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# Scientific Initiation as a strategy for the development of Scientific Literacy in basic education students: reflections from the *Cientista Aprendiz*

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***Abstract:*** Scientific initiation has benefits for scientific education, but few studies focus on schools. Thus, we investigated a Program of Scientific Initiation offered by a private school in São Paulo. We aimed to identify: i) a number of students that were participated in this program (2006 to 2019); ii) the areas and themes that were researched by the participants; iii) possible gender differences. We analyzed some documents, did some statistical tests, and did an Open Data Categorization. We identified the growth of student enrollments, indicating an enlargement of their interest in scientific topics. We also identified a greater number of researches in Biological Sciences, but gender differences were not identified, just an asymmetry in the areas of interest of students. More spaces for the development of the Nature of Science in schools are necessary, as well as the constant dialogue about the insertion of women in scientific careers.

***Keywords****:* Scientific Literacy. Scientific Initiation. Basic Education.

## La Iniciación Científica como estrategia de desarrollo para la Educación Científica del estudiante en la enseñanza básica: reflexiones del "Programa Cientista Aprendiz"

***Resumen***: Los programas de iniciación científica muestran beneficios para la Educación Científica del estudiante, pero pocos estudios se enfocan en la enseñanza básica. Así, se investigó un programa de iniciación científica ofrecido por una escuela privada en São Paulo, con el objetivo de identificar: i) el número de estudiantes matriculados (2006 a 2019); ii) las principales áreas y temas investigados por los participantes; iii) posibles diferencias de género relacionadas con la matrícula de estudiantes y las áreas analizadas. Se realizaron análisis de documentos, pruebas estadísticas y "Categorización Abierta". Fue detectado el crecimiento de la matrícula de estudiantes, lo que indica la expansión de su interés por temas científicos. También se observó un mayor número de investigaciones en Ciencias Biológicas. No se identificaron diferencias de género relacionadas con la matrícula de estudiantes, sin embargo fue identificada una asimetría en las áreas de interés de los estudiantes. Es necesaria la ampliación de espacios para el desarrollo de la naturaleza de la ciencia en las escuelas, así como el diálogo constante sobre la inserción de la mujer en las carreras científicas.

***Palabras clave***: Educación Científica. Iniciación Científica. Enseñanza Básica.

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*REnCiMa*, São Paulo, v. 13, n. 4, p. 1-23, jul./sep. 2022

# A Iniciação Científica como estratégia de desenvolvimento da Educação Científica do aluno na Educação Básica: reflexões a partir do Programa "Cientista Aprendiz"

***Resumo:*** Programas de iniciação científica apresentam benefícios para a Educação Científica do aluno, porém poucos estudos são focados na Educação Básica. Assim, investigou-se um programa de iniciação científica oferecido por uma escola privada de São Paulo, pretendendo-se identificar: i) o número de estudantes matriculados (2006 – 2019); ii) as principais áreas e temas pesquisados pelos participantes; iii) possíveis diferenças de gênero relacionadas ao ingresso dos discentes e às áreas pesquisadas. Realizaram-se análise documental, testes estatísticos e "Categorização Aberta". Detectou-se o crescimento de matrículas, indicando a ampliação do interesse dos alunos pelas temáticas científicas. Também se identificou um número maior de pesquisas nas Ciências Biológicas. Diferenças de gênero, relacionadas ao ingresso dos estudantes, não foram identificadas, porém houve assimetria quanto às áreas de interesse dos participantes. Ampliar os espaços para o desenvolvimento da natureza da Ciência nas escolas se faz necessário, assim como o constante diálogo sobre a inserção feminina nas carreiras científicas.

***Palavras-chave:*** Educação Científica. Iniciação Científica. Educação Básica.

## 1 Introduction

*Why teaching and learning Science is essential?* For many years, teachers and students have faced this issue in educational environments. However, answering this question today is especially important, as much scientific knowledge produced over the centuries has been challenged and even denied by some sectors of society. We believe that science education could decrease the chances of such attitudes towards scientific knowledge and expand the acknowledgement of its value for life in society.

To answer the question proposed, we will do a brief historical review of the 1950s, when the scientific movement gained momentum in the United States. However, it is worth noting that discussions about Science teaching can be found before, for example, in John Dewey's (1859-1952) works, as stated by Santos (2007). We can say that the scientistic impulse owed mainly to the North American concern with Russian scientific development, which ended up echoing in the school context of the period (LAUGKSCH, 2000). In 1958, the American researcher Paul Hurd introduced the expression *scientific literacy*, promoting intense discussions in the academic environment, which also extended to schools. Thus, the importance of Science teaching in those spaces was stressed, ensuring that students approached Science and "doing Science", which changed the approach to this area in American educational institutions. Later, this debate expanded to other countries, sowing the idea of the need to offer students adequate science education.

*REnCiMa*, São Paulo, v. 13, n. 4, p. 1-23, jul./sep. 2022

Between the 1980s and 1990s, in Brazil, Science teaching was centered on making students acquire scientific knowledge through the massive transmission of content. Back then, one of the efficiency indices of a teacher was the number of pages of texts passed on to students, who should passively "absorb" the information. Students were expected to memorize theories, concepts, and scientific processes, implying the construction of the image of a competent student as an individual capable of becoming a "depositary of knowledge" (CHASSOT, 2003). Thus, as in the United States and other countries, proposals for Science teaching concerned with the students' education for citizenship aiming at their performance in society have become recurrent in the Brazilian educational context. Soon, expressions such as "scientific education" and "scientific literacy" became increasingly present in the vocabulary of academics in the Brazilian educational area, fostering heated debates about these concepts and their implications for science teaching in the country.

In this scenario, we can say that even today, there are discussions about the meaning and use of those expressions that hinder researchers' efforts in their studies in the area. As Sasseron and Carvalho (2011) attest, the difficulty may owe to the translations into Portuguese since the English term *scientific literacy* has been translated into our language as *letramento científico*, while in Spanish and French, they use *alfabetización científica* and *alphabétisation scientifique*, respectively. Over the years, new nomenclatures appeared to designate the objective of science teaching related to the citizen formation of individuals, such as the expressions *enculturação científica* [scientific enculturation] (SASSERON and CARVALHO, 2011) and *educação científica* [scientific education] (SANTOS, 2007), for example. In this article, we will use the term *scientific education* (hereinafter, SE) as we believe this expression to be more consistent with the reflections proposed in this study. Thus, like Santos (2007), we adopted:

> the differentiation between *alfabetização* and *letramento* because, in the school tradition, *alfabetização científica* has been considered in the sense of mastering the scientific language, while *letramento científico*, in the sense of the use of the social practice, seems to be a myth far from classroom practice. By using the term *letramento*, we seek to emphasize the social function of scientific education in opposition to the restricted meaning of school education (SANTOS, 2007, p.479).

In this context, the author believes that scientific education can be considered a simpler process related to the mastery of scientific language. Scientific literacy, on the

*REnCiMa*, São Paulo, v. 13, n. 4, p. 1-23, jul./sep. 2022

other hand, includes mastering both scientific language and social practice. SE, therefore, aimed at its broadest degree, encompasses both processes mentioned above (i.e., education and literacy).

Based on this, and answering the starting question, we believe that today, one of the main justifications for teaching and learning Science in schools is precisely to promote students' SE, preparing them for life in society and enabling them to make ethical and conscious decisions, which aligns with many studies in the area, such as those by Assunção and Nascimento (2019) and Reis *et al*. (2019). Unesco (2000) also argues that scientific education, at all levels and without discrimination, is a fundamental requirement for democracy. This argument is similar to the ideas defended by Laugksch (2000), who points out a close relationship between scientific education and the economic well-being of a nation. With this in mind, science teaching in schools should not be focused merely on the "transmission" of content but should provide the development of broader skills and competencies in students. In this regard, we agree that:

> it is necessary to improve science teaching to educate critical, creative citizens who can think and solve problems in their surroundings and who participate in building a more democratic and fair society. In this sense, this teaching can also contribute to the awareness of Science as part of the culture and not just to train scientists or specialists in the area (LONGHI and SCHROEDER, 2012, p. 548).

It is worth mentioning that those ideas have also been present in Brazilian curriculum documents since the late 1990s, such as the "Parâmetros Curriculares Nacionais" (BRASIL, 1998) and the current "Base Nacional Comum Curricular" — BNCC (BRASIL, 2018a).

Among the possibilities in the development of students' SE, the importance of their adequate understanding of what is called the "Nature of Science", as some studies show (such as COSTA and ZOMPERO, 2017; HARRES, 2008; PRAIA *et al*., 2007; SANTOS, 2007; SASSERON and CARVALHO, 2008). Harres (2008) argues that this type of approach enables students to build a more humane view of Science, overcoming possible distorted understandings of it, such as those that relate the area to the production of absolute truths through a neutral practice exempt from any feeling. With similar reasoning, Santos (2007) argues that understanding the Nature of Science is essential since it allows the student to understand the implications of scientific

*REnCiMa*, São Paulo, v. 13, n. 4, p. 1-23, jul./sep. 2022

activity, as it does not distance itself from social problems. For this, the researcher considers that developing students' knowledge related to the History, Philosophy, and Sociology of Science is also essential to achieve such goals.

Based on this context, in Brazil, the results of a study carried out by the Center for Management and Strategic Studies (Centro de Gestão e Estudos Estratégicos - CGEE) indicate that 73% of respondents think that Science and Technology bring only benefits (or more benefits than harm) to society. Furthermore, for 41% of them, scientists are "intelligent people who do useful things for humanity" (BRASIL, 2019). Scenarios like this show how Brazilian scientific education is below the desired level and how important it is to invest in expanding scientific and technological dissemination, bringing the ordinary citizen closer to these areas. Thus, the need to expand SE development spaces in educational environments is reiterated.

One of the possibilities to bring students closer to the Nature of Science would be through the development of activities related to "scientific doing". In this regard, researchers such as Alves *et al*. (2012) argue that, from teaching with research, each student tends to commit to their own learning. This means that when they become intellectually and emotionally involved with elaborating their research proposals, the students attribute unique meanings to the topics studied. Therefore, among the activities capable of bringing the student closer to "scientific doing", scientific initiation (SI) stands out. Massi and Queiroz (2010, p. 174) define SI as "a process in which the set of indispensable knowledge is provided to introduce young people to the rites, techniques, and traditions of Science". It should be noted that, although this concept comes from the university context, initially associated with undergraduation, over the last decades, scientific initiation has expanded to basic school (BRASIL, 2012; 2018b).

Several nomenclatures were given to scientific practice in the school context, such as "scientific pre-initiation" and "junior scientific initiation", among other possibilities. In this article, we have adopted the expression "scientific initiation" as we consider it more appropriate, considering the definition of the word "initiation" in the dictionary: "The act of giving or receiving the first elements of a practice or the rudiments related to an area of knowledge. E.g.: i. scientific" (HOUAISS, 2007, p.1620). Thus, we believe that the basic education student, when developing a scientific research project, is already being "initiated" in that universe.

Activities focused on SI in basic education are believed to have a positive impact

*REnCiMa*, São Paulo, v. 13, n. 4, p. 1-23, jul./sep. 2022

on the improvement of young people's maturity, even helping them in their professional and career choices (ARANTES and PERES, 2015). It is also possible to highlight the gains for the emotional dimension of the scientist student, such as the improvement of their self-confidence, autonomy, responsibility, discipline, and the improvement of their critical sense and their ability to establish interpersonal relationships (ARANTES and PERES, 2015; CABERLON, 2003; CALAZANS, 1999). In the cognitive dimension, we can cite the improvement in understanding of the scientific method (such as the ability to establish objectives, define procedures, collect and analyze data, and evaluate results) and the ability to disseminate science (such as writing reports, systematizing information and communicating results), which also increase the learner's ability to solve problems in different spheres of their lives (ARANTES and PERES, 2015; FIOR, 2003).

Based on this, initiatives from different educational institutions for the proposition of scientific initiation in the school context can be identified in Brazil, from the 1980s, mainly due to the incentive of public educational policies at the time. As Oliveira and Bianchetti (2018) highlight, such policies aimed to improve the levels of permanence of public school students in high school and seek to develop young people's interest in Science, contributing to the early identification of new talents for the area. One of those initiatives was the "Programa de Vocação Científica" (Provoc) of the "Escola Politécnica de Saúde Joaquim Venâncio" (EPSJV), of the "Fundação Oswaldo Cruz" (Fiocruz-RJ), in 1986. Arantes and Peres (2015) comment that Provoc is the milestone for the scientific initiation of basic education students, and served as a model for the creation of the junior scientific initiation (Iniciação Científica Júnior - ICJ) by the "Conselho Nacional de Desenvolvimento Científico e Tecnológico" (CNPq), in 2003. The ICJ, in turn, was (and still is) a programme for granting research grants to students at the elementary and high-school levels to prepare young people for the incorporation and management of new technologies. Also, the creation of this programme was related to the need to improve Brazilian development indicators in Science, Technology and Innovation, as pointed out by Oliveira and Bianchetti (2018). Thus, between 2011 and 2016, the authors registered an increase of almost 50% in the number of scholarships granted to basic education students by the junior scientific initiation programme, observing the consolidation of a policy of prioritization and expansion of SI to this educational stage.

In this context, Arantes and Peres (2015) identified the existence of 126 SI

*REnCiMa*, São Paulo, v. 13, n. 4, p. 1-23, jul./sep. 2022
Revista de Ensino de Ciências e Matemática

programmes aimed at high school distributed in 33 federal universities, 15 state universities, 26 federal institutes of higher and technological education, 12 non-profit private institutions and seven institutes of teaching and research. Other initiatives, called “Science Clubs”, are also found in the literature, being defined by Schmitz and Tomio (2019) as “educational practices of non-formal education articulated with formal education”. Based on a literature review, those authors estimated the existence of more than 500 Science Clubs in operation in Latin America, distributed in schools in countries such as Argentina, Uruguay, Chile, Ecuador, Peru, and others. In Brazil, Mancuso *et al*. (1996) state that the first Science Clubs appeared in traditional and confessional institutions. However, from the 1970s, those actions were consolidated and gave rise to the main clubs in the country today, concentrated mainly in the South and Southeast regions. Tomio and Hermann (2019), in turn, state that until 2017, there were about 77 Science Clubs in Brazil.

Although initiatives related to “science doing” in elementary schools are increasingly present in the context of science teaching, few investigations in this regard are found in the literature (LONGHI and SCHROEDER, 2012). Therefore, many doubts and questions arise on the subject, such as: What is the profile of students entering those activities? What areas of knowledge students choose the most for their research? What themes do they choose and why? Are there gender differences in student enrollment in those initiatives? And for the choice of the investigated topics? In this context, with this article, we intend to expand the understanding of the “scientific doing” in basic school. We believe that studies with this approach are necessary to provide more knowledge about the students who participate in those activities. As a result, proposals more suited to their learning expectations may be more frequent, contributing to better success of those actions in basic education.

The following section brings more details about this research.

## 2 Methodology

This research has a qualitative approach (LANKSHEAR and KNOBEL, 2008). The object of study is a scientific initiation program (“Programa Cientista Aprendiz” — PCA) developed by a private school in São Paulo, SP, Brazil. This programme emerged in 2006 when some teachers from that institution noticed students’ great interest in laboratory activities, which were part of the Science classes in elementary school II. Therefore, the teachers found that expanding the spaces for students to approach scientific investigation, research, and cultural practices was necessary.

The *Cientista Aprendiz* currently belongs to the elective disciplines of the school in question and, like such disciplines, it is offered after school hours for students from the 8th grade of elementary school II to those in the 3rd grade of high school. Among the objectives, we highlight the students' introduction to a researcher's experience, which creates opportunities for them to develop autonomy, discipline, and the ability to observe, formulate hypotheses, write, and communicate.

In this scenario, the main criterion for a student's admission to the PCA is their interest in scientific activities. So, there is no direct link between participation in the program and the student's grades in different school subjects. Thus, from the students' involvement in the pedagogical activities developed in class, the teachers (especially the 7th-grade Science teachers), together with the school's pedagogical guidance team, indicate them to participate in the PCA. If the students accept participating, they are introduced to a group of advisors from different areas to develop projects according to their interests (i.e., the students themselves define their research topic).

Most advisors of the *Cientista Aprendiz* work in the institution under study. However, some others are hired exclusively to advise students in the program. It is worth noting that most of them hold a Master's or a Ph.D. degree, which ensures that students have contact with mentors who have already experienced the development of scientific research. It is also important to say that the advisors are divided by areas of knowledge, namely: Biology, Chemistry, Physics, Engineering and its Technologies, Human Sciences, and Technology and Innovation. Currently, the PCA has 25 teachers-advisors.

The activities of the *Cientista Aprendiz* take place from Monday to Friday, when students and advisors meet for one and a half hours. The students can choose the best shift for them, taking into account their advisors' available days and shifts. In this way, in the same class/time, the teacher can advise up to three groups of research projects, which can be developed individually or in pairs of students.

Starting from the importance of knowing the students, aiming at the development of educational activities closer to their learning expectations and capable of motivating them (MIRAS, 2001), with this research, we intended: i) to identify the number of students enrolled in the *Cientista Aprendiz*, from 2006 to 2019; ii) identify the main areas and research themes chosen by the participating students; iii) identify possible gender differences related to the enrollment of students in the program and the research areas they chose. For this, we carried out a documentary analysis (BELL, 2008) from the PCA registers produced from 2006 to 2019. As materials analyzed in this investigation, we point out: i) the enrollment records of students in the period; and ii) the summaries of research developed by them over the years (in total, we analyzed 506 summaries).

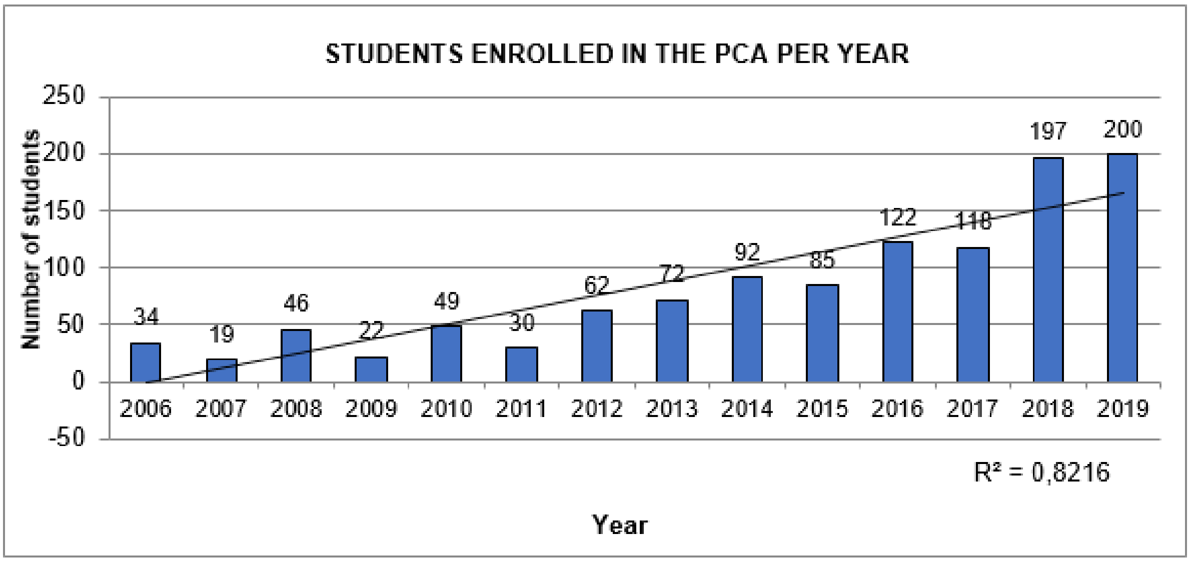
We made simple quantifications for the first item mentioned above and used some statistical tests for data analysis. For the summaries (second item described above) and the consequent separation of project areas, we carried out the methodology of “Open Categorization” (as defined by Strauss and Corbin, 2008), describing the following final categories: 1) Biological Sciences – encompasses projects focused on the following subareas: General Biology, Biochemistry, Genetics, Biophysics, Botany, Pharmacology, Zoology, Immunology, Ecology, Microbiology, Morphology, Cytology, Parasitology, and Physiology; 2) Human Sciences — projects focused on the following subareas: Philosophy, Geography, Sociology, Psychology, Anthropology, Education, Archeology, Political Science, History, and Theology; 3) Health Sciences — projects focused on the following subareas: Medicine, Dentistry, Nursing, Speech Therapy, Nutrition, Collective Health, Physiotherapy and Occupational Therapy, and Physical Education; 4) Exact and Earth Sciences — projects focused on the following subareas: Physics, Mathematics, Chemistry, Agrarian, Geosciences, Astronomy, and Oceanography; 5) Engineering — projects focused on the following sub-areas: Electronics, Sanitary, Medical, Production, Transport, Civil, Naval, and Oceanic Electrotechnics, Chemical Engineering, Mining Engineering, Aerospace Engineering, Materials and Metallurgical Engineering; and 6) Social and Applied Sciences — projects focused on the following subareas: Information Technology, Law, Museology, Administration, Communication, Economics, Social Work, Architecture and Urbanism, Domestic Economy, Urban and Regional Planning, Industrial Design, Demography, Tourism and Information Science. It is noteworthy that those categories were established only as an aid in identifying students’ areas and topics of interest: since, in most cases, scientific research is carried out in a multidisciplinary way, we know that, in practice, limits between areas of knowledge cannot be rigidly established.

Based on this, we present more details about the results and the reflections made from them in the following section.

## 3 Results and Discussion

From the data obtained, we verified the increase in students' enrollments in the *Cientista Aprendiz* over the years. We consider it a positive result since this growth represents, in our view, indications of students' increasing interest in scientific research. Comparing the years 2006 and 2019, the increase is approximately 488%. Furthermore, we can notice a continuous average growth in the number of student enrollments, as shown in Figure 1, in which there is a linear trend line presenting a coefficient of determination equal to $R^2 = 0.8216$. This coefficient varies between 0 and 1, indicating how much data can be represented by the model in question. This means that the closer to 1, the greater the possibility of claiming that the model fits the data. Therefore, we can say that our results are, statistically, close to linear growth, on average, in the analyzed period.

Figure 1: Students enrolled in the *Cientista Aprendiz* between 2006 and 2019




Source: Authors

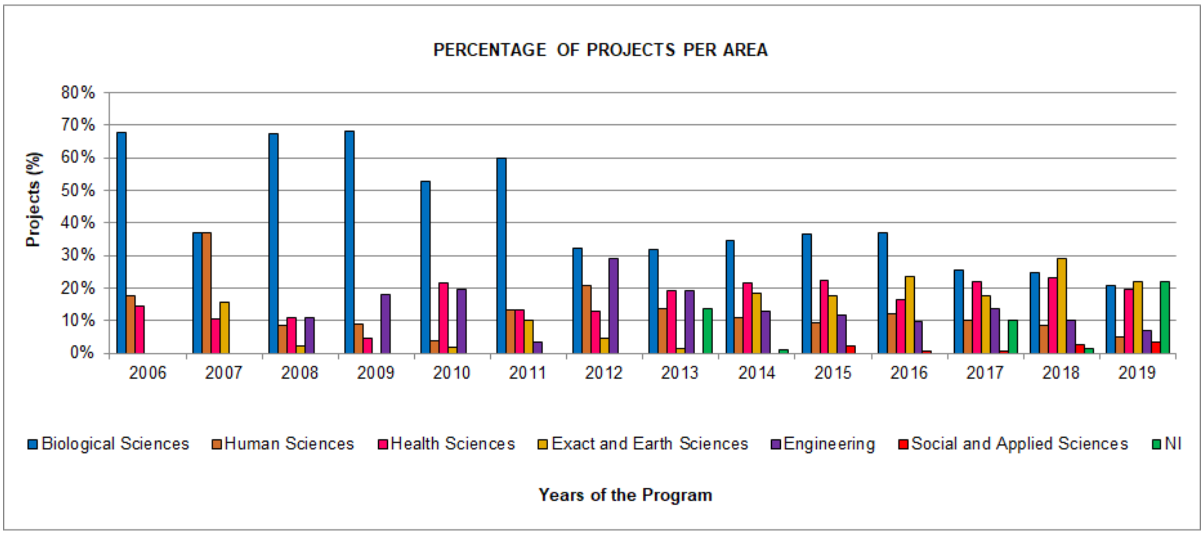
Considering the increase in the number of students enrolled in the *Cientista Aprendiz* (Figure 1) and the possibility of such an increase reflecting the expansion of students' interest in Science and in "scientific doing", we cannot fail to mention the results observed in some studies. Cunha *et al*. (2014), for example, investigating the perception of Science and Technology presented by high school students, concluded that few expressed an interest in pursuing scientific careers, which was also detected in a research carried out by Goulart and Gois (2015) and by the study presented by the "Ministério da Ciência, Tecnologia e Inovações" (MCTI) in 2019 (BRASIL, 2019). The latter also found that the search for information related to Science and Technology (S&T) in the media had declined (in the case of newspapers, print journals, and television) or had remained low (in the case of access to information about S&T on the internet, radio programs, books, among others), compared to data obtained from research carried out by the same agency in previous years.

Based on this framework, it is essential to highlight the important role of scientific education and the popularization of Science to arouse the curiosity of the population for “scientific work” and, specifically, the interest of young people in these careers, which is similar to the ideas defended by Goulart and Gois (2015) and by the study developed by the MCTI mentioned above. However, we ask ourselves: how can educators encourage students to enter professions with a scientific focus if, often, classes developed in schools are focused merely on the transmission of ready and finished content? In view of this, agreeing with Cunha *et al*. (2014), we argue that educational institutions should promote actions to increase young people’s interest in Science, and the Science Clubs (and the *Cientista Aprendiz*) represent some of those possibilities for action. We believe those spaces provide differentiated learning about the various areas of Science, since the students can investigate topics of their interest that are often part of their daily realities (SCHMITZ and TOMIO, 2019). We also agree with Longhi and Schroeder (2012) and believe that the experiences lived in those clubs allow students to develop critical thinking: from the activities they develop in those spaces, they understand that the production of scientific knowledge depends on research processes and theoretical concepts. With this, students can recognize the differences between scientific results and personal opinions, aspects also highlighted by Alves *et al*. (2012).

Regarding the areas chosen by the students to develop their research projects, we note the prevalence of Biological Sciences in the first years of the program (2006 to 2011), followed by a drop in 2012 and subsequent maintenance of a relatively stable number of projects, balanced with other areas in the following years. Human Sciences and Health Sciences have also been present since the creation of the PCA, with the former holding, between 2006 and 2007, the second position among the topics most investigated by students. Although in smaller numbers, since 2007, Exact and Earth Sciences and Engineering have been part of the research topics chosen by students at the *Cientista Aprendiz*. Finally, Social and Applied Sciences are the areas of least interest in research by the students engaged in the program (Figure 2).

*REnCiMa*, São Paulo, v. 13, n. 4, p. 1-23, jul./sep. 2022

Figure 2: Percentage of projects developed in each area present in the *Cientista Aprendiz*. In the figure, “NI” (“Unidentified”) refers to projects in which we could not identify the topic the student chose




Source: Authors

Regarding the most investigated research topics within each mentioned area, it was possible to observe a prevalence of Ecology (e.g., environmental education) in Biological Sciences, representing approximately 31.3% of the projects. Botany (e.g., plant physiology) and Pharmacology (e.g., drug development) were also very present themes in the research, totaling 19.08% and 16.28% of the works, respectively. Themes with a frequency of less than 4% were included in the category Others. Among them, issues related to biotechnology, human nutrition, and fungi stand out.

In Human Sciences, most of the projects were related to teaching and learning (24.17%). Thus, investigations on scientific education and scientific writing were included in this category. Themes related to Psychology (e.g., motivation) and the challenges of adolescence (e.g., identity formation in teenagers) were also subjects widely investigated by studebts, representing around 20% and 12.5% of the total projects, respectively. In the Others category, which encompasses less researched subjects (with a frequency of less than 4%), projects on Politics, Economics, the LGBTQIA+ movement, among others, were included.

In the Health Sciences area, “cancer” was the most investigated topic in approximately 20.45% of the projects. Then, “neurodegenerative diseases” (e.g., Alzheimer’s disease) and “food” were the most frequent themes in a total of about 10.91% and 6.82% of occurrences, respectively. The Others category (subjects with a frequency of less than 4%) included projects that addressed water quality, effects of ultraviolet radiation on humans, Chagas disease, diabetes, and celiac disease, among other possibilities.

In Exact and Earth Sciences, the most researched subjects were related to aerospace (e.g., Astronomy), with 34.87% of the projects, and Chemistry (e.g., Electrolysis), with approximately 14.87% of the research proposals. However, investigations on Agricultural Sciences (e.g., mining residues in the soil) and energy (e.g., heat) were also frequent, with about 12.82% and 9.74 of the total occurrences. In fewer numbers (less than 4%) and, therefore, included in the Others category were projects on Quantum Physics, nuclear radiation, and wavelength.

Among the topics most frequently researched by students in the field of Engineering, energy transformation (e.g., harnessing solar energy) stands out, with 29.41% of occurrences, and Medical Engineering (e.g., development of prostheses), with 17.45% of projects. Among the least investigated subjects (less than 4%) in this area, included in the Others category, there are: ambient lighting, veterinary technology, and automobile technologies.

Finally, in Social and Applied Sciences, the most researched subjects were related to Technology, in general (about 68.75% of occurrences). Thus, projects on Computer Science and augmented reality were frequent. Other themes in this area were related to Urbanism (approximately 18.75% of the projects), such as the construction of smart cities, for example. Chart 1 below presents a summary of the topics most researched by the *Cientista Aprendiz* students, over the years, within each area listed.

Chart 1: Percentage of projects developed by the *Cientista Aprendiz* students in each area between 2006 and 2019

| AREA | THEMES | % | AREA | THEMES | % |
|---|---|---|---|---|---|
| **Biological Sciences** | Ecology | 31.3 | **Exact and Earth Sciences** | Aerospace | 34.87 |
| | Botany | 19.08 | | Chemistry | 14.87 |
| | Pharmacology | 16.28 | | Agricultural | 12.82 |
| | Microbiology | 5.60 | | Energy | 9.74 |
| | Zoology | 5.34 | | Electric | 7.69 |
| | Human Cytology | 4.33 | | Mathematics | 4.62 |
| | Human Physiology | 4.07 | | Acoustic | 4.1 |
| | Others | 8.65 | | Others | 11.28 |
| | Not identified | 5.34 | | | |
| **Human Sciences** | Teaching-learning | 24.17 | **Engineering** | Energy Transformation | 29.41 |
| | Psychology | 20.00 | | Medical | 17.65 |
| | Challenges of adolescence | 12.50 | | Residential | 12.5 |
| | School management | 6.67 | | Environmental | 7.35 |
| | Inclusion | 6.67 | | Thermal | 5.88 |
| | Political Geography | 5.00 | | Computational | 5.15 |
| | Others | 10.83 | | Others | 20.59 |

| | | | | | |
|---|---|---|---|---|---|
| | Not identified | 14.17 | | Not identified | 6.62 |
| **Health Sciences** | Cancer | 20.45 | **Applied Social Sciences** | Information Technology | 68.75 |
| | Neurodegenerative diseases | 10.91 | | | |
| | Nutrition | 6.82 | | Urbanism | .8,75 |
| | Psychiatric illnesses | 6.82 | | | |
| | Therapies | 5.91 | | Not identified | 12.50 |
| | Drug consumption | 4.55 | | | |
| | Surgery | 4.09 | **Not identified** | - | 6.08 |
| | Others | 33.64 | | | |
| | Not identified | 6.82 | | | |

Caption: The percentages were established for each area listed. The category called Not identified refers to projects in which the abstract (and/or title) was not found. Thus, in those cases, it was not possible to categorize them within a specific area or theme. It is also worth noting that Engineering normally develops some type of prototype, which differs this type of research from the others. Source: Research data. Source: Authors

Although the data presented in Figure 2 and Chart 1 reflect the topics of greatest interest to students in the *Cientista Aprendiz*, it is worth mentioning that in its first years, the number of supervisors was limited and was basically concentrated in the area of Biological Sciences. For us, this limitation may have conditioned the students' choices since they did not have options for advisors in various fields of knowledge. With the growth of the program and the consequent expansion of the students' demand for research in different areas, new teachers were hired, making the team multidisciplinary and offering students more investigation possibilities.

Based on this, we perceive similarities between our results and the research carried out by the "Ministério da Ciência, Tecnologia e Inovações" — MCTI (BRASIL, 2019), previously mentioned. Among the topics of students' major interest were Medicine and Health and the Environment, which is in line with our data. Saucer *et al.* (2007), in turn, detected a strong presence of Astronomy among the subjects elementary school students were the most interested in, which is also similar to what we observed in our study. In this context, we believe that a student's choice of topics is related to the social relevance of the research, which is also pointed out by Alves *et al.* (2012) and Lima (1998). The latter also suggests that such choices may be related to issues that cause concern to students and/or arouse their curiosity, showing a link with the information they already have, with which we also agree.

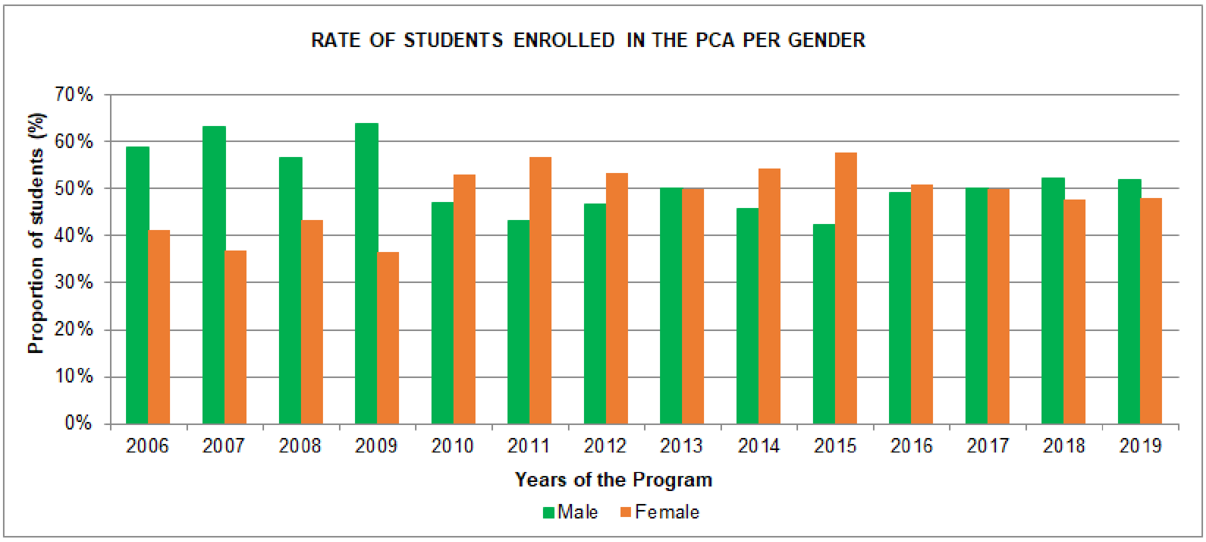
The low interest in the scientific area and the low demand for these careers, previously mentioned, affect students of both sexes (GOULART and GOIS, 2015). However, in a study carried out by Cunha *et al*. (2014) with high school students from

*REnCiMa*, São Paulo, v. 13, n. 4, p. 1-23, jul./sep. 2022

the five Brazilian regions, we found that the number of female students interested in pursuing their studies in scientific careers was lower when compared to the male students. On average, 18.6% of the female students surveyed declared an interest in becoming scientists, while this number was 26.9% for male students.

Our results did not detect significant differences in enrollments related to gender in the *Cientista Aprendiz*. We reached this conclusion when performing the Test for Homogeneity, also known as the Chi-Square Test, which is usually used to verify whether a binomial variable (in this case: gender) is independent of another (i.e., number of students enrolled). Thus, from the test, we obtained a $p = 0.7588$ which, at a significance level of 5%, allowed us to state that there is independence between the number of enrollments and the gender of the student in the *Cientista Aprendiz*. Although we did not find discrepancies related to enrollment by gender, we identified a certain asymmetry in the participation of male and female students in that program when we observed the proportion of each gender in relation to the total number of enrollments. Thus, we noticed a slight prevalence of male students from 2006 to 2009 and 2018 and 2019 and of female students from 2010 to 2012 and 2014 to 2016 (Figure 3):

Figure 3: Proportion of students enrolled in the *Cientista Aprendiz* divided by gender




Source: Authors

Research with a similar focus, such as that by Arantes and Peres (2015), detected the majority of female students joining the *Programa de Vocação Científica* (Provoc), mentioned earlier in this text. According to the authors, the female students predominated from 1986 and 1996 and, of the total number of participants until 2010, 68.5% of the participants were women. It is worth mentioning that, although our numbers and those of Arantes and Peres (2015) show a more balanced female participation - and sometimes participating more than the male students, we believe that on a broader scale these scenarios may represent exceptions, when we think about the insertion of women in scientific professions. As Leta (2003) states, Science has historically been seen as a male activity, and between the 15th and 17th centuries, few women from the aristocratic classes played roles in this area. In the 18th century, according to the author, this situation changed little, as women's access to scientific activities was mainly due to their family position; for example, if they were the wives or daughters of a researcher, they were allowed to support Science by caring for collections, cleaning glassware, illustrating experiments, translating texts, among other few possibilities. This situation began changing only after the second half of the 20th century due to the need for human resources for strategic areas (which included scientific activity) and the feminist movement and the struggle for equal rights, which allowed women greater access to scientific education and careers that were traditionally occupied by men (LETA, 2003).

Despite the increasing female participation in Science as of the 20th century, we know that there is still much to be done to ensure that women are properly recognized and have the same opportunities as men in this area. Teixeira and Costa (2008) found that university students remembered fewer female than male scientists, indicating the lack of female role models related to scientific careers. Regarding the chances of success in those professions, Leta (2003) and Velho and León (1998) state that they are still low for female researchers, since the occupation of women in high administrative positions in universities, for example, is still lower compared to men in the same spaces. Other investigations, such as the study developed by the National Science Foundation (NSF, 1996), an important North American agency that finances scientific research, point to similar results, indicating that the situation above does not refer only to the Brazilian context.

In this scenario, different groups in several countries have studied the barriers that prevent female progression in Science and, as a result, have promoted actions to mitigate them. L'Oreal, for example, has been working with gender issues related to Science, investing large amounts of money in research grants for women (TEIXEIRA and COSTA, 2008). UNESCO, in turn, is another institution that has been dedicated to expanding initiatives for greater female inclusion in the academic-scientific environment. Finally, we can mention the United Nations (UN), which has gender

*REnCiMa*, São Paulo, v. 13, n. 4, p. 1-23, jul./sep. 2022

equality as one of the Millennium Development Goals outlined in 2000 (GOULART and GOIS, 2015).

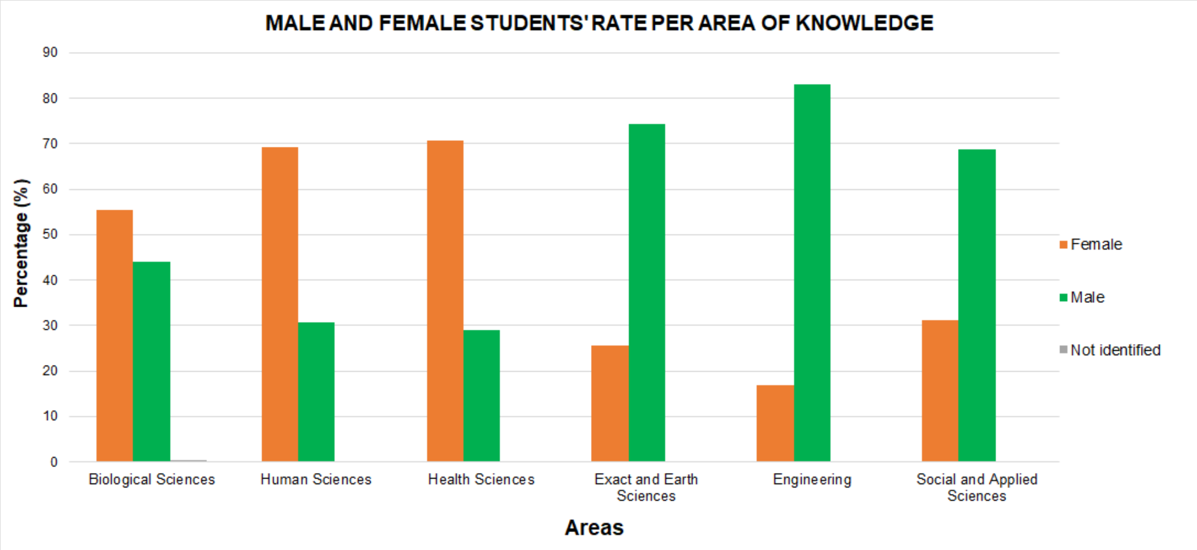
Based on this, we believe that the school can play an important role in encouraging students to enter areas in which they are traditionally taught not to be interested, such as Science, for example. Thus, we agree with Teixeira and Costa (2008) and believe that educators can be good means of disseminating Science among young people since:

> it is potentially – not exclusively – teachers who have the possibility to effectively initiate a change in mentality that allows for a greater insertion of women as citizens interested in scientific knowledge. Women should be encouraged to scientific practice during their basic education, with pedagogical methods and teaching practices that motivate them to be interested in Science and, in particular, in Physics, overcoming existing inequalities. *(*TEIXEIRA and COSTA, 2008, p.221).

With this in mind, when we turn our analysis to the data from the *Cientista Aprendiz*, we notice that since its creation in 2006, there have been more female (mostly Masters and PhDs) than male advisors. Thus, we believe that this context may be contributing to the students' feeling motivated to be part of the program, contributing to a greater balance between the participation of students in this school activity, as previously shown in Figure 3. Furthermore, we believe that other initiatives of the educational institution of which the *Cientista Aprendiz* is a part (such as the inclusion of themes that address the equality of rights between men and women in the different school spheres and discussion spaces offered by the institution) may be enabling deeper reflections on the insertion of women in several professional careers (including the scientific), making the students more interested in occupying those diverse spaces.

When we checked the possible differences related to the choices of themes and the gender of the participant, we noticed a prevalence of female students' engagement in Biological Sciences, Health Sciences, and Human Sciences. Similarly, we observed a high number of male students in research in Exact and Earth Sciences, Engineering, and Social and Applied Sciences (the latter closely related to Technology). Figure 4 below represents our results:

Figure 4: Percentage of projects developed in each area separated by gender.




Source: Authors

When performing the Chi-Square Test to see the independence of the binomial variables (project area and gender), we detected $p$ = 1.016x10$^{-34}$, lower than the significance level of α = 0.05. Hence, we could identify the dependence between the project area chosen by the students in the *Cientista Aprendiz* and their gender. Based on this, we observe, again, similarities between our research and the study carried out by the MCTI (BRASIL, 2019). In the latter, we saw a great interest of the female gender in areas related to Medicine and Health when compared to their interest in the areas of Technology. Cunha e*t al.* (2014) are other researchers who point to similar results: according to them, although women represented almost half of the researchers registered with the CNPq in 2008, their distribution by areas of knowledge was uneven. In Linguistics (Human Sciences) and Health, for example, the percentage of women was 67% and 60%, respectively. In the Exact Sciences and Engineering, on the other hand, the number of researchers was approximately 33% and 26%, respectively. This context is not exclusive to the Brazilian reality; we must remark: Cunha *et al*. (2014) also cite a study carried out by the University of California in 2010, when it was detected that more than 70% of the PhDs in Psychology were awarded to women. However, in the areas of Physics, Engineering, and Mathematics, the number of these titles granted to females was less than 28%.

Given the landscape above, we wonder why. Resuming the literature in the area, we found that Teixeira and Costa (2008) explain the scenario by stating that the leading cause for the small participation of women in Exact Sciences (especially Physics) owes to the fact that women are often “expelled” from this field due to the

*REnCiMa*, São Paulo, v. 13, n. 4, p. 1-23, jul./sep. 2022

mechanisms of career advancement, which work as true "gender filters", which Velho and Leon (1998) also pointed out. The latter and Cunha *et al.* (2014) believe that one of the probable causes for those differences may be associated with the education that boys and girls receive from their families, added to the stereotypes related to each group. Thus, boys are often more encouraged to deal with instruments associated with "boys' things" (such as tools, cars, machines, and computers, among others), while girls are encouraged to deal with subjects considered more "girlish", related to the areas of Health and Education, which end up being part of their future interests.

Based on what has been presented, we deem it urgent that actions be implemented to minimize gender differences between areas, allowing more significant insertion of female students in spaces that have traditionally been considered to belong to the "masculine universe". Therefore, we emphasize i) the importance of educational policies being designed to enhance teaching methods that respect gender differences and allow practices that lead to overcoming the lack of equity between them (as defended by Teixeira and Costa, 2008); ii) the importance of expanding the dissemination of Science in schools, allowing for more information to reach the students and making them understand their aptitudes for the continuation of their professional life also in scientific careers (as defended by Tabak, 2010); iii) the need for teachers to be aware of their essential role in this context, being prepared to question the construction of "man" and "woman" in our society, deconstructing possible gender patterns that, perhaps, have been developed by the male and female students due to stereotypes commonly popularized in society.

## 4 Final Considerations

This work adds to other studies that aim to contribute to the expansion of knowledge about the development of scientific initiation in basic schools. We believe that a deeper understanding of these aspects can enable greater success in students' scientific education, thus expanding the spaces for promoting and developing scientific education in educational environments.

This research does not intend to generalize the results for all school settings since we recognize as a limitation the fact that our analysis is based on a single teaching context. However, we consider that our investigation enhances other studies, bringing new elements capable of promoting reflections in this field, especially related to the development of the Nature of Science as a crucial part of the female and male students' scientific education in basic school.

We have detected a growing number of enrollments in the *Cientista Aprendiz* over the years, which, in our view, indicates the expansion of students' interest in Science topics. We also detected a higher number of investigations related to Biological Sciences, although the other areas of knowledge that are part of the PCA have been expanding their scope of action in recent years. Differences in enrollments by gender, contrary to many studies, were not identified in our research. However, when we focused our analysis on the areas chosen by the students, we found that female students showed less interest in the Exact and Earth Sciences, corroborating the scenario of other investigations.

In conclusion, we reiterate that students' scientific education must be addressed in educational policies and school environments, expanding the possibilities of reflection and development of the Nature of Science. Furthermore, we reinforce the need for constant dialogue on the inclusion of women in scientific careers (especially in Exact and Earth Sciences and Engineering) to encourage and motivate them to continue their studies in areas often mistakenly demarcated as belonging to the "masculine universe".

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