid vision of science and technology, mediated by practical uses and the underlying responsiveness of technology, to connections with the sociocultural environment, which account for the impact produced by the project to promote the scientific vocation for the purposes of social appropriation of knowledge from which these results are derived. Reasons that motivate the realization of new research that continues reinforcing the learned notions to produce permanent changes in the behavior of students, as well as in teacher training in order to minimize decontextualized practices in science education [16].

In Colombia there is a palpable evolution of the STI approach, which highlights the importance of addressing scientific education from the academy. In this way, STI does not distance itself from populations and ethnic groups, which is why there is an interest in the vision of ethnic groups and their relationship with science and technology, visualizing points of convergence and divergence between cultural knowledge and that endorsed by science, demonstrating that many of their practices carry science within themselves [7, 17-19]. Being consistent with the guidelines of Colombian public policies where the social appropriation of knowledge is motivated in the path of building dialogical spaces, understanding knowledge within the framework of a process of adaptation and reinterpretation in the different sociocultural contexts where it is produced [20].

Regarding the notions of technology and innovation, it was evident how children and adolescents illustrate the processes of historical transitions through the change of instruments and tools. Among their examples, the means for cooking food stands out, highlighting that in the past cooking was done in artisanal stoves whose main fuel was firewood, but that, thanks to innovation, currently This activity can be carried out in a stove.

Based on the above, it is key to highlight that innovation is a vital axis for the elements of science and technology, highlighting that academic spaces within the educational system must promote innovation and production of science based on their competencies [21]. Thus, children and adolescents believe in innovation as a driver of change and transformation, which improves established processes and creates new opportunities to impact the needs of the social context in which they live.

Similarly, Castillo, et al. [22] mention that it is essential to link the industrial sectors and online education to create ideas and transfer scientific capabilities that allow facing the challenges that converge within the reality of Latin America, a vision that is shared by the participants of the study in terms of that they create a representation of innovation as opportunities for improvement and spaces to express creativity.

5. Conclusion

The perceptions of the participants are conditioned by the particular characteristics of the context in which this population interacts, added to the intervention of the cognitive activity and the autonomy of each individual that configure a significant representation expressed through a heterogeneous set of objects, images, symbols, things, ideas, places or events adopted by tradition or by norms accepted by the majority around science, technology and innovation, incorporating significant elements of the culture of the zenú people, which help to interpret their identity and their differences in relation to other social groups.

Furthermore, the results obtained here allow us to reveal the sense of belonging and the educational and ecological potential of this territory as a starting point for designing pedagogical intervention strategies that contribute to the promotion of scientific vocation, science, technology and innovation from the school curriculum, with the capacity to

articulate scientific and/or academic knowledge with ancestral empirical knowledge, taking advantage of opportunities , global dynamics and local potential in the school.

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