

STEAM approach in Rio Grande Do Norte: a longitudinal analysis based on experiences published in FEBRACE

ABSTRACT

Dennys Leite Maia

dennys@imd.ufrn.br

0000-0002-9536-2025

Universidade Federal do Rio Grande do Norte, Natal, Rio Grande do Norte, Brasil.

Francelmo Guimarães de Farias

francelmo@ufrn.edu.br

0000-0002-0115-3055

Universidade Federal do Rio Grande do Norte, Natal, Rio Grande do Norte, Brasil.

Ismenia Blavatsky de Magalhães

ismenia@imd.ufrn.br

0000-0003-2390-0194

Universidade Federal do Rio Grande do Norte, Natal, Rio Grande do Norte, Brasil.

Roseli de Deus Lopes

roseli.lopes@usp.br

0000-0001-8556-6473

Universidade de São Paulo, São Paulo, São Paulo, Brasil.

The promotion of investigative and creative practices with Brazilian students through the STEAM Education approach has been central in discussions about educational innovation, and the development of a nation. Initiatives such as the Brazilian Science and Engineering Fair (FEBRACE) stimulate an investigative culture, creativity, innovation, and entrepreneurship in Brazilian K-12 Education. The objective of this paper was to map and analyze the experiences developed in Rio Grande do Norte (RN) published in the twenty editions of FEBRACE. Bibliographic and documentary research procedures were employed to carry out a longitudinal survey of the abstracts published in the Fair Proceedings from 2003 to 2022, to extract information regarding STEAM practices from RN. The research has a qualitative-quantitative approach as it covers statistical procedures that provided the description and interpretation of data. The 239 abstracts from RN at FEBRACE indicated a growing trend in the participation of teachers and students from RN throughout the historical series. Mossoró represents a hub of STEAM practices in the state, due to the influence of initiatives that favor local science fairs. Despite the emphasis on works in the areas of Exact and Earth Sciences, many abstracts focus on aspects related to the semi-arid region. The results led to the conclusion that RN has experience with practices related to STEAM in K-12 Education with a focus on solving context problems. However, it is necessary to disseminate the practices to other teachers from different areas of knowledge.

KEYWORDS: STEAM Approach, K-12 Education, FEBRACE, Innovative Practices, Rio Grande do Norte.

1 INTRODUCTION

Among the eight essential competences for the full exercise of citizenship is the basic competence in mathematics, sciences, and technology (LOPES, 2020). However, data presented by the Program for International Student Assessment (PISA) report the Brazilian students' low proficiency in reading, mathematics, and sciences. Respectively, 68% and 45% of 15-year-old Brazilians are below the minimum and basic knowledge level in mathematics and sciences, thus revealing a critical situation (OECD, 2019).

Rio Grande do Norte (RN) is the second Brazilian state with greater income inequality and the first in its region, the Northeast (BRASIL, 2022), which reinforces these alarming national indices. According to the Prova Brasil (examination taken by students in the 5th and 9th years of K-12) data, the percentage of students in K-12 in RN with proper mathematics proficiency is below the national average and is one of the lowest in the Northeast region. Only a quarter of the students in the 5th year in RN show minimally satisfactory mathematics learning. This index is even worse in the 9th year, in which only 10% show the proficiency expected from this age group (QEDU, 2022).

Low proficiency in these areas hampers the development of reasoning, logical-mathematical knowledge, and affects critical and creative thinking, and the ability to reflect upon one's reality. In addition to the education damage, the lack of such abilities limits the individuals' potential and affects the development of the entire region, mainly those most vulnerable such as RN. According to Bell *et al.* (2018), the identification of talents in the sciences, technology, engineering, and mathematics (STEM) areas is fundamental for the scientific, technological, and economic advancement of a country. In emerging nations such as Brazil, the promotion of actions in sciences, technology and Innovation (CT&I) is a strategy towards technological independence, mainly in a decolonial perspective.

Taking that into consideration, investigative and creative practices must be promoted among Brazilian students, starting from K-12, so that they can fully develop their skills and their talents are revealed early in life. The approach called STEAM education, an acronym for *Science, Technology, Engineering, Arts and Mathematics*, has been central in the discussions about education innovation since the early years of schooling. Such approach promotes experiments in which the learners are the protagonists in the solution of an everyday life problem. Due to its integrative view of the different areas related to it in an inter and transdisciplinary manner (D'AMBRÓSIO, 2020), the STEAM approach contributes to the preparation of young individuals to act in response to the demands of contemporary society.

In a survey of scientific publications about reports or analysis of experiments developed using the STEAM approach in Brazil, Maia, Carvalho and Appelt (2021) found only eight works limited to four federative units (Rio Grande do Sul, Paraná, São Paulo and Distrito Federal), which are among the most economically developed ones. Considering the Brazilian cultural, social, and economic diversity, such innovative pedagogical practices must be disseminated throughout the country, mainly in the most deprived regions such as the Northeast and North, to prevent an increase in the existing education and social inequalities. Those responsible for planning the education cannot repeat past errors like copying

foreign education models that do not reflect the Brazilian reality or the characteristics of different parts of this country.

Seeking a self-referred STEAM approach, that is, one that is connected to the Brazilian youth's reality and education needs (LOPES *et al.*, 2022), some initiatives are developed by educators and institutions. One of them is the Brazilian Sciences and Engineering Fair (FEBRACE), which was created and held since 2003 to stimulate investigative culture, creativity, innovation, and entrepreneurship in Brazilian education. According to Lopes, Ficheman and Saggio (2022, p. XXV), FEBRACE main objectives are:

(...) to lead to innovative teaching practices in schools and stimulate new vocations in sciences and engineering [...] so that students design and develop investigative projects that are creative and meaningful to society, thus revealing new vocations among learners.

Such objectives insert the experiences published in FEBRACE as innovative practices in K-12 aligned to the STEAM approach. For this reason, associated with the Fair, the STEAM TechCamp Brazil was implemented in 2018. It aims at creating a network of teachers and education professionals to articulate and improve actions linked to this approach in the Middle and High School education public networks. Resuming the cut proposed in this article, as a part of the national action that was presented in virtual format in 2020, the Education, Culture, Sports, and Leisure State Secretariat of Rio Grande do Norte (SEEC/RN) promoted the Potiguar, adjective that means belonging to the state of Rio Grande do Norte, STEAM *TechCamp* and gathered teachers and students from 28 out of the 167 Potiguar municipalities (STEAM TECHCAMP POTIGUAR, 2022).

Although these initiatives represent relevant steps for the promotion and dissemination of STEAM practices in Brazil, they are still scarce and not well disseminated in RN. Therefore, it becomes relevant to know what has been produced, and then propose coordinated actions along with the existing ones, to broaden the repercussion and coverage of the STEAM approach in Potiguar schools. Considering that, the objective of this article was to map and analyze the experiences developed in Rio Grande do Norte and published in the twenty editions of the FEBRACE. To achieve this aim, a longitudinal survey of abstracts published in the FEBRACE proceedings from 2003 to 2022 was carried out, seeking to characterize the Potiguar STEAM practices.

Having clarified the problem, justification, and objective of this article, we move on to present the theoretical background of the study, the analysis and the methodological procedures designed for its development. At the end, the considerations allowed by the research are put forward.

2 THEORETICAL BACKGROUND

The Brazilian National Common Core Curriculum (BNCC - Base Nacional Comum Curricular), in one of its general competencies, indicates that mathematical and scientific languages are necessary for the students to be able to share information, experiences, ideas, and feelings in different contexts, and in the production of meanings (BRASIL, 2017). Therefore, it is of paramount importance to stimulate scientific initiation throughout K-12, provoking in students “curiosity, willingness to learn how and why things are the way they are, why something works like this or that, feel like and be able to explain things, recreate, and reinvent, so that they can also create and invent” (LOPES, 2020, p. 15).

Going beyond scientific and technological education, the STEAM approach is seen as a teaching strategy suitable for the development of abilities inherent in the 21st century citizens such as collaboration, communication, creativity, and critical thinking. Riley (2020, p. 1) emphasized that the STEAM education is “a learning approach that uses science, technology, engineering, arts, and mathematics as access points to guide students’ investigation, dialogue, and critical thinking”. Taking that into consideration, teaching practices anchored in STEAM promote the development of students’ practical, cognitive, and socioemotional practices, via the exploration of real-life problems, with investigative and creative experiences addressed in an inter and transdisciplinary way.

According to Maia, Carvalho and Appelt (2021), in general, Brazilian STEAM practices are developed by using Project Based Learning (PBL), with high school students, integrating teachers from different areas of knowledge. However, the experiences published are specific and carried out during the school extra-curricular shift (MAIA; CARVALHO; APPELT, 2021). To advance in the dissemination of STEAM practices, they must be also developed in other phases of K-12, considering students’ possibilities.

Bacich and Holanda (2020) suggested that Brazil, considering its social, cultural, and education specificities, must follow the example of other countries that already implemented the STEAM approach in their curricula and have reached good results. The high school integrative theme that emphasizes STEAM education supported by the BNCC competences might be an indication of that trend. On the other hand, limiting or reinforcing STEAM practices to the final years of K-12 might hinder talents and give the idea that investigative and creative practices are specific of a certain age group in school.

When experiencing STEAM throughout K-12, learners can awaken their interest in subjects usually seen as the villains of the school routine such as mathematics and motivate them to work improving that field. Ficheman, Saggio and Lopes (2008, p. 2) already emphasized that over a decade ago:

In Brazil, the transformation of a consumer society into a producer of technology aiming at problem solving is urgent. To achieve that, we need to focus on teaching projects that encourage students and teachers to develop research. Also, the use of methodologies, either scientific or from engineering, must be stimulated to adjust research to the desirable standards, making them research documents for future generations.

Even if it is not broadly used in Brazil, STEAM education is already seen as a strategy to promote innovation and incentivize the development of the digital transformation section and the scientific and economic independence. The National Strategy for Science, Technology and Innovation describes the approach as “one of the priorities of the education policies aiming at innovation themes” (BRASIL, 2016, p. 54), confirming the STEAM approach as relevant for the implementation of such experiences in K-12 education.

Initiatives such as FEBRACE and the STEAM *TechCamp* evidence the trend of investigative and creative practices in K-12.

Since 2003, FEBRACE has been held as a teaching strategy focusing on the dissemination and sharing of scientific and technological research, becoming a national movement able to stimulate and develop investigative culture, innovation, and entrepreneurship in elementary, high school and technical courses in Brazil (FEBRACE, 2020, p. 10).

For departing from a space of stimuli to scientific dissemination and moving towards innovative teaching practices, FEBRACE is a movement that promotes innovation in both the research and development (R&D) field and in education. For boosting projects in the seven areas of knowledge— Agrarian, Biological, Exacts and Earth, Human, Health, and Social Sciences along with Engineering – this movement cooperates with both the overcoming of a limited view of sciences that privileges natural and exact sciences, and the creation of opportunities for the development of technologies to cater for the different demands in society. These characteristics are central in STEAM, which proposes an approach to the problems of real life, in a holistic way, by integrating different areas of knowledge, linked to the local specificities and demands.

On the other hand, the restrict conception of sciences still has to be overcome since it is a positivist inheritance of research that denied qualitative approaches, and the technician and instrumental view of STEM, whose only purpose was the generation of workforce for the areas explored. For a long time, human and social sciences, for example, were classified as a second category of studies. This seems to be noticeable in the top works presented at the FEBRACE which are mostly in areas such as engineering, exact sciences, and then human sciences (FEBRACE, 2020). In the research developed by Lopes *et al.* (2022), they investigated the perception of teachers who took part in different editions of the STEAM *TechCamp* Brazil, and reported that a broad awareness of sciences was only present in the discourse of 21% of the respondents. Considering that FEBRACE and its developments contribute to the STEAM approach conception in Brazil, it seems relevant to identify how these implications occur.

Cajueiro and Gonçalves (2022) surveyed abstracts published in the FEBRACE proceedings to analyze the role of science clubs in the dissemination and popularization of sciences in the state of Pará. In addition to collecting the works linked to those clubs in Pará, the researchers interviewed teachers involved in the projects. As a result of their analyses, they pointed out that the publication of works and participation in FEBRACE motivated by science clubs, represented formative experiences regarding scientific culture in social and environmental dimensions. They promoted the appreciation of community knowledges and the production of artifacts to solve local problems. Moreover, those authors proved that practices related to the STEAM approach resulted in gains to both students

and teachers in different dimensions such as scientific, cultural, social, and mainly educational.

The aspects listed show the relevance of knowing the impact of practices favored by the FEBRACE in specific contexts of the country. Such knowledge contributes to interventions, which enhance new practices and provide changes in favor of greater diversity of investigative works, related to both the problems approached by the students and the areas of knowledge involved. Finally, STEAM experiences start from the everyday problem/situation, which make sense to the learners and whose solution creates a feeling of belonging to that community.

Next, we present the methodology employed in this research, which mapped Potiguar studies published in all FEBRACE editions held up to 2022. From this starting point, we looked for characteristics of the Potiguar STEAM practices, the municipalities where the experiments were carried out, the areas covered, and the teachers who have been promoting education innovation in Rio Grande do Norte to learn more about this approach from them.

3 METHODOLOGY

This qualitative-quantitative research employed statistical procedures that enabled the data description and interpretation carried out for the “structural analysis of the phenomenon with quantitative methods and a process analysis employing qualitative methods” (SCHNEIDER; FUJII; CORAZZA, 2017). To achieve such aim, bibliographic and document research was adopted to extract information related to practices of the Potiguar STEAM approach, published in abstracts of the proceedings¹ of 20 FEBRACE editions. Initially, all files available at the FEBRACE webpage from 2003 (first edition) to the most recent (considering the research moment) in March 2022, were accessed and downloaded.

Since we expected to generate a large data set and to optimize their systematization and extraction from the proceedings by different members of the research team², an electronic form was elaborated. Thus, the information inserted in the form were automatically organized and tabulated in an online electronic spreadsheet.

To meet the group’s research interests, the form required filling in the following information of each work identified: (i) year of the FEBRACE edition in which the work was presented and published; (ii) title, and (iii) abstract, as published in the proceedings; (iv) names of authors/students, to identify students’ protagonism; (v) name of authors/teachers, evidencing the advisors that might have had more experience with innovative teaching practices; (vi) area and (vii) subarea of knowledge in which the work was inserted; (viii) Potiguar municipality where the experiment was carried out; followed by (ix) the school or institution to which the authors were linked; their (x) administrative sphere, whether municipal, state, federal, or private; the (xi) level of K-12 those students were enrolled in, and (xii) possible general observations about the record.

In this article, a cut was made, and the abstracts were mapped according to the FEBRACE editions to identify time aspects; frequency of participation, and students’ and teachers’ profiles; the areas and subareas of knowledge identified, seeking to understand whether there was a prevailing subarea and how it

emerged considering the specificities of the Potiguar territory. For this reason, it was necessary to record the municipalities represented at the FEBRACE; and the administrative sphere of the schools to identify the contexts in which such practices occurred.

The following questions were devised to guide the analysis: (i) how many works developed in RN were presented at the FEBRACE throughout those 20 years? (ii) Which Potiguar municipality or region presented the highest number of works at the FEBRACE? and (iii) which areas and subareas were explored more often and how do they relate to the local demands?

The survey was conducted between December 2021 and April 2022 to include the latest FEBRACE edition and complete the time series of all editions held for a longitudinal analysis. The data organized in the spreadsheet, before carrying out the preliminary analysis, were revised to avoid inconsistencies, repeated data, or divergences with the original basis. Next, the statistical treatment was performed to interpret the information, and from the data gathered, the analyses presented and discussed below was carried out.

4 RESULTS AND DISCUSSIONS

Throughout the twenty FEBRACE Editions, 5,912 works originated from all Brazilian federation units were published. Rio Grande do Norte was represented in eighteen editions. Only the two earliest (2003 and 2004) did not record the Potiguar participation. In those editions, out of the 27 Brazilian federative units, only five states (Acre, Amapá, Roraima, Piauí, Sergipe, and RN), all belonging to the Northern and Northeastern regions, did not take part in the Fair (FICHEMAN; SAGGIO; LOPES, 2008), which confirms the gap found in these regions regarding the dissemination of such practices. Overall, 239 Potiguar experiences were shared at the FEBRACE, representing 4% of the total of publications in the fair, considering all its editions. Taking into account that the Potiguar population represents 1.7% of the national population, this index suggests greater representativeness of the state proportionally at the FEBRACE.

In the historical series analyzed, 486 authors from Rio Grande do Norte took part as students, while 209 were teachers who advised the experiments developed and published. It seems relevant to emphasize that eight participants who had participated as students in the past, also appeared as advisors some years later. The FEBRACE experience might have motivated them to choose the teaching career and support and replicate the positive experience they had had in the past with their students when they became teachers.

Regarding the participants' gender, although a certain balance was noticed between participant girls (52%) and boys (48%), the same was not observed in relation to teachers, whose majority was composed by male teachers (63%). These findings indicate that, on the one hand, there is already equality in the participation and interest of both genders of students in investigative and creative practices, but it is still necessary to advance in the representation and incentive to the participation of Potiguar female teachers in the fair.

When the frequency of participation was analyzed, one student was found to have presented in four editions. Among teachers, this number was higher since

four teachers have participated in seven different editions of FEBRACE. Those who advised the highest number of works, appeared with nine publications – three of those who took part in seven editions and one who participated in five of them. The average number of teachers per work was 1.6 and a little over $\frac{1}{4}$ of the Potiguar teachers advised works in two or more FEBRACE editions. Such indices demonstrate significant frequency in the participation of Potiguar teachers in the experience of advising STEAM practices and presenting them in the said fair.

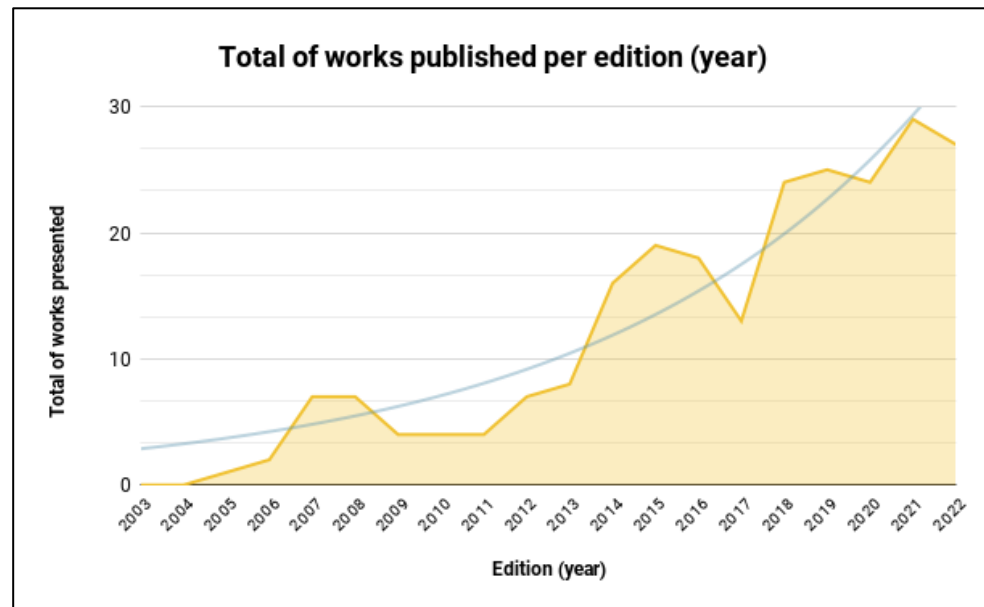
When focusing on education and research experience, the five teachers with the highest number of works advised throughout the time series investigated were analyzed, their respective areas included: two with a language degree, two graduated in chemistry, and one in physics. In that group, one had a doctorate degree and a post-doctoral experience, which suggests solid education in research; three had master's degrees, and one had a specialization degree. Although this was not a significant sample, the data indicated certain balance between exact and human sciences, with a small advantage for the former, and teachers who had developed at least one study at the graduate level.

Having characterized the participants, we will now present a profile of the STEAM experiments of Rio Grande do Norte at FEBRACE.

4.1 Number of works generated in RN and published at FEBRACE

The 239 works were distributed throughout eighteen out of the twenty editions. The first RN participation occurred in 2005 with a study developed in the municipality of Macaíba, located in the metropolitan region of Natal. According to the data, a growing trend was observed in the Potiguar participation over the years (Graph 01). While 2014 shows the greatest increase in the number of publications among the editions (in percentage) when compared to previous editions, 2021 was the one with the highest absolute number of works presented and published. The five most recent editions (2018, 2019, 2020, 2021, and 2022) outstood for reaching almost 60% of the RN experiments reported in the historical series of the fair.

Graph 01: Total of Potiguar works published per FEBRACE edition



Source: Research data (2023).

From the data collected in this phase of the research, we could not identify any fact justifying the increase observed in 2014, or regarding the small decrease seen in 2017. When considering the historical series up to 2016, one could expect that the number of works published in 2017 would be around seventeen, when the real number observed was thirteen. This fact might have suffered some influence of the phase of assessment of the abstracts submitted and, certainly, depended on the number of works that were submitted to the event at the time. This information is not available per edition. Thus, we could only identify that in 2014, all sixteen works came from public institutions, either state or federal.

In the whole historical series, the greatest participation was that of state schools (57%), followed by federal public schools, mainly represented by the Federal Institutes spread throughout the state (IFRN), and schools and academic units of the Federal University of Rio Grande do Norte (UFRN), which offer technical courses (32%). Although the Potiguar public schools certainly face difficulties and those identified in the study did not represent a significant sample of the total number of schools in the state, these findings help to demystify the idea that public schools, in general, do not have conditions to offer differentiated teaching practices with excellence to their students.

On the other hand, it seems relevant to analyze the concentration of six out of each ten Potiguar works published at FEBRACE in the five last editions. A relevant piece of information is that 34% of the total of the historical series (or 60% of the cut of the five most recent years) were developed in the years of the Covid-19. The 2021 edition, the central year of the pandemic, was that with the highest number of works in the temporal series, with 29 Potiguar productions. This might indicate that the fact of being the fourth state with the highest number of top works in the 2020 edition (FEBRACE, 2020) stimulated more submissions in the following year. Anyway, even in the adverse context of the pandemic, the Potiguar presence continued to show a growing trend.

The eight works published in the 2020, 2021, and 2022 editions revealed that both the distancing period promoted by the Covid-19 pandemic, which froze several economic activities, including schools and imposed the emergency remote teaching, did not prevent the continuity and development of investigative and creative practices. We could also observe that in seven cases, the health crisis was a motivation for the development of solutions or attenuating measures for the adverse context brought about by the coronavirus dissemination. The problems addressed by young Potiguar researchers were included in different areas of knowledge, suggesting a broader conception of sciences, and that the experiments focused on the specific demands of their communities.

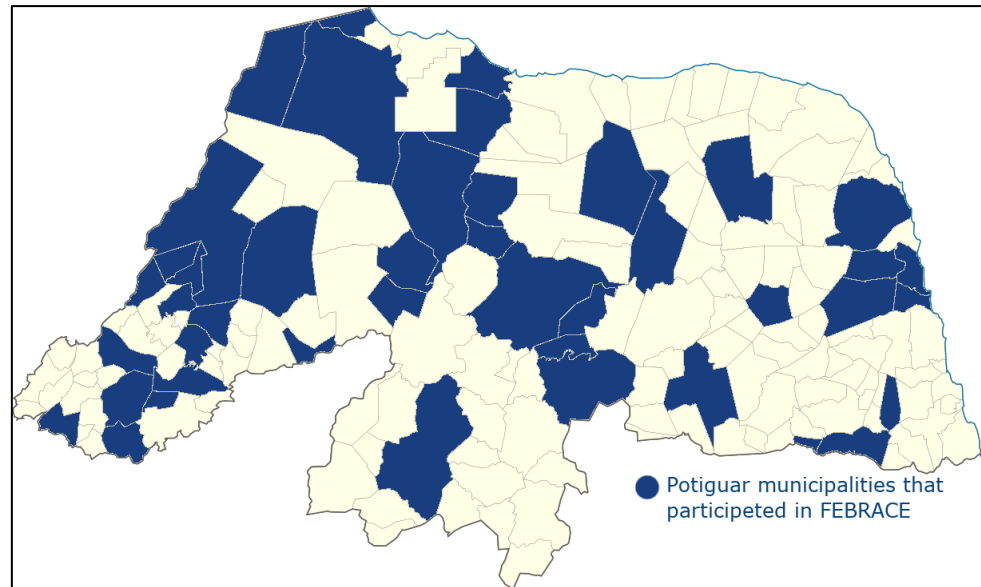
Abstracts that explored the impacts and effects of Covid-19 addressed aspects related to social and human sciences such as the use of social networks and mental health during the pandemic (OLIVEIRA *et al.*, 2021) or the causes of lack of compliance with social isolation by part of the community in one municipality (OLIVEIRA; MEDEIROS; FERREIRA, 2021). Some belonged to the agrarian sciences area such as the development of biodegradable alternatives due to the shortage of cardboard during the pandemic period (SILVA *et al.*, 2022); while others originated in biological sciences and engineering such as the production of biodegradable masks with coconut and/or cashew elements (DIAS; SILVA, 2021; 2022; NOGUEIRA; DANTAS, 2021) and the design of totems as automatic dispensers of gel alcohol aiming at the virus spread prevention (SILVA-JÚNIOR *et al.*, 2021).

Those Potiguar works published at FEBRACE confirmed the findings by Cajueiro and Gonçalves (2022) who identified the relationship of objects developed in Pará with the local demands and cultural specificities. In this brief time cut, a coherent broad view of sciences is observed in the development of STEAM practices and in the presentation of social and humanistic projects. This also confirms that investigative and creative practices promote transdisciplinary learning experiences aiming at action and intervention in the everyday life of the community by approaching different areas of knowledge.

4.2 Potiguar municipalities represented at FEBRACE

Throughout the eighteen RN participations in the FEBRACE historical series, 43 Potiguar municipalities were represented (26%), with students and teachers coming from them (Figure 01). Out of those 43, 29 municipalities had more than one work presented at the FEBRACE editions. The municipality with the highest number of participations was Mossoró, in the Western region, recording 48 abstracts published in fourteen different editions of the fair, followed by the capital with 32 occurrences, and Tibau, also in Western Potiguar, with seventeen experiments.

Figure 01: Potiguar municipalities that participated in FEBRACE.

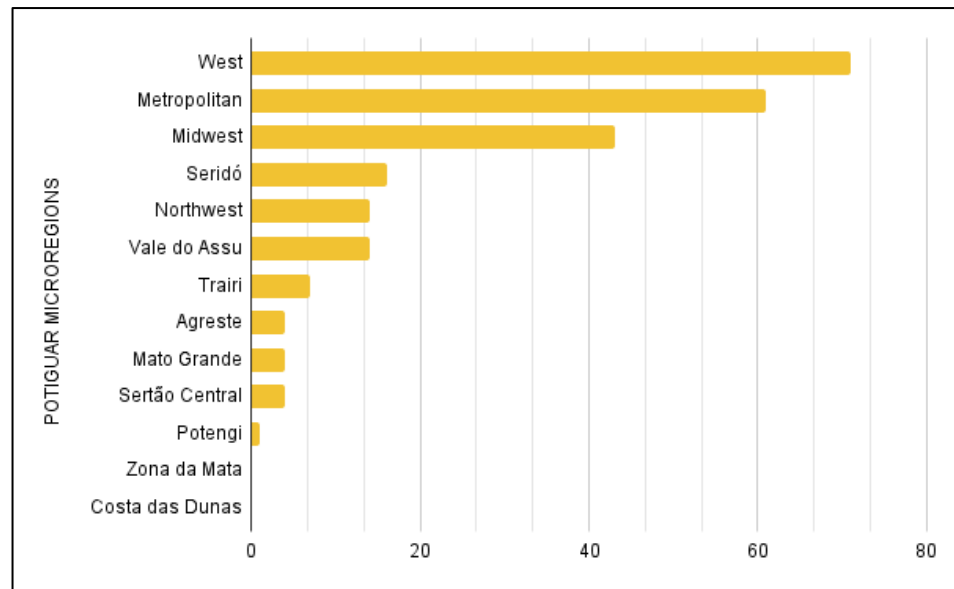


Source: Research data (2023).

This fact shows that there is a center of STEAM practice development in RN, it is located in the interior of the state, in the northeastern semi-arid. Mossoró, the largest town in area and the second largest in population, has economic and cultural influence in the Potiguar western region. Thus, considering the western microregion, a total of 71 works was recorded, corresponding to 30% of the Rio Grande do Norte total participation. In such case, the metropolitan region of Natal was the second most represented at FEBRACE, with 61 abstracts or 26%. Considering the estimates that 46% of the RN population reside in the capital metropolitan region, we could infer that the participation of students and teachers from the interior of the state was proportionally higher.

Therefore, the highest volume of innovative practices was not generated in the state capital, where there are usually better conditions and opportunities regarding different aspects. Although the Potiguar western region also has a large urban and economic center like Mossoró, it outstands among the other regions, including the one where Natal is located, and this influences other regions. Thus, the midwestern and northwestern regions recorded 43 and 14 works, respectively. It seems relevant to highlight that the interiorization of innovative practices aligned with the STEAM approach was observed in RN. Moreover, out of the thirteen microregions of the state, eleven were represented in some FEBRACE edition (Graph 02), indicating the dissemination of experiments all over the Potiguar territory.

Graph 02: Number of works per Potiguar region



Source: Research data (2023).

In addition to the economic aspect, and considering the impact of science clubs as identified by Cajueiro and Gonçalves (2022) in Pará, we believe that the consolidated existence of the Science for All Program at the Potiguar Semiarid³, a partnership between the Federal Rural University of the Semiarid (UFERSA), State University of Rio Grande do Norte (UERN), and SEEC/RN, has great influence in the dissemination of investigative and creative practices in the region. The objectives of the program include to stimulate the youth's interest in science in the remote locations of the semiarid region. To achieve that, the program carries out actions for the education of teachers and students of K-12 education regarding the scientific method. It also supports the organization of science fairs in schools and in the regional offices of the SEEC/RN, the organization of the Potiguar Semiarid Science Fair, and incentivizes the participation of the best works in national and international fairs.

RN has four local fairs affiliated to the FEBRACE, which places the state in the third position in the Northwestern region (next to Bahia, after Ceará and Pernambuco) and among the ten states of the country with the highest number of events (FEBRACE, 2022). Two of the Potiguar science fairs are from Mossoró, one of them is the Potiguar Semiarid Science Fair, another is held in Açu, and the fourth is in Natal. These findings confirm the Western region as the center of STEAM practices in Brazil and their interiorization in RN. Moreover, the importance of actions providing the dissemination and sharing of investigative and creative practices in K-12 is evidenced, and confirmed in the Potiguar context, a trend identified by the FEBRACE Organization Committee (2020, p. 11) at the national level:

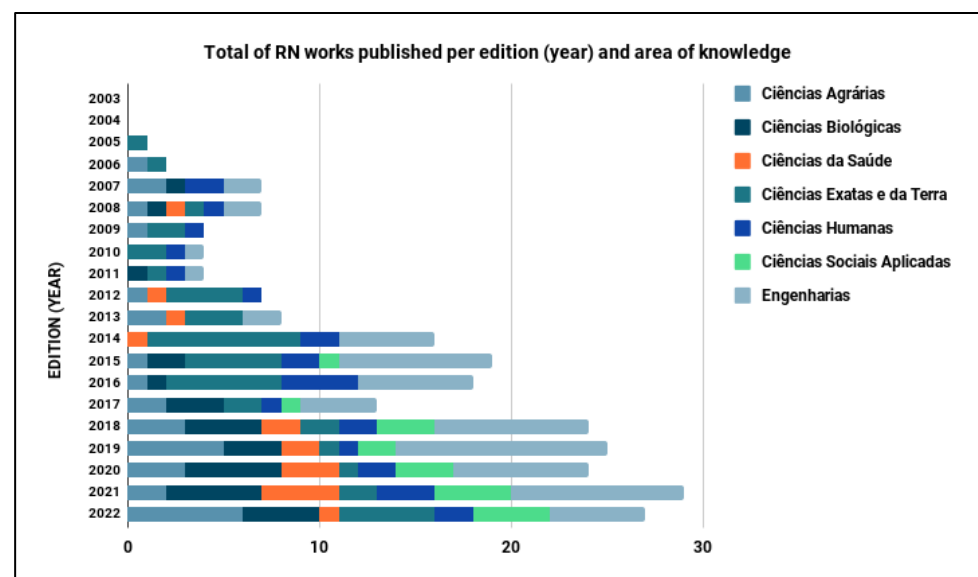
In addition to creating opportunities for the dissemination of research, science fairs and scientific shows present professional paths for young students, awakening scientific and technological vocations, becoming instruments for the improvement of elementary, high, and technical schools, stimulating, and favoring innovative teaching practices in schools.

Therefore, holding science and engineering fairs where K-12 students present their works was confirmed as a stimulus for the development and dissemination of investigative and creative projects, aligned to the STEAM approach in different settings, including municipalities quite distant from large urban areas. Such experiments demystify scientific research, incentivize the use of the existing technology and the development of new technologies for the solution of problems by local individuals (students) who are related to the community (FICHEMAN; SAGGIO; LOPES, 2008). The STEAM approach can and must be disseminated to other regions of the country, to meet local interests, respecting and valuing local culture and characteristics, and promoting equal conditions for all in education.

4.3 Areas of knowledge explored in the works presented/published

Works presented at FEBRACE are organized in seven areas of knowledge, considering their subareas. Potiguar abstracts were identified in all areas throughout the FEBRACE historical series and in five editions, all areas appeared in the works originated in Rio Grande do Norte (Graph 03).

Graph 03: Works from RN per FEBRACE edition per area of knowledge



Source: Research data (2023).

However, we verified that in the time series, there is an emphasis on RN productions related to the exact and earth sciences and engineering. In the longitudinal analysis, 71 productions were identified that were related to engineering and 47 to exact and earth sciences, which represented almost half of the Potiguar abstracts published in the FEBRACE proceedings (49%). While exact and earth sciences was the area with the highest frequency of works in the different editions of the fair (17) – 2007 was the only year when it was not represented – the engineering area held the highest number of publications, distributed in 14 editions.

One might infer that the emphasis on the engineering and exact and earth sciences is mainly supported by a limited conception some individuals have of

sciences. This might even include teachers involved in the STEAM approach and their beliefs regarding the concept of sciences. Lopes *et al.* (2022) identified such limited conception in participants in the STEAM *TechCamp*. Such finding reveals that it is still necessary to propose actions stimulating the development of works in other areas of knowledge. Teachers' education regarding the STEAM approach is among these actions, which might encourage teachers from different areas to implement investigative and creative practices. In addition, for being inherently interdisciplinary, the experiments might involve different teachers, from different academic backgrounds, in the mediation and execution of projects along with their students. For example, one of the teachers with the highest number of abstracts at the FEBRACE was graduated in language and advised works in the areas of human sciences, applied social sciences, health sciences and engineering, and the outstanding teacher of 2022 was from Mossoró, had a degree in social sciences, and articulated a project in the subarea of architecture and urbanism (FEBRACE, 2022).

The third top area is agrarian sciences - with 31 records – which are aligned to the demands and specificities of the semiarid climate. The abstracts address typical processes and products of the Potiguar agricultural and livestock activity such as goat, cashew, shrimp, honey, sweetcorn, in addition to solutions for the scarcity of water in the region, which demonstrates the core characteristic of the STEAM approach, that is, to explore problems of the real world and close to the students' everyday life.

Regarding the subareas, Potiguar experiments were predominantly in electronics (32), chemistry (22), computing sciences (16), education (15), ecology and agricultural engineering (both with 13), and agronomy (11). This set of works represents 49% of the projects carried out in RN that were presented at the FEBRACE. This shows the need to propose actions valuing and stimulating the development of projects in other areas of knowledge as a way of encouraging more Potiguar teachers to develop STEAM practices in K-12.

Resuming the main aim of this article – to map and analyze experiments developed in RN and published in the twenty editions of the FEBRACE – we can state that it was achieved in this study. Not only could we demonstrate the presence of Potiguar works in almost all editions of the fair (2003-2022), but we also identified the municipalities where students and teachers of K-12 carried out practices guided by the STEAM approach, thus revealing the relation of such investigative and creative projects with local demands and characteristics.

5 FINAL CONSIDERATIONS

This study enabled the recognition of practices aligned with the STEAM approach in Rio Grande do Norte, from the abstracts published in the twenty editions of the FEBRACE held up to 2022. It evidenced the constant presence of Potiguar representatives from the third edition of the fair onwards with a growing trend in the number of submissions annually. This indicates the growth and dissemination of investigative and creative practices in Potiguar K-12 education.

The 239 RN works presented at the FEBRACE came from 43 municipalities of the state and almost all Potiguar microregions. A relevant finding is that the experiments concentrated in the western region, boosted by works developed in schools from Mossoró and local science fairs. The metropolitan region of Natal came second in number of works, highlighting practices linked to the IFRN.

As for the areas of knowledge, this study revealed a concentration of works in the engineering and exact and earth sciences areas, suggesting a limited view and many times reinforced by the common sense that sciences, research, and development are characteristics almost exclusively related to these areas. On the other hand, we identified the existence of teachers graduated in other areas of knowledge that have developed practices related to the STEAM education, with an interdisciplinary approach. It seems relevant to emphasize the importance of encouraging experiments with teachers from the most diverse areas of knowledge, to broaden investigative and creative practices, so that scientific knowledge can be developed in other areas.

RN has shown experience with STEAM-related practices in K-12. Several teachers and students became top presenters at FEBRACE and were even selected to represent the country in international science fairs. In another phase of this research, we intend to contact those teachers to learn more about STEAM practices with them. These initiatives must be disseminated more broadly among other teachers in the state to stimulate them to develop investigative and creative practices.

Our results showed that although public schools of the state network have difficulties, they have developed successful experiments aligned to the characteristics of the students' context. Such experiments must be seen by all teachers as also related to them and their own students. This should promote science popularization and dissemination of STEAM practices in the Potiguar and Brazilian K-12 education.

ABORDAGEM STEAM NO RIO GRANDE DO NORTE: UMA ANÁLISE LONGITUDINAL A PARTIR DE EXPERIÊNCIAS PUBLICADAS NA FEBRACE

RESUMO

A promoção de práticas investigativas e criativas com estudantes brasileiros por meio da abordagem Educação STEAM, tem sido central nas discussões sobre inovação educacional e desenvolvimento de um país. Iniciativas como a Feira Brasileira de Ciências e Engenharia (FEBRACE) estimulam a cultura investigativa, a criatividade, a inovação e o empreendedorismo na Educação Básica brasileira. O objetivo deste artigo foi mapear e analisar as experiências desenvolvidas no Rio Grande do Norte (RN) publicadas nas vinte edições da FEBRACE. Utilizaram-se procedimentos da pesquisa bibliográfica e documental para realizar um levantamento longitudinal dos resumos publicados nos Anais da Feira de 2003 a 2022, para extrair informações relativas às práticas STEAM potiguares. A pesquisa tem caráter quali-quantitativo por abranger procedimentos estatísticos que propiciaram a descrição e interpretação dos dados. Os 239 resumos potiguares na FEBRACE indicaram uma tendência de crescimento da participação de professores e estudantes do RN ao longo da série histórica. Mossoró representa um polo de práticas STEAM no estado, devido à influência de iniciativas que favorecem feiras de Ciências locais. Apesar da ênfase em trabalhos nas áreas de Ciências Exatas e da Terra, muitos resumos focam aspectos relativos ao semiárido. Conclui-se que o RN possui experiência com práticas relacionadas à abordagem STEAM na Educação Básica e que elas estão focadas na solução de problemas do contexto. Entretanto, é preciso disseminar as práticas com demais professores, de diversas áreas do conhecimento.

PALAVRAS-CHAVE: Abordagem STEAM, Educação Básica, FEBRACE, Práticas Inovadoras, Rio Grande do Norte.

NOTES

1. FEBRACE proceedings and publications: <https://febrace.org.br/acervo/anais-e-publicacoes/>.
2. Members of the Interdisciplinary Group of Studies and Research on Computing in Education (GIlfE), of the Federal University of Rio Grande do Norte (UFRN), linked to the Mathematics Learning Objects Platform team (OBAMA – obama.imd.ufrn.br).
3. Retrieved from: cienciaparatodos.com.br.

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Mailing address: Dennys Leite Maia - dennys@imd.ufm.br

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