REVISTA TÓPICOS
ISSN 2965-6672 | Qualis A2

SCIENTOMETRIC STUDY ON THE COURSE TIMETABLING PROBLEM IN EDUCATIONAL INSTITUTIONS

ESTUDO CIENTOMÉTRICO SOBRE O PROBLEMA DA ELABORAÇÃO DE HORÁRIOS DE AULAS EM INSTITUIÇÕES DE ENSINO

Ciências Humanas • 18/03/2026

REGISTRO DOI: 10.70773/revistatopicos/773816378

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ABSTRACT

The efficient allocation of teaching hours in educational institutions represents a central challenge for academic management. This study aimed to investigate, through a scientometric approach, the main methodologies, trends, and scientific collaborations involved in the course timetabling problem over the past decades. The scientometric analysis was conducted through a systematic search for scientific articles published between 1969 and 2025 in the Web of Science, Scopus, and SciELO databases, using keywords related to the topic. After a rigorous selection process, the data were analyzed using the Bibliometrix package in the R environment, enabling the mapping of publication patterns, collaboration networks, leading authors, prominent journals, and the evolution of applied methodologies. The results reveal continuous growth in scientific output on course timetabling, with publications concentrated in a few high-impact journals and dominated by a small group of authors and institutions. A strong presence of international collaborations was identified, along with a predominance of integer programming, heuristics, and hybrid approaches, in addition to recent advances in the integration of machine learning methods. From a scientometric perspective, these findings contribute to understanding the field's development, highlighting the importance of global collaborations and methodological innovations for improving timetabling practices in educational settings. The study concludes that, despite significant progress, important gaps remain, particularly regarding the geographic distribution of research and the depth of collaboration networks. The results underscore the need for future studies to explore different institutional contexts and the application of emerging technologies to enhance academic time management. Among the limitations, the dependence on international indexing databases stands out, which may limit the

scope of retrieved articles and potentially exclude relevant works not published in indexed journals. As future directions, further analysis in regional contexts and the investigation of the impact of new technologies, such as artificial intelligence, on the timetabling field are recommended.
Keywords: Scientometrics; Course Timetabling; Integer Programming; Scientific Collaboration; Scheduling

RESUMO

A alocação eficiente de horas letivas em instituições de ensino representa um desafio central para a gestão acadêmica. Este estudo teve como objetivo investigar, por meio de uma abordagem cientométrica, as principais metodologias, tendências e colaborações científicas envolvidas no problema de elaboração de horários de aulas nas últimas décadas. A análise cientométrica foi conduzida por meio de uma busca sistemática de artigos científicos publicados entre 1969 e 2025 nas bases de dados Web of Science, Scopus e SciELO, utilizando palavras-chave relacionadas ao tema. Após um rigoroso processo de seleção, os dados foram analisados utilizando o pacote Bibliometrix no ambiente R, permitindo o mapeamento de padrões de publicação, redes de colaboração, autores principais, periódicos de destaque e a evolução das metodologias aplicadas. Os resultados revelam um crescimento contínuo na produção científica sobre elaboração de horários de aulas, com publicações concentradas em alguns periódicos de alto impacto e dominadas por um pequeno grupo de autores e instituições. Foi identificada uma forte presença de colaborações internacionais, juntamente com uma predominância de programação inteira, heurísticas e abordagens híbridas, além de avanços recentes na integração de métodos de aprendizado de máquina. De uma perspectiva cientométrica, essas descobertas

contribuem para a compreensão do desenvolvimento da área, destacando a importância das colaborações globais e das inovações metodológicas para aprimorar as práticas de elaboração de horários em ambientes educacionais. O estudo conclui que, apesar do progresso significativo, ainda existem lacunas importantes, principalmente em relação à distribuição geográfica da pesquisa e à profundidade das redes de colaboração. Os resultados ressaltam a necessidade de estudos futuros explorarem diferentes contextos institucionais e a aplicação de tecnologias emergentes para aprimorar a gestão do tempo acadêmico. Entre as limitações, destaca-se a dependência de bases de dados de indexação internacionais, o que pode limitar o escopo dos artigos recuperados e potencialmente excluir trabalhos relevantes não publicados em periódicos indexados. Como direções futuras, recomenda-se uma análise mais aprofundada em contextos regionais e a investigação do impacto de novas tecnologias, como a inteligência artificial, na área de elaboração de horários.
Palavras-chave: Cientometria; Elaboração de Horários de Cursos; Programação Inteira; Colaboração Científica; Planejamento

INTRODUCTION

The efficient allocation of teaching hours in educational institutions is essential to ensure educational quality. This practice directly impacts administrative efficiency, faculty satisfaction, and student academic performance. It is a central concern in university management, as it directly influences institutional productivity, student outcomes, and the quality of academic activities (Kanwal, Rafiq and Afzal, 2023).

Studies have shown that the way faculty time is distributed among teaching, research, and outreach activities significantly affects both individual faculty outcomes and the achievement of institutional goals (Milem, Berger and Dey, 2000; Creamer, 1999). Moreover, workload allocation decisions must balance administrative and pedagogical demands, while considering structural constraints and faculty preferences, which further complicates the problem (Link, Swann and Bozeman, 2008). In this context, understanding and optimizing these processes is essential for ensuring more efficient human resources management (HRM) in higher education institutions, promoting better working conditions for faculty and improving the quality of educational offerings.

With the exponential growth in the diversity of courses and teaching modalities, traditional scheduling methods have been increasingly challenged to adapt to more complex and dynamic demands. The current literature discussesseveral optimization techniques, such as linear programming and heuristics, applied to the workload allocation problem, covering a wide range of educational contexts. These studies are crucial for developing practices that not only address logistical requirements but also support the pedagogical objectives of institutions. Research in this area has shown that the effective implementation of these methodologies can significantly improve resource management and the overall educational experience.

Despite the development of various methods to optimize workload allocation, there remains limited understanding of how these methods perform across different types of educational institutions. Each institution has its own needs, constraints, and goals, making it

essential to understand how methodologies can be effectively adapted and applied in diverse contexts.

Furthermore, there is significant potential to integrate modern technologies, such as artificial intelligence and geographic information systems, into workload allocation methodologies. These technologies can enhance the effectiveness of existing models by providing new ways to analyze data, predict needs, and optimize resources.

This study aims to address these gaps through a robust scientometric analysis. Bibliometric and scientometric approaches are well-established methodologies for mapping trends, key actors, and publication patterns in specific scientific fields (Donthu, Kumar, Mukherjee, Pandey and Lim, 2021). Research on workload allocation methods holds significant academic relevance, as it provides an in-depth understanding of teaching time management practices, which are critical to educational quality. Furthermore, systematizing the available information on this topic will allow for the identification and mapping of existing research gaps, promoting the development of new approaches and methods, and thereby contributing to innovations in education and numerical methods.

Consequently, this study seeks to identify the main methodologies used in workload allocation, exploring their applications, effectiveness, and limitations. A bibliographic research approach was employed to extract relevant scientific articles from established databases such as Web of Science (WOS), Scopus, and SciELO. The analysis covers the period from 1969, with pioneering articles, to February 2025. For data analysis, we employed the Bibliometrix software, operating within the R programming environment,

allowing for the investigation of patterns and trends in the academic literature. This analysis also facilitated the identification of collaboration networks and the observation of the evolution of research over time. Such an approach not only enriches the theoretical discussion but also provides practical guidelines for academics, educational managers, and policymakers aiming to improve time management practices in educational institutions.

Only five relevant review articles were found on academic timetabling problems, published at different times and addressing complementary perspectives, as summarized in Table 1. These review articles, published over more than two decades, demonstrate the evolution of techniques and approaches to timetabling, consolidating knowledge and setting directions for future research.

Table 1: Comparison of the main review articles on academic timetabling problems

Article	Review Focus	Main Techniques Analyzed	Contributions/Findings
Schaerf (1999)	General formulations and techniques for timetabling (school, course, and exam)	Genetic algorithms, tabu search, simulated annealing, constraint satisfaction	Classification of problems and techniques; emphasis on AI
Qu et al. (2008)	Search methodologies and system development for exam timetabling	Heuristics, local search, evolutionary algorithms, ant colony optimization, hybrid methods	Identification of trends and challenges; benchmark standardization

Teoh et al. (2013)	Use of metaheuristics for academic scheduling problems	Tabu search, genetic algorithms, simulated annealing, ACO, PSO, hyper-heuristics	Analysis of algorithm categories and their practical applications
Bashab et al. (2020)	Systematic mapping of metaheuristics in university timetabling	Grey Wolf Optimizer, Cat Swarm Optimization, hybrid algorithms	Identification of trends and gaps in the adoption of hybrid algorithms
Gu et al. (2025)	Technical review of integer programming and machine learning in timetabling	Integer programming, machine learning, hybrid solutions, use of CPLEX and Gurobi	Demonstration of the superiority of integer programming and the potential of AI integration

However, these reviews did not address fundamental aspects such as the dominance of certain countries in publications, co-authorship networks among researchers, or the application of essential analytical tools such as Bibliometrix. This gap limits the understanding of the geographic distribution and academic collaborations in the field. Regular bibliometric analyses are essential to monitor the evolution of this research area and to keep the scientific mapping up to date. This is crucial for capturing emerging trends and significant advancements and integrating them into practical models to address these challenges, thereby reinforcing the importance of this study. The primary objective of this article is to investigate the predominant methodologies used for workload allocation in educational institutions. Specifically, the goal is to identify the most effective and widely adopted techniques, as well as to examine the trends and innovations that have influenced

research in this field over the years. To achieve this, we adopted the methodological guidelines proposed Zupic and Čater (2015), which outline five steps for conducting bibliometric and scientometric analyses:

- Definition of the research objective.
- Construction of the bibliographic corpus through the careful selection of databases and keywords
- Application of analytical techniques such as co-authorship, co-citation, and keyword analysis
- Visualization of networks and trends using Bibliometrix.
- Interpretation of results the scientific development of the field under study.

1. MATERIALS AND METHODS

1.1. Data Collection

The data collection for this study covers publications from 1969 to February 2025, aiming to capture the evolution of scheduling techniques in educational institutions. Three databases recognized for their broad academic coverage were used: Web of Science (WOS), SciELO, and Scopus. These platforms were selected for their relevance and international reach in disseminating high-quality research.

The search was conducted using a specific combination of keywords to ensure the relevance and precision of the collected articles. The

keywords used were: "timetabling" AND ("linear programming" OR "integer programming" OR "binary programming" OR "heuristic*") AND ("school*" OR "university*" OR "professor").

The chosen keywords—"Scheduling Problem," "Timetabling," "Linear Programming," "Integer Programming," "Binary Programming," "Heuristic," and combinations such as "School* OR University* OR Professor"—were carefully selected to encompass various aspects of the timetabling problem in educational settings.

The keyword "Scheduling Problem" was included because it broadly covers the central issue of scheduling that this study aims to address. It helps capture articles discussing both the challenges and solutions related to the efficient organization of timetables, which is the core of timetabling problems.

"Timetabling" specifically directs the search toward the academic and school context, ensuring that the retrieved articles are directly applicable to the scope of this study.

Techniques such as "Linear Programming," "Integer Programming," and "Binary Programming" are essential to this research as they represent specific mathematical methods used in schedule optimization.

- "Linear Programming" addresses problems modeled by linear relationships, which are common in scheduling contexts.

- "Integer Programming" is particularly relevant when decision variables must be integers, a typical requirement in workload allocation.

- "Binary Programming" applies to situations where decisions are binary, such as assigning a class to a specific time slot, making it easier to model "yes or no" choices.

The inclusion of "Heuristic" as a keyword opens the search to articles discussing approximate solution methods, which are crucial for solving complex optimization problems that are often too large or computationally intensive for exact methods. Such methods are indispensable in timetabling, where practical and efficient solutions are frequently required. Finally, the terms "School* OR University* OR Professor" help filter the search to focus on different educational levels and perspectives within academic environments, ensuring the study addresses workload allocation across a variety of educational contexts, from schools to universities.

The articles were initially filtered to remove duplicates using an automated script that ensured efficient exclusion of repeated records across the databases. After the duplication, an additional screening was conducted to exclude publication types that did not align with the study's focus, such as conference proceedings, book chapters, and other non-scientific works. Only original research articles were retained for analysis.

Duplicate removal was performed using the Bibliometrix 4.1.3 package Aria and Cuccurullo (2017) implemented in R version 4.4.0, ensuring accurate identification and exclusion of 54 duplicated documents across the databases.

The complete analysis corpus, comprising 370 articles selected from Web of Science, Scopus, and SciELO, is listed in Appendix A,

ensuring reproducibility and transparency regarding the data used in this study.

To ensure the relevance of the analyzed documents, only original research articles that addressed workload allocation methodologies applied to educational institutions were included. Documents such as reviews, book chapters, conference papers, and others that did not present bibliometric or quantitative data were excluded. In this process, five review articles were removed.

The initial selection identified 424 documents distributed across the databases as follows: 345 in Web of Science, 68 in Scopus, and 11 in SciELO. After removing duplicates and applying the exclusion criteria, the final analysis corpus consisted of 223 articles. The selection process flow, detailed in Fig. 1, follows an adapted PRISMA protocol structure. The complete list of the 223 articles included in the final corpus is available in Appendix A, ensuring the transparency and reproducibility of this study.

Descriptive analyses and scientific mapping were conducted using the Bibliometrix 4.1.3 package Aria and Cuccurullo (2017), implemented in R version 3.4.1 R Core Team (2023). The analyzed period spanned from 1969 to 2025, and the results provide a detailed overview of the scientific output and collaboration trends in the field. Throughout the analysis process, 101 sources were identified, including journals and books, totaling 223 scientific documents.

The annual growth rate of the publications was 1.98%, reflecting a continuous, albeit modest, increase in scientific output over the years. The average document age was 11.1 years, indicating that most of the literature is relatively recent, with a strong concentration of

publications in recent years. On average, each document received 19.41 citations, demonstrating a considerable impact of the analyzed publications within the research field. In total, the documents cited 3,871 references, indicating the diversity and depth of the material consulted by the authors.

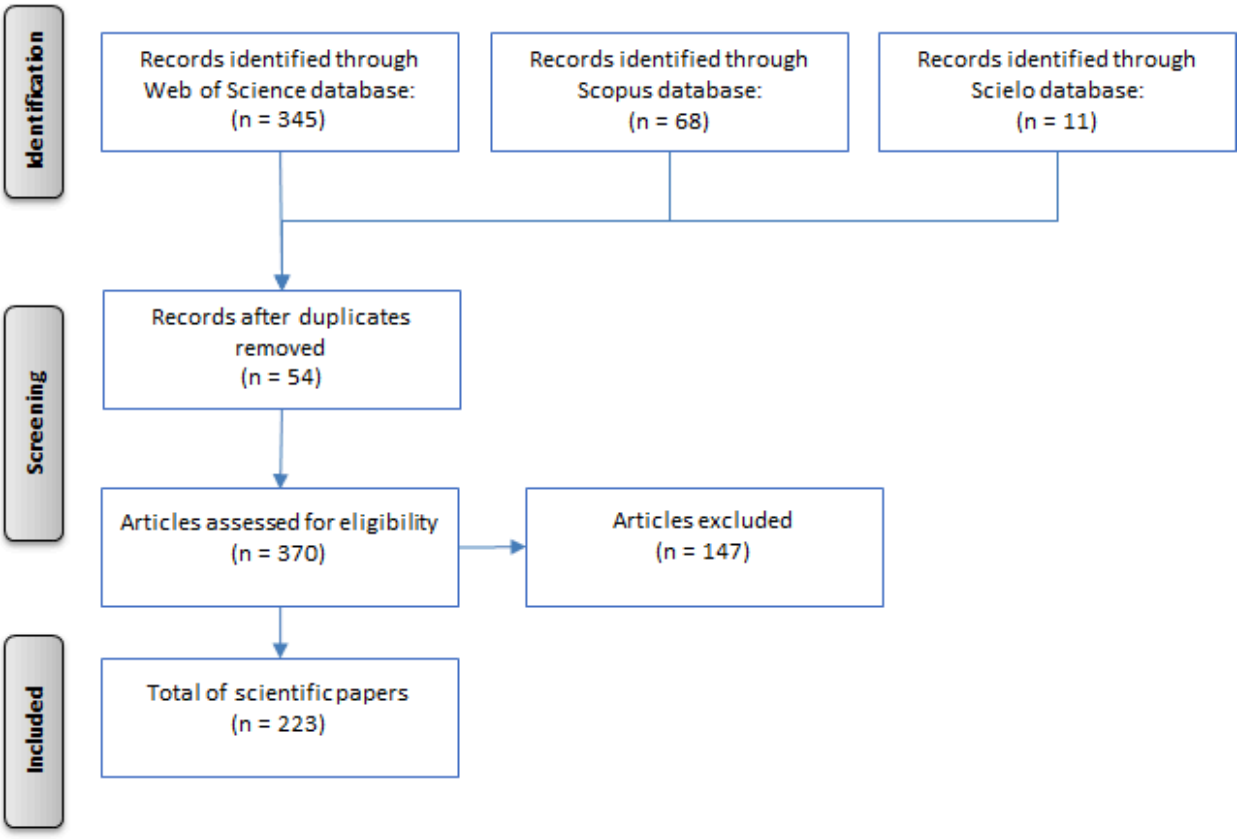
Regarding authorship, 536 distinct authors were identified, with 25 authors responsible for single-authored articles. Although single-authored contributions represent a small portion of the total, the data reveal substantial collaboration among researchers. On average, each document had three co-authors, highlighting the collaborative nature of scientific research in this field. Additionally, approximately 23.32% of the documents involved international co-authorship, underscoring the global interaction and knowledge exchange among researchers from different countries. Fig. 2 illustrates this finding.

A total of 563 keywords provided by the authors themselves were observed, reflecting the diversity of approaches and topics addressed in the documents. These data indicate a wide range of subjects within the scientific literature, highlighting the complexity and interconnection of research themes over time.

1.2. Temporal Trends In Publication And Authorship

The graph of annual scientific production, shown below in Fig. 3 , illustrates the evolution of research output over the years, highlighting fluctuations in the number of published articles. Scientific production was relatively modest in the early years, with significant peaks beginning in the 2000s, particularly in 2009 and 2016.

Figure 1: PRISMA flow diagram adapted to the study selection process.



This sharp growth may reflect the rising interest and increased collaboration in the related research areas, driven by technological advancements, changes in funding policies, and emerging academic trends. From 2020 onward, a slight stabilization in publication volume is observed, with a projected decline in the number of publications for 2025, possibly due to external factors or shifts in the dynamics of scientific research.

In addition to analyzing annual publication output, it is important to consider the implications of Lotka's Law (Lotka, 1926) for the distribution of authorship among researchers. According to this law, the frequency of scientific publications follows a distribution suggesting that a small number of authors contribute the majority of articles, while most researchers publish very few. In a typical Lotkaian distribution, it is expected that about 60% of researchers

contribute only one article, while a much smaller proportion (usually between 1% and 2%) is responsible for a large share of the publications.

To illustrate this trend, the scientific production data can be analyzed through the lens of Lotka's Law, seeking to verify whether the authorship pattern follows an exponential distribution, as suggested by Lotka. In the data presented, it is possible to observe that a small fraction of authors has contributed to the majority of articles, particularly after the rise in publication output starting in 2000. This behavior supports the idea that the growth of scientific production is driven by a limited group of researchers who, over time, become responsible for an increasing volume of contributions (see Fig. 4).

1.3. Trends In Scientific Journals

The analysis of source dispersion according to Bradford's Law revealed that scientific production on the subject is highly concentrated in a small number of journals, known as core sources. The top five journals in the rank- ing—European Journal of Operational Research, Computers & Operations Research, Journal of Scheduling, Annals of Operations Research, and Journal of the Operational Research Society—constitute Zone 1, collectively accounting for 81 articles, which represents approximately 72% of the total analyzed.

This concentration is visually highlighted in Fig. 5 by a shaded area covering the portion corresponding to the core journals, reinforcing the central characteristic of Bradford's Law: a small group of sources is responsible for the majority of the relevant output on a given topic.

Figure 2: Distribution of publications by country, distinguishing single-country (SCP) and multiple-country (MCP) contributions

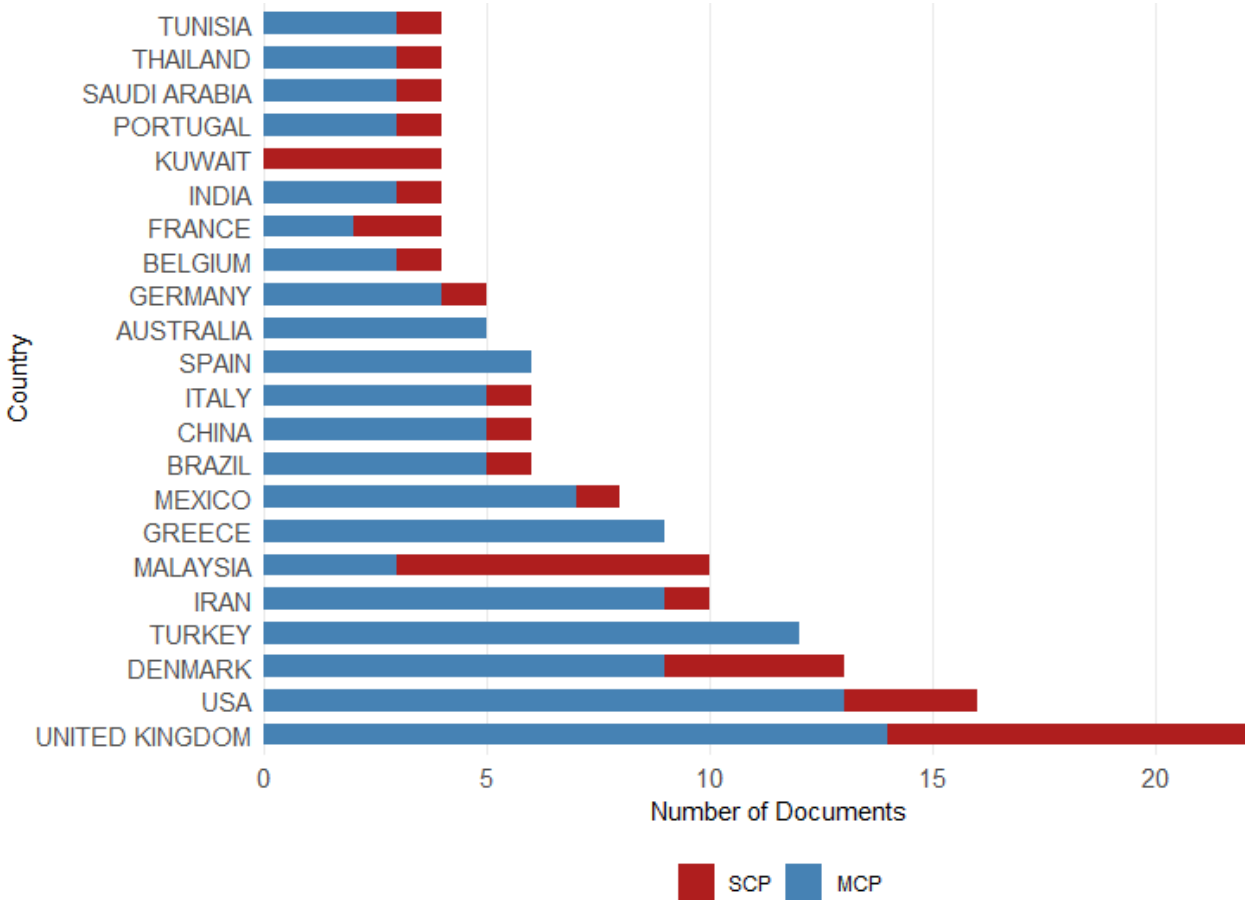
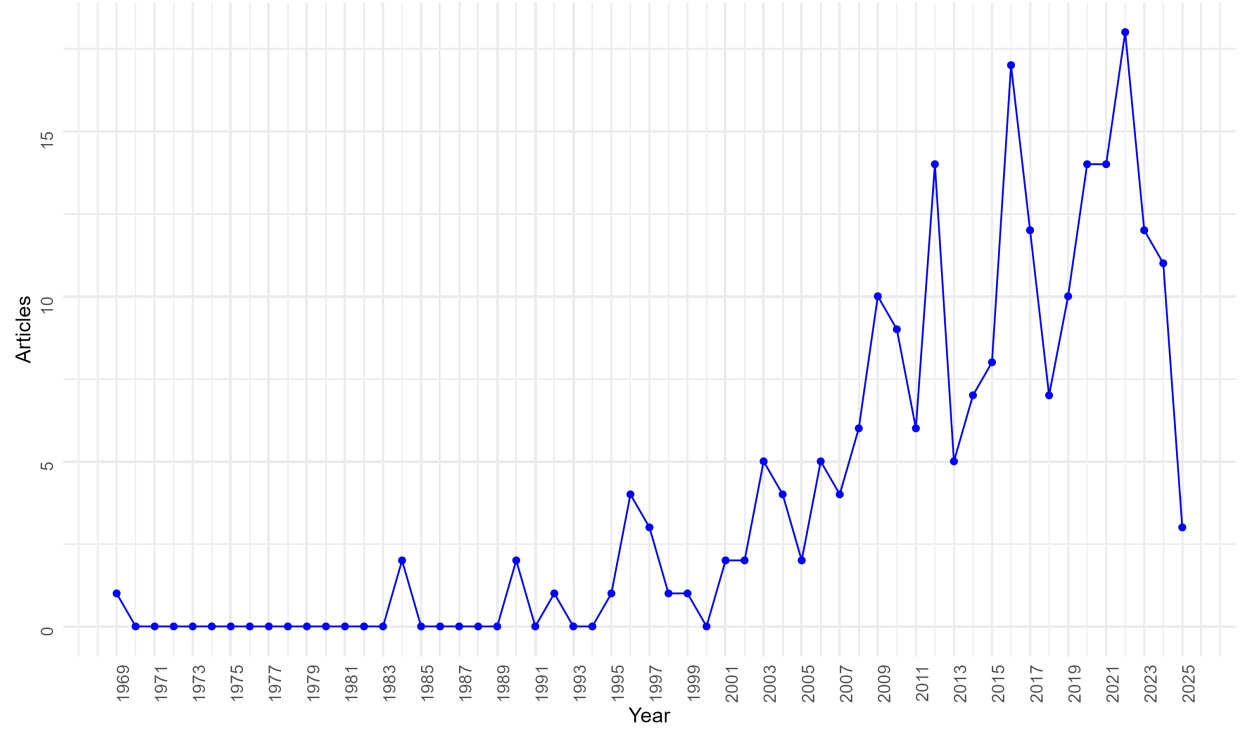


Figure 3: Graph of the annual production of scientific articles.



From the sixth-ranked journal onward, there is a sharp decline in publication frequency, marking the beginning of Zone 2, which comprises sources with lower and more dispersed contributions. These findings confirm the typical pattern described by Bradford's Law, serving as a useful tool for librarians and researchers in the strategic selection of essential journals for collections and systematic reviews.

Figure 4: Bradford's Law: concentration of publications in a few core journals

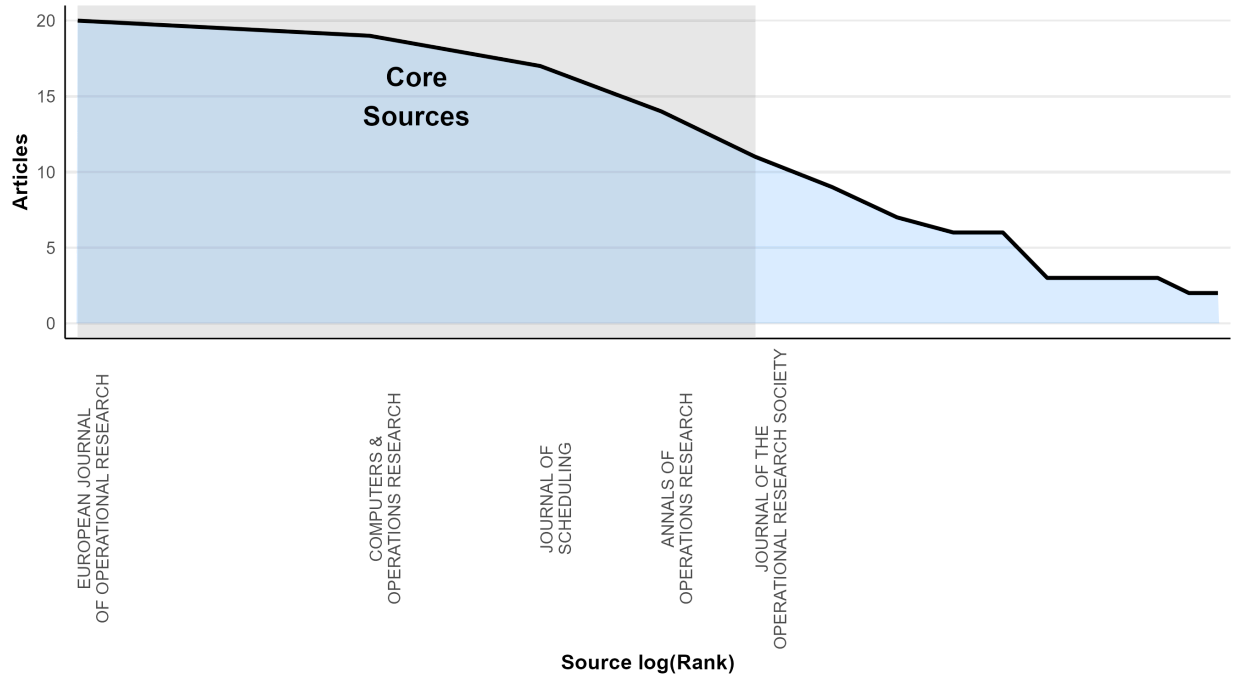
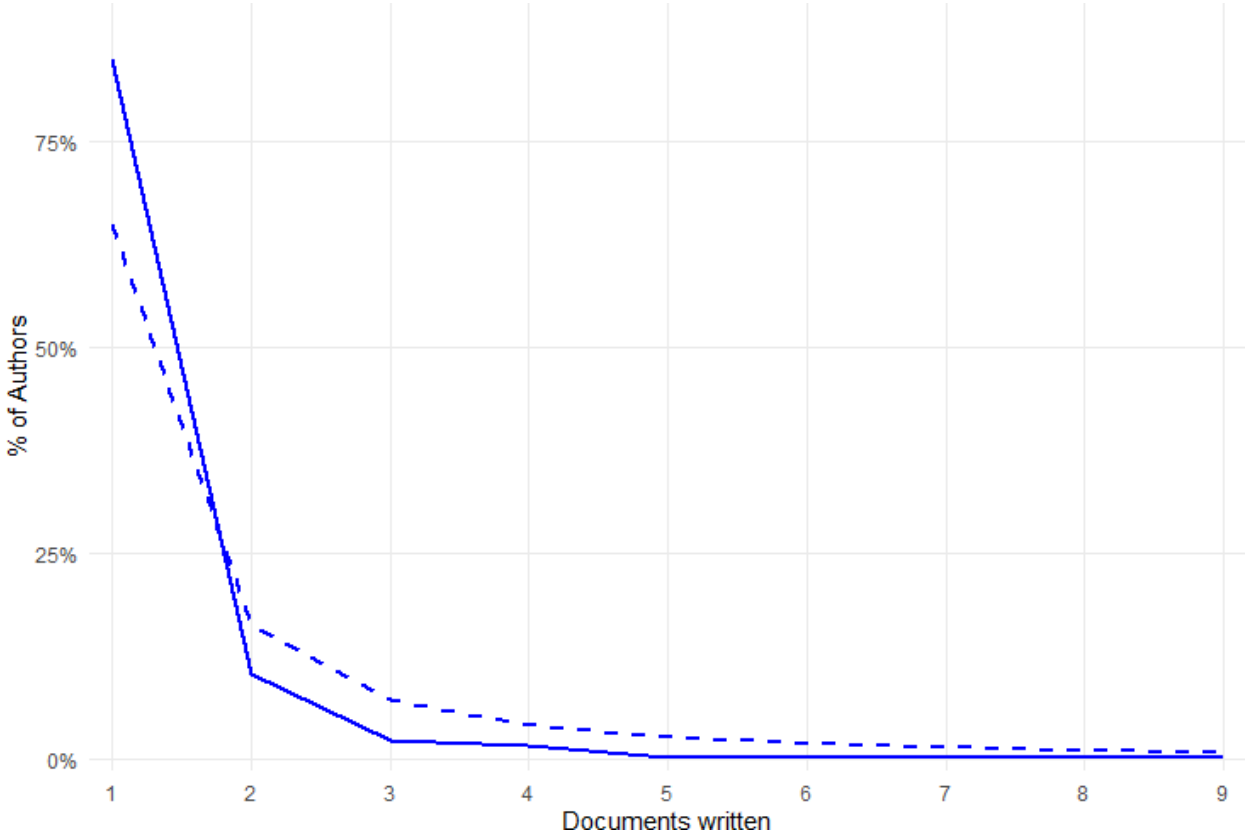


Figure 5: Author Productivity According to Lotka's Law.



The word cloud presents the 51 most frequent keywords related to timetabling and associated research areas, with "timetabling" standing out as the most cited term, appearing 80 times, followed by "integer programming" (45 occurrences) and "heuristics" (33 occurrences) (see Fig. 6).

1.4. Structure And Collaborative Networks In The Scientific Field

Other notable keywords include "university course timetabling," "optimization," "scheduling," "tabu search," and "metaheuristics," reflecting the extensive application of advanced computational techniques, such as integer programming and genetic algorithms, in addressing the timetabling problem.

These results confirm that the field is methodologically driven by mathematical programming and heuristic- based approaches, reinforcing the relevance of computational optimization methods in solving increasingly complex scheduling problems in academic environments.

Figure 6: Word cloud of the 51 most frequent keywords that appeared at least three times

The international collaboration network among authors and institutions was analyzed based on co-authorship data by country, reflecting academic and scientific connections represented by joint publications. The data reveal a wide range of collaborations, with some recurring partnerships standing out. For example, the United Kingdom emerged as a key player, with frequent collaborations with Malaysia (a frequency of 5), Ireland (a frequency of 3), Australia, New Zealand, the Czech Republic, and Turkey (each with a frequency of 2). Malaysia also played a central role, engaging in intensive collaborations with Australia, Ireland, and Saudi Arabia.

These collaborations are visualized in a network graph (see Fig. 7), where each node represents a country and each edge (connection line) represents a collaborative relationship. The thickness of the edges is proportional to the frequency of collaboration, highlighting the pairs with the highest levels of scientific interaction.

The co-authorship network analysis not only quantifies collaborative production but also maps the social structure of science, identifying central authors, thematic clusters, and the diffusion of knowledge

across different communities. This demonstrates that dense and well-connected networks indicate mature scientific fields, while fragmented networks may signal emerging areas or fields lacking integration. Furthermore, the structural analysis of these networks, using metrics such as centrality, density, and modularity, reveals how knowledge circulates and identifies which authors or institutions act as bridges between different subfields, playing a strategic role in scientific dissemination.

Co-authorship network analysis not only quantifies collaborative production but also maps the social structure of science, identifying central authors, thematic clusters, and the diffusion of knowledge across different communities. Prior studies have shown that dense and well-connected networks are typically associated with mature scientific fields, whereas fragmented networks may reflect emerging areas or fields lacking integration (Newman, 2001; Liu, Bollen, Nelson and Van de Sompel, 2005). Furthermore, the structural analysis of these networks—through metrics such as centrality, density, and modularity—provides insights into how knowledge circulates and which authors or institutions act as bridges between subfields, thereby playing a strategic role in the dissemination of scientific knowledge (Ding, 2011; Yan and Ding, 2012; Abbasi, Hossain and Leydesdorff, 2012).

1.5. Citation Patterns Among Documents And Journals

This scientometric study analyzed the 11 most cited articles related to workload allocation and course scheduling in educational institutions, providing a comprehensive overview of the most influential approaches in the field (see Fig. 8). These articles primarily focus on the development of mathematical models, metaheuristic

algorithms, and hybrid techniques to address the complex problem of university timetabling.

The work by Daskalaki, Birbas and Housos (2004) proposes an integer programming formulation to solve real- world academic scheduling cases, while Lü and Hao (2010) and Hao, a, Yang, Zhou and Xie (2023) introduce an adaptive tabu search algorithm for course timetabling, widely cited for its effectiveness. Several studies, such as those by Edmund K. Burke (2006), Chiarandini, Birattari, Socha and Olivia (2006), and Qu, Burke, McCollum, Merlot and Lee (2009b), explore the combination of case-based heuristics and hybridizations with graph-based methods and evolutionary algorithms, standing out for their practical applications and adaptability.

Figure 7: International Network on Timetabling Research

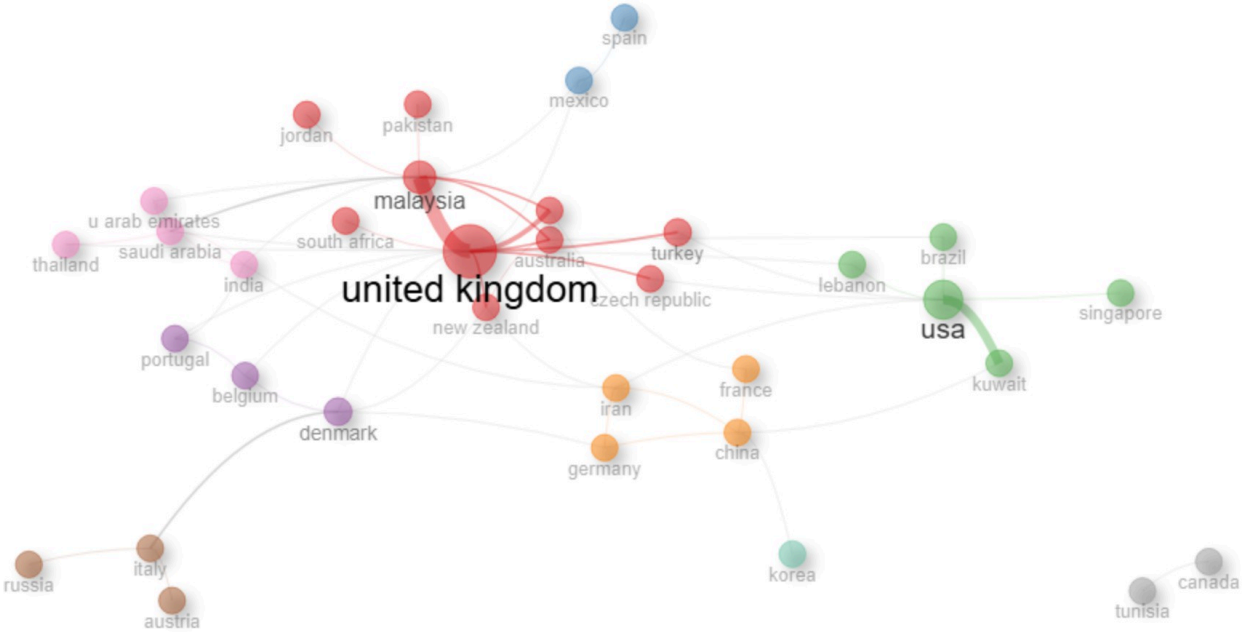
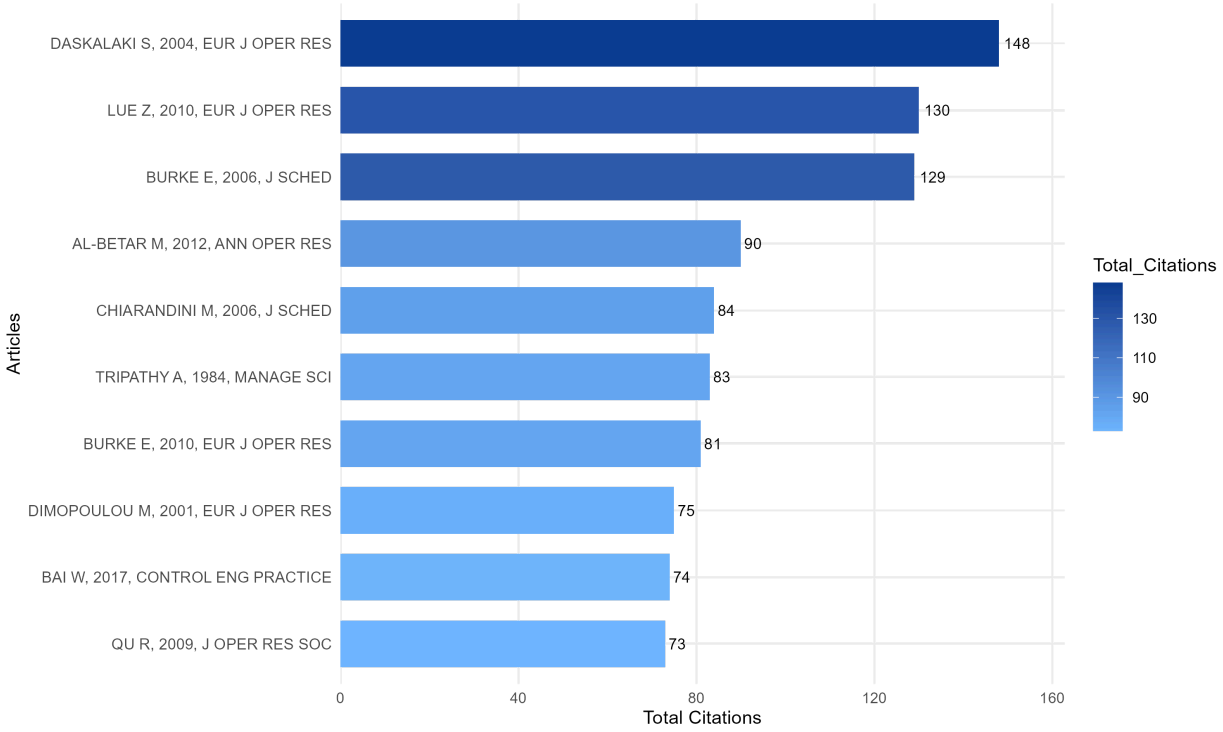


Figure 8: Citation distribution of the top 10 influential papers on workload allocation and course scheduling



Other articles, such as those by Al-Betar and Khader (2012) and Dimopoulou and Miliotis (2001), expand the field by introducing methods such as harmony search and integrated systems for both course and exam scheduling. The classic work by Tripathy (1984) is also noteworthy, as it applied binary integer programming to school timetabling problems, marking an early and significant contribution to the field.

2. RESULTS

Through a scientometric approach, this study investigated the predominant methodologies used for workload allocation in educational institutions, identifying the main techniques, trends, and innovations reported in the academic literature over the past decades.

The analyses revealed a continuous, although modest, growth in scientific production on the topic, with a greater concentration of publications beginning in the 2000s and a stabilization in recent years. The findings showed that a small number of authors and

journals account for most of the relevant publications, consistent with Lotka's and Bradford's Laws. A notable presence of international collaborations—particularly between countries such as the United Kingdom, Malaysia, and Ireland—highlights the global and multidisciplinary nature of the field.

Among the key methodologies identified, integer programming, metaheuristic algorithms, and hybrid techniques stood out, with integer programming proving particularly effective in addressing real-world academic scheduling problems. The integration of machine learning methods with mathematical models is emerging as a trend, enhancing the robustness and adaptability of proposed solutions. However, important gaps remain, such as the in-depth analysis of collaboration networks, the geographic distribution of research, and the application of these methodologies across diverse institutional and industrial contexts.

This study addressed key questions about the dynamics of research on workload allocation in educational institutions. The results revealed a significant increase in publications starting in the 2000s, followed by a period of stability in recent years. This pattern reflects not only the maturation of the field but also the influence of key publications that have contributed to its consolidation. In terms of authorship and institutions, the analysis highlighted that most scientific output and citations are attributed to a small group of researchers and academic centers, emphasizing the critical role of established leadership and international collaborations in advancing the field.

The analysis of journals showed that scientific production is highly concentrated in a few high-impact journals, particularly those

focused on Operational Research and Computer Science, which serve as key platforms for disseminating methodological advancements in the sector. Finally, the co-authorship and scientific collaboration networks demonstrated high density, with notable partnerships among Anglophone and emerging countries in the field of data science applied to education, promoting global knowledge integration and encouraging the formation of increasingly diverse collaborative groups.

From a practical perspective, the findings emphasize the need for continuous updates to workload allocation practices, encouraging the adoption of innovative and collaborative methodologies. For researchers, understanding the trends and gaps in the field can guide future investigations and strengthen collaboration networks. For educational managers, the evidence supports the selection of tools and approaches that best meet institutional needs, promoting greater efficiency and educational quality.

This study has some limitations, including the dependence on data available from major indexing databases and potential biases related to keyword selection. Additionally, other types of publications, such as technical reports or theses, were not considered, which could have provided a more comprehensive view of the field.

For future research, we recommend conducting comparative studies in different regional and institutional contexts, as well as integrating other analytical methodologies, such as content analysis and educational data mining. Further investigations into the impact of emerging technologies, particularly artificial intelligence, on the transformation of scheduling processes in various educational systems are also encouraged.

Therefore, this study reinforces the relevance of scientometric analysis as a strategic tool for understanding and improving time management in educational institutions, offering pathways for innovation, collaboration, and efficiency in the educational management field.

3. CONCLUSION

Through a scientometric approach, this study presented a comprehensive overview of the predominant methodolo- gies and emerging trends in workload allocation in educational institutions. The results revealed a continuous growth in scientific publications on the topic since the 2000s, followed by stabilization in recent years, indicating the maturation of the field and growing interest in innovative solutions for academic management.

A small group of authors and institutions was found to significantly lead the production and dissemination of knowledge, underscoring the central role of international collaborations, especially among countries such as the United Kingdom, Malaysia, and Ireland.

Additionally, it was found that most methodological advancements are published in high-impact journals, particularly those focused on Operational Research and Computer Science, which act as strategic channels for the consolidation and standardization of best practices in the field. The scientific collaboration networks proved to be dense and dynamic, with the emergence of new groups and the intensification of international partnerships, contributing to the expansion of knowledge exchange and the strengthening of the field on a global scale.

From a practical perspective, the findings of this study offer valuable insights for academic management, showing that the selection of appropriate methodologies can optimize faculty workload allocation, balancing administrative, pedagogical, and scientific demands. These findings reinforce the need for institutional policies that consider not only the quantitative distribution of time but also the qualitative impact of faculty activities on student education and scientific productivity.

Despite the observed progress, important gaps remain, such as the lack of applied studies in diverse regional and institutional contexts, particularly in emerging institutions and developing countries. Additionally, few analyses currently evaluate the real impact of workload allocation on indicators such as teaching quality, faculty satisfaction, and institutional performance. Therefore, future research should advance the development of integrated and contextualized metrics of faculty productivity, addressing the balance between teaching, research, outreach, and academic management.

Finally, the integration of emerging technologies, such as artificial intelligence, decision support systems, and educational data mining, stands out as a promising strategy to improve workload allocation across different educational systems. This study contributes to the understanding of current practices and points to concrete pathways for developing more efficient, collaborative, and sustainable solutions in faculty time management and the enhancement of educational quality in higher education.

4. DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

AI use: The author used ChatGPT (GPT-5o, OpenAI) to help compile information, organize content, and draft the English text; the author reviewed the output and is fully responsible for the publication.

5. ACKNOWLEDGEMENTS

This research was carried out with the support of the Coordination for the Improvement of Higher Education Personnel (CAPES), Brazil – Doctoral scholarship.

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