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Review

Teacher Assignment Problem: A Bibliometric Analysis from 1976 to 2024

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Abstract: Using the methodology of bibliometric analysis, we analyze the scientific publications related to the Teacher Assignment Problem (TAP), published from 1976 to 2024 in the scientific reference databases. We started by identifying 199 articles, which, after applying the exclusion criteria, remained for analysis 43 articles. Then, we identify the relevant authors, the most cited articles, and the most popular keywords, as well as the bibliographic coupling relationships, cocitation and problem-solving techniques, allowing us to systematize and graphically illustrate the evolution of publications over time. In terms of TAP automatic solution techniques, we note that Integer Programming and its variants dominate with 17 articles. This is followed by evolutionary techniques, where they master genetic algorithms with 5 articles. Thus, on the one hand, we were able to obtain an overview of the scientific scenario of the evolution of publications related to the TAP, and on the other hand, we found that there is still room for contribution in this area.

Keywords: Distribution Teaching Service; Teacher Assignment Problem (TAP); Bibliometric Analysis; TAP automatic solution.

1. Introduction

One of the recurring problems that a higher education institution must solve every year is the Teaching Service Distribution (TSD), known in literature as Teacher Assignment Problem (TAP). This is a crucial phase, as it is almost imperative that the TSD/TAP is fully defined before the timetable generation process. Today, almost all university planning and management activities tend to be automated or assisted by using computing to generate solutions automatically or semi-automatically. In literature, the theme related to the automatic solution of TAP began to be explored in 1976, where Breslaw [1] treats it with the designation of "Faculty Assignment Problem". From 1997 onwards, the designation "Teacher Assignment Problem" (TAP) [2], [3] [4] also began to be used.

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The main objective of this article is to obtain an overview of the scientific scenario of the evolution of scientific publications related to TAP worldwide. To prepare this scientific survey, we identified the following data for each article: year, type of publication, relevant authors, bibliographic coupling, citations, cocitations, methodologies and techniques for the solution of the TAP.

This article was developed following the methodology of bibliometric analysis that uses performance measurement techniques and networks for the production and dissemination of scientific knowledge, on the subject of TAP in the period from 1976, the year of registration of the first article on the subject in scientific databases, until the year 2024.

This work is divided into 7 chapters. In the introduction, we frame the work, in chapter 2 we present the problem of the Teacher Assignment Problem. Next, in chapter 3 we address the methodology used for the investigation, making the basis of the bibliometric analysis and the methodological procedures, describing how it was developed. In chapters 4 and 5 we present the results obtained through bibliometric analysis and analysis of the network of publications, as well as their discussion and interpretation. In chapter 6 we present a synthesis of the survey of the methods and techniques that the authors propose for the solution of the problem of distribution of teaching services, and finally, in chapter 7 we present the final conclusions of the work, as well as suggestions for future investigations.

2. Teacher Assignment Problem

The problem of the Distribution of Teaching Service consists of assigning teachers classes of curricular units – theoretical, theoretical-practical, practical or laboratory – taking into account their preferences and their qualifications to teach them [5] and complying with a set of restrictions imposed by legislation.

Scheduling problems in university management are often modeled as combinatorial optimization problems and solved automatically using typical methodologies for solving these problems [6].

In addition to the problem of Teaching Service Distribution, other scheduling problems commonly encountered in University Management are the following [7], [8]: University Timetables, Exam Schedule, and Room Allocation. Other scheduling problems are solved in the daily routine of each University. Among these, the following stand out: defining the number of classes for each curricular unit, assigning students to classes, student schedules, assigning invigilators for exams, and scheduling meetings.

2.1. Formalization of the problem

Due to the large number of constraints of hard implementation and forms of evaluation of the solution, very subjective, is not easy to formalize the concept of Teaching Service Distribution. So, simplifying some constraints, we formalize the concept of problem Teaching Service Distribution as a combinatorial optimization problem.

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Suppose the existence of:

- A set of Teachers = $\{T_1, T_2, ..., T_n\}$ – teachers who teach at the University;
- A set of Courses = $\{C_1, C_2, ..., C_n\}$ – courses taught at the University;
- A set of Sections = $\{S_1, S_2, ..., S_n\}$ – sections of different courses taught at the University;
- A set of Periods = $\{P_1, P_2, ..., P_n\}$ – different teaching periods (semesters, trimesters, etc.).

It is also known:

- $Preferences_i$ = $\{Pref_1, Pref_2, ..., Pref_n\}$, $\forall$ i $\in$ Teachers, corresponding to the preferences of teachers regarding the teaching of each Course;
- $Capabilities_i$ = $\{Cap_1, Cap_2, ..., Cap_n\}$, $\forall$ i $\in$ Teachers, corresponding to the capacities of teachers regarding the teaching of each Course;
- $Importance_i$, $\forall$ i $\in$ Teachers, representing the importance of each teacher at the University;
- $MaxHours_i$, $\forall$ i $\in$ Teachers, assigning each teacher a maximum annual hours;
- $MinHours_i$, $\forall$ i $\in$ Teachers, assigning each teacher a minimum annual hours;

The decision variables are:

- Regent = $\{RC_1, RC_2, ..., RC_n\}$ where $RC_i \in$ Teachers, corresponding to the regents of the various courses taught at the University;
- Service = $\{SS_1, SS_2, ..., SS_n\}$ where $SS_i \in$ Teachers, corresponding to the teachers assigned to each of the sections of several courses taught at the University;

Thus, Teaching Service Distribution consists of defining the values assigned to the variables of Regents and Service in order to:

$$\text{Minimize } f = \Sigma w_{load} * f_{teaching_load} + w_{adequacy} * f_{teaching_adequacy} \quad (1)$$

Where:

- w_{load} and $w_{adequacy}$ the relative weights given to respect for desired teaching loads for teachers and the adequacy of the teachers to teaching the courses;
- $f_{teaching_load}$ a function that measures the respect for the teaching load of teachers.
- $f_{teaching_adequacy}$ a function that measures the respect for the preferences and adequacy of the teachers to teach the courses.

3. Materials and methods

This article aims to characterize and analyze scientific publications related to the theme of “Teacher Assignment Problem” (TAP), produced since there is registration in scientific

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databases (1976) until 2024, in the following databases: Scopus, Web of Science (WoS) and Google Scholar. To this end, we carried out a structured literature review, using the methodology of bibliometric analysis. To carry out the analysis, we used the five-step model [9] for data collection and comprehensive evaluation of the topic, with the aim of identifying the most influential articles and authors, determining the most relevant methodologies and solution techniques, and guidelines for future research. We present the five steps in detail below.

3.1. Definition of search terms

We surveyed the words and expressions used over time to identify the topic. Thus, we defined the following keywords: "Teacher Assignment Problem," "Teaching Assignment Problem," "Academic Load Distribution," "Teaching Service Distribution," "Faculty Assignment Problem," and "Teacher Allocation". The defined query is presented in table 1:

Table 1. Definition of a search query.

Database	Search query
Scopus	TITLE-ABS-KEY("Teacher Assignment Problem" OR "Teaching Assignment Problem" OR "Academic Load distribution" OR "Teaching Service Distribution" OR "Faculty assignment problem" OR "Teacher Allocation")
Web of Science	TI=("Teacher Assignment Problem" OR "Teaching Assignment Problem" OR "Academic Load distribution" OR "Teaching Service Distribution" OR "Faculty assignment problem" OR "Teacher Allocation") OR AB=("Teacher Assignment Problem" OR "Teaching Assignment Problem" OR "Academic Load distribution" OR "Teaching Service Distribution" OR "Faculty assignment problem" OR "Teacher Allocation") OR AK=("Teacher Assignment Problem" OR "Teaching Assignment Problem" OR "Academic Load distribution" OR "Teaching Service Distribution" OR "Faculty assignment problem" OR "Teacher Allocation")
Google Scholar	We use the Publish Or Perish Application, applying the Query defined for Scopus

3.2. Initial results

On April 20, 2024, we proceed to the application of the search queries defined in each of the scientific databases, using the advanced search tools in each web system. For the Google Scholar database, we use the Publish or Perish application, applying the query defined for Scopus. No filter has been placed at the post type or year level. Thus, in this research, a total of 199 publications were obtained, distributed as follows, as shown in table 2.

Table 2. Initial results.

Scopus	Web of Science	Google Schoolar	Total
61	37	101	199

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3.3. Refinement of results

All 199 publications were analyzed, and we applied a set of exclusion criteria: 1) duplicates; 2) posters, editorial, tutorial, minutes and theses; 3) item not available; 4) article outside the domain. In case of duplicate publications, we consider the publication in the following order of preference: Scopus, Web of Science, and Google Scholar.

156 publications were excluded: 66 duplicates and 90 by applying the other criteria, respectively: 2) 7 articles; 3) 4 articles and 4) with 79 articles. Thus, after applying the exclusion criteria, a total of 43 publications were obtained, distributed as follows, table 3.

Table 3. Results after refinement

Scopus	Web of Science	Google Schoolar	Total
29	0	14	43

3.4. Initial statistics

Of the 43 publications that remained after the exclusion criteria were applied, 26 are scientific journal articles and 17 are conference articles. Although the period under analysis (1976-2024) comprises 48 years, only in 25 years have there been publications of articles. Thus, the first article was published in 1976, and only 11 years later, in 1987, there are publications, then in 1989, and then after 6 years, in 1995 and 1997, again having an interregnum of 5 years, to have articles again in 2002. Since 2002, the theme has received the attention of the scientific community, with 5 articles published in 2013 and 2020. We emphasize that from 2002 to 2024, there are publications in all years, with the exception of the years 2003, 2005 and 2012.

We can also observe that the maximum number of articles published was 5 per year, in the following years: 2013, 2020 and 2024, 3 articles: 2015 and 2018, 2 articles: 2022 and 2023, in all other years, only 1 article.

3.5. Data analysis

We analysed the data from the 43 publications in two parts, a "bibliometric analysis" and a "network analysis", presented respectively in chapters 4 and 5. Before proceeding with the automatic analysis with the selected tools, it was necessary to add the records (articles) obtained via Google Scholar to the file with the Scopus format.

In both analyses, we used MS Excel and Google Sheets, in the initial preparation, in the grouping of the data and the creation of the graphs. We also use the VOSviewer software package for the construction and visualization of bibliometric networks. In figure 1, we can see the trend of publications and the respective number of citations over the period under analysis (1976-2024).

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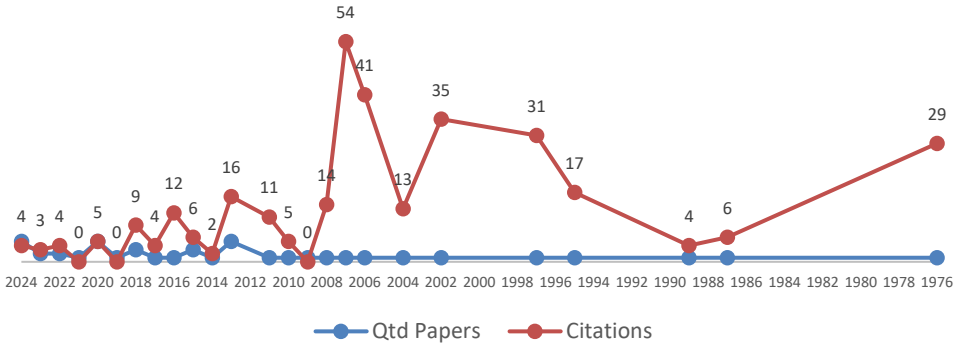

Figure 1. Publications / citations per year.

The articles with the most citations were published between 1995 and 2007, with an average of 31 citations, and the article [10] published in 2007 has 54 citations. We also highlight that the first article is from 1976, with 29 citations.

4. Bibliometric analysis

The bibliometric analysis focused on the following data: title of the article, authors, year of publication, citations, keywords and references. The following sections provide author and keyword statistics.

4.1. Articles

Table 4 shows the list of all 43 articles analyzed in this study, with the following data: title and number of citations, in descending order of year of publication.

Table 4. Initial results.

#	Title	Citations
1	The Faculty Assignment Problem in Higher Education: A Shapley Value-Based Approach [45]	1
2	Using Machine Learning to Optimize Resource Allocation and Management Strategies in Colleges and Universities [46]	0
3	Research on the Model of Teaching Staff Allocation in Private Universities Based on Discrete Firefly Algorithm [47]	0
4	Multi-objective faculty course timeslot assignment problem for tutorial and laboratory courses [48]	2
5	Multi-objective faculty course assignment problem based on the double parametric form of fuzzy preferences [49]	1
6	Teacher Assignment Problem: A Bibliometric Analysis from 1976 to 2021 [50]	2
7	Automatic Resolution of Teacher Assignment Problem: A Bibliometric Analysis from 1976 to 2022 [51]	1
8	An improved group teaching optimization algorithm based on local search and chaotic map for feature selection in high-dimensional data [11]	3
9	Optimal student/school/class/teacher/classroom matching to support efficient public school system resource allocation [13]	1

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#	Title	Citations
10	A mathematical programming tool for an efficient decision-making on teaching assignment under non-regular time schedules [14]	0
11	Interactive planning of competency-driven university teaching staff allocation [15]	0
12	Group teaching optimization algorithm: A novel metaheuristic method for solving global optimization problems [16]	4
13	Multi-objective Faculty Course Timeslot Assignment Problem with Result-and Feedback-Based Preferences [17]	0
14	A Decision Support Tool for Multi-Objectives Teaching Assignment Problem [18]	1
15	The department team teaching assignment problem using zero-one integer programming [19]	0
16	Analysis of Integer Programming Model of Academic Load Distribution [20]	0
17	Modeling and solving academic load distribution problem [21]	3
18	Competence Management in Teacher Assignment Planning [22]	5
19	An intelligent bio-inspired algorithm for the faculty scheduling problem [23]	1
20	Optimizing student learning: a faculty-course assignment problem using linear programming [24]	4
21	A MILP model for the teacher assignment problem considering teachers' preferences [25]	12
22	Modelling practical placement of trainee teachers to schools [26]	4
23	Approximation algorithms for the teachers assignment problem [27]	0
24	A mathematical model and a GRASP metaheuristic for a faculty-course assignment problem for a University in Saudi Arabia [28]	2
25	A column generation mathematical programming approach for a class-faculty assignment problem with preferences [29]	5
26	Multi-agent system for teaching service distribution with coalition formation [30]	5
27	A heuristic algorithm for solving the faculty assignment problem [31]	5
28	A Genetic Algorithm based Solution to the Teaching Assignment Problem [32]	1
29	Solving Teacher Assignment problem by Asynchronous Cooperative Parallel Genetic Algorithm [33]	0
30	Solving the teacher assignment problem by two metaheuristics [34]	11
31	Teaching assignment problem solver [35]	5
32	Teaching service distribution as coalition formation [36]	0
33	A genetic algorithm for the teacher assignment problem for a University in Indonesia [4]	14
34	Solving the teacher assignment-course scheduling problem by a hybrid algorithm [10]	54
35	Mathematical programming models and algorithms for a class-faculty assignment problem [37]	41
36	Preferences based decision-making model (PDM) for faculty course assignment problem [38]	13
37	An application of genetic algorithm methods for teacher assignment problems [3]	35
38	The teacher assignment problem: A special case of the fixed charge transportation problem [2]	31
39	A knowledge based approach to the faculty-course assignment problem [39]	17
40	An improved approach to solution of the faculty assignment problem [40]	4
41	A Simulation of the Faculty-Assignment Problem: An Integer Programming Approach [41]	2
42	Modeling multiple criteria in the faculty assignment problem [42]	6
43	A linear programming solution to the faculty assignment problem [1]	29

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4.2. Relevant authors

In table 5, we can see the relevant authors (first author), with the number of articles and the respective number of citations, in the table with 5 citations or more. From the analysis of the table, we conclude that 1 author has 4 articles, 1 author has 3 articles, 4 authors have 2 articles, and these 6 authors have 144 citations. The 14 authors in the table total 297 citations. The other 18 authors, not shown in the table, have a total of 28 citations. Thus, the 43 articles have a total of 325 citations.

Table 5. Authors with 5 or more citations.

First author	Articles	Citation
Gunawan A.	3	79
Al-Yakoob S.M.	2	46
Wang Y.-Z.	2	35
Hultberg T.H.	1	31
Breslaw J.A.	1	29
Partovi F.Y	1	17
Parthiban P.	1	13
Domenech B.	1	12
Moreira J.J.	4	8
Yang C.W.	2	6
McClure R.H.	1	6
Szwarc E.	2	5
Hosny M.I	1	5
Hmer A.	1	5
14	**27**	**297**

Table 6 presents the list of 10 articles with 10 or more citations, which add up to 257 of the 325 citations.

Table 6. Articles with 10 or more citations.

#	Article	Citation	%
25	Solving the teacher assignment-course scheduling problem by a hybrid algorithm [10]	54	21,0
26	Mathematical programming models and algorithms for a class-faculty assignment problem [37]	41	16,0
28	An application of genetic algorithm methods for teacher assignment problems [3]	35	13,6
29	The teacher assignment problem: A special case of the fixed charge transportation problem [2]	31	12,1
34	A linear programming solution to the faculty assignment problem [1]	29	11,3
30	A knowledge based approach to the faculty-course assignment problem [39]	17	6,6
24	A genetic algorithm for the teacher assignment problem for a University in Indonesia [4]	14	5,4

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#	Article	Citation	%
27	Preferences based decision-making model (PDM) for faculty course assignment problem [38]	13	5,1
12	A MILP model for the teacher assignment problem considering teachers' preferences [25]	12	4,7
21	Solving the teacher assignment problem by two metaheuristics [34]	11	4,3
	10	**257**	

4.3. Keyword Statistics

Next, we will present the keywords most frequently used by authors in the list of keywords.

Table 7 shows the list of keywords most frequently used by the authors, with at least two occurrences.

Table 7. Most used keywords in articles.

Keyword	Freq.	Keyword	Freq.
Teaching	8	Class Scheduling	2
Assignment Problems	7	Computational Results	2
Scheduling	6	Education	2
Combinatorial Optimization	5	Electric Power Plant Loads	2
Algorithms	4	Genetic Algorithms	2
Integer Programming	4	Integer Linear Programming	2
Linear Programming	4	Mixed-Integer Programming	2
Optimization	4	Np-Completeness	2
Teacher Assignment Problem	4	Pareto Optimal Solutions	2
Timetabling	4	Pareto Principle	2
Mathematical Models	3	Teacher Assignment	2
Mathematical Programming	3	Teaching Assignment Problem	2
Problem Solving	3	Timetabling Problem	2
Bicriteria Problems	2		

In figure 2, we present the graphical representation of the most frequently used keywords.

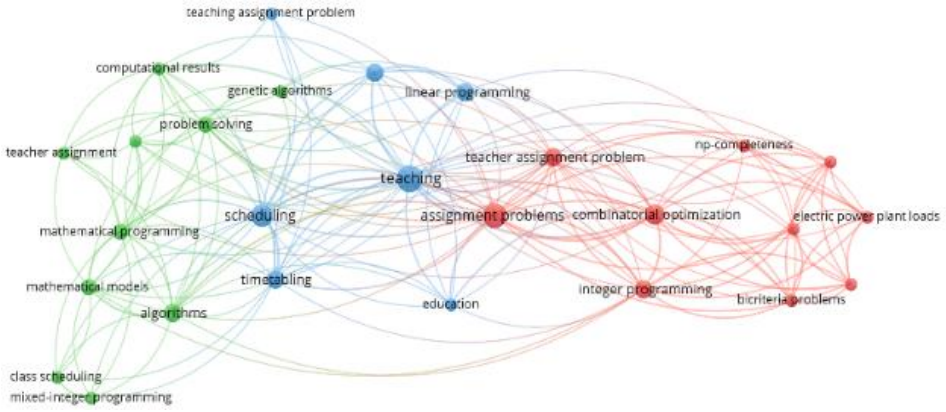

Figure 2. Most popular keywords.

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5. Analysis of the publication network

In the analysis of the network of publications, we used the techniques of bibliographic coupling and cocitation. The bibliographic coupling and cocitation relationships between two articles are created through a third article. Thus, when two articles are cited by a third article, there is a cocitation relationship between them [43]. Similarly, when two articles cite the same article, they are bibliographically coupled [44]. The following sections present the application of these scientific mapping techniques.

5.1. Bibliographic coupling

Through the technique of bibliographic coupling, we will establish relationships between the 43 articles analyzed in this work.

Table 8 shows the grouping of authors according to bibliographic coupling. It displays 5 clusters with their respective articles, number of citations and number of links.

Table 8. Cluster analysis based on bibliographic coupling relationships.

Cluster	Articles	Citation	Links
1	[2], [20], [21], [26], [27]	31, 0, 3, 4, 0	2, 5, 9, 4, 2
2	[15], [22], [35]	0, 5, 5	22, 26, 5
3	[23], [30], [36]	1, 0, 5	9, 5, 25
4	[3], [4], [34]	11, 14, 35	30, 24, 3
5	[25], [29], [37]	12, 5, 41	22, 9, 6
	17	**172**	**208**

5.2. Cocitation analysis

Through the cocitation analysis technique, we established relationships between the 43 articles analyzed in this work. Table 9 shows the grouping of authors according to the cocitation ratio, filtering articles that have at least 5 citations and presents 4 clusters with the respective authors, number of citations and number of links.

Table 9. Cluster analysis based on cocitation relationships.

Cluster	Authors	Citation	Links
1	Birbas, T.	7	121
	Burke, E.K.	18	265
	Carter, M.W.	6	100
	Daskalaki, S.	8	127
	De Werra, D.	8	96
	Housos, E.	6	101
	Laporte, G.	6	100
	Petrovic, S.	9	158
	Qu, R.	5	98
2	Bocewicz, G.	5	101

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Cluster	Authors	Citation	Links
	Gunawan, A.	16	292
	Ng, K.M.	15	274
	Poh, K.L.	6	113
	Szwarc, E.	6	117
	Wang, Y.Z.	6	120
	Wikarek, J.	5	95
3	Glover, F.	6	83
	Lau, N.	5	125
	Ong, H.L.	6	121
	Reis, L.P	20	269
4	Cardoso, D.M.	6	109
	Hultberg, T.H.	6	109
	Kolokolov, A.A.	8	43
	Zaozerskaya, L.A.	7	41
	24	**196**	**3178**

In the following figure, we present the graphical representation of the cocitation relationships, generated through the VOSviewer software.

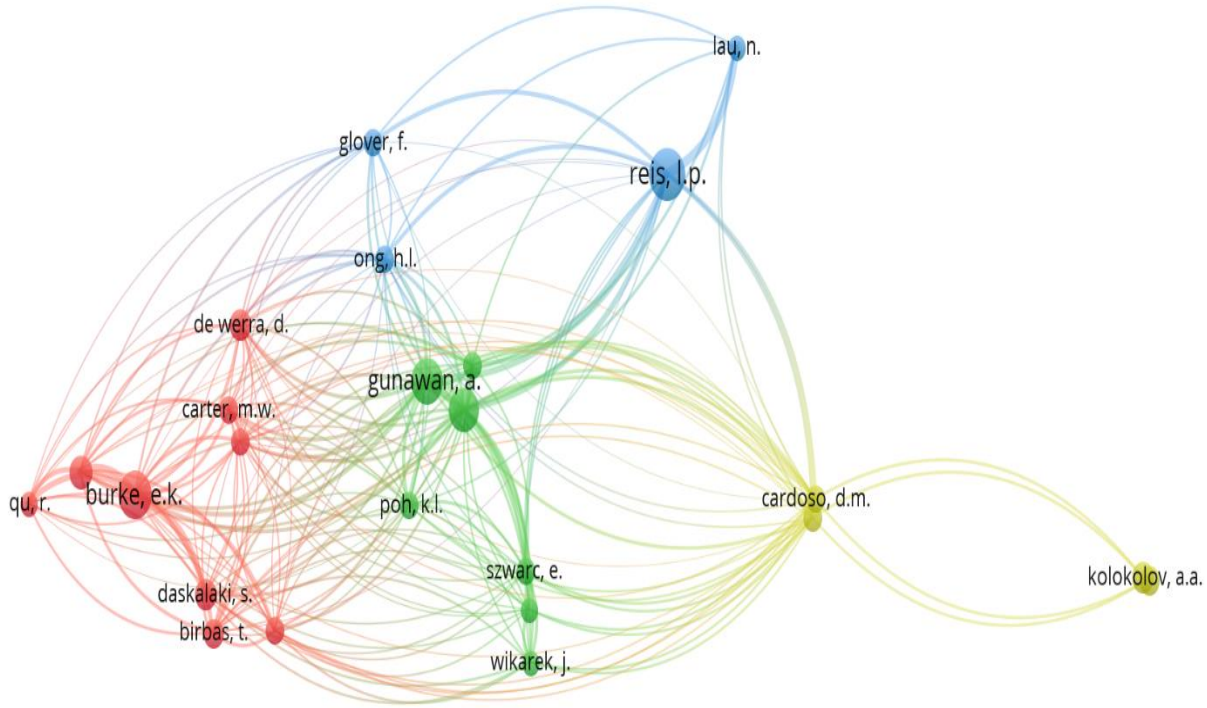

Figure 3. Authors with cocitation relationships

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6. Methods and techniques of solution

In this chapter we survey the methods and techniques that the authors of the 43 articles under analysis propose for the solution of the Distribution of Teaching Service. Table 10 shows the techniques most used in the analyzed articles.

Table 10. Methods and techniques.

Technique	Articles
Integer Linear Programming	[1], [12], [20], [21], [26], [41], [42]
Mixed Integer Linear Programming	[2], [13], [14], [24] [29] [37]
Genetic Algorithm	[3], [4], [18], [32], [33]
Zero-One Integer Programming	[19], [39], [40], [48]
Constraint Satisfaction Problems	[15], [35]
Greedy	[25], [10]
Group Teaching Optimization Algorithm	[11], [16]
Tabu search	[12], [34]
Ant Colony Optimization	[12]
Simulated Annealing	[34]
Analytic Hierarchy Process	[38]
Asynchronous Cooperative Parallel Search	[33]
Bees Algorithm	[23]
Column Generation	[29]
Demon algorithm	[23]
Fuzzy Programming	[17]
Firefly	[47]
GRASP	[28]
Heuristic Algorithm	[31]
Hill Climbing	[23]
Knowledge based system	[39]
Particle Swarm Optimization	[12]

In the previous table, we identified 23 techniques in 37 articles. Thus, we note that Integer Programming and its variants (Integer Linear Programming, Mixed Integer Linear Programming and Zero-One Integer Programming) dominate with 17 articles. Interestingly, the technique is used in the first article from 1976 [1] and also in one of the last articles from 2024 [48]. This is followed by evolutionary techniques, where they master Genetic algorithms with 5 articles.

Table 11 shows a table identifying the software package or programming language used to apply the solving techniques.

Table 11. Software package or programming language.

Technique	Articles
CPLEX Solver	[3] [25], [26], [29], [37]
CPLEX Solver + GAMS Solver	[13], [21], [24], [28], [31]

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Technique	Articles
Lingo Software	[15], [17], [19], [41], [42]
C++	[32], [10]
Java Cream Solver	[35]
Prolog	[39]

In the previous table we identified 6 software packages or programming languages in 19 articles. We highlight that in 15 of the articles, the authors used third-party software packages for the implementation and testing of their approaches to automatic solutions of the Faculty Service Distribution.

7. Conclusion

In this article we present a structured review through the methodology of bibliometric analysis, on the scientific publications related to the "Teacher Assignment Problem" (TAP), published since records began, from 1976 to 2024, in the following databases: Scopus, Web of Science and Google Scholar. We started by identifying 199 articles, which, after removing the duplicates and applying the exclusion criteria, left 43 articles for analysis. Although we searched in 3 databases, after removing the duplicates, giving priority to Scopus articles and applying the exclusion criteria, we only used articles from Scopus (29 articles) and Google Scholar (14 articles).

Although the period under analysis, from 1976 to 2024, comprised 48 years, only in 25 years were there publications of articles. The first article was published in 1976, and only 11 years later, in 1987, there are publications, then in 1989, and then after 6 years, in 1995 and 1997, again having interregnum of 5-year, to have articles again in 2002. Since 2002, the theme has received the attention of the scientific community, with 5 articles published in 2013 and 2020. We emphasize that from the year 2002 to 2024, there are publications in all years, except for the years 2003, 2005 and 2012.

We can also observe that the maximum number of articles published was 5 per year, in the following years: 2013, 2020 and 2024, 3 articles: 2015 and 2018, 2 articles: 2022 and 2023, in all other years, only 1 article. This subject, within university management, has been the one that has deserved the least attention from research.

In terms of automatic solution techniques of the Teaching Service Distribution, we note that Integer Programming and its variants dominate with 17 articles. This is followed by evolutionary techniques, where they master Genetic algorithms with 5 articles.

However, on the one hand, we were able to obtain an overview of the scientific scenario of the evolution of scientific publications related to TAP worldwide, and on the other hand, we found that there is still room for contribution in this area.

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