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Impact of an Interface Metaphor Based on Algorithmic Thinking on Academic Performance in Public Accounting Students

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Abstract: Accounting education currently faces challenges related to traditional methodologies focused on mechanical and repetitive processes, limiting the development of analytical, digital, and logical reasoning skills among university students. In this context, interface metaphors and algorithmic thinking emerge as pedagogical strategies aimed at strengthening the structured understanding of complex processes. The objective of this research was to evaluate the impact of an interface metaphor based on algorithmic thinking on the academic performance of Public Accounting students. The study was conducted under a quantitative approach using a quasi-experimental pretest-posttest design with control and experimental groups. The pedagogical intervention was implemented through an interface metaphor called Flow-Grid v1.0, designed to visually represent accounting processes through interactive flowcharts synchronized with spreadsheets. Fifth-semester Public Accounting students participated in the study, evaluating dimensions related to algorithmic thinking, spreadsheet management, and accounting processes.

The results showed statistically significant differences between the pretest and posttest in the experimental group, revealing improvements in overall academic performance and in the evaluated dimensions. Likewise, intergroup statistical analyses demonstrated superior performance in the experimental group compared to the control group after the pedagogical intervention.It is concluded that the interface metaphor based on algorithmic thinking constitutes an effective pedagogical strategy to strengthen academic performance in Public Accounting students by promoting logical, sequential, and procedural understanding of accounting processes within digital learning environments.

Keywords: Algorithmic thinking, interface metaphors, academic performance, accounting education, human-computer interaction, meaningful learning.

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1. Introducción

Higher education currently faces the challenge of transforming traditional methodologies focused on content transmission into pedagogical approaches that promote logical reasoning, problem-solving, and meaningful learning. In Public Accounting programs, this need is particularly relevant because a large proportion of educational processes continue to rely on mechanical exercises and repetitive procedures, limiting the development of analytical and digital competencies required in contemporary professional contexts [1].

Several studies have reported that academic performance in accounting education is affected by traditional teaching methodologies, low student participation, and limitations in the integration of technological tools aimed at meaningful learning. Likewise, international studies indicate that students present deficiencies in logical reasoning, understanding of sequential processes, and practical application of accounting knowledge in real-world contexts [2].

In this context, algorithmic thinking has gained relevance as an educational strategy oriented toward strengthening processes of logical organization, sequencing, and structured problem solving [3]. Complementarily, interface metaphors, addressed from the perspective of Human-Computer Interaction, facilitate the understanding of digital systems through visual representations closely related to user experience, thereby promoting interaction and cognitive knowledge construction.

However, accounting education still presents limited experimental evidence regarding the pedagogical impact of interface metaphors grounded in algorithmic thinking. Most digital tools used in this field focus primarily on operational and functional aspects, without incorporating visual structures aimed at strengthening the logical understanding of accounting processes [4]. Furthermore, few quasi-experimental studies have analyzed the effect of these types of strategies on the academic performance of university students in Public Accounting [5].

In response to this problem, the present study proposes an interface metaphor called *Flow-Grid v1.0*, designed to visually represent accounting processes through interactive flowcharts synchronized with spreadsheets. Consequently, the objective of this study was to evaluate the impact of an interface metaphor based on algorithmic thinking on the academic performance of Public Accounting students through a quasi-experimental design with control and experimental groups.

2. Research Methodology

This study was conducted under a quantitative approach using a quasi-experimental pretest-posttest design with control and experimental groups, commonly employed in educational research aimed at evaluating the effects of pedagogical interventions in real-world contexts [6].

The population consisted of students enrolled in the Public Accounting program at Universidad CESMAG. A non-probabilistic convenience sampling method was used, resulting in a total sample of 54 students enrolled in the fifth-semester course *Advanced Excel*. The control group consisted of 29 students from the 2025-II academic period, whereas the experimental group was composed of 25 students from the 2026-I academic period.

The independent variable corresponded to the interface metaphor based on algorithmic thinking called *Flow-Grid v1.0*, designed as an interactive environment to visually represent accounting processes through flowcharts synchronized with spreadsheets. The dependent variable was academic performance, evaluated in the dimensions of algorithmic thinking, spreadsheet management, and algorithmic thinking applied to accounting processes.

For data collection, a questionnaire entitled *Prior Knowledge* was specifically designed for this research. The instrument consisted of 16 multiple-choice items with a single correct answer, distributed into four sections: demographic information, algorithmic thinking, spreadsheets, and algorithmic thinking applied to accounting processes. Evaluation was performed using a numerical scale ranging from 0 to 5 points.

Content validity was established through expert judgment involving three Ph.D. holders in Education, Computer Science, and Accounting. Additionally, Fleiss' Kappa index was calculated, obtaining a value of 0.89, indicating a very high level of agreement among evaluators. Likewise, Aiken's V coefficient presented overall values above 0.96, demonstrating excellent content validity [7]. Instrument reliability was evaluated through a pilot test applied to 32 participants with characteristics similar to those of the study sample. Internal consistency analysis using Cronbach's alpha yielded a value of $\alpha = 0.959$, indicating excellent reliability.

The pedagogical intervention was implemented through the *Flow-Grid v1.0* tool, grounded in principles of User-Centered Design (UCD) and algorithmic thinking. The interface metaphor enabled the visual representation of accounting processes through interactive flowcharts synchronized with spreadsheets, promoting logical organization, sequencing, and structured problem-solving processes in accounting tasks.

The experimental group worked through a didactic sequence based on algorithmic thinking during 22 academic sessions equivalent to 2200 minutes of intervention. In contrast, the

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control group developed the same thematic content through the conventional methodology commonly used in the Public Accounting program.

For statistical analysis, descriptive and inferential tests were conducted using IBM SPSS Statistics software. Initially, the Shapiro-Wilk normality test was applied, which is recommended for small samples [12]. Since most dimensions did not present normal distribution ($p < 0.05$), non-parametric Wilcoxon signed-rank tests for related samples and Mann-Whitney U tests for independent samples were employed [8], [13]. In cases where normality assumptions were satisfied, Student's t-test for related and independent samples was applied. The significance level established for the analyses was $\alpha = 0.05$.

3. Research results

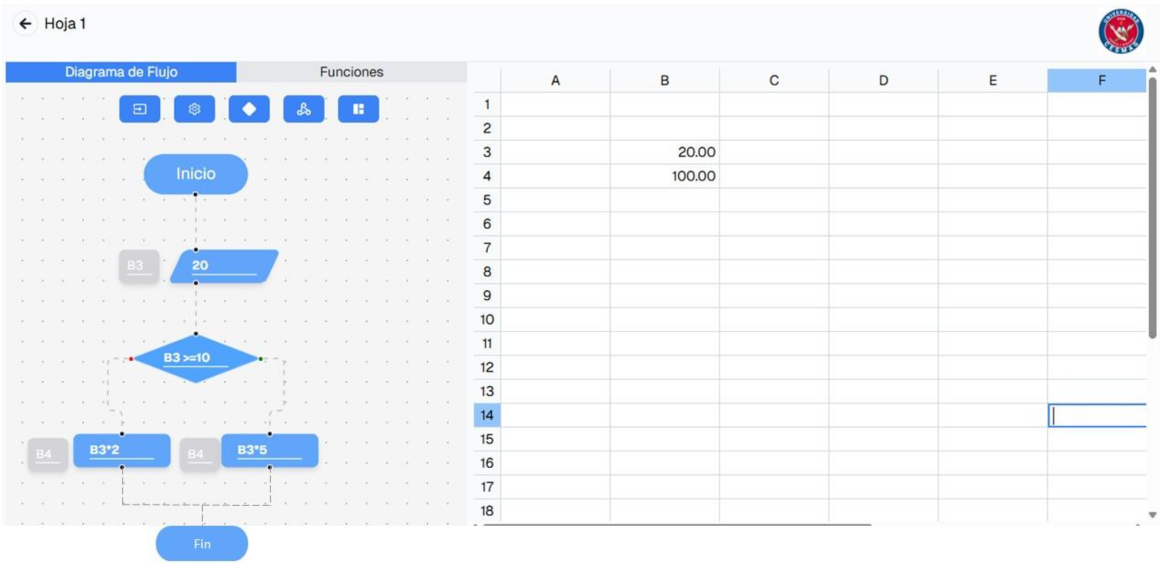
The interface metaphor called *Flow-Grid v1.0* was developed as an interactive environment grounded in the principles of User-Centered Design (UCD) and algorithmic thinking. Its purpose was to visually represent accounting processes through flowcharts synchronized with spreadsheets, facilitating the logical and sequential understanding of procedures performed in Excel. Similar approaches have demonstrated that visual environments based on algorithmic structures can strengthen reasoning and procedural comprehension in digital learning contexts [5].

To provide methodological support for the construction of the interface metaphor, a systematic literature review following the approach proposed by Kitchenham and Charters was conducted to identify Human-Computer Interaction methodologies applied to the development of visual and sequential environments in higher education. As a result of the search and screening process, 98 articles were initially identified, from which 32 studies were finally selected according to thematic relevance and methodological rigor criteria. The findings revealed a predominance of methodologies associated with visual and operational metaphors, user-centered design, and interactions based on algorithmic structures. These results are consistent with studies highlighting the relevance of visual representations and interface metaphors in supporting learning processes and cognitive interaction with digital systems[8].

The *Flow-Grid v1.0* tool was structured through interactive flowcharts composed of start, input, process, and decision nodes, enabling the sequential representation of accounting procedures and the automatic validation of results in synchronized spreadsheets. This integration promoted logical reasoning, sequential organization, and procedural understanding during activities related to mathematical, statistical, logical, and financial functions in Excel. Previous studies have shown that algorithmic visualization tools contribute to the strengthening of problem-solving and structured reasoning skills in educational environments [9].

Figura 1

General architecture of the Flow-Grid v1.0 interface metaphor



The sample consisted of 54 students from the Public Accounting program at Universidad CESMAG, distributed into a control group (n = 29) and an experimental group (n = 25). In both groups, most participants belonged to socioeconomic strata 1 and 2, and all participants resided in the city of Pasto, which contributed to maintaining geographical homogeneity between the comparison groups. The sociodemographic characteristics of the participants are presented in Table 1.

Table 1

Sociodemographic characteristics of the control and experimental groups

Variable	Category	Control (n)	Control (%)	Experimental (n)	Experimental (%)
Gender	Female	18	62.1	12	48.0
	Male	11	37.9	13	52.0
Place of residence	Pasto	29	100.0	25	100.0
Socioeconomic status	Stratum 1	14	48.3	12	48.0
	Stratum 2	11	37.9	11	44.0
	Stratum 3	4	13.8	2	8.0

The descriptive results of the pretest revealed low initial levels of academic performance across the evaluated dimensions. In algorithmic thinking, both groups obtained median scores of 1, indicating difficulties related to logical organization, sequencing, and structured problem-solving. In spreadsheet management, both groups reached a median score of 2, while in algorithmic thinking applied to accounting processes the experimental group showed a slightly higher initial performance compared to the control group. The Shapiro-Wilk normality test revealed non-normal distributions in most evaluated dimensions ($p < 0.05$), justifying the use of non-parametric statistical tests for subsequent inferential analyses.

After the implementation of the interface metaphor based on algorithmic thinking, both groups showed improvements across the evaluated dimensions; however, the experimental group achieved higher levels of academic performance compared to the control group. In the algorithmic thinking dimension, the experimental group reached a median score of 3 compared to 2 in the control group. In spreadsheet management, the experimental group obtained a median score of 6, whereas the control group achieved a median score of 5. Likewise, in algorithmic thinking applied to accounting processes, the experimental group reached the highest median score observed in the study (Md = 7), indicating greater strengthening of procedural comprehension and structured problem-solving skills related to accounting tasks. The descriptive posttest results are presented in Table 2. These findings support previous research indicating that visual and interactive representations can improve procedural understanding and logical reasoning in technology-enhanced learning environments

Table 2

Descriptive results of the pretest and posttest by group

Moment	Group	Algorithmic thinking	Spreadsheet management	Algorithmic thinking in accounting processes	Total score
Pretest	Control	1	2	1	5
Pretest	Experimental	1	2	2	5
Posttest	Control	2	5	6	12
Posttest	Experimental	3	6	7	16

Figure 2

Comparison of median scores in the pretest and posttest between groups

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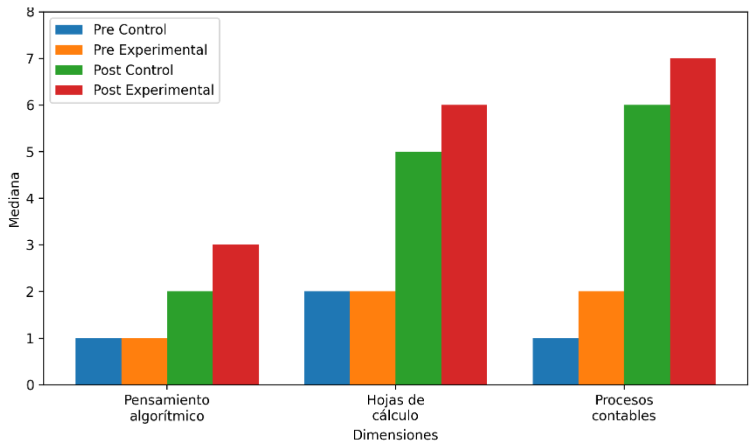

The intragroup analyses revealed statistically significant differences between the pretest and posttest in both groups and across all evaluated dimensions ($p < 0.05$). In the experimental group, significant improvements were observed in algorithmic thinking ($Z = -4.355$; $p < 0.001$), spreadsheet management ($Z = -4.404$; $p < 0.001$), and algorithmic thinking in accounting processes ($Z = -4.425$; $p < 0.001$). Although the control group also showed improvements after the instructional process, the descriptive and inferential results indicated higher levels of performance in the experimental group following the implementation of *Flow-Grid v1.0*. These findings are aligned with studies emphasizing the role of algorithmic thinking and visualization tools in promoting logical reasoning and sequential problem-solving skills

Table 3

Intragroup comparison between pretest and posttest

Dimension	Group	Statistic	p	Interpretation
Algorithmic thinking	Control	Z = -3.896	< 0.001	Significant
	Experimental	Z = -4.355	< 0.001	Significant
Spreadsheet management	Control	Z = -4.469	< 0.001	Significant
	Experimental	Z = -4.404	< 0.001	Significant
Algorithmic thinking in accounting processes	Control	Z = -4.488	< 0.001	Significant
	Experimental	Z = -4.425	< 0.001	Significant
Total score	Control	t = -10.175	< 0.001	Significant
	Experimental	Z = -4.385	< 0.001	Significant

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Note. The Wilcoxon signed-rank test was applied to dimensions with non-normal distribution. For the total score of the control group, Student's t-test for related samples was applied.

In the intergroup comparison, pretest results showed no statistically significant differences between the control and experimental groups ($p > 0.05$), confirming initial equivalence between the evaluated groups. However, posttest results revealed statistically significant differences in favor of the experimental group in algorithmic thinking ($U = 25.000$; $p < 0.001$), spreadsheet management ($U = 142.000$; $p < 0.001$), algorithmic thinking in accounting processes ($U = 167.500$; $p < 0.001$), and total score ($U = 63.500$; $p < 0.001$).

Table 4

Comparación intergrupo en la preprueba y posprueba

Moment	Dimension	Statistic	p	Interpretation
Pretest	Algorithmic thinking	U = 318.500	0.417	Not significant
	Spreadsheet management	U = 354.500	0.885	Not significant
	Algorithmic thinking in accounting processes	U = 262.500	0.073	Not significant
	Total score	t = -0.900	0.372	Not significant
Posttest	Algorithmic thinking	U = 25.000	< 0.001	Significant
	Spreadsheet management	U = 142.000	< 0.001	Significant
	Algorithmic thinking in accounting processes	U = 167.500	< 0.001	Significant
	Total score	U = 63.500	< 0.001	Significant

Figure 3

Comparison of the total score between the control and experimental groups in the posttest

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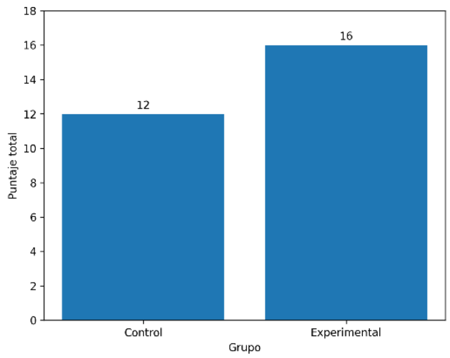

Overall, the results demonstrate that the implementation of the interface metaphor based on algorithmic thinking produced significant effects on students' academic performance, particularly in processes related to logical reasoning, sequencing, and the application of accounting procedures through digital tools

4. Discussion

The results obtained demonstrate that the implementation of the interface metaphor based on algorithmic thinking produced favorable effects on the academic performance of Public Accounting students, particularly in the dimensions of algorithmic thinking, spreadsheet management, and algorithmic thinking applied to accounting processes. The statistically significant differences observed in the posttest between the control and experimental groups suggest that the pedagogical intervention mediated by *Flow-Grid v1.0* contributed to strengthening logical reasoning, sequencing, and structured problem-solving processes related to accounting tasks. Similar findings have been reported in studies emphasizing the relevance of algorithmic thinking for enhancing logical organization and problem decomposition skills in digital learning environments [10]

One of the main findings of the study corresponds to the improvement observed in the algorithmic thinking dimension. Although both groups showed progress after the instructional process, the experimental group achieved higher performance levels. This result suggests that the visual representation of processes through interactive flowcharts facilitated the understanding of logical sequences and procedural relationships, promoting the structured organization of spreadsheet-based tasks. In this regard, the findings are consistent with previous research indicating that algorithmic thinking strengthens abilities related to problem decomposition, sequential reasoning, and logical modeling in educational contexts [11]

Likewise, the results obtained in the spreadsheet management dimension revealed that the interface metaphor enabled a better operational and functional understanding of the tools used in Excel. Unlike traditional methodologies centered on the mechanical repetition of procedures, the implemented strategy promoted procedural understanding through the visual integration of flowcharts and automated spreadsheet operations. This may explain the increase observed in the median scores of the experimental group after the pedagogical intervention. Previous studies have highlighted that visualization environments and interactive representations contribute to improving comprehension and navigation within digital systems [12]

In the dimension of algorithmic thinking applied to accounting processes, the highest level of performance in the study was observed, with the experimental group reaching a median score of 7 compared to 6 in the control group. This finding is particularly relevant because it demonstrates the ability of the interface metaphor to strengthen the logical understanding of complex accounting procedures. The synchronization between flowcharts and spreadsheets enabled the visual representation of mathematical, statistical, logical, and financial operations, facilitating the sequential comprehension of accounting processes and reducing abstraction levels during learning. Similar studies have shown that visual representations can support procedural reasoning and improve structured problem-solving processes in technology-enhanced educational environments

From the perspective of Human-Computer Interaction, the findings suggest that interface metaphors constitute effective pedagogical strategies for mediating cognitive processes in educational contexts. The visual and interactive representation of processes reduced the cognitive load associated with understanding complex procedures, facilitating sequential navigation, identification of relationships, and structured validation of results. Consequently, the interface metaphor functioned not only as a technological tool, but also as a cognitive mediation mechanism aimed at strengthening meaningful learning. These findings are aligned with studies indicating that interface metaphors and visual interaction models facilitate users' understanding of digital environments through the construction of mental representations and cognitive associations[13].

Another relevant aspect concerns the initial equivalence between the control and experimental groups. The pretest results showed no statistically significant differences, strengthening the internal validity of the study and allowing the observed posttest differences to be attributed to the pedagogical intervention implemented through *Flow-Grid v1.0*. This aspect is particularly important in quasi-experimental research because it reduces the possibility of biases associated with prior differences in participants' knowledge levels

Despite the favorable results, the study presents some limitations. The sample was selected through non-probabilistic convenience sampling and consisted exclusively of students from a single academic program and institution, limiting the generalizability of the findings to other educational contexts. Furthermore, the intervention was implemented within a single academic course; therefore, future research could evaluate the impact of interface metaphors based on algorithmic thinking in other areas of knowledge and through experimental designs involving larger samples and greater methodological control.

Finally, the findings suggest that the integration of algorithmic thinking, visual metaphors, and Human-Computer Interaction represents a pedagogical alternative with the potential to transform traditional methodologies in accounting education. In this sense, *Flow-Grid v1.0* constitutes a proposal oriented not only toward the instrumental use of digital tools, but also toward strengthening cognitive processes related to logical comprehension, sequencing, and structured problem solving in academic and professional contexts

5. Conclusions

The results obtained allow concluding that the implementation of the interface metaphor based on algorithmic thinking had a favorable effect on the academic performance of Public Accounting students. The statistically significant differences observed in the posttest revealed higher performance levels in the experimental group compared to the control group in the dimensions of algorithmic thinking, spreadsheet management, and algorithmic thinking applied to accounting processes.

The *Flow-Grid v1.0* interface metaphor contributed to strengthening processes related to logical reasoning, sequential organization, and structured problem solving through the visual integration of flowcharts and spreadsheets. This articulation facilitated the procedural understanding of accounting activities developed in Excel, contributing to reducing abstraction levels during the learning process.

The findings suggest that algorithmic thinking constitutes a relevant pedagogical strategy for strengthening analytical and digital competencies in accounting education. The visual and interactive representation of processes facilitated the understanding of logical structures and operational relationships, promoting more meaningful learning processes compared to traditional methodologies focused on the mechanical repetition of procedures.

From the perspective of Human-Computer Interaction, the results demonstrate that interface metaphors can play a relevant role as cognitive mediation mechanisms in educational contexts. In this study, the synchronization between flowcharts and spreadsheets enabled the transformation of complex accounting procedures into more understandable visual representations for students, facilitating sequential navigation and structured validation of results.

Likewise, the initial equivalence observed between the control and experimental groups strengthens the internal validity of the study, allowing the differences identified in the posttest to be attributed to the pedagogical intervention implemented through *Flow-Grid v1.0*. This suggests that the improvement observed in the experimental group did not depend on prior differences in participants' knowledge levels, but rather on the impact of the developed pedagogical strategy.

Finally, it is concluded that the integration of algorithmic thinking, visual metaphors, and Human-Computer Interaction represents a pedagogical alternative with the potential to transform traditional methodologies in accounting education. Consequently, *Flow-Grid v1.0* constitutes a proposal oriented not only toward the instrumental use of digital tools, but also toward strengthening cognitive processes related to logical understanding, sequencing, and structured problem solving in academic and professional scenarios.

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