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LOGO na Educação: Construindo Fundamentos Lógicos e Aprimorando o Pensamento Matemático
LOGO in Education: Building Logical Foundations and Enhancing Mathematical Thinking
LOGO en la educación: Construyendo Bases Lógicas y Potenciando el Pensamiento Matemático
LOGO dans l'éducation: Construire des Fondements Logiques et Améliorer la Pensée Mathématique

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Resumo
Este artigo apresenta um projeto que integra programação e robótica ao ensino fundamental por meio do software SuperLogo. O objetivo foi avaliar seu impacto no desempenho acadêmico dos estudantes de uma escola municipal localizada no município de Foz do Iguaçu, Paraná, Brasil. A metodologia envolveu capacitação técnica para professores, suporte com um manual

instrucional e implementação de atividades pedagógicas. O estudo acompanhou 125 alunos ao longo de cinco anos, com uma faixa etária entre 6 a 10 anos. A análise considerou três índices de desempenho: *(i)* a relação entre Médias de Notas e Alunos (GS), *(ii)* a Variação Percentual e Médias de Notas (PG) e *(iii)* a Variação Percentual e Alunos (PS). Os resultados indicaram um impacto positivo: 77,6% dos alunos melhoraram seu desempenho, 21,6% apresentaram queda e 0,8% permaneceram estáveis. O crescimento médio anual variou de 9,99% (2018) a 23,54% (2023). A introdução do software SuperLogo se mostrou como uma ferramenta eficaz para o ensino de Matemática e raciocínio lógico na educação pública.
Palavras-chave: Desempenho acadêmico, Ensino fundamental, Robótica educacional, SuperLogo.

Abstract
This article presents a project that integrates programming and robotics into elementary education with SuperLogo software. The objective was to assess its impact on the academic performance of students at a municipal school in Foz do Iguaçu, Paraná, Brazil. The methodology involved technical training for teachers, support through an instructional manual, and the implementation of pedagogical activities. The study monitored 125 students over a five-year period, aged between 6 and 10 years. The analysis considered three performance indicators: (i) the relationship between Grade Averages and Students (GS), (ii) the Percentage Variation and Grade Averages (PG), and (iii) the Percentage Variation and Students (PS). The results indicated a positive impact: 77.6% of the students showed improvement in performance, 21.6% experienced a decline, and 0.8% remained stable. The average annual growth ranged from 9.99% (2018) to 23.54% (2023). The introduction of the SuperLogo software proved to be an effective tool for teaching Mathematics and logical reasoning in public education.
Keywords: Academic performance, Elementary school, Educational robotics, Superlogo.

Resumen

Este artículo presenta un proyecto que integra la programación y la robótica en la educación primaria mediante el uso del software SuperLogo. El objetivo fue evaluar su impacto en el rendimiento académico de los estudiantes de uma escuela municipal de Foz do Iguaçu, Paraná, Brasil. La metodología incluyó capacitación técnica para los docentes, apoyo a través de un manual instructivo y la implementación de actividades pedagógicas. El estudio hizo un seguimiento de 125 alumnos durante un período de cinco años, con edades comprendidas entre los 6 y los 10 años. El análisis consideró tres indicadores de desempeño: (i) la relación entre Promedios de Notas y Alumnos (GS), (ii) la Variación Porcentual y Promedios de Notas (PG) y (iii) la Variación Porcentual y Alumnos (PS). Los resultados indicaron un impacto positivo: el 77,6 % de los estudiantes mejoraron su rendimiento, el 21,6 % presentaron una disminución y el 0,8 % permanecieron estables. El crecimiento promedio anual osciló entre el 9,99 % (2018) y el 23,54 % (2023). La introducción del software SuperLogo demostró ser una herramienta eficaz para la enseñanza de Matemáticas y del razonamiento lógico en la educación pública.

Palabras clave: Rendimiento académico, Educación primaria, Robótica educativa, SuperLogo.

Résumé

Cet article présente un projet intégrant la programmation et la robotique à l'enseignement primaire à travers l'utilisation du logiciel SuperLogo. L'objectif était d'évaluer son impact sur la performance académique des élèves de d'une école municipale de Foz do Iguaçu, dans l'État du Paraná, au Brésil. La méthodologie a impliqué une formation technique destinée aux enseignants, l'élaboration d'un manuel d'instructions, ainsi que la mise en œuvre d'activités pédagogiques. L'étude a suivi 125 élèves sur une période de cinq ans, âgés de 6 à 10 ans. L'analyse a pris en compte trois indicateurs de performance: (i) la relation entre Moyenne des Notes et Élèves (GS), (ii) la Variation en Pourcentage et Moyenne des Notes (PG), et (iii) la Variation en Pourcentage et Élèves (PS). Les résultats ont indiqué un impact positif : 77,6 % des élèves ont amélioré leurs performances, 21,6 % ont connu une baisse et 0,8 % sont restés stables. La croissance annuelle moyenne a varié de 9,99 % (2018) à 23,54 %

(2023). L'introduction du logiciel SuperLogo s'est révélée être un outil efficace pour l'enseignement des Mathématiques et du raisonnement logique dans l'éducation publique.

Mots-clés: Performance académique, Enseignement primaire, Robotique éducative, SuperLogo.

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Introduction

The advent of the technological era, driven by the prelude of the industrial age, has profoundly transformed social interaction and established technology as an essential element for human survival. More than merely facilitating mechanical and industrial processes, its impact extends across various fields, including health, culture, and, most notably, education (Mayor & Forti, 1998). In the educational context, using technological tools fosters dynamic and engaging learning, creating a creative environment for knowledge construction. Educational robotics, in turn, integrates these tools into teaching at different levels, enabling students to assemble and program robots, thereby bridging theory and practice. This multidisciplinary approach enhances logical reasoning and facilitates the application of concepts across various fields of knowledge (Castilho, 2002).

In the 1960s, Seymour Papert, director of the Epistemology and Learning Group at MIT, recognized the growing influence of technology on society and, inspired by Jean Piaget's theories, developed the concept of constructionism, which emphasizes learning through experimentation and interaction, particularly via computers (Correia & Silva, 2005). Within this framework, Papert and a group of MIT researchers created the LOGO programming language, designed to allow children over the age of six to program and draw geometric figures. LOGO, shaped by principles from Artificial Intelligence, the Lisp programming language, and Piagetian theory, revolutionized education by promoting logical thinking and shifting the focus from mere knowledge validation to active knowledge construction (Júnior, 2002).

In this context, the LOGO programming language brought innovation to education by enabling children to control an on-screen robot, represented by a turtle, to create drawings and explore programming concepts. By transforming the computer into an interactive tool, LOGO stimulates cognitive development through experimentation. Its methodology stands out by placing control of the learning process in the hands of the child, allowing them to explore and develop projects based on their own interests. Unlike traditional methods, there are no single or predetermined answers; knowledge is constructed through reflection on the outcomes generated by the commands, making learning more interactive (Brasão, 2021; Pimentel, 2011).

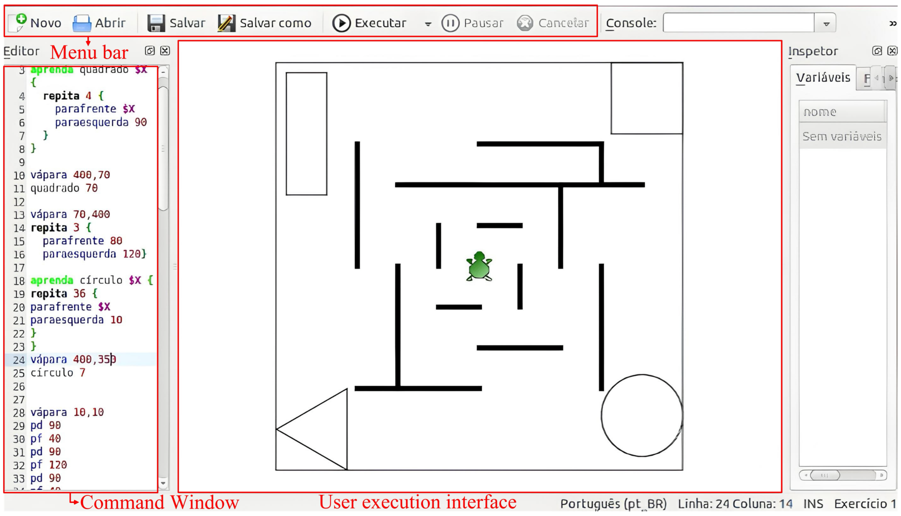
In the educational context, students lack motivation toward their studies has become an increasing challenge, particularly due to strong competition from technologies and toys that capture their interest more than school does. The absence of engaging stimuli in the school environment contributes to passivity, indiscipline, and even dropout rates. This highlights the need to make learning more engaging by adopting innovative pedagogical strategies and integrating technological resources to spark curiosity and a desire to learn, especially in subjects such as mathematics (Marques, 2019).

Unlike other programming languages that require more advanced prior knowledge for effective use, the LOGO language allows users to achieve meaningful results with a reduced set of commands, making its learning process more accessible due to the lower complexity involved in creating activities. Another distinctive feature is the possibility for users to define their own words, which are incorporated into the language's vocabulary (Tulio Chella, 2002).

The introduction of Robotics and Programming in basic education, particularly in the early years of elementary school, has proven to be an effective strategy for stimulating children's cognitive development, fostering their autonomy, creativity, and logical reasoning. The use of accessible technologies, such as the SuperLogo® software, based on the LOGO language, facilitates digital inclusion in both public and private education, allowing teachers to use the tool to make learning more interactive and accessible (Piaget & Inhelder, 2000).

Figure 1 presents the initial screen of the SuperLogo® software. The initial interface includes a command window, where users can input and execute instructions using the available buttons. Additionally, there is a Menu Bar that provides access to various tools and features of the program, facilitating its usability.

Figure 1: SuperLogo® programming environment.



This language promotes hands-on learning by letting students explore concepts through programming the turtle to solve problems. As they run commands, they compare the results with their expectations. The integration of methodology and software turns errors into opportunities for learning. Programming the turtle starts with analyzing how it should act leading children to reflect on their own thinking. Like early learning through exploration, LOGO encourages understanding by using mistakes as learning tools, not failures (Correia & Silva, 2005).

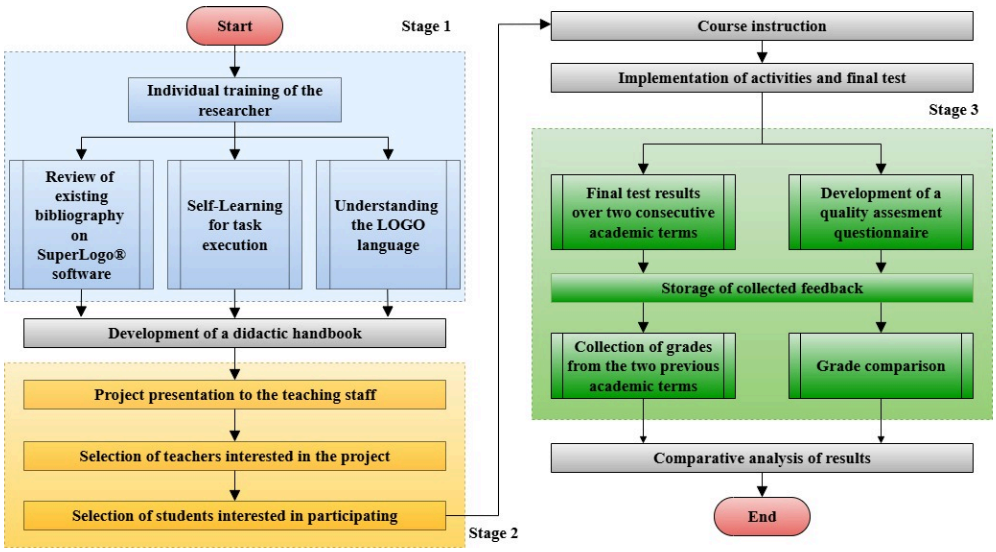
Based on this position, this study aims to evaluate the academic performance of 3rd-grade (8-9 years old) students at a municipal school in Foz do Iguaçu, Paraná, Brazil, following the implementation of SuperLogo® software based on the previously analyzed characteristics of the LOGO language and methodology, as well as the educational challenges identified. Performance was assessed using linear and nonlinear regression models and validated through regression metrics, providing a quantitative measure of the software's impact on Mathematics, Basic Robotics education, and the development of logical reasoning in a public elementary school context.

The implementation environment in public schools faces three main challenges: *(i)* teachers' lack of familiarity with the subject; *(ii)* the integration of pedagogical robotics elements into their lessons; and *(iii)* the lack of a well-equipped computer and robotics laboratory. Despite progress in digital inclusion, many public schools continue to struggle with barriers that hinder students' engagement with STEM and technology fields. In this context, promoting active participation, encouraging problem-solving, and fostering key skills are essential to making robotics education more dynamic and effective (Oliveira et al., 2015). Further implementation details are provided in (NIED/Unicamp, 2019).

Methodology

The main stages of the methodology to be adopted are described, from researcher training to the comparative analysis of results based on the feedback obtained. As shown in Figure 2 , the project consists of three main stages, comprising the processes and sub-processes necessary to achieve the desired outcomes.

Figure 2: Methodological flowchart.



Stage 1 aims to train the researcher through bibliographic research and theoretical foundation, combined with hands-on learning of the LOGO language. This is accomplished through the execution of test routines, enabling

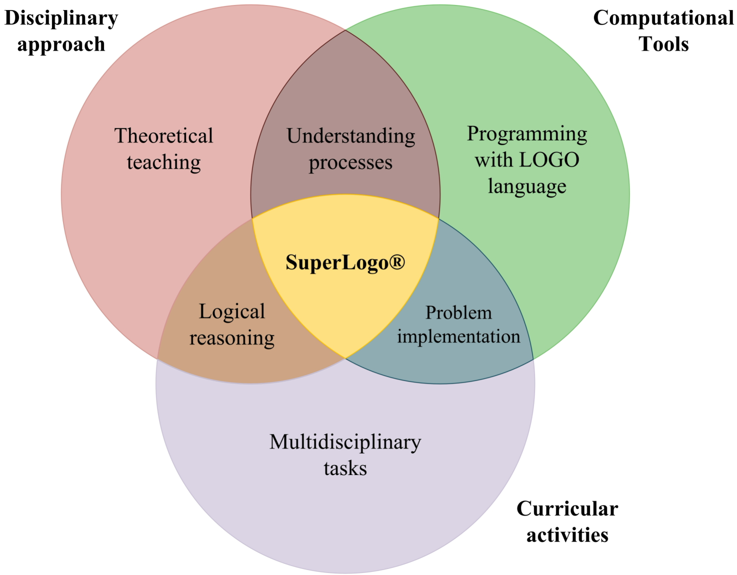
an understanding of the technical approach of the SuperLogo® and its application with robots. The outcome is consolidated into a didactic handbook.
Stage 2 involves presenting the project to elementary school mathematics teachers at the participating school, followed by the selection of interested teachers and the students who will join the classes and commit to improving their performance in the subject. Once the groups are defined, the course is conducted through weekly lessons, utilizing computational resources provided by the school or the students themselves. At the end of the course, students undergo a practical assessment, in which they develop a program using SuperLogo®.
Stage 3 focuses on evaluating the course results by administering a quality assessment questionnaire to teachers, showed in Table 1. The analysis combined two complementary data sources: students' academic grades and teachers' qualitative feedback. The quantitative dimension consisted of comparing the average grades from the first two academic terms—prior to the introduction of the programming and robotics course—with those from the two subsequent terms in which students participated in the project. In parallel, teachers provided structured feedback on students' engagement, reasoning, and collaboration, which was triangulated with the grade data. This approach made it possible to measure the project's impact on academic performance.

Table 1: Questions on the Use of SuperLogo®.

Did you notice an improvement in students mathematics grades after using SuperLogo®? If so, in what way?
Did SuperLogo® help develop students logical reasoning for solving mathematical problems? Can you provide examples?
Was there greater interaction and collaboration among students during activities with SuperLogo®? How did this manifest?
Did students demonstrate more autonomy in solving mathematical problems after using the software?
Would you recommend the continued use of SuperLogo® in mathematics teaching? Why?

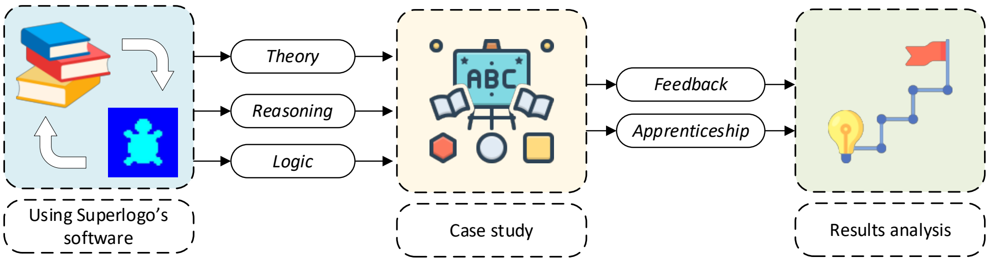
This study employs a case study design, allowing for an assessment of the implementation of SuperLogo® in mathematics education. The analysis of grade averages adopts a positivist perspective focused on measurable performance changes, whereas the integration of teachers' feedback adds an interpretative lens to reveal the pedagogical effects involved.
Although the stages are developed sequentially, they remain interrelated, enabling a dynamic integration of concepts. This structure highlights the connection between disciplinary content, computational tools, and curricular activities, as shown in Figure 3. At the center of this intersection, SuperLogo® serves as a convergence point for process understanding, logical reasoning, and problem-solving, illustrating its role in bridging theoretical and practical teaching through computational applications

Figure 3: Representation of connections in the educational process.



This systematic approach, summarized in the framework illustrated in Figure 4, enables an understanding of the proposed methodological development and allows for an evaluation, across different teaching stages, of how SuperLogo® can impact the performance of elementary school students. A detailed explanation of how this approach is implemented is provided in the following subsections.

Figure 4: Framework guiding the analysis of SuperLogo® in the study case porposed.



Disciplinary Approach in Classes

The methodological approach of the lessons is structured around a preliminary theoretical study, conducted after stage 1 and before the beginning of the educational sessions. This study aims to provide a better understanding of the tool to be used. In this process, the computer is integrated as a pedagogical tool that enables students to explore their intellectual potential and develop multidisciplinary ideas, enhancing their ability to reflect and abstract through successive actions (De Almeida, 2012).

The educational sessions were structured in collaboration with the school's pedagogical team to create an engaging environment, making the content learned in the classroom more appealing. The curriculum included topics such as the use and functionality of the SuperLogo® and the application of the LOGO language in connection with students' curricular components. As a pedagogical strategy, creativity and experimentation—through trial and error—were encouraged to solve problems.

Pedagogical Activities and Final Test

The planning of the developed activities aims to balance traditional teaching-learning practices in the classroom with activities that use the computer as a pedagogical tool. These activities are structured within interactive environments, encouraging students to investigate, formulate hypotheses, and refine their initial ideas. The educator's role is crucial in identifying strategies that help students understand the significance of science, its structures, and its social implications, while also fostering the development of logical thinking through the formulation of estimates and hypotheses (Moraes, 2010).

In the LOGO environment, students take control of the computer, using a programming language that aligns with their cognitive process. The methodology suggests that, by teaching the turtle to "think," children gain a deeper understanding of their own reasoning. During this stage, students begin to develop their own projects, such as drawing houses or animals, thereby materializing the LOGO methodology in the teaching-learning process. The course concludes with a final test, in which students apply their acquired knowledge to create a program using the SuperLogo® (Papert, 1985).

Comparative Analysis

To assess the impact of the course, a comparative analysis will be conducted based on three main indices: *(i)* the relationship between the Grade Averages and Students (GS); *(ii)* the Percentage Variation and Grade Averages (PG); and *(iii)* the Percentage Variation and Students (PS). The use of these three indices is justified by their ability to capture complementary aspects of students' academic performance after the integration of SuperLogo®. The GS index highlights how improvements in grades are distributed across the class. The PG index measures proportional growth in academic performance, providing a comparison between pre- and post-intervention results. The PS index assesses the extent to which the number of students showing improvement increases over time.

In the context of Brazilian elementary education, the academic year is traditionally divided into four bimester terms (or, in some cases, trimesters). For the purposes of this study, two distinct averages were established: Average 1 and Average 2. The Percentage Variation (PV) is described by Equation (1)

$$PV = \frac{Average_2 - Average_1}{Average_1} . 100\ [\%] \tag{1}$$

where $Average_2$ is the arithmetic average of the grades from the last two academic terms, and $Average_1$ is the arithmetic average of the grades from the first two academic terms in a school year in which the project had not yet been implemented. The comparison between these two averages is relevant because it enables the identification of significant improvements in performance throughout the year, isolating the effect of the intervention—the use of SuperLogo®. This methodological approach is especially appropriate in the Brazilian basic education system, where bimester-based assessments are systematic and standardized, thus providing consistent indicators of student learning over time.

The methods adopted for this evaluation include Simple Linear Regression (SLR, Quadratic Regression (QR), Polynomial Regression (PR). The use of three regression models—SLR, QR, and PR—was motivated by the need to test the robustness of the indices under different mathematical assumptions. Applying and comparing different models allows the analysis to avoid artificially constraining correlations to linear behavior, ensuring the selection of the most representative model. The index that best satisfies the regression metric criteria is then chosen for more detailed evaluation. The main information, along with the justification for applying each model, is presented in Table 2.

Table 2: Main characteristics of each linear and non-linear model.

Model	**Characteristics**		
SLR	Evaluates standard and predictable behavior		
QR	Evaluates peak and inflection points, representing performance peaks		
PR	Captures, with greater precision, fluctuations over the bimonthly period		
Description	**Contemplates and does not contemplate**		
Captures curvature patterns	✗	✓	✓
Flexibility in more dispersed data	✗	✓	✓
Risk of overfitting	✗	✓	✓
Easy interpretation	✓	✗	✗
Legenda:	✓ Contemplate;	✗ Does not contemplate.	

Source: (Montgomery et al., 2012).

Through this approach, it will be possible not only to measure the initiative's impact on students' academic performance but also to validate the effectiveness and efficiency of the project's implementation.

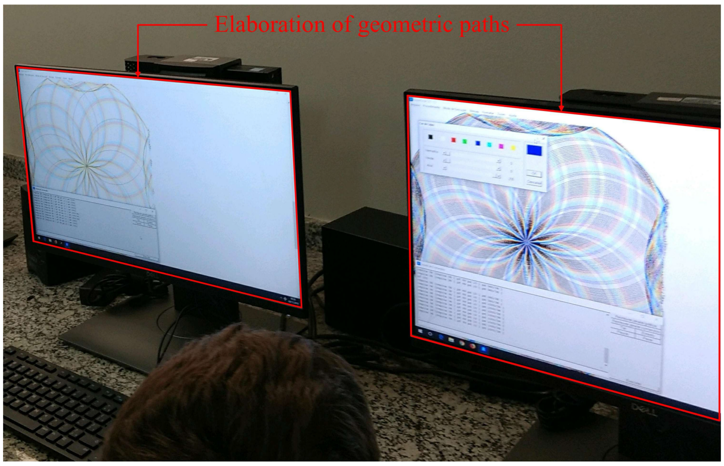
To analyze the proposed models, tools such as Python facilitate the implementation of these regressions. With libraries like sklearn, numpy, and scipy*sklearn, numpy* e *scipy* (NumPy team, 2025; scikit-learn team, 2025; SciPy team, 2025), it is possible to test different models and evaluate their performance metrics, ensuring that the selection is based on statistical criteria. The selection of these three models aims to validate whether the constructed indices exhibit a significant correlation, thereby determining which should be further examined in the analysis. This choice is based on identifying the correlation between the implementation of SuperLogo® and students' academic performance, prioritizing the index that most accurately represents this relationship and ensures a more consistent analysis of the project's impacts.

Results and Discussion

The educational sessions covered topics such as: *(i)* the functionalities of the SuperLogo®; and *(ii)* the use of the LOGO language, linked to students' curricular components. For the evaluated years 2018–2023 (excluding 2020 due to the impact of the COVID-19 pandemic) the analysis revealed interesting patterns regarding the fit of the regression models to the students' grades. The case study focused on a sample group of 25 students per year from the 3rd grade of elementary school. Their grades were requested from the school and stored for comparative analysis.

As illustrated in Figure 5, the activities conducted during the last two terms focused mainly on constructing geometric figures, directly connected to the mathematics curriculum. The initial lessons, however, had a dual purpose: introducing students to the SuperLogo® software and stimulating logical reasoning through figure construction. These early activities were essential in engaging students, gradually enabling them to create shapes on their own. This initial stage not only captured their interest but also helped position the software as both educational and enjoyable, creating a solid base for tackling more complex mathematical problems later.

Figure 5: Example of an activity conducted with the students.



Validation of Academic Performance Indices

After completing the formulated activities, an analysis of the GS, PG and PS indices was conducted using the proposed regression models to identify the relationships between individual grades and academic performance before and after the implementation of the activities. To validate these relationships, the previously mentioned regression methods were applied, allowing the calculation of the necessary metrics to evaluate the relationship between the PV variable and the average grades obtained.

The third-degree polynomial model consistently showed the best fit across the evaluated metrics, with the highest R^2 values among the models tested. The PG index stood out over the years, achieving the highest regression coefficients—such as 0.461 in 2018—while GS reached only 0.085 in the same year. This trend continued in subsequent years, with PG maintaining superior fit across all models. In contrast, the GS index exhibited very low R^2 values (0.000 to 0.097), indicating poor explanatory power. Similarly, the PS index showed low fit, with R^2 generally below 0.120, reflecting high data dispersion and limited predictive capacity.

The evolution of models over time reinforces the superiority of more sophisticated approaches. In 2019, the third-degree polynomial model provided the best fit for PG (0.336) and GS (0.039), surpassing the values obtained by the linear model (0.301 and 0.000, respectively). This trend continued in subsequent years, with 2021 and 2022 further consolidating greater effectiveness. In 2023, the polynomial model reached 0.433 for PG, once again standing out as the most effective approach for capturing the complexity of the data.

Thus, it was concluded that PG was the best-fitted index across the regression models. Furthermore, the third-degree polynomial model proved to be the most efficient alternative, offering a greater explanatory capacity of data variability, especially for the PG index.

Academic Performance Results Through the PG Index

Based on the analysis of the metrics, the PG index represents students' academic performance over the academic terms. The calculation of student performance is conducted using Equation (1). Figure 6, along with Table 3, illustrates this progression, allowing for a comparison of average grades between the first two and the last two terms from 2018 to 2023.

In addition to providing an overview of the class's overall performance, the index also enables a more detailed individual-level analysis of students. In this representation, arrows are used to visualize variation, with green arrows generally indicating improvement and red arrows denoting decline.

Figure 6: Annual student performance from 2018 to 2023, excluding 2020.

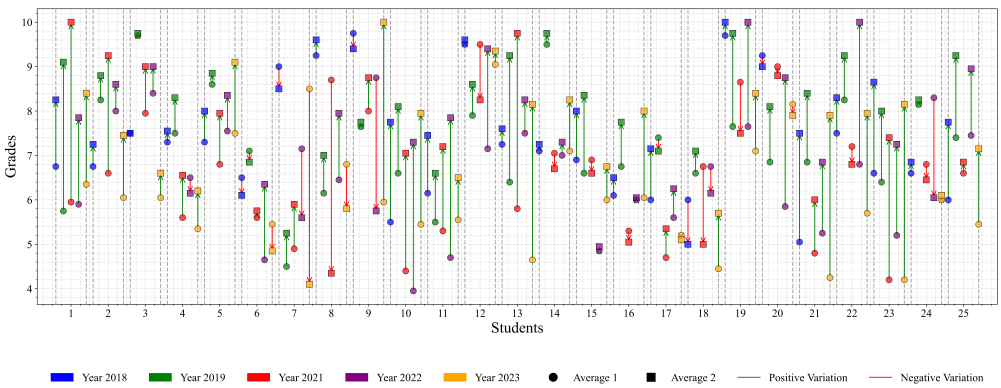


Table 3: Individual student performance from 2018 to 2023 (except 2020).

Student	Year				
	2018	**2019**	**2021**	**2022**	**2023**
	Average Performance [%]				
	9.99	**15.30**	**13.66**	**18.01**	**23.54**
	Individual Performance [%]				
1	22.22	58.26	68.07	33.05	32.28
2	7.41	6.67	40.15	7.50	23.14
3	0.00	0.52	13.21	7.14	9.09
4	3.42	10.67	16.96	-5.38	15.89
5	9.59	2.91	16.91	10.60	21.33
6	-6.15	-3.52	2.68	36.56	-11,01
7	-5.56	16.67	20.41	-21.68	-51.76
8	3.78	13.82	-50.00	23.26	-14.71
9	-3.59	1.31	9.38	-34.29	68.07
10	40.91	22.73	60.23	84.81	45.87
11	21.14	20.00	35.85	67.02	17.12
12	1.05	8.86	-13.16	31.47	3.31
13	4.83	44.53	68.10	10.00	75.27
14	2.11	2.63	-4.96	4.29	16.20
15	15.94	26.52	-4.35	2.06	12.50
16	6.56	14.81	-4.72	0.83	32.23
17	19,17	-4.05	13.83	11.61	-1.92
18	-16.67	7.58	-25.93	-8.89	28.09
19	3.09	27.45	-13.29	30.72	18.31
20	-2.70	18.25	-2.22	49.57	-3.07
21	48.51	22.63	25.00	30.48	85.88
22	10.67	12.12	-5.56	47.06	39.47
23	31.06	25.00	76.19	39.42	94.05
24	3.79	1.23	-5.15	-27.11	1.67
25	29.17	25.00	3.79	20.13	31.19

In some cases, specific issues are highlighted, as observed with Student 7 in 2023, Student 8 in 2021, and Student 9 in 2022. These cases may reflect performance drops greater than the class average or may relate to progress in other dimensions, such as logical reasoning or engagement, as reported by teachers. This integrative interpretation helps reveal more nuanced patterns of student development, providing a broader understanding of SuperLogo®'s potential impact on mathematics learning. Furthermore, the data indicates consistent student acceptance of the software throughout the years analyzed.
An increase in average academic performance is observed over the years, starting at 9.99% in 2018 and reaching its peak in 2023 (23.54%), following a significant rise in 2022 (18.01%). However, a decline in performance was identified between 2019 and 2021, from 15.30\% to 13.66%, possibly due to the impact of the COVID-19 pandemic in 2020. This overall growth indicates an improvement in learning and the effectiveness of the adopted pedagogical strategies. The sharp increase between 2021 and 2023 suggests that factors such as new teaching approaches and greater adaptation to educational technologies may have positively impacted student performance.
In total, 97 students (77.60%) showed improvement, while 27 (21.60%) experienced a decline, and only 1 (0.80%) remained stable. 2019 recorded the highest number of students with positive performance (23), whereas 2021 had the highest number of students with declining performance (10). Variations in academic performance may be linked to external factors such as methodological changes, resource availability, or differences in the teaching-learning process.
Individual highlights further emphasize this diversity in performance. Student 23 recorded the highest individual improvement, reaching 94.05% in 2023. Meanwhile, in 2022, Student 10 achieved the largest individual growth, with 84.81%, indicating significant progress. On the other hand, the lowest performance levels ranged from -16.67% in 2018 (Student 18) to -51.76% in 2023 (Student 7), revealing that some students faced difficulties over the years. The data suggest that most students improved their performance over time, but challenges remain, especially for those who experienced sharp declines. This underscores the need for closer pedagogical support and the

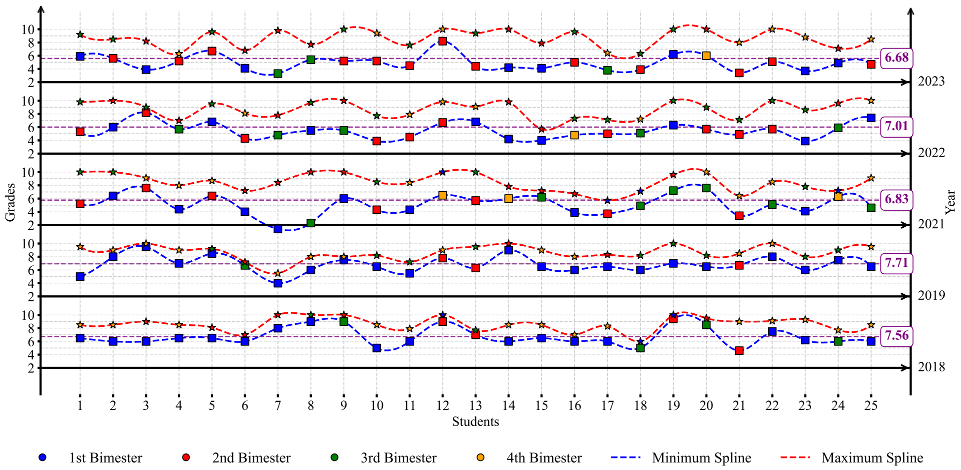
implementation of adaptive teaching methodologies, ensuring that all students receive adequate support for their learning.

Identification of Trends and Performance Patterns

The analysis of student's grade distribution over the years enables the identification of academic performance trends and the evaluation of result progression. Figure 7 illustrates this behavior by presenting the grade variation from 2018 to 2023, highlighting the maximum and minimum grades recorded per academic term each year and each bimonthly. Additionally, the use of trend curves provides a clearer visualization of students with the highest and lowest performance, enabling a more detailed analysis of overall class behavior over time. The red dashed line represents the trend of the highest grades, indicated by a star symbol, while the blue dashed line represents the trend of the lowest grades, marked with a square symbol.

The results indicate that, in all the years analyzed, most minimum grades were below the overall average, with this percentage increasing over time. In 2018, 76% of the minimum grades were below the overall average, a proportion that rose to 88% in 2021 and reached 92% in 2022 and 2023.

Figure 7: Max and min grade distribution per term by year.



This trend suggests a growing discrepancy between struggling students and the rest of the class, highlighting the need for pedagogical strategies aimed at bridging this gap. On the other hand, maximum grades showed a more stable trend, with most students achieving values above the annual average. In 2018, 2019, and 2021, 88% of the maximum grades were above average, while in 2022, this increased to 92%, before returning to 88% in 2023.

Another notable aspect observed in the graph is the fluctuation in general annual averages, which ranged between 6.68 and 7.71 over the analyzed period. This trend underscores the importance of implementing educational interventions that provide the necessary support for lower-performing students, helping to reduce learning inequalities.

Teachers' Feedback on SuperLogo's Classroom Impact

In addition to the quantitative assessment presented in the previous sections, a qualitative analysis was conducted based on the responses provided by teachers concerning Table 1 These responses consisted of brief comments reflecting their experiences using SuperLogo® in elementary education. The triangulation of these responses revealed recurring patterns regarding student performance, logical reasoning, and collaboration, thereby contextualizing the impacts resulting from the implementation of the software.

A recurring theme was the improvement in students' academic performance, attributed to increased engagement in dynamic tasks involving command execution and geometric constructions. Teachers emphasized that the immediate visual feedback provided by the software facilitated both conceptual understanding and procedural fluency, contributing to more consistent academic outcomes.

Another important aspect was the development of logical reasoning and problem-solving skills. According to the reports, SuperLogo® helped students deconstruct mathematical problems into sequential steps and enhanced their understanding of geometric relationships. While the tool itself is relatively simple, teachers noted an initial learning curve. Students required time and repeated exposure before they could use the commands autonomously, which highlights the importance of continued instructional support, particularly during the introductory phase.

Collaboration also emerged as a strong feature of the learning environment created by SuperLogo®. The software encouraged active participation and peer-to-peer cooperation, especially in tasks involving the creation of geometric figures. Teachers observed that this collaborative dynamic not only stimulated creativity but also improved the quality of strategies used to approach problem-solving situations.

Gradual gains in student autonomy were also reported. After the initial familiarization period, many students began executing basic commands independently, although still relying on teacher validation. This transition reflects the role of SuperLogo® in promoting student agency, provided it is supported by intentional pedagogical guidance.

Finally, teachers highlighted the software's potential for interdisciplinary application. In addition to its relevance in mathematics, SuperLogo® was recognized for fostering logical thinking and creativity in other subjects, particularly Art. This indicates its usefulness as a cross-curricular tool capable of supporting integrated learning experiences.

In sum, the implementation of SuperLogo® contributed to measurable improvements in performance, reasoning, autonomy, and collaboration. These outcomes reinforce the software's potential as a valuable educational resource—especially when its use is accompanied by adequate time for student familiarization, intentional instructional support, and interdisciplinary planning.

Conclusion

The implementation of the LOGO language and SuperLogo® in elementary education has proven effective in supporting mathematics learning and in fostering cognitive skills such as logical reasoning, creativity, and autonomy. In this context, qualitative results further highlighted that the program enhanced motivation and engagement, as students benefited from immediate visual feedback and more dynamic learning experiences. Although initial adaptation required additional support and time, continuous pedagogical mediation proved essential in consolidating understanding and ensuring student inclusion.

The interdisciplinary dimension of the project also deserves emphasis. By connecting mathematics with other areas, SuperLogo® strengthened the relationship between theory and practice while fostering collaborative learning and creativity. These findings suggest that the software can be effectively used not only to consolidate mathematical concepts but also to encourage transversal skills that extend beyond a single discipline.

Future work could build on these results by exploring the use of SuperLogo® in other subject areas, including Science, Technology, and Languages. Such applications would allow for the evaluation of its broader pedagogical potential and contribute to the development of interdisciplinary approaches that promote computational thinking, creativity, and problem-solving across the school curriculum.

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