Revista ARACÊ
ISSN: 2358-2472

# DEVELOPING INVESTIGATIVE SKILLS ADDRESSING THE THEME OF COASTAL ENVIRONMENTAL PROBLEMS

https://doi.org/10.56238/arev7n3-016

**Submitted on:** 02/05/2025 **Publication date:** 03/05/2025

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## ABSTRACT

In the school and professional environment, science education is essential in the development of the investigative profile to train professionals with aptitude for scientific research. In this work, the benefits of implementing investigative activities using active, experimental and practical methodologies addressing topics related to coastal zones, environmental problems and science teaching were analyzed. The research was developed based on activities of the Researcher's Learning Center (CAP) of the Center for Training and Research in the Environment (CEPEMA/USP), which offers a space in which students can experiment with this methodology and investigate different problem-situations. The objective of this research was to verify whether the performance of activities in the CAP brings benefits to the development of investigative skills addressing guiding themes related to coastal environmental problems. Data were obtained through opinion/perception questionnaires and statistically analyzed. The results revealed how the implemented activities stimulated the students' interest in the proposed themes and the development of investigative skills. Although new academic studies are needed to deepen the knowledge on the subject, the methodology applied in this research obtained an index of 0.75 in Crombach's alpha coefficient. This demonstrates that the data obtained in the opinion questionnaire answered by the students after the activity were representative for the scope of the research. This observed success points to the possibility of innovation in the way of evaluating teaching, which can be replicated for other educational institutions.

**Keywords:** Investigative Skills. Coastal Environmental Problems. Researcher Apprentice Center (CAP). Science Teaching.

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## INTRODUCTION

The Brazilian coastal zone covers 7,491 kilometers and in several regions environmental problems of the most varied types are detected, including those arising from anthropogenic impacts. Thus, it is necessary to stimulate reflection and research on various solutions to such coastal environmental problems. The Brazilian scenario, however, indicates the lack of interest of students in general in studying and in school subjects, according to the results of the evaluation of the last two Basic Education Development Indexes (IDEB, 2017 and 2019).

The environmental problem cannot fail to be addressed through education, as it is about sensitizing these students about issues such as the conscious use of our resources and sustainability (NASCIMENTO et al, 2018). However, the article by Nascimento et al. (2018) points out that this environmental theme has been omitted in teachers' practices. Non-formal education, therefore, can represent an opportune space for carrying out activities with active, experimental and practical methodology focused on the development of investigative skills addressing, among other topics, coastal environmental problems. Moretto (2002) cites examples of skill, such as: identifying variables, understanding phenomena, relating information, analyzing problem situations, synthesizing, judging, correlating and manipulating.

In this work, the concept of non-formal education used the definitions of Coombs et al. (1973), Gadotti (2005) and Connal and Sauvageot (2005): any educational activity organized outside the formal education system, with a lower degree of systematization and bureaucratization, does not necessarily need to follow a sequential system, may contain variable duration and workload, and may or may not grant learning certificates.

Valentino (2000) suggests that learning to solve problems in a variety of contexts promotes the development of a general capacity to solve problems that can be transferred to new contexts and, therefore, a proposal that privileges this situation should be considered.

One of the spaces for non-formal education in Brazil is the Center for Training and Research in the Environment (CEPEMA/USP). It is located in the municipality of Cubatão, in the Baixada Santista. Through the work of its Education and Dissemination Center, it seeks alternatives for the teaching of science, through the incorporation of participatory methodologies, investigation of problem-situations and experimental activities. The project of the Researcher Apprentice Center (CAP) began in 2013, to provide an interactive space

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through investigative activities, aimed at basic education students. The project offers a script of activities in the various areas of science in which students can investigate various problem situations. Students from the municipal schools of Baixada Santista visit this university space, where they are fundamentally able to use and develop skills.

The new National Common Curricular Base - BNCC (BRASIL, 2017a) emphasizes the need for students to be encouraged to use skills more frequently and the need for the presence of research and communication skills in the activities proposed to students.

This work is also in line with the trends described by the United Nations (UN) in the 2030 Agenda released in 2015 at the United Nations Summit for Sustainable Development, to which Brazil is a signatory. The agenda presents 17 Sustainable Development Goals (SDGs) and 169 targets, with which States committed to "work tirelessly towards full implementation" by 2030 (UNITED NATIONS, 2019). Of the 17 SDGs, this research relates to SDG No. 4 "Quality Education" defined as: "Ensure inclusive and equitable quality education, and promote lifelong learning opportunities for all"

It is possible to identify how the definition of the Sustainable Development Goal highlights the issue of equal access to quality education. This work was developed online in collaboration and working together with the Department of Education and the educational institution of the municipality where the research took place. The participating students are from a public school and did the activities with materials they had access to at home, during the COVID-19 pandemic. SDG No. 4 concentrates 29 indicators focused on education. Among them, the 4.7 indicator is described as:

> "By 2030, ensure that all learners acquire the knowledge and skills necessary to promote sustainable development, including but not limited to through education for sustainable development and sustainable lifestyles, human rights,..."

The school involved in the research is a component of the municipal school network of São Vicente/SP, a city located in the Brazilian coastal zone. The themes of the chosen activities had the objective of working on coastal environmental problems, to relate the contents learned in the meetings, with the reality of the region in which the students were inserted. In addition, the focus of the methodology of the activities is to stimulate the use of investigative skills in students during the dynamics

Still linked to the characteristic of the study area, in 2017 the UN issued a declaration defining the decade 2021 – 2030 as the "Ocean Decade". The decade will

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provide a unifying framework to enable countries to achieve all the priorities of the 2030 agenda related to the oceans. Therefore, it is essential to include the municipalities located in the coastal zone (such as São Vicente) in studies that stimulate active and critical learning of coastal environmental problems. This research, inserted in this scope, seeks to favor the knowledge of students about their coastal region and value the importance of this ecosystem. In this sense, the decade of the oceans for sustainable development was conceived by the United Nations (UN) so that we can enjoy these services consciously and without harming the largest ecosystem on planet Earth (IOC-UNESCO, 2020).

It is known that in school science is not very attractive: knowledge of the natural environment has been replaced mainly by the teaching of principles and rules that are difficult to apply to real life (MORA, 2013). Consequently, creating and implementing a model where the student's skills are exercised, instead of a simple reproduction of content without apparent applications, can result in a complementation in the teaching-learning process of science.

## OBJECTIVE

In this context, the objective of this study was to analyze the possibility of teaching about coastal environmental problems by encouraging the use of investigative skills within the school context, articulating the formal teaching applied by the municipal school, with the non-formal teaching introduced by the methodology of activities of the Researcher Learning Center.

Specifically, the hypotheses inserted in this study were that the methodology employed brings benefits in the development of investigative skills and stimulates interest in the themes of the activities that encourage reflection on environmental problems. And, finally, to apply a metacognitive methodology, where students self-evaluated their interest in the topics covered, as well as the investigative skills they were able to develop.

## METHODOLOGY

The research was quantitative-qualitative, as suggested by Bogdan and Biklen (1994), where in practice, the researcher introduces changes in the school environment, implementing investigation tasks that require students to play a different, more active and more collaborative role. It also requires the sharing of information, the performance of

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laboratory work and the joint writing of conclusions as observed in other authors (FREIRE, 2004).

The municipal public school EMEF. Lions Club located in the Vila São Jorge neighborhood, municipality of São Vicente/SP was selected to participate in this research. About the performance of EMEF. Lions Club, the school's gap about the goal was the same as that of the municipal network of the city of São Vicente, one point of difference. The results were 5.2 in the IDEB 2017 (BRASIL, 2017b), and the target was 6.2 and 5.4 in the IDEB 2019 (BRASIL, 2019), with a stipulated target of 6.4. Even with a small performance improvement, the deficit about the stipulated remained the same, demonstrating that there was no evolution in the situation (BRASIL, 2017b, 2019). This deficit in performance was one of the reasons for selecting the school to carry out the research.

The project was carried out with students from three classrooms of the 8th grade of the aforementioned school, an age at which the students showed interest in activities with this type of methodology, as previously demonstrated by Gouw and Bizzo (2016). The authors also emphasize the importance of working in the indicated age group, as it precedes high school, where many students begin to direct their professional paths and school dropout data increase (IBGE, 2018).

Initially, meetings were held with teachers and pedagogical coordinators of the school to organize and synchronize the realization of the activities chosen by the Researcher Learning Center (CAP) with the school routine. The participating students were informed, in the first meeting, about the completion of the consent form by the parents or guardians and the consent form by the minors. The research aimed to insert as many students as possible who wanted to participate to reach the largest number of people. In all consent forms (guardians and participating students) made in *Google Forms* there is an icon to mark the acceptance of participation.

The activities, meetings and interviews took place through conferences on the *Zoom* or *Google Meet platform*. The authors of the research opted for the platform already used in the school's subjects (*Google Meet*) to carry out the activities, to adapt to the convenience and prior knowledge of the participants. The lack of obligation to participate also allowed the presence of students to be associated with a true interest in participating in the research. As the work used scientific methods involving human beings, the work was evaluated and approved by the Research Ethics Committee of the Federal University of

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São Paulo (UNIFESP) and by Plataforma Brasil. The investigative skills developed by the students and analyzed in this article are described in Chart 1.

**Table 1.** Investigative skills.

| SKILL | DESCRIPTION |
|---|---|
| **H1** | Understand what you were asked to do |
| **H2** | Observe |
| **H3** | Concentrate |
| **H4** | Measure and use units of measurement |
| **H5** | Sort or organize |
| **H6** | Drawing or Schematizing |
| **H7** | Analyze the data |
| **H8** | Compare |
| **H9** | Record data in the activity sheet |
| **H10** | Work as a team |
| **H11** | Raising hypotheses |
| **H12** | Use the microscope or magnifying glass |

Chart 2 outlines the days on which the ten meetings took place, schedules, themes and activities of the CAP held. The meetings lasted an average of one hour and thirty minutes. Only in the last meeting were two activities proposed, as they had a primarily experimental character, illustrating the anthropic environmental impact (environmental pollution activity) or that foster sustainable and environmentally responsible practices (important recycling activity). These activities are available on the project's pages on its social networks, in the description of the project's Instagram, at the link: www.instagram.com/capcepema/. All these moments had recording and chat saved in the researchers' *Google Drive*. This model has been little worked on in academia and the success of the application of these activities can emerge as an innovation for the educational system.

**Table 2.** Dates of the meetings and activities carried out.

| DATE | ACTIVITIES (Problem situation) |
|---|---|
| 27/8/2021 | ROCKS AND MINERALS AT HOME<br>(Do you know the rocks and minerals? Did you know that they are in our day-to-day lives and not just in nature?) |
| 03/9/2021 | MAP INTERPRETATION<br>Do you know your area? |
| 10/9/2021 | BRAZILIAN BIOMES<br>(Do you know the Brazilian biomes?) |
| 17/9/2021 | BRAZILIAN BIOMES 2 |

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| | |
|---|---|
| | (What relationship do humans establish with their biome?) |
| 01/10/2021 | UNDERSTANDING THE IMPORTANCE OF ANIMALS<br>(Could you imagine this planet without animals? Do they have the same characteristics?) |
| 08/10/2021 | GETTING TO KNOW SOME MARINE ANIMALS<br>(Have you ever noticed the animals that inhabit the beaches?) |
| 22/10/2021 | DISCOVERING PLANT CHARACTERISTICS<br>(Have you noticed how plants can be very different from each other?) |
| 29/10/2021 | MOON PHASES AND VISIBLE NATURAL PHENOMENA<br>(Have you ever observed the phases of the moon? What about natural phenomena in the sky? |
| 17/11/2021 | WATER COMPARISON<br>(Can all the waters be consumed) |
| 26/11/2021 | 1- UNDERSTANDING THE IMPORTANCE OF RECYCLING<br>(Do you think all our garbage can be disposed of in the same way?)<br>2 – ENVIRONMENTAL POLLUTION<br>(Can you imagine our environment being all polluted? Would there be life?) |

**Note:** Shared drive folder. Accessible on CAP - @capcepema's Instagram. Link: https://www.instagram.com/capcepema/.

## DATA COLLECTION

In this study, the data collection instruments were the questionnaires in focus groups (KRUEGER; CASEY, 2000). According to Alves et al. (2008), questionnaires, about methodologies, methods or forms of data collection, are the second most used form of collection. Fejes and Gouw (2012) explain that the self-assessment model using rubrics allows analyzing how students evaluate their conduct throughout a teaching-learning process in a metacognitive way. The questions of the methodological tool (questionnaires) follow this model and were segmented into two categories: interest in the theme of the activity and development of investigative skills. The opinion/perception questionnaires were made from *Google Forms* (a form tool of Google tools).

The representativeness coefficient of the chosen questionnaire was Crombach's alpha applied by the IBM SPSS v.20 software (IBM, 2011) because it is commonly applied in opinion questionnaires that use the Likert scale. The reliability data obtained are presented in Tables 1 and 2. Table 1 shows the n sample = 92, this was the number of questionnaires submitted to Crombach's alpha coefficient. This means that all samples answered by the students were analyzed, and no case was excluded. Data on the development of investigative skills could not be calculated by the coefficient, as it allowed the respondent to choose more than one alternative.

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**Table 1.** Table of cases of questionnaires processed by the software and submitted to the Crombach's alpha coefficient test.

| Case Processing Summary | | | |
|---|---|---|---|
| | | N | % |
| Cases | Valid | 92 | 100,0 |
| | Excluded | 0 | ,0 |
| | Total | 92 | 100,0 |

**Note:** Valid = Valid, Excluded = Excluded, Cases (each questionnaire represents a case) = Case, N = n sample. Source: Software (IBM, 2011).

Table 2 shows the reliability result obtained in the calculation of Crombach's alpha coefficient. It is possible to observe that all eight questions of the questionnaire were analyzed and calculated for their reliability and representativeness. In addition, the two questions involved in this study were categorized in the objective as the analysis of aspects related to the students' interest in the theme of the activities.

**Table 2.** Reliability statistics of Crombach's alpha coefficient.

| Reliability Statistics | |
|---|---|
| Cronbach's Alpha | N of Items |
| ,750 | 8 |

**Note:** Reliability Statistics = Reliability Statistics, N of items = Number of items (questions). 0.75 = 75%. Source: Software (IBM, 2011).

It is possible to observe in the data in Table 2 that the questionnaire questions evaluated by the coefficient obtained a reliability of 0.75 (75%). This index is categorized as substantial confidence categorized between the indices of 0.61 (61%) and 0.80 (80%). Starting at 0.81 (81%), it is considered near-perfect reliability. In academic studies, an index above 0.70 (70%) is considered representative (LANDIS, KOCH, G.G., 1977).

## STATISTICAL ANALYSIS OF THE DATA

The answers to the opinion questionnaires prepared and made available on *Google Forms,* answered by the participating students about the meetings held, were treated in an Excel spreadsheet due to the greater availability of the tool's resources. Subsequently, these data were analyzed using descriptive statistics tools and graphical analyses developed in the MINITAB 17 software (MINITAB, 2014). The graphic analyses elaborated were: summary graph of descriptive statistics and heat map.

The graphical summary includes graphs: data histogram with an overlapping normal curve, boxplot, 95% confidence intervals. A 95% confidence interval indicates that 19 out of 20 samples from the same population will produce confidence intervals that contain the

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population parameter (MINITAB, 2014). The graphical abstract also displays a table containing the descriptive statistics (mean - standard deviation - variance, median - first quartile - third quartile, sample size N), the Anderson-Darling normality test, and the confidence intervals (mean and median). The Anderson-Darling statistic measures how well the data follow a specific distribution, in this research the normality test was done. If the p-value for the Anderson-Darling test is lower than the significance level chosen, in this study 0.05, it is concluded that the distribution is normal (MINITAB, 2014).

Another approach elaborated was a heat map in an Excel spreadsheet to illustrate the investigative skills most selected by the students in all activities. The map shows the percentages that each investigative skill, addressed in this research, was chosen in the activities carried out and also demonstrates the average percentage of skill selection in all activities. The heatmap method points to "warmer" colors for higher percentages and less "warm" colors for lower percentages.

The questions and variables of the questionnaire had to pass a reliability test to verify whether the data obtained were really meaningful. The coefficient that was used for verification was Crombach's alpha using the IBM SPSS v.20 software (IBM, 2011). The tables with the results of the Crombach Alpha reliability coefficient of the students' perception questionnaire are presented in the Results and Discussion section. Only the questions on the Likert scale (Likert, 1932) of the questionnaire on the students' perception of the activities categorized in the topics of interest in the theme were verified. The index was chosen because it is commonly applied in opinion questionnaires that use the Likert scale model.

## RESULTS AND DISCUSSION

In this section, the data obtained from the opinion questionnaires filled out by the students after each meeting to carry out the dynamics applied with the students participating in this study are presented. The results are presented and described in two sections, related to the objectives. The section demonstrates the descriptive statistics of the questions of the questionnaire regarding the students' interest in the guiding themes of the activities (coastal environmental problems) and the second section focuses on how each of the activities stimulates the use of investigative skills.

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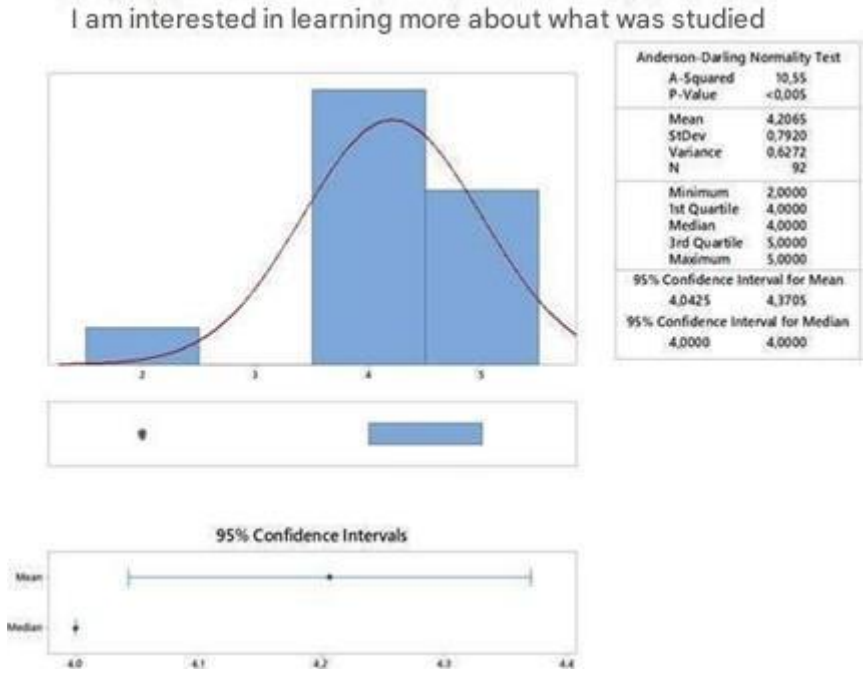
ASPECTS OF STUDENTS' INTEREST IN THE THEMES OF THE ACTIVITIES

Question 1d of the perception questionnaire addressed the interest in learning more about what was studied. This question was categorized within the objectives of the aspects of interest in the theme of the activity. The descriptive analysis is presented in Figure 1.

**Figure 1.** Descriptive statistics of the answers to Question 1d.




**Legend:** 1 = "nothing", 2 = "little", 3 = "I don't know", 4 = "a lot" and 5 = "totally". Mean = Mean, StDev= Standard deviation, Median = Median, Minimum = Lowest chosen index, Maximum = Highest chosen index, Variance = Variance. N = Number of questionnaires in the sample. Prepared in Minitab software with survey data.

The analysis of the data shows that the distribution is not normal. According to the Anderson Darling normality test (pvalue<0.005), the students' choices tend to be options 4 (very) and 5 (totally). The average answer to Question 1d was 4.2065, referring to option 4 ("very"), whose 95% confidence interval is between 4.0425 and 4.3705, not reaching the value of the next option (5 = totally). The median was established at 4 "very", corroborating the average indication. These data show that the tendency of the answers to Question 1d tended to choose option 4 = a lot, which statistically demonstrated that students are interested in deepening the topics studied in the activities.

The descriptive analysis represents the answers to the form referring to this Question 1 and is shown in Figure 2 and the results are similar to the results of Question 1d. The mean value was 4.0761, the 95% confidence interval of the mean was between 3.9045 and 4.2477, where the lower limit falls into band 3 "I don't know". This may be a

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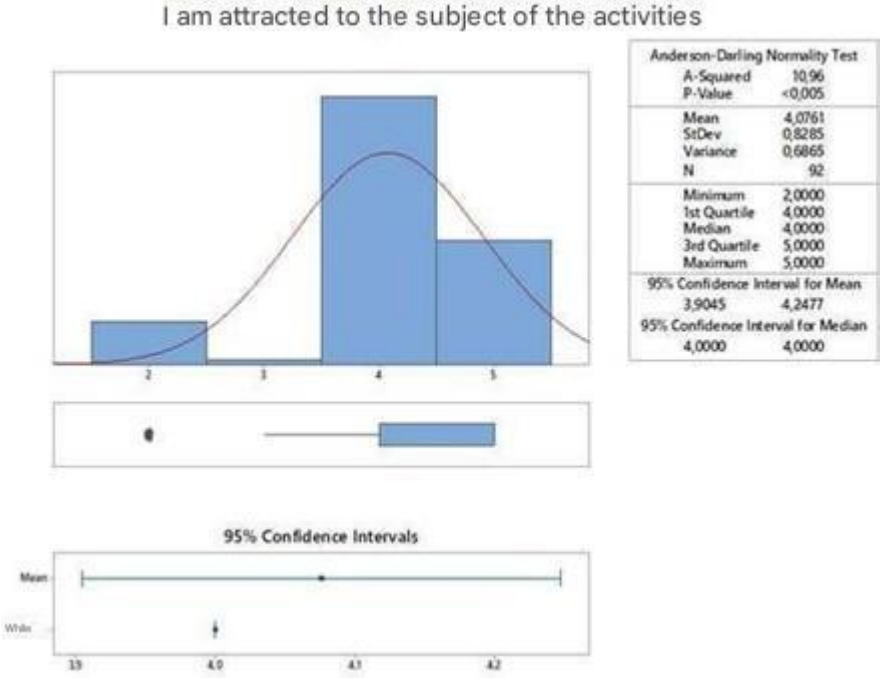
result of the greater dispersion of the answers given that the standard deviation is 0.8285, as there is a higher occurrence of evaluations 2 "little" and the mean is sensitive to extreme values. However, the median is 4 "very much" and the quartiles vary between 4 and 5, demonstrating that most students were very attracted to the subject.

**Figure 2.** Descriptive statistics of the answers to Question 1e




**Legend:** 1 = "nothing", 2 = "little", 3 = "I don't know", 4 = "a lot" and 5 = "totally". Mean = Mean, StDev= Standard deviation, Median = Median, Minimum = Lowest chosen index, Maximum = Highest chosen index, Variance = Variance. N = Number of questionnaires in the sample. Prepared in Minitab software with survey data.

We can conclude that the students found the themes of the activities interesting. Thus, it is verified how the methodology can stimulate the students' interest in environmental problems of the coastal zone in a practical and experimental approach.

## HOW THE VARIOUS THEMES RELATE TO THE USE OF INVESTIGATIVE SKILLS IN EACH ACTIVITY

Another key aspect of the research was to try to understand the behavior of the development of investigative skills. The students selected how many skills they thought had been developed. More than one skill could be stimulated and developed in an activity.

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**Table 3.** Skill development by activity.

| Activity | H1 | H2 | H3 | H4 | H5 | H6 | H7 | H8 | H9 | H10 | H11 | H12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **A1** | 100 % | 100 % | 85% | 46% | 38% | 23% | 77% | 38% | 31% | 46% | 54% | 15% |
| **A2** | 92% | 75% | 83% | 17% | 58% | 0% | 58% | 67% | 50% | 33% | 42% | 0% |
| **A3** | 100 % | 100 % | 64% | 0% | 45% | 0% | 55% | 55% | 55% | 27% | 36% | 0% |
| **A4** | 100 % | 88% | 88% | 0% | 38% | 0% | 88% | 50% | 75% | 25% | 63% | 13% |
| **A5** | 100 % | 90% | 70% | 10% | 60% | 0% | 60% | 40% | 60% | 20% | 60% | 0% |
| **A6** | 91% | 91% | 45% | 9% | 64% | 9% | 64% | 55% | 36% | 27% | 73% | 0% |
| **A7** | 100 % | 83% | 33% | 50% | 67% | 0% | 67% | 50% | 50% | 17% | 50% | 0% |
| **A8** | 100 % | 89% | 56% | 11% | 67% | 22% | 89% | 67% | 56% | 11% | 67% | 0% |
| **A9** | 83% | 83% | 33% | 0% | 50% | 0% | 67% | 83% | 33% | 50% | 67% | 0% |
| **A10** | 100 % | 100 % | 17% | 17% | 17% | 0% | 50% | 67% | 50% | 33% | 67% | 0% |
| **Total** | **97%** | **90%** | **62%** | **16%** | **51%** | **7%** | **67%** | **55%** | **49%** | **29%** | **57%** | **3%** |

**Note:** Prepared in Microsoft Excel software with survey data. The more intense the color, the higher the percentage.

It is important to note that activity 1 (Rocks and minerals at home) and activity 7 (Discovering the characteristics of plants) had in H4 (measuring and using units of measurement), one of the skills with the lowest percentage of choices within the questionnaires, indicating a choice index of 30% and 34%, respectively. Some other noteworthy data were the high values (88% selection) of H7 (analyze data) in activity 4 (Brazilian biomes 2), 20% above the general average and 89% in activity 8 (Moon phases and natural phenomena), 21% above the general average. It is also worth mentioning the data from activity 9 (Comparison of waters) in skills H8 (compare) and H10 (teamwork), with percentages of 83% and 50%, respectively, with values 28% and 21% above the general average. These results indicated the development of an important skill in the scientific method. The importance of exercising teamwork is also valuable, not only for professional life, but also socially, as highlighted in the new BNCC (BRASIL, 2017).

An important counterpoint was to discuss the results of the activities of day 10 (Recycling and Environmental Pollution), 9 (Water Comparison) and 7 (Discovering the characteristics of plants) in the H3 skill (concentrate) which were marked, respectively, 45%, 29% and 29% below the general average. The activity on day 10 (Recycling and Environmental Pollution) also presented a percentage markedly below the total average in the H5 skill (Classify or organize), but the objective of this activity was to stimulate attitudes and contact with sustainable practices (The importance of recycling), in addition to showing

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a practical experiment that evidences the damage of anthropogenic impacts (Environmental pollution). An activity with a below-average index does not show that the activity in question does not develop certain skills, especially if the skill mentioned has a high overall average. It only demonstrates the fact that other dynamics are more effective.

## FINAL CONSIDERATIONS

The stimulus to carry out this research also appears from the intention to understand and collaborate in improving the alarming indices obtained by Brazilian elementary education in national evaluations such as IDEB and in international evaluations such as PISA, where there was low performance in the area of science of Brazilian students. Thinking of alternatives that excite students and introduce the use and development of investigative skills is one of the focuses of attention of professionals and researchers in the area today. Practices and the introduction of investigative skills in the classroom are topics that have recently begun to be studied by academia, as well as the online teaching model. This research sought to introduce new methodologies, investigative practices and evaluation models within these themes. Therefore, complementary works on the themes involved in this research are necessary.

In the results obtained by the research, it was observed in the quantitative analyses how the methodology used brought benefits to stimulate interest in the themes of the activities (coastal environmental problems) and development of investigative skills in the school context of Elementary School II in which the participating students are inserted. Equal access to quality education worked on in research with practical investigative activities carried out in the online model, with students from public schools and with accessible materials found at home is in line with indicators described in SDG No. 4 (UN, 2019). It also helps in structuring projects for the "Ocean Decade" by working on environmental problems that occur in the coastal zone, in a coastal city. The students were encouraged to work on investigative skills by looking at their regional context in a different way from what they were used to.

The questionnaire created in the research obtained an index of 0.75 in Crombach's Alpha coefficient, demonstrating that the data obtained in the opinion questionnaire answered by the students after the activity are representative for the scope of the research. This observed success points to the possibility of innovation in the form of evaluation that was applied in this work.

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In this way, significant learning is favored, discovered through a new way of evaluating. Expanding this study to reach more school actors and educational institutions is important, not only to better understand the area of study, but also to provide new elements to all involved, benefiting the quality of education in Brazil.

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