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Connections between Natural Science and Mathematics: Options for Research in the Classroom

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Abstract: In view of the profusion of information, which we are currently subjected to, it is important that students can develop the skills they need to accurately research reliable information as part of their scientific education. To this end, teachers guide them in their investigations through activities that enable them to better understand today's relevant topics, using knowledge from different subjects. On the basis of this premise, this article intends to understand what students believe and perceive, when it comes to research as part of their formal education and the importance of each subject to their investigations. For this task, we involved 32 students from the eighth grade of an elementary school in the state of Rio Grande do Sul / Brazil in participatory lectures and they were also asked to complete questionnaires in order to capture their current understanding. Mixed Research Methods were used to analyze the data, including the collection and analysis of qualitative and quantitative data. The results of the study showed that students see research as a way of delving into certain subjects and that it is more relevant to subjects such as Science and Geography. This suggests the need for including more educational activities aligned to the complete set of subjects and the benefits they would provide in encouraging them to look at the world in that way.

Key Words: Research; Education through research; Science and Mathematics Teaching.

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I. INTRODUCTION

The degree of options today when it comes to education, has increased due to how easy it is to find information on the internet. However, it is important that students are able to understand what they are studying and fundamentally that they know how to select content from reliable sources and that they apply some scientific scrutiny, so as to avoid the effects of the digital divide.

Schools need to train students to cope with the rapid social changes and to be able to learn and develop values that are appropriate to the contemporary challenges in the face of the students' current perception of research and the need to ensure that they develop the skills necessary for self-development and to be able to make the connections between different areas of knowledge.

Santos et al., (2020) point out that the Brazilian school system has been unable to help students learn how to use the internet productively; it is failing to encourage good habits in its students for the most productive use of internet access and, therefore, is contributing to the increase in the second-level digital divide in different regions and social classes; which has been aggravated by the covid-19 pandemic and the suspension of classroom activities.

The current major problems, socially and across the world, need to have multidisciplinary or interdisciplinary analysis of their various respective areas. Therefore, the great challenge for the teachers is to come up with complete and concrete teaching methods and integrated educational activities that meet contemporary needs.

From this point of view, research activities using technology have a fundamental role to play in school activities. They can be used as part of a shift from fragmented activities to an integrated and contextualized approach (RAMOS, 2014; ROCHA, 2015), in order to find, in creative thinking, the primary lever with which to train students in being competent researchers (DEMO, 2011a; ROCHA, 2015).

Educating students in research and investigation significantly contributes to giving them the ability to understand the world beyond what is common sense. The second general competence from the National Common Core Curriculum (BRAZIL, 2017, p. 9) is: "Exercise intellectual curiosity and employ the subjects' own approaches, including research, reflection, critical analysis".

In view of the responsibilities placed upon education, this study proposes to look at the connections for the subjects of science and mathematics and the perception of students in the eighth grade of elementary school around carrying out research at school.

II. THEORETICAL FOUNDATION

2.1 CONNECTIONS BETWEEN MATHEMATICS AND NATURAL SCIENCE

It is important to produce activities in context which combine the different subjects that make up the school curriculum, when looking to identify teaching activities that suit current educational needs, and while concentrating on the various perspectives of the different areas of knowledge. This way, it is possible to identify better and more effective solutions, for the issues to be dealt with and for helping to deal with the problems that society faces. (ROCHA, 2015; AGUIAR et al., 2019).

According to Harnisch (2002), educational research shows that the problem with science education is that students are not required to master the concepts that make science so fascinating. "In mathematics, the content is limited to questions that ask 'What 'and there is very little that addresses 'How' or 'Why should I care' (HARNISCH, 2002, p. 1, our translation). By focusing on these two areas, it would be possible to link together science and mathematics in the classroom, as well as their importance in everyday life (DAL-FARRA, 2010).

A lot of social and economic information, through graphs and tables, is presented by the media all the time. In this sense, the teaching of statistics as part of mathematics, is an important part of their education as citizens, enabling them to understand the world through the discussion and manipulation of this information and, also, enabling them to make decisions, thereby ensuring that they can interpret the data for themselves. From this point of view, we can see that students, when they make connections between daily life and their formal studies, are able to apply their statistical knowledge to various situations (DAL-FARRA, 2010; CARVALHO; SOLOMON, 2012).

According to Walman (1993, p. 1) "Statistical literacy is the ability to understand and critically evaluate the statistical results that permeate our lives on a daily basis - together with the ability to appreciate the contribution that statistical thinking can make to public and private, professional and personal decisions".

With regard to Data and Probability Analysis, the NCTM (National Council of Teachers of Mathematics) in the United States points out that students, over the 12 years of basic schooling, are expected to develop skills in:

• asking questions that can be answered through collecting, organizing and recording data;
• selecting and using appropriate statistical methods for data analysis;
• developing and evaluating inferences and predictions based on data;
• understanding and applying basic probability concepts (NCTM, 2000).

In this document, the NCTM specifies the skills and how they can be developed from early years up to the end of basic education, starting from within the family and experimenting, through to concrete and abstract representation. In accordance with these principles, the BNCC (National Common Core Curriculum) divides mathematics into five thematic units based on its knowledge areas: Numbers; Algebra; Geometry; Quantities and Measures and Probability and Statistics.

More specifically, the teaching of statistics provides a link to research in science, making it possible to examine data from different sources in order to solve everyday situations. In this way, teachers of mathematics, science and other subjects can work together so that connections can be made between the content and students can learn in a complete and autonomous way, since, according to the BNCC, elementary students should develop the following abilities from mathematics:

• To be able to recognize that Mathematics is a human science, [...] and a living science, which plays a part in solving scientific and technological problems and in supporting discoveries and inventions, including some with an impact on the world of work.
• To be able to develop logical reasoning, the spirit of investigation and the ability to produce convincing arguments, using mathematical knowledge to understand and act in the world.
• To be able to make systematic observations of quantitative and qualitative matters from social or cultural activity, in order to investigate, organize, present and explain relevant information, to interpret and evaluate them critically and ethically, producing convincing arguments.
• To be able to deal with problems in different situations, [...] using various records and tools (graphs, tables, diagrams, as well as text written in the mother tongue and other languages to describe algorithms, such as flowcharts, and data).
• To be able to cooperate with their peers, working together to plan and develop research to answer questions and find solutions to problems [...]. (BRAZIL, 2017, p. 264).

The BNCC recommends using problem-solving approaches to develop skills to collect, organize, present, interpret and analyze data in various situations, so that they will be self-sufficient and know how to make judgments and take decisions (BRAZIL, 2017, p. 274).

2.3 TEACHING THROUGH RESEARCH

The classroom is a living space, where experience and research can be exchanged. Therefore, the teacher is not just a provider of knowledge, since both (student and teacher) are partners in the teaching-learning process. Therefore, when organizing the planning of activities, the teacher must take into account any issues, queries, questions, previous knowledge, values, discoveries or interests the students may have (RAMOS, 2014).
This proposal is in line with the BNCC, as it considers Science as an area of knowledge that enables students with their scientific education. It explores further aspects of their self-awareness, their relationships with others, nature, technology and with the environment, so that they will act with respect, responsibility, solidarity and cooperation in society.

The investigative approach should put the student first when it comes to learning and applying the processes, practices and procedures associated with developing scientific and technological knowledge. At this stage of a child's education, it must be related to open issues and problems considered in context, so as to stimulate their curiosity and creativity in identifying procedures and looking for solutions that are theoretical or experimental [...]. It is worth mentioning that learning how to obtain information, present it and critically analyze it, is more important than actually getting it. (BRAZIL, 2017, p. 551).

Nowadays, with so many different communication and information channels available, students face new problem from the instant access to information. It is up to the teacher to understand the nature of the current work and to know how to choose, among the many options, the most relevant ones, concentrating on the use of day-to-day experiences and using what students already know, so that their activities are meaningful and interesting, and they can contribute to discussions and classroom analysis (RAMOS, 2014).

The word "pesquisa" ("research" in english) comes from the Latin "perquirere", which means to look for; seek carefully; look for everywhere; find out; inquire; ask; investigate; searchthoroughly (BAGNO, 2007). A researcher learns how to build upon his own knowledge by carrying out research. Therefore, people should be introduced to research from an early age, particularly as children need to develop their own self-awareness and their creativity, ability and to understand how to find out the information they need when they are confronting something unknown.

School-based research in Brazil became popular in the 1990s due to the studies of Pedro Demo. The author uses this to divide research into two principles: educational and scientific.

First, it is important to look at research as a scientific principle and as an educational principle. We are using research mainly as a teaching method, as a way of educating, and not just to develop our knowledge. Well, if we accept that, then research means that education should be about asking questions, so that the individual can learn how to think. This is the idea of creating a subject who can operate independently, who is free because they can exercise a critical awareness and make their own proposals. (DEMO, 2011, p. 22).

In education, research is seen as a way to understand the world, where reflection on a subject provides more wisdom than simple common sense, which requires the teacher be permanently investigating his subject area.

The teacher needs to develop skills sequentially and systematically throughout their academic career, to locate, select and use information that enable students to develop information literacy and thereby be able to learn independently, not only in fact throughout their school education, but also for the rest of their lives (KUHLTHAU, 2010).

Moraes and Galiazzi (2002) point out that, from the moment that the teacher starts teaching through research, he introduces investigation as a part of teaching every day, using it as a central part of his methodology. Even though it can make students, who are not familiar with this methodology, uncomfortable at the beginning, once they realize that they are learning from it, it motivates them considerably to complete their research activities.

From this point of view, Demo (2015) advises of the need to differentiate research as part of daily routine from research for a specific result, because, according to him, the first should be a normal activity, so that they are used to looking at daily life in a critical way, encouraging critical awareness and experience. While, when used for a specific result, research should be a concrete identifiable product, such as planning a project or some teaching material (DEMO, 2015).

The essential aspect of educating through research is that the teacher is a researcher, i.e. He has to manage research as a scientific and educational principle and practice it daily. Research is the result of the systematic planning from preparing classes and is not something without purpose. It can also emerge from the discussions between the teacher and the students, whereby both learn from working on identifying problems and justifying research. However, it is not enough to have initiative and be able to critically analyze, it is also essential that the student knows how to explain what he has discovered and what he understands.
Within the classroom, the student must be given the opportunity to question and discuss subjects of interest, to be able to ask questions and write essays. Such practices help students to develop their self-expression and show

that they are capable of being responsible for their own learning and organization (NICOLINI; MORAES, 2005).

According to Demo (2011a), the existing methods for education through research, don't satisfy the need for competence. Based on the assumptions presented above, a competent teacher will be able to plan their own educational methods using research, which, in turn, will lead to better performance from the students thusly trained.

III. MATERIALS AND METHODS

The educational activities were carried out with a class of eighth grade students in elementary school in the extreme south of Brazil. They were initially given a questionnaire with open questions using a Likert scale. Subsequently, participatory lectures were held on the topic of the respiratory and cardiovascular systems.

This article analyzes the results based on the perceptions of the 32 students, regarding research and its relevance to school activities and about the importance of carrying out research in each subject within the school curriculum.Students demonstrated high experience with research activities because the school has educational practices related to projects in the curricula.

The results from the open questions were analyzed using Content Analysis (BARDIN, 2006; BAUER; GASKELL, 2008) and the quantitative data from the Likert scale ranging from 1 (totally disagree) to 5 (totally agree) were analyzed using the mean averages, standard deviations and coefficients of variation. The Kruskal-Wallis test was also used to verify statistical significance.

The integration of the qualitative and quantitative components was carried out by merging the results and producing a Convergent Design (CRESWELL, 2010; DAL-FARRA; LOPES, 2013; DAL-FARRA; FETTERS, 2017).

IV. RESULTS AND DISCUSSIONS

Figure 1 displays the results from the degree of agreement the students expressed regarding the relevance of the theme "research" to the different subjects within the school curriculum. Values around 1 (one) indicate total disagreement with the relevance of the theme to the subject in question, and values around 5 (five), indicate total agreement.

Figure 1 - Approach to the theme of research in respect of the subjects

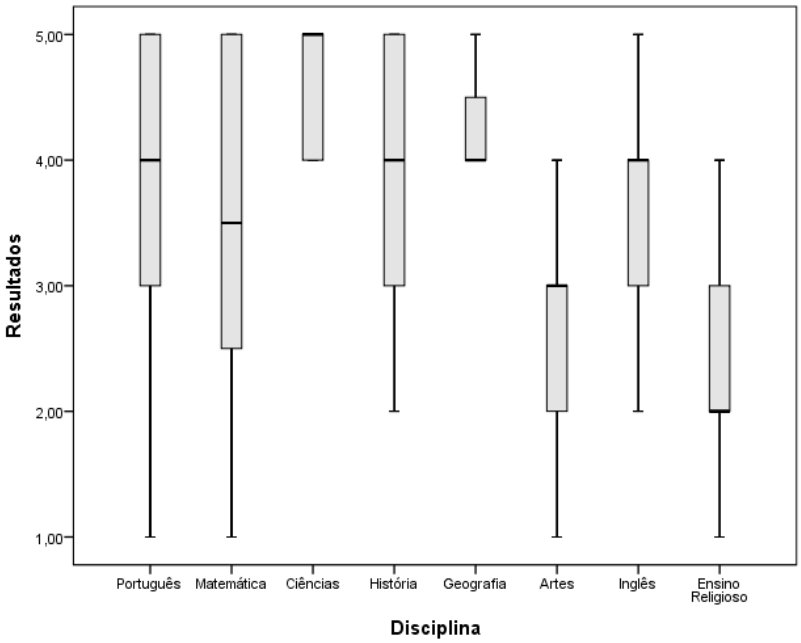

Figure 01 shows that the students gave higher scores and therefore showed greater agreement for the subjects of Science and Geography. Table 01 compares the average in relation to the relevance of each subject to the research process, in a more specific way.

Table No. 1: Mean, standard deviation and coefficient of variation in relation to the relevance of the discipline to classroom research

Subjects	Mean Average ± SD		CV
Science	4.53 ± 0.51	a	11.26
Geography	4.09 ± 0.64	ab	15.65
History	3.94 ± 0.95	b	24.11
Portuguese	3.81 ± 1.17	b	30.71
English	3.63 ± 1.07	b	29.48
Mathematics	3.56 ± 1.34	b	36.64
Art	2.77 ± 0.96	c	34.66
Religious Education	2.47 ± 0.92	c	37.25

Results from analysis of the mean average ± Standard Deviation
Source: Produced from research data (2019).
Kruskal-Wallis' Test. Different letters refer to differences between groups

It appears that the average scores were higher for Science and Geography, without any significant difference between them ($p = 0.63$). It is also of interest that Geography showed no significant difference to History, Portuguese, English or Mathematics. Lower averages were also given for Art and Religious Education ($p = 0.92$). Therefore, Science was the subject most commonly associated with scientific research by students, along with Geography. This result could be partly due to the fact that the research being carried out as part of the investigation was completed as part of the Health Education lessons, leading to students making a connection between the topic and the subject that this topic is normally part of.

It should also be mentioned that the low score assigned to Mathematics suggests that in the students' eyes, the investigative process isn't needed for an area of knowledge with an average score of 3.56. However, as can be seen in Table 1, this was the subject with the highest standard deviation (1.34) and with a high coefficient of variation (36.64), which indicates that there was a strong difference of opinions among students' regarding the use of mathematical knowledge in classroom research. Therefore, it is important to conduct educational activities that use mathematics as part of a broader look, where this important subject can be used to present results that help us to better understand the variables under analysis.

From a broader standpoint, in view of these results and the importance of investigations carried out by students, we can see that using integrated educational activities featuring different subjects can help students to understand that it is important to study subjects together because it enables them to be better armed when it comes to looking at the world around them (MORAES; GALIAZZI, 2002; HARNISCH, 2002; DEMO, 2011b).

In order to further understand what students consider research to be, they were given an open question on the subject. The results are in Table 02.

Table No. 2: Theperception of "what research is"*	n = 32
To become more knowledgeable about the subject.	28 (87.5%)
To discover more about a particular subject	9 (27.9%)
The contribution to the study	4 (12.5%)
To be able to know something interesting	2 (6.3%)
Very important	2 (6.3%)
Study Method	2 (6.3%)
Help with grades	1 (3.1%)
Benefit school activities	1 (3.1%)
Putting learning into practice	1 (3.1%)
To support ideas and theories	1 (3.1%)
To discover something new	1 (3.1%)
More useful for some than others	1 (3.1%)

*Questions with more than one option

We can see from the qualitative data that the students have a more focused image of research as a way to increase knowledge on the topics they study, with little mention of method or the intended strategy of using it to "look at the world" as recommended by those authors who discuss the relevance of classroom research based educational activities (MORAES; GALIAZZI, 2002; HARNISCH, 2002; DEMO, 2011b).

According to Santos (2020), it is important that educational policies seek to deal with the issue of second level digital exclusion on a large scale, by providing teachers and students with the knowledge and skills to be able to use the Internet productively and responsibly, which includes having adequate access in classrooms across the country.

When we merge the results of the quantitative and qualitative data, we can see that students do not see research as a tool for every subject, and therefore, they believe that studying or even examining classroom topics in depth, does not need any knowledge or techniques which are traditionally linked to other subject areas which could be included as part of the research.

We therefore have to consider the role of the teacher as someone who encourages learning and the opportunities for working across subject areas as part of integrated activities at the school, using research and all the potential that research methods and teaching plans can provide today. The various opportunities that come from collecting quantitative and qualitative data and, especially, what the students can do with the information, as well as their investigations into understanding it better provide strong support for creating educational activities based on the context of the world around them (RAMOS, 2014; DAL-FARRA; FETTERS, 2017).

A paper on science education in basic education by the National Research Council of the United States (2012) identifies the following possible actions for developing integrated educational activities from early childhood education up to high school:

1) Ask questions and establish the issues;
2) Develop and utilize models;
3) Plan and carry out research;
4) Analyze and interpret data;
5) Use mathematics and computational methods;
6) Produce explanations and develop solutions;
7) Construct arguments based on evidence;
8) Collect, evaluate and present information.

Such actions presuppose the integrated inclusion of different subjects, on the assumption that any attempt to understand phenomena that occur around us, cannot be done without using other areas of study, especially when research is carried out by students. This requires teachers, who work with students at every grade, to work together. These issues are not only relevant to science education but can be applied to the analysis of other phenomena from social studies and their historical processes (ROCHA et al., 2015; FIGUEIREDO; GROENWALD, 2019).

Therefore, it is important to overcome the traditional fragmentation of the subject of the curriculum, so that they can be considered when students carry out research to have a better understanding of the world around them.

V. FINAL CONSIDERATIONS

From the analysis of the results from this study, we noted that the students saw science and geography as the subjects for which research was most relevant. This result was based on quantitative data, complemented by qualitative results, which showed that research was viewed as a way of expanding knowledge, rather than as a technique to help students to be better at understanding the world around them.The investigative process has continuity due to the great interest of the students in conducting research

Further research on this topic will be able to look more deeply into the results or perhaps, identify ways that research can be developed to be used in the classroom to enable students to develop their research skills, which they can then use in their later studies, whether in school or in their normal activities. Wherever they are looking to better understand what is taking place in the world around them.

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