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Research articles

The use of Scratch in teaching Combinatorial Analysis: a study with high school students based on the Three Pedagogical Moments

O uso do Scratch no ensino de Análise Combinatória: uma investigação com estudantes do Ensino Médio baseada nos Três Momentos Pedagógicos

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Abstract

This article presents partial studies from the first author's dissertation and provides some evidence of the contributions of Scratch software in solving problem situations involving Combinatorial Analysis. This research was applied to a second-year high school class in a public school in the central region of Rio Grande do Sul. The study activities involving Scratch were organized into a Learning Unit, structured with the Three Pedagogical Moments methodology. This is a case study with a mixed-methods research approach, of a descriptive nature. Qualitative data were analyzed using content analysis techniques, and quantitative data using the Wilcoxon test and the Binomial test for proportions. The results showed a significant increase in the learning of Combinatorial Analysis concepts. It was also observed that students analyzed, researched, and developed problem situations, as well as their respective codings, actions that contributed to solving new challenges. In this context, the use of Scratch has proven to be a powerful digital tool for learning, promoting the development of problem-solving skills through programming and experimentation.

Keywords: combinatorial analysis; Scratch; computational thinking; Three Pedagogical Moments; high school.

Resumo

Este artigo apresenta os estudos parciais da dissertação do primeiro autor e apresenta algumas evidências das contribuições do *software* Scratch na resolução de situações-problemas que envolvem Análise Combinatória. Essa pesquisa, foi aplicada em uma turma do segundo ano do Ensino Médio de uma escola da rede pública da região central do Rio Grande do Sul. As atividades de estudo que envolveram o Scratch foram organizadas em uma Unidade de Aprendizagem, estruturada com a metodologia dos Três Momentos Pedagógicos. Trata-se de um estudo de caso com abordagem de pesquisa mista, de natureza descritiva. Os dados qualitativos foram analisados a partir da técnica de análise de conteúdo e os dados quantitativos com o teste Wilcoxon e o Teste Binomial para proporções. Os resultados evidenciaram um aumento significativo na aprendizagem dos conceitos de Análise Combinatória. Observou-se, ainda, que os estudantes analisaram, pesquisaram e elaboraram situações-problema, bem como suas respectivas codificações, ações que contribuíram para a resolução de novos desafios. Nesse contexto, o uso do Scratch mostrou-se uma ferramenta digital potencializadora da aprendizagem, favorecendo o desenvolvimento de habilidades de resolução de problemas por meio da programação e da experimentação.

Palavras-chave: análise combinatória; Scratch; pensamento computacional; Três Momentos Pedagógicos; ensino médio.

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INTRODUCTION

Brazilian legislation on education emphasizes that, starting in elementary school, there is a need to "[...] develop logical reasoning, a spirit of inquiry, and the ability to produce convincing arguments, using mathematical knowledge to understand and act in the world" (Brasil, 2018, p. 267). Various mathematical concepts can contribute to this development from the early years of elementary school. Among them, those related to Combinatorial Analysis stand out, because by proposing problems involving counting and organizing possibilities, for example, they meet the guidelines of the National Common Curriculum (BNCC) and promote the structuring of logical reasoning, the investigation of different solution strategies, and the justification of results through mathematical arguments. An example of this is the passwords we use in various situations in real life (apps, bank accounts, credit cards, etc.), probabilities in games, among others. These situations bring mathematics closer to reality, making its knowledge meaningful and strengthening the ability to understand and act critically in the world. Roa Guzmán (2000, p. 9) points out that

> [...] combinatorial problems and the techniques used to solve them have had and continue to have profound implications for the development of other areas of mathematics, such as probability, number theory, automata theory and artificial intelligence, operations research, combinatorial geometry, and topology. (own translation).

However, studies by Lós and Gusmão (2025), Contessa et al. (2020), and Silveira (2020) indicate that high school students have learning difficulties in relation to Combinatorial Analysis, evidenced mainly by the abstraction of concepts, confusion between arrangements, combinations, and permutations, and the mechanical use of formulas without understanding. These studies highlight that the obstacles stem from traditional methodologies that lack context and the absence of visual or practical resources, which leads to demotivation and poor performance. The studies suggest that strategies such as error analysis, active methodologies, and the use of digital technologies can make teaching more meaningful, encouraging students to investigate and argue mathematically.

These results are similar to those of Prediger, Berwanger and Mörs (2009), Silva (2023) and Silva Neto (2020) regarding mathematics. According to Prediger, Berwanger and Mörs (2009), "Although mathematics is present in people's daily lives, it is not well received, becoming the least interesting subject in schools, which is particularly noticeable in the final grades of elementary school" (p. 23). According to Silva (2023), the lack of interest in mathematics is linked to traditional teaching practices and the absence of connection with real-life situations. Silva Neto (2020) points out that the perception of complexity and the lack of contextualization contribute to students considering mathematics complicated and demotivating. To improve this scenario, new teaching and learning methods and methodologies are being created and used, notably active methodologies (such as flipped classrooms and project-based learning), the use of games and interdisciplinarity, and the incorporation of digital technologies (software, applications, and virtual environments). These resources seek to overcome traditional practices centered on memorization and promote greater engagement and conceptual understanding.

According to Fonte (2008, p. 14), "Given the era we live in, with rapid access to information, it is necessary to rethink mathematics teaching in the area of combinatorial analysis, promoting more and more investigation, reflection, and creativity".

Furthermore, in a society increasingly connected to digital systems and devices, Information and Communication Technologies (ICT) and Digital Information and Communication Technologies (DICT) are part of everyday life in today's society and have gained increasing prominence in educational institutions. Therefore, it is very important that teaching activities provide contact with ICT/DICT, whether as users or producers.

In this study, we propose using Scratch software, as it "[...] was created with the aim of valuing learning through experimentation—learning by doing [...]" (Hentges; Bulegon, 2016, p. 406). It is a visual and playful programming language that uses blocks that fit together to generate command codes. This language encourages creativity, protagonism, and autonomy among its users. And yet

> When using Scratch in the classroom, possible alternatives for students' cognitive growth were identified, as well as flexibility in applying methodological strategies in the classroom, including the possibility of breaking with traditional teaching methodologies used in schools on several occasions, since it provides solutions to predefined or undefined problems in an attempt to challenge thinking to find answers to the case, without them being ready-made (Lima; Ferrete; Vasconcelos, 2021, p. 602).

Scratch is based on mathematical concepts such as Cartesian coordinates, variables, and numbers, as well as concepts of logic. In this sense, our research started from the following question: How can Scratch software contribute to solving problems involving combinatorial analysis? Our goal was to analyze the contributions of Scratch software to learning concepts involving combinatorial analysis.

Among the available software, we chose Scratch because the problem situations involving combinatorial analysis concepts require not only the analysis and interpretation of the data presented, but also the search for the most appropriate strategies and/or mathematical formulas to achieve the expected solution.

This process is somewhat similar to building a code in Scratch, as it is necessary to analyze the project's objective and outline a strategy to develop it. It can be quick, using a few blocks, or it can take longer, requiring the determination of sets of blocks for each desired action.

This work is supported by the BNCC (Brasil, 2018, 2022), which highlights that by developing knowledge of programming languages, students expand their ability to access and produce information in a critical, meaningful, and ethical manner. In addition, by mastering algorithms, data visualization, and analysis—elements of Computational Thinking—students will develop skills and competencies that will enable them to face everyday challenges and take ownership and responsibility for their actions.

THE TEACHING OF COMBINATORIAL ANALYSIS

Combinatorial Analysis can be described, in general terms, as "the part of mathematics that analyzes discrete structures and relationships" (Morgado et al., 2016, p. 1). Methods and techniques for solving counting problems are studied. The methods addressed during the research were: Multiplicative Principle, Simple Permutation, Permutation with Repetition, Simple Arrangement, Arrangement with Repetition, and Simple Combination (Dante, 2016; Santos; Mello; Murari, 2007).

Although these concepts are studied in different school years, discrete structures and relations are defined in greater depth in high school. However, their teaching is generally focused on pedagogical practices marked by the mechanical use of formulas, without conceptual depth or further analysis (Lós; Gusmão, 2025). Studies by Silveira (2020) show that the teaching of combinatorial analysis is still based on inadequate pedagogical practices, centered on formulas, which hinder understanding and lead to student disinterest. Contessa et al. (2020), in their studies, identified that students resort to keywords in problem situations to choose a formula for their resolution, failing to interpret the questions correctly, which often leads to errors and learning difficulties.

SCRATCH[1] *SOFTWARE*

Scratch software is a free, open-source platform that uses block-based programming to enable the creation of games, presentations, and interactive stories. With an easy-to-use interface, it can be used both online and offline. It was developed by Mitchel Resnick at the Massachusetts Institute of Technology (MIT) Media Lab in 2007, located in Boston, USA.

Scratch is applicable in both primary and secondary education, serving as an introductory tool to programming and more advanced coding. Its level of complexity varies according to the audience and the objectives of use. Its creations and activities can easily incorporate a wide range of teaching areas. Figure 1 shows the Scratch creation environment.

[1] Available for manipulation and download at Scratch (2024).

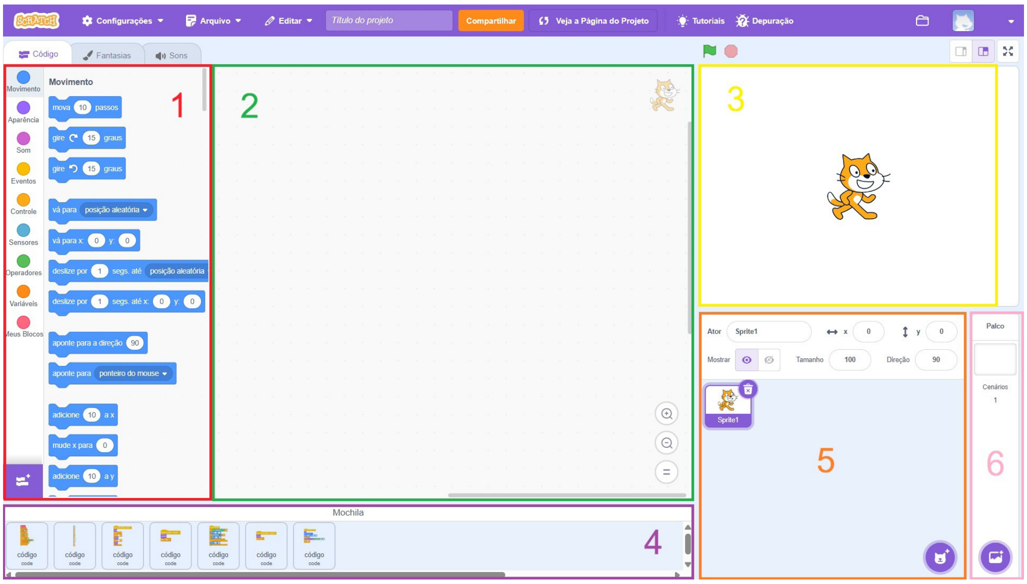

Figure 1. Scratch software Interface.
Source: Author's files.

Chart 1. Description of the main areas of Scratch.

1) Block palette: this is where the instruction blocks are located, which are responsible for each type of action within the software. They are grouped by category: movement, appearance, sound, events, control, sensors, operators, variables, and my blocks. In the latter, users can create their own blocks

2) Editor de *script*: área onde são colocados os blocos para formar os *scripts*, ou seja, são produzidas as programações responsáveis por dar comportamento, posição, tamanho e características aos cenários e personagens de cada projeto

3) Área de visualização: local onde é possível visualizar o funcionamento dos códigos criados no editor de *script*.

4) Mochila: área onde é possível guardar códigos para utilizar em diferentes projetos. Presente apenas na versão *online*.

5) Atores: é a parte onde se pode criar e modificar os atores do projeto.

6) Palco: local onde estão as ferramentas para criar e modificar os cenários do projeto

Source: Elaborated by the authors.

The Scratch screen (version 3.0) consists of columns, the left one of which, for example, contains the programming commands, presented in different colorss of each type of command. Its main areas are described in Chart 1.

To create a project in Scratch, you need to drag blocks into the script editor and connect them together. When you click on a set of blocks, the command will be played back in the preview area. If there is a syntax error, the action will be executed differently than intended, or a warning will be displayed indicating that the code will not work correctly. To illustrate this process, Figure 2 shows a simple maze game project.

The example in Figure 2 shows four codes, one for each arrow on the keyboard, which use the same sequence of blocks. What differs are the values that must be added for each direction of movement. To build it, an Events block (assigning a specific key to the code), a Movement block (adding 10 units to the x or y axis), a Control block (determining what should happen when a sensor is activated), a Sensor block (indicating that when the actor touches the black color, the code inside the Control block is activated), and another Movement block (this will be activated by the sensor that will make the actor move 10 units in the opposite direction of the key used, giving the impression that it is standing still).

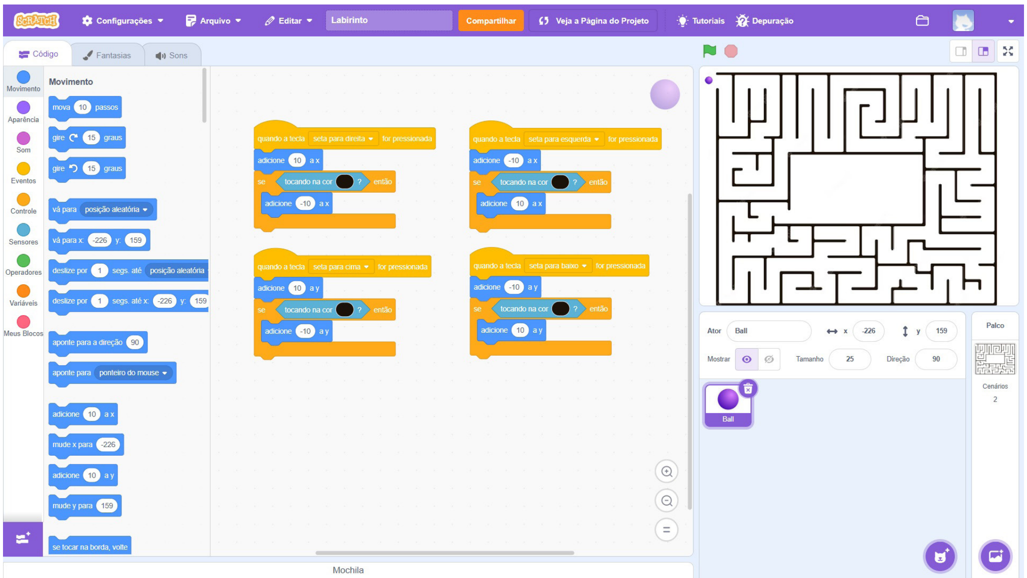

Figure 2. Example of the project at Scratch.
Source: Elaborated by the author using Scratch *online*.

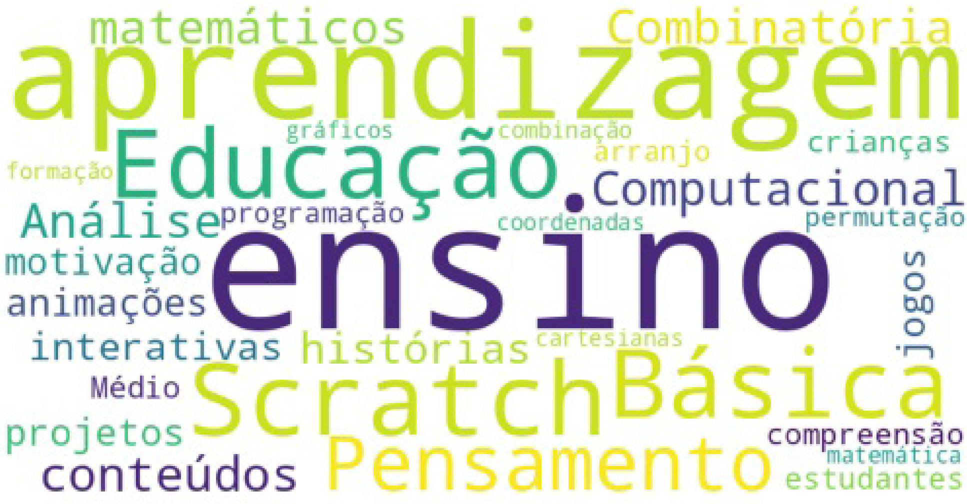

Figure 3. Concepts highlighted in the analyzed works.
Source: elaborated by the authors.

RELATED WORK INVOLVING SCRATCH SOFTWARE IN BASIC EDUCATION

Our research in the CAPES Thesis and Dissertation Catalog, covering publications from the last 10 years on the use of Scratch for teaching Combinatorial Analysis, points to a total of 47 publications, 24 of which were in the field of Mathematics. Based on our reading and summarizing of these works, we created a word cloud (Figure 3) to understand the uses of Scratch in Basic Education.

The alignment of the use of Scratch software with the assumptions of the BNCC and Digital Culture in the context of Mathematics Education is evident. Concepts such as Computational Thinking, Combinatorics, teaching, programming, learning, and Education stand out, indicating the centrality of the development of mathematical skills associated with logical reasoning, problem solving, and conceptual understanding. The recurrence of these concepts points to pedagogical practices that favor the articulation between mathematical concepts and digital resources, which reinforces the understanding that the integration of Scratch in mathematics teaching contributes to innovative practices and meaningful learning, in line with the mathematical skills and abilities provided for in the BNCC.

The mathematical concepts addressed in the dissertations analyzed are: geometry, algebra, functions, among others; however, only Zanini (2021) addressed combinatorial analysis. In his dissertation, Zanini (2021) created a website featuring interactive stories built in Scratch that address different situations in combinatorial analysis. With this website, the author sought to contribute to the teaching and learning of this subject, considering that these stories could spark students' interest.

In addition to this dissertation, we highlight the research by Bulegon and Hentges (2019). These authors report that they used Scratch with children aged 9 to 11 from a public school in central Rio Grande do Sul, developing animations, games, interactive stories, etc. As a result, they highlight the interest aroused in the children, the learning of concepts related to Computational Thinking, and the reinforcement of mathematical content such as graphs and Cartesian coordinates.

Silva (2018) used Scratch to aid understanding and motivation in teaching Combinatorial Analysis to second-year high school students through project development. The students, assisted by the researcher, built codes to calculate Arrangement, Permutation, and Combination over 21 periods of 50 minutes each. According to the author, these activities motivated his students and facilitated their understanding of the content. We highlight this work because it illustrates an important function of Scratch, remixing, which involves the reuse and/or modification of existing codes to create new productions.

In summary, it can be said that the use of Scratch for teaching and learning Combinatorial Analysis is still in its infancy.

METHODOLOGY

The research that gave rise to this article took a mixed approach (qualitative and quantitative), given that the problem is complex, social in nature, and suggests the use of both approaches. The qualitative approach enabled a contextualized understanding of the subjects and the meanings attributed to their experiences (Minayo, 2002), as it is characterized by the collection of descriptive data and the search for a detailed understanding of the phenomena investigated (Gil, 2008). In this study, we primarily analyzed quantitative data from pre- and post-test questionnaires in order to identify the potential of using Scratch in the teaching and learning of combinatorial analysis by students. According to Chizzotti (2001), qualitative research does not exclude the use of measurable data. As for technical procedures, we adopted the case study method to investigate a contemporary phenomenon in a specific educational context (Yin, 2001).

Two questionnaires and the projects developed by participants using Scratch were used for data collection. These projects were monitored during development and subsequently shared with the researcher via email. Observation and a teaching practice diary were used for recording purposes. The data were analyzed in two ways: through content analysis and statistical tests. We used the Wilcoxon test (to verify the normality of the variables) and, in the individual study of the questions, a Binomial Test – proportions was applied. IBM SPSS software (Version 25) was used as a computational tool for statistical data analysis.

Fourteen students from a second-year high school class at a public school in the municipality of São João do Polêsine, Rio Grande do Sul, participated in the study. Data collection took place during regular mathematics classes in the morning, totaling eight class hours distributed throughout the period of the pedagogical intervention. The activities were carried out in the school environment, in the classroom, and integrated into the subject's curriculum.

The research subjects were chosen intentionally, considering the relevance of the content selected for the research — Combinatorial Analysis — which is part of the second-year high school curriculum, as well as the possibility of integrating digital resources, such as Scratch software. In addition, the research location was selected due to the academic partnership established with the class teacher, who is linked to the same Graduate Program as the researcher, which enabled the development of activities and data collection. The teaching activities with Scratch were organized into a Learning Unit (LU) as described below.

LEARNING UNIT (LU) – ACTIVITIES DEVELOPED

The LU on Combinatorial Analysis, planned with Scratch, was organized according to the Three Pedagogical Moments (TPM) methodology proposed by Delizoicov, Angotti and Pernambuco (2007), which presents the following stages: Initial Problem-Solving (IPS), Knowledge Organization (KO), and Knowledge Application (KA). During IP, the knowledge and difficulties presented by the students are identified, so that in KO the acquired knowledge can be reviewed and new concepts developed, and in CA all this learning is put to the test with applications and activities. It is important to note that student development is the main result of this process. Test scores can help identify this evolution, but the reasoning presented when performing the activities is more relevant in this process.

The application was divided as follows (Chart 2): pre-test (PI stage), familiarization and use of the Scratch software and review of the contents of Combinatorial Analysis (OC stage) and project development and post-test (AC stage). In Chart 2, we present the Learning Unit (LU) proposed for this research.

The first meeting was reserved for presenting the project to the students, followed by the pre-test. At the second meeting, after checking the pre-test results, there was a review of the concepts of Combinatorial Analysis, problem-solving strategies, and clarification of questions about the content. At the third meeting, Scratch and its features were presented, after which the participants solved problems related to the content in the software. Finally, they were given the task of creating a Combinatorial Analysis activity in Scratch. In the following meetings, the participants' projects were developed and finalized. In the last meeting, a post-test was conducted to quantitatively assess whether there had been a change in the participants' performance in solving the proposed exercises.

RESULTS AND DISCUSSION

This project was submitted to the Research Ethics Committee (CEP) of the Franciscan University (UFN), in accordance with resolution 510/16 of the National Council for Ethics in Research (CONEPE), and approved under number 6,421,396. After its approval by the CEP, the data were collected and analyzed. Its results are presented here.

Each participant answered the pre-test questions individually. The analysis of the results of these questions formed the basis for the revision of the Combinatorial Analysis content in Lesson 3. In the following meetings, the participants were taken to the school's computer room, equipped with Chromebooks (laptops that use the ChromeOS operating system, developed by Google, with a focus on speed, simplicity, and cloud integration). The Scratch software was introduced, presenting its tools and project possibilities. An activity with five Combinatorial Analysis problem situations was created in Scratch by the researcher and served as an example of possible coding and actions that could be performed with the software.

Chart 2. Learning Unit on Combinatorial Analysis with Scratch.

TMP	Classes/hours	Actions
PI	Classes [1] and [2] - 2 h	Presentation of the Activity Proposal; Signing of the Informed Consent Form; Pre-Test
OC	Class [3] - 1 h	Review of Combinatorial Analysis Concepts
OC	Classes [4] and [5] - 2 h	Getting started with Scratch; Application of an activity developed with Scratch on Combinatorial Analysis
AC	Classes [6] and [7] - 2 h	Learning Assessement
AC	Classes [8] - 1 h	Post-Test

Source: Elaborated by the authors.

Next, the participants formed groups and began creating projects with Scratch, which should have the concepts of Combinatorial Analysis as their theme. Finally, the other action was the application of the post-test, putting into practice the knowledge of Combinatorial Analysis that they had developed.

Three groups sent projects by email to the researcher. The first group presented two questions (Figure 4): one on the Multiplicative Principle and another on Permutation. In these, the participants sought to use images that are present in the statements, showing harmony between writing and visualization of the project.

In these projects, it is possible to identify the use of some concepts of Combinatorial Analysis, such as the multiplicative principle and permutation, and the development of the initial steps within Scratch. The selection of each block that composed the code for each project contributed to analysis, pattern recognition, abstraction, decision making, logical reasoning, and elements that favor the learning of Combinatorial Analysis. The second group created two questions (Figure 5): the first to solve a simple permutation; the second with a permutation with repetition.

From this image, it is clear that there was a concern to use visual elements from the statement in the presentation. In the first situation, the group intended to use the word "giraffe" for the situation, but as there was a repeated letter, they decided to name the character so that the question would be about a simple permutation. Something that was missing in this case was the symbol "!" to represent the factorial in the formula. In the second situation, the participants began solving the question using the expression $P_n = n!$, from the simple permutation calculation, but the solution presented refers to permutation with repetition,

$$P_n^{\alpha,\beta,\gamma} = \frac{n!}{\alpha!\beta!\gamma!} \quad (1)$$

Among the projects submitted, group 3 presented the most difficult questions (Figure 6), as they were taken from university entrance exams. To select the questions, participants researched, analyzed, and solved them before deciding to use them in their project. To complete the activities, they remixed parts of ready-made Scratch projects that they found in an online tutorial. They also reported that they enjoyed working with Scratch and found it relatively easy to use.

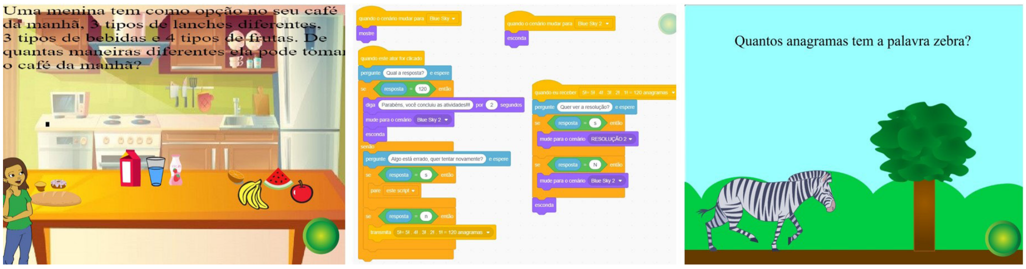

Figure 4. Situations 1 (Multiplicative Principle) and 2 with one of the encodings (Permutation) from group 1.
Source: Author's files.

Figure 5. Situations 1 (Simple permutation) and 2 (Permutation with repetition) from group 2.
Source: Authors' files.

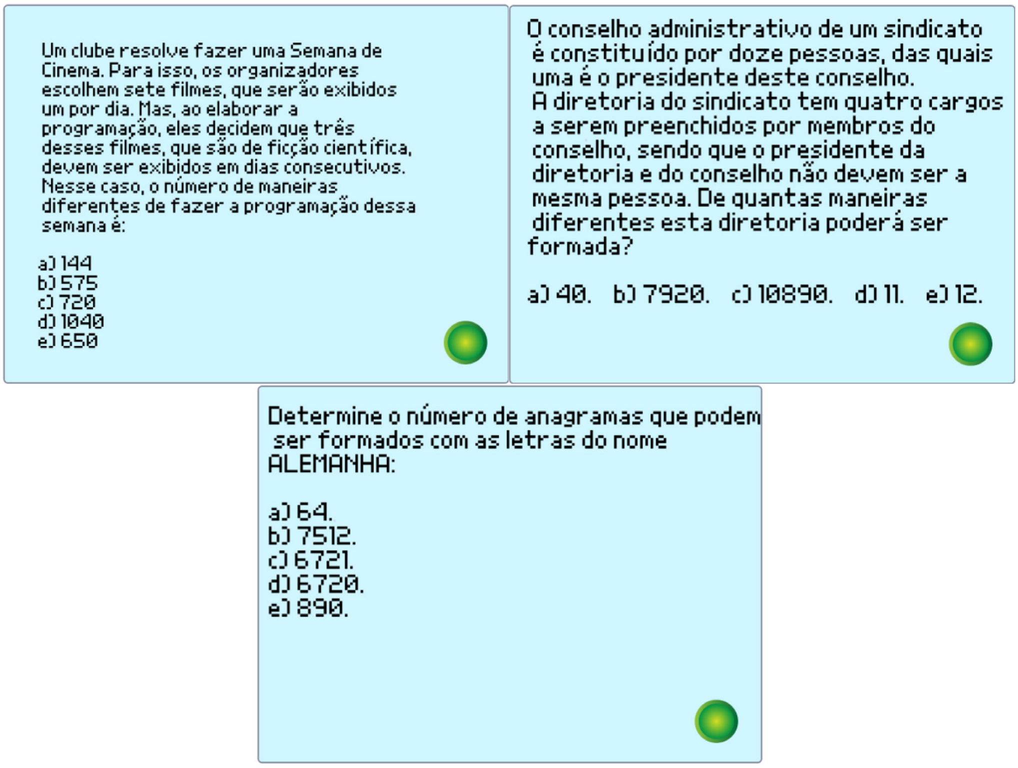

Figure 6. Situations 1 (Permutation), 2 (Simple Arrangement) and 3 (Permutation with repetition) from group 3.
Source: Authors' files.

The first question, taken from an entrance exam for the Federal University of Minas Gerais (UFMG - 2000), contains two permutations: one for the possibilities of consecutive films ($P_3 = 3!$) and another for films during the week ($P_5 = 5!$, it should not be 7 because the 3 consecutive films are considered as one element). Finally, the results of the permutations are multiplied together, 3! × 5! = 6 × 120 = 720. The second question, taken from the entrance exam for the State University of São Paulo (UNESP - 2003), addresses a simple arrangement. Of the twelve people on the board, one is the president and cannot be president of the board of directors. Thus, there are 11 possibilities for the position of board chair, and the other three positions on the board can be calculated by P^3, which results in 990. Multiplying 11 by 990, we then have 10,890 different possibilities for the board. Finally, they used a situation involving the number of anagrams of a word. The last question deals with a case of permutation with repetition. In this case, we have the permutation of all the letters of the word, divided by the permutation of the repeated letters.

Thus, $\frac{9!}{3!}$ resulting in 6,720 possible anagrams.

While the other projects had to be answered with the final value of the situation, in this one alternatives were given and the answer was given by the corresponding letter. It is possible that they used this form of answering because two questions were from college entrance exams, which are multiple choice. In any case, the selection of questions indicates recognition of the concepts of combinatorial analysis and knowledge of it for its resolution. The use of Scratch helped students overcome difficulties in combinatorial analysis by enabling the transformation of abstract concepts into manipulable visual experiences. This approach clarified the distinction between arrangement and combination and demonstrated, in a practical way, how permutation with repetition works. These results corroborate the findings of Hentges and Bulegon (2016), who state that Scratch promotes learning by doing. Similarly, the tool offers an alternative for students' cognitive development through its flexibility and the new methodological possibilities it provides (Lima; Ferrete; Vasconcelos, 2021), in addition to promoting activities that stimulate investigation, reflection, and creativity (Fonte, 2008).

ANALYSIS OF COMBINATORIAL ANALYSIS LEARNING

Before and after developing projects with Scratch, participants took tests containing questions on combinatorial analysis (Chart 3) to measure Scratch's contribution to learning combinatorial analysis.

To solve the problems, participants used the Multiplicative Principle (MP) for most of the situations proposed. According to the class teacher, during her Combinatorial Analysis classes, she emphasized the importance of using this principle to solve problems on this topic. Questions 1, 2, and 4, which addressed the concepts of (1) Multiplicative Principle, (2) Simple Arrangement, and (4) Simple Permutation, were the ones with the most correct answers. The fifth question, "How many anagrams does the word CAR have?", 7 got it wrong because they interpreted it as a simple permutation and not with repetition. The third situation was a case of simple combination, and none of the participants managed to arrive at the expected result. The participants interpreted it as a simple arrangement and/or used the multiplicative principle incorrectly. As for question 5, which dealt with a permutation with repetition, only 6 of the 13 participants present got it right. In this case, most of those who got it wrong solved it as a simple permutation, failing to divide the result by the repeated elements.

In the post-test, after the research activities were applied, questions 3 and 5 showed the greatest increases in correct answers. Some participants still continued to use the Multiplicative Principle for resolution, but showed better interpretation of the problem situations.

The number of correct and incorrect answers for each question was entered into IBM SPSS software (version 25), and the Wilcoxon and Binomial tests were applied. The differences were considered significant, as the results showed a p-value < 0,05.

The data in Table 1 show a significant difference in the increase in the number of correct answers ($p = 0.014$). Before the activities proposed with Scratch, students had an average performance of 3 correct answers, and after, it increased to 4.1, which highlights the contributions of the proposed activities.

Table 2 shows that questions 3 ($p = 0.001$) and 5 ($p = 0.0148$) had a significant increase in participants' scores. Question 3 had a yield that went from 0% correct answers to 50%, and in question 5, students had an increase in correct answers that went from 46.1% to 91.7%. The increase in the number of correct answers in each question can be seen in Figure 7.

Only question 2 did not show an increase in the number of correct answers. In the other questions, students had more correct answers in the post-test than in the pre-test. Thus, we understand that the activities proposed using Scratch contributed to the learning of the topic of combinatorial analysis.

Chart 3. Pre-test and Post-test Questions.

1) Uma lanchonete vende uma promoção de lanche a um preço único. No lanche, A snack bar sells a snack promotion at a single price. The snack includes a sandwich, a drink, and a dessert. Three sandwich options are offered: special hamburger, vegetarian sandwich, and hot dog with all the trimmings. There are two drink options: apple juice or guaraná. For dessert, there are four options: cherry cupcake, chocolate cupcake, strawberry cupcake, and vanilla cupcake. Considering all the options offered, how many ways can a customer choose their snack?
2) How many four-digit natural numbers can be formed using the digits 2, 3, 4, 5, 6, 7, 8, and 9?
3) We need to set up a graduation committee with 3 members. 10 people have applied. How many different ways can this committee be formed?
4) How many anagrams can we create with the word BRAZIL?
5) How many anagrams does the word CAR have?

Source: Elaborated by the authors.

Table 1. Analysis of pre and post test moments – Wilcoxon Test.

Pre		Post		p
Medium	SD	Medium	SD	
3	1.3	4.1	0.7	0.014

SD = Standard Deviation.

Source: Research data.

Table 2. Analysis of individual questions before and after the test – Binomial test for proportion.

Questions		Pre	Post	p
1	Accuracies	10	12	0.0761
	Performance	76.9%	100%	
2	Accuracies	9	8	0.8908
	Performance	69.2%	66.7%	
3	Accuracies	0	6	0.001
	Performance	0%	50%	
4	Accuracies	10	12	0.0761
	Performance	76.9%	100%	
5	Accuracies	6	11	0.0148
	Performance	46.1%	91.7%	

Source: Research data.

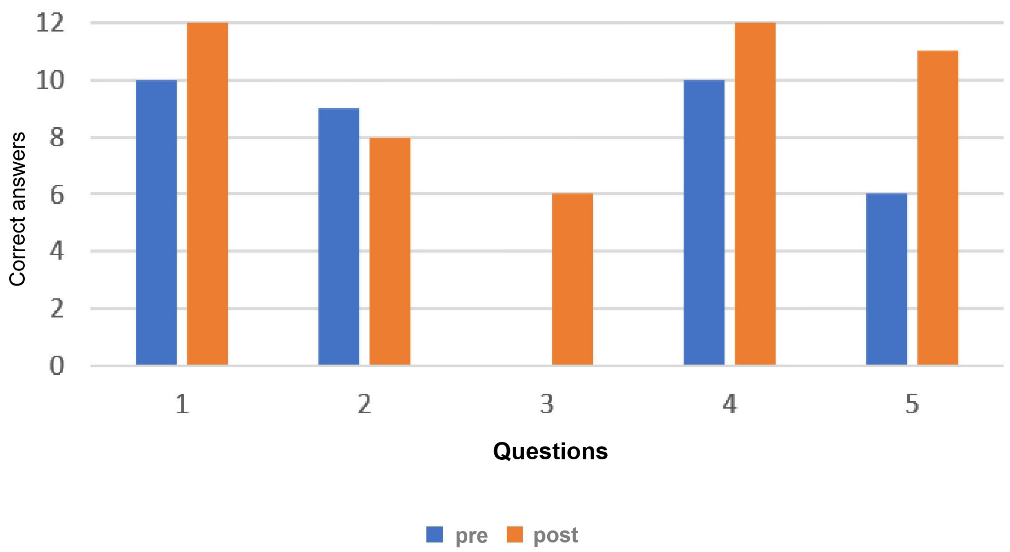

Figure 7. Comparative Graph between pre and post – test.
Source: Research Data.

FINAL CONSIDERATIONS

With the aim of analyzing the potential and contributions of Scratch software in solving problems involving combinatorial analysis, this research was conducted with 14 students in their second year of high school at a state school in Rio Grande do Sul.

Based on a theoretical review, it was found that interpreting the statements and choosing the most appropriate solution method are the main obstacles faced. There was also a lack of studies using Scratch as a tool to support the understanding of Combinatorial Analysis.

The results showed that the TMP methodology and Scratch contributed to overcoming these gaps. The students' participation in developing projects with Scratch revealed a basic knowledge of Combinatorial Analysis, noticeable in the choice and creation of problem situations and in the application of the software as a teaching resource. It was observed that they analyzed, researched, and created problem situations, as well as their respective coding; actions that, according to the students themselves, contributed to the resolution of other issues later on. Scratch's visual and interactive interface helped students overcome difficulties in combinatorial analysis because it transformed abstract concepts (such as arrangement, combination, and permutation with repetition) into concrete experiences, allowing for the manipulation of elements, immediate simulations, and comparison of results, the resolution of problems in a logical and creative way, the conscious use of digital resources, and the active construction of knowledge through programming and experimentation.

Among the limitations of the study, it should be noted that the participants had their first contact with Scratch in this work, which influenced their performance in developing activities focused on the application of combinatorial analysis concepts. On the other hand, the use of Scratch enabled the learning of a programming language and contributed to the expansion of digital literacy.

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Authors contribution

LLN: Conceptualization, Methodology, Project management, Data management, Data collection, Statistical analysis, Data analysis, Resources, Software, Visual data preparation, Writing. CTM: Methodology, Statistical analysis, Data analysis, Resources. AMB: Conceptualization, Methodology, Project management, Validation, Writing, Review.

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