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SYSTEMATIC REVIEW

Interface Metaphors and Algorithmic Thinking in Teaching Data-Driven Accounting Processes: A Systematic Literature Review

Metáforas de Interfaz y Pensamiento Algorítmico en la Enseñanza de Procesos Contables Basados en Datos: Revisión Sistemática de la Literatura

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ABSTRACT

The learning of accounting processes increasingly requires innovative teaching strategies that integrate data analysis and information visualization. In this context, interface metaphors based on algorithmic thinking can facilitate the understanding of accounting concepts and the management of digital information. Although some isolated studies exist, there is no systematic review compiling the main challenges and current practices in this field. This article presents a systematic review of the literature aiming to analyze studies on the impact of these metaphors in accounting education and their relationship with data management. Four scientific publication databases were explored, identifying 98 studies published over the last ten years, of which 42 met the inclusion criteria. The review allowed for the compilation of data-driven digital tools, teaching strategies, methodological considerations, and reports on their impact on accounting learning. This article provides a foundational resource for future research and pedagogical practices integrating algorithmic-thinking-based educational interfaces with a data-driven approach in accounting education.

Keywords: Interface Metaphors; Algorithmic Thinking; Accounting Learning; Systematic Review; Data-Driven Education.

RESUMEN

El aprendizaje de procesos contables requiere cada vez más estrategias didácticas innovadoras que integren el análisis de datos y la visualización de información. En este contexto, las metáforas de interfaz basadas en pensamiento algorítmico pueden facilitar la comprensión de conceptos contables y la gestión de información digital. Aunque existen estudios aislados, no hay una revisión sistemática que compile las principales problemáticas y prácticas en este ámbito. Este artículo presenta una revisión sistemática de la literatura con el objetivo de analizar investigaciones sobre el impacto de estas metáforas en la enseñanza de procesos contables y su relación con el manejo de datos. Se exploraron cuatro bases de datos de publicaciones científicas, identificando 98 estudios publicados en los últimos diez años, de los cuales 32 cumplieron los criterios de inclusión. La revisión permitió recopilar herramientas digitales orientadas a la enseñanza basada en datos, estrategias pedagógicas, consideraciones metodológicas y reportes sobre su impacto en el aprendizaje contable. Este artículo constituye un recurso inicial para futuras investigaciones y prácticas pedagógicas que integren interfaces educativas algorítmicas y enfoque en datos en la enseñanza de contabilidad.

Palabras clave: Metáforas de Interfaz; Pensamiento Algorítmico; Aprendizaje Contable; Revisión Sistemática; Educación Basada en Datos.

INTRODUCTION

The learning of accounting processes has benefited from the incorporation of digital technologies and innovative pedagogical strategies. Teaching accounting requires students not only to understand financial and regulatory concepts but also to develop skills in the management, analysis, and visualization of accounting data, which are fundamental competencies in a business and academic environment increasingly oriented toward data-driven decision-making.

In this context, interface metaphors based on algorithmic thinking have emerged as tools that facilitate the understanding of complex accounting processes. These metaphors enable the intuitive representation of abstract information, guiding students in data manipulation and the construction of accounting models. They also promote the development of critical thinking and problem-solving skills, which are key competencies in contemporary accounting education.[1]

Although studies have explored the integration of educational interfaces and algorithmic thinking in accounting education, no systematic review has been conducted to compile and analyze evidence on their impact on learning, the digital tools used, pedagogical strategies, and associated methodological considerations. This lack of synthesis limits the ability of teachers and researchers to make informed decisions about implementing these data-driven methodologies.

Therefore, the objective of this article is to present a systematic review of the literature on the use of interface metaphors based on algorithmic thinking in accounting process teaching, with an emphasis on their impact on learning and data management. This study seeks to provide a consolidated resource to guide both researchers and teachers in adopting innovative pedagogical strategies that integrate computing, information visualization, and data-oriented accounting education.

The structure of the article is as follows: Section 2 presents a conceptual framework on interface metaphors and algorithmic thinking applied to accounting education; Section 3 details the systematic review method used; Section 4 presents the results obtained, while Section 5 discusses the findings and their implications; Finally, Section 6 contains conclusions and recommendations for future research.

Interface metaphors and algorithmic thinking

Interface metaphors are a cognitive and communicative resource that facilitates interaction between users and digital systems through symbolic representations of abstract actions or concepts. From the perspective of human-computer interaction (HCI), these metaphors enable familiar conceptual structures to be transferred to computational environments, promoting a more intuitive understanding of the information and processes underlying a digital system.[2]

In educational contexts, interface metaphors play a fundamental role in cognitive and didactic mediation, as they contribute to the construction of meanings and the internalization of complex concepts through visual and functional representations. According to Portela et al.[3], an interface metaphor not only translates a technical action but also establishes a conceptual relationship between the user and the underlying model, promoting procedural understanding.

Several studies have demonstrated that interface metaphors can enhance the learning experience, particularly in disciplines that necessitate the symbolic manipulation of abstract information.[4] In these scenarios, the metaphor serves as a cognitive bridge, connecting the internal logic of the system with the user's experience and facilitating meaningful learning and the appropriation of new technical languages.

In the field of accounting, the adoption of interface metaphors is particularly relevant, given that data-based accounting systems integrate multiple visual representations, such as information flows, dashboards, or algorithmic diagrams, which require a conceptual understanding of the accounting process and digital information processing.[5] Therefore, the use of visual and operational metaphors can facilitate the interpretation of digital accounting procedures, as well as the development of cognitive skills associated with analysis and decision-making.

Algorithmic thinking, in turn, is defined as the ability to formulate, break down, and structure solutions to problems using logical sequences of steps or procedures.[6] This type of reasoning is an extension of computational thinking and is an essential component of contemporary education, as it fosters skills such as abstraction, decomposition, and process automation.

In accounting education, algorithmic thinking enables the representation of financial operations and information flows as systematic procedures that can be modeled using data structures, decision rules, or processing algorithms.[7] This contributes not only to a more accurate understanding of accounting processes but also to their articulation with data-driven digital environments.

Furthermore, algorithmic thinking promotes a transition from simply memorizing procedures to understanding the rationale behind operations, strengthening meaningful learning and logical reasoning. When combined with digital tools, it allows students to interpret patterns, relationships, and dependencies within accounting systems, fostering a culture of data analysis and evidence-based decision-making.[8]

Contemporary accounting education faces the challenge of integrating digital literacy and data analysis as core competencies for professional training. The rise of accounting analytics, artificial intelligence, and ERP systems has transformed the nature of accounting learning, which now requires skills to interpret and model structured information in digital environments.[9]

Data-centric teaching strategies promote active learning, in which students interact with databases, visualizations, and accounting simulators that replicate real processes of recording, consolidation, and financial analysis. These practices, combined with appropriate interface metaphors, facilitate the understanding of abstract relationships between data, algorithms, and economic decisions.

The integration of interface metaphors and algorithmic thinking into accounting teaching involves the creation of interactive learning environments where visual representations and logical procedures coexist. These environments allow students to understand not only the accounting result, but also the computational process that generates it.[10]

This integration promotes deep learning and the development of hybrid technical, analytical, and reflective skills necessary for contemporary accounting practice. Consequently, interface metaphors based on algorithmic thinking are positioned as an emerging approach of high educational value within data-oriented accounting education.[11]

METHOD

For the systematic review of the literature presented in this article, a methodological approach based on the guidelines of Kitchenham et al.[12] was adopted. The methodological process was based on the collection, organization, and analysis of bibliographic data and metadata to ensure the traceability, transparency, and reproducibility of the study.

The method employed enabled us to identify, analyze, and synthesize the evidence available in relevant scientific sources, taking into account the theoretical contributions, teaching strategies, and technological tools reported over the last decade. Figure 1 illustrates the general stages of the methodological process employed in this review.

Figure 1. Stages of the systematic literature review

Research Questions

The main objective of this review was to analyze the scientific literature related to the use of interface metaphors based on algorithmic thinking applied to the teaching of data-oriented accounting processes.

To this end, the following research questions (RQ) were formulated:

- RQ1: What types of interface metaphors have been used in data-driven accounting education?
- RQ2: How has algorithmic thinking been integrated into accounting learning processes?
- RQ3: What digital tools or environments are reported for accounting teaching supported by data and algorithmic thinking?
- RQ4: What pedagogical strategies and learning outcomes are evident in the literature on the integration of interface metaphors and algorithmic thinking?

The PICO model (Population, Intervention, Comparison, and Outcomes) was used to define and organize the research questions. This tool is commonly used in systematic reviews to structure searches and define the core elements of the study.[13] Table 1 presents the definition of these concepts.

Table 1. Definition of concepts according to the PICO model

Criterion	Description
Population	Studies on accounting process teaching and data-based education.
Intervention	Application of interface metaphors and algorithmic thinking in teaching
Comparison	Traditional accounting teaching strategies without technological mediation.
Results	Impact on learning, conceptual understanding, and analytical skills.
Context	Higher education in accounting programs and related disciplines.

Search strategy

The search strategy was designed to ensure comprehensiveness, relevance, and reproducibility. The following scientific databases were explored: Scopus, Web of Science, IEEE Xplore, ScienceDirect, and RedALyC. Combinations of controlled terms and keywords in English and Spanish related to the central categories of the review were used. Table 2 presents the main terms, their synonyms, and the filters applied to them.

The searches were structured using Boolean operators and standardized descriptors in English and Spanish, considering both main terms and synonyms related to interface metaphors, algorithmic thinking, and data-driven accounting learning. Table 2 details the terms, combinations, and filters applied during the search. The inclusion of metadata, such as year of publication, language, document type, and subject field, allowed us to refine the information and ensure its relevance to the review's objectives.

Table 2. Search Terms, Synonyms, and Filters

Main term	Synonyms	Filters applied
Interface metaphors and algorithmic thinking in data-driven accounting education	Educational interfaces	Year of publication ≥ 2020
	Visual metaphors	Language: English or Spanish
	Data and metadata-based learning	Subject area: education, technology, accounting
	Accounting learning environments	Metadata completeness: title, abstract, keywords, DOI
	Algorithmic reasoning in accounting processes	

The search string was constructed using Boolean operators such as AND and OR, which allowed terms to be combined and results to be filtered accurately. For example, combinations such as the following were applied: ("interface metaphors" AND "algorithmic thinking") AND ("accounting education" OR "data-driven learning").

This procedure allowed us to retrieve relevant information and minimize redundancies, prioritizing articles with structured data and complete metadata.

Selection

All studies included in this review were analyzed; the following items were taken into account in the evaluation process: title, keywords, abstract, introduction, background, state of the art, methodology, results, and conclusions. Likewise, inclusion and exclusion criteria were defined in the review process.

The inclusion criteria are defined as follows: scientific documents related to studies on the use of interface metaphors and algorithmic thinking in the teaching of data-based accounting processes, or their synonyms. Similarly, the exclusion criteria defined are: studies that do not have a corresponding bibliographic citation; documents that do not contain the search terms or their synonyms; works focused solely on the development of accounting software without an educational component; and documents that are not available for download.

The selection of primary sources was carried out in four stages (because four specialized databases were considered), each of which consisted of three phases:

- Phase 1: elimination of duplicate articles;
- Phase 2: elimination of non-downloadable articles;
- Phase 3: application of inclusion and exclusion criteria.

As a result of the database search, a total of 98 studies were found; and after applying the inclusion and exclusion criteria, a total of 42 documents relevant to the analysis were obtained.

Quality Assessment

Seven criteria were taken into account in the quality assessment process for the selected documents: source origin, content relevance, study impact, research objective clarity, study context, methodological design objectivity, and scientific rigor in data and metadata analysis.

These seven criteria correspond to three fundamental elements of quality management: planning, organization, and control.

The evaluation involved reading and analyzing all 32 selected documents, as well as systematically eliminating duplicate articles, excluding non-downloadable articles, and verifying the inclusion and exclusion criteria defined in Section 3.3.

The results of this process are presented in table 3, which shows the documents retrieved, duplicated,

excluded, and finally selected in each database consulted.

Table 3. Quality assessment in search and selection processes

Main term	Search result	Duplicate files	Excluded files	Relevant files	Database
Interface metaphors and algorithmic thinking in data-driven accounting education	30	3	13	10	Scopus
	26	2	10	9	Web of Science
	22	3	9	8	IEEE Xplore
	20	2	14	5	RedALyC
Total	98	10	46	32	

This quality assessment ensured methodological consistency and the integrity of the data and metadata analyzed. In addition, the process ensured that the selected documents met standards of validity, currency, and scientific relevance, contributing to the reliability of the systematic review results.

Data Extraction and Synthesis of Results

Given that the main objective of this systematic study is to determine the state of the art on interface metaphors and algorithmic thinking in the teaching of data-based accounting processes, once the search for terms in each database had been carried out and the three corresponding phases had been applied, the findings of the relevant documents were analyzed, considering both the content and the associated bibliographic metadata.

The results obtained in the systematic review are presented below, based on the information extracted from the selected studies and their respective author citations.

RESULTS

The results obtained after the systematic review process reflect a growing intersection between accounting education, algorithmic thinking, and the management of educational data and metadata. This convergence demonstrates the field's evolution toward a more analytical pedagogical practice, supported by the processing and visualization of structured information.

Of the 32 selected studies, four main thematic categories were identified that synthesize the conceptual, methodological, and technological trends in the literature:

1. Interface metaphor models and approaches.
2. Development of algorithmic thinking in accounting education.
3. Digital tools and data visualization applied to learning.
4. Data-based pedagogical strategies and learning outcomes.

Analysis of bibliographic metadata also revealed increased scientific output since 2020, concentrated in indexed education and technology journals, indicating sustained growth in academic interest in data-driven approaches to accounting education.

Interface Metaphor Models and Approaches

The studies reviewed show that interface metaphors function as cognitive structures that facilitate interaction between users and digital accounting systems. In most cases, the research combines semiotic analysis, visual modeling, and metadata management to describe how these metaphors enable the representation of complex financial processes through computational analogies.[14]

Most studies identified a recurring use of visual and operational metaphors, especially in accounting visualization tools and financial recording systems. These metaphors enable students to visually explore data and identify patterns that reflect the behavior of accounting processes. In this context, the interface becomes a symbolic representation of the system, where metadata, such as variable names, categories, or hierarchical relationships, play an essential role in understanding the informational structure.[2]

Likewise, research highlights that interface metaphors must be consistent with the ontology of accounting data to avoid ambiguities in visual interpretation. The use of well-designed analogies not only improves usability but also reinforces the semantic consistency and traceability of metadata, ensuring that educational processes based on digital platforms maintain fidelity between the conceptual model and its computer representation.[15]

Development of Algorithmic Thinking in Accounting Education

Algorithmic thinking is emerging as a key cross-cutting skill for contemporary accounting education. This type of reasoning fosters the ability to structure, break down, and automate financial processes through

logical sequences of operations. The literature reviewed suggests that teaching accounting from an algorithmic perspective enhances students' understanding of information flows, enabling them to interpret accounting operations as programmable and analyzable processes.[7]

The studies analyzed demonstrate that algorithmic thinking enables a more comprehensive approach to the accounting data life cycle, as it integrates the stages of capture, classification, processing, and visualization. This approach promotes data and metadata literacy, as students learn to identify not only numerical values but also the informational structure that contextualizes them. As a result, future professionals acquire a systemic understanding of digital processes, which enhances the quality and auditability of accounting information.[6]

Additionally, algorithmic thinking enhances the development of analytical and problem-solving skills, thereby facilitating evidence-based decision-making. The review reveals that this approach is not limited to the use of technological tools, but promotes a pedagogical reconfiguration in which students act as process designers, rather than just as consumers of information. This generates an epistemological shift towards a more logical, reflective, and data-oriented accounting education.[2]

This paradigm is supported by broader research on algorithmic thinking. It has been demonstrated that algorithmic thinking, encompassing decomposition, abstraction, pattern recognition, and the creation of logical sequences, is emerging as a crucial dimension of higher learning, enhancing students' capacity to tackle complex problems and devise practical solutions.[16] In the context of accounting, the integration of algorithmic thinking with programming, modeling, and process logic is helping to train professionals who are capable of optimizing and automating financial processes, thereby combining accounting and analytical skills to adapt to advanced digital environments.[17]

The incorporation of algorithmic thinking into accounting education requires a transformation of curriculum design, teaching methods, and assessment. Students move beyond simply applying accounting rules and begin to analyze how those rules can be automated, optimized, or adapted using algorithms, which undoubtedly contributes to a more robust, flexible professional education in line with today's digital environments.[18]

Digital Tools and Data Visualization Applied to Learning

The use of digital tools is one of the most developed areas in the literature reviewed. These platforms, which include accounting simulators, interactive dashboards, and algorithmic visualization systems, allow students to experiment with real or simulated data, promoting active and contextualized learning. In 64 % of the studies, the use of visual analysis software or data mining tools applied to the accounting environment is documented, reflecting a growing interest in data science-mediated education.[19]

The use of digital tools is one of the most developed areas in the literature reviewed. These platforms, which include accounting simulators, interactive dashboards, and algorithmic visualization systems, allow students to experiment with real or simulated data, promoting active and contextualized learning. For example, the study "Using dashboards and data visualizations in teaching accounting",[20] documents how the use of dashboards and data visualizations in accounting courses improves both students' technical knowledge and analytical skills.

Research indicates that data visualization is crucial for transforming numerical information into comprehensible knowledge. Digital environments enable students to analyze relationships, dependencies, and trends through dynamic graphics that represent accounting processes in a nonlinear manner. This approach facilitates the interpretation of results and validation of procedures, while generating educational metadata on learning behavior, such as response times, navigation paths, and frequency of use, which can be utilized in educational analytics processes.[21]

Consistently, the authors reviewed agree that visualization tools not only improve the user experience but also increase the transparency and reproducibility of data, which are essential characteristics in evidence-based educational research. In particular, the use of accounting dashboards has established itself as an effective strategy for linking information analysis with financial decision-making, simultaneously integrating data and metadata management.[22]

Visualization platforms applied to accounting learning have also demonstrated their potential to encourage student self-regulation by providing immediate feedback on their performance. A study on learning dashboards found that students who frequently accessed performance charts improved their goal setting and modified their study behavior based on the data observed.[20]

In the context of accounting, data visualization allows students to interact with large volumes of transactions and financial flows, transforming that data into graphical representations that facilitate the detection of irregularities, patterns, or dependencies that would be difficult to observe solely from traditional accounting books. For example, the study "Using Tableau to visualize data and drive decision-making" showed that accounting students who used interactive dashboards were able to make more informed decisions than the control group.

Digitized accounting simulators that incorporate visualization elements also contribute to the generation of educational metadata—such as resolution times, student navigation paths, and review frequencies for each module—which can be used to build learning profiles and adapt the educational experience to each student. A

study on the design of accounting information systems based on visualization technology showed that capturing this metadata significantly improved the traceability and auditability of the learning system.[23]

Visualization tools also contribute to the transparency of accounting data by allowing students to examine not only the final financial statements but also the entire process that generated those statements, including the algorithmic transformations applied. The systematic review on learning dashboards notes that the design of both user- and process-oriented visualizations improves the reproducibility of educational and financial analyses.[24]

In collaborative teaching situations, interactive dashboards enable groups of students to work in real-time on the same set of accounting data, jointly identify patterns, and validate audit or financial accounting hypotheses through shared visualizations. Recent studies have found that these types of tools increase collective engagement, facilitate analytical discussions among peers, and promote deep learning in data-driven accounting environments.[22]

The integration of data visualization with project-based methodologies in accounting education strengthens the connection between theory, practice, and real data analysis. By developing real dashboards on accounting processes, students not only apply accounting knowledge but also build models, create visualizations, and reflect on the data itself, which promotes the transfer of learning to the professional context.[25]

Data-Based Teaching Strategies and Learning Outcomes

Data-based pedagogical strategies represent the most cross-cutting component identified in the review, as they integrate both the use of technological tools and cognitive approaches associated with algorithmic thinking. These strategies prioritize interaction between the student and the data, allowing learning to be constructed from the analysis, comparison, and interpretation of accounting information. Project-based learning, combined with data analysis and the simulation of accounting processes in digital environments, is the most frequently documented practice.[26]

The results suggest that these strategies improve conceptual understanding of accounting by fostering an investigative and analytical attitude. Teachers can monitor student progress by capturing interaction metadata, such as the sequence of actions, navigation patterns, or task execution time, which provides deeper insight into the learning process. This translates into adaptive and personalized education, in which pedagogical decision-making is based on empirical evidence derived from educational data.[27]

As shown by Msekelwa[28] in their study on data-driven pedagogy, capturing information about student interaction allows for real-time adjustments to pedagogical design, promoting personalized learning and the development of analytical skills. This reinforces the idea that integrating digital tools and data analytics not only enhances conceptual understanding but also fosters active and reflective learning.

Likewise, the review indicates a growing interest in the use of predictive models and learning analytics, which utilize metadata to anticipate student performance and potential difficulties. These practices enhance the traceability of the educational process and facilitate the development of preventive support strategies.[29] Taken together, the studies reviewed confirm that the combination of algorithmic thinking, interface metaphors, and data management drives a more intelligent, measurable, and results-oriented pedagogy.

A review of predictive models in learning analytics in higher education reveals that these techniques enable the anticipation of student performance and difficulties, thereby strengthening the traceability of the educational process and facilitating preventive support interventions.[30] The application of these tools ensures that teaching is not only reactive but also proactive, based on evidence gathered from student interaction and performance.

In the field of accounting education, López-Fernández et al.[31] document how learning analytics applied to digital environments enable the capture of relevant metadata to monitor student participation and performance. This demonstrates that the combination of algorithmic thinking, interface metaphors, and data management drives a more intelligent, measurable, and results-oriented pedagogy, aligning accounting education with the skills required in modern professional contexts.[32]

CONCLUSIONS

The findings of this systematic review show that the convergence of algorithmic thinking, digital tools, and data visualization is central to contemporary accounting education. The integration of these strategies enables students not only to comprehend financial processes but also to develop analytical skills, automation skills, and the ability to interpret and manage metadata, thereby strengthening their data literacy.

It is evident that, although significant advances have been made in the use of dashboards, simulators, and data analysis software, a greater consensus is still needed on methodologies, teaching models, and evaluation criteria to optimize data-based accounting education. Pedagogical strategies that focus on projects and interaction with real or simulated data have a positive impact on conceptual understanding, problem-solving, and evidence-based decision-making.

In summary, the systematic review allowed us to compile, synthesize, and categorize the findings of 42 recent studies, confirming that accounting education is evolving toward a data-driven, intelligent, and measurable model. This approach raises the need to design flexible curricula, incorporate interactive digital tools, and develop cross-cutting skills in algorithmic thinking and data management. Metadata literacy and the use of educational analytics are emerging as strategic elements in training professionals who can adapt to complex digital financial environments based on quantitative information.

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