Bibliometric Analysis Augmented by Artificial Intelligence: Implementation of pyBibX and a Practical Guide

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Abstract

In addition to providing performance-based information on variables such as author, journal, and country, bibliometric analysis studies can provide in-depth insights into trends in the field by creating scientific maps through text mining based on keywords, titles, and abstracts. Various software such as Vosviewer, Bibliometrix, SciMAT, BipExcel, and CiteSpace are frequently used in such analyses. However, these programs fall short when it comes to manipulating data or merging publications from different databases. The aim of this article is to provide an overview of the pyBibX application and its main features, as well as to examine the studies published in the Journal of National Education in terms of various variables. This will be achieved by using the potential benefits and effects of artificial intelligence-supported bibliometric analysis on the Scopus database data of these studies as an example. With the analysis carried out for this purpose, it is shown how the distribution of academic productivity in the journal according to years, keywords, and thematic clusters can be done with the pyBibx application.With the analysis carried out for this purpose, it is shown how the distribution of academic productivity in the journal according to years, keywords, and thematic clusters can be done with the pyBibx application. The application revealed that the journal, particularly in the post-pandemic periods, prominently featured themes such as distance education and digital transformation.

Keywords: bibliometrics analysis, bibliometrics tools, pyBibx, artificial intelligence, Journal of National Education

Introduction

Bibliometric analysis has become a widely adopted approach for studying developments and trends in various academic disciplines, including the field of artificial intelligence (AI) (Hajkowicz et al., 2023; Tiwari et al., 2023). This analytical approach uses statistical techniques to examine publication and citation data, thus revealing patterns and insights that can significantly guide research strategies and future directions (Donthu et al., 2021). The increasing volume of literature calls for effective tools to conduct these analyses, as traditional methods can be labor- and time-intensive, especially when dealing with extensive datasets. Developers have developed various bibliometric analysis applications to overcome these challenges, streamlining the process and enhancing the accessibility of bibliometric insights. For example, tools such as VOSviewer, SciMAT, and Bibliometrix are tools that can be used to visualize bibliometric networks and facilitate a deeper understanding of the connections between authors and publications (Moral-Muñoz et al., 2020; Van Eck & Waltman, 2010). By utilizing these tools, researchers can not only measure academic productivity but also explore the intellectual makeup of their discipline and thus develop a more informed approach to future research endeavors (Lim & Kumar, 2024). However, given the unique features of each tool, researchers must select the most suitable software for their needs (Moral-Muñoz et al., 2020).

One of the most important developments in bibliometric analysis in recent years has been the integration of AI technology into bibliometric analysis. An emerging tool in this area is pyBibX, an AI-powered bibliometric analysis application (Pereira et al., 2023). The pyBibX application is a new AI-powered bibliometric analysis tool that aims to provide researchers with a modern and intelligent platform for discovering and understanding trends in academic literature. This study aims to analyze the studies published in the Journal of National Education based on various variables, showcasing the use of pyBibX, a new software for bibliometric analysis. We sought answers to the following questions about the bibliometric view of the Journal of National Education, which we accessed from the Scopus database:

1. What is the distribution of the studies published in the Journal of National Education?
2. Which topics are mostly addressed in the articles published in the Journal of National Education, and what is the thematic relationship between these topics?
3. How do the trends in the keywords of the articles published in the Journal of National Education change over the years? Which keywords have become prominent in certain years?
4. Which thematic groups are the articles published in the Journal of National Education divided into as a result of cluster analysis, and what are the similarities or differences between these groups?

pyBibx and Features

pyBibx is a Python-based library designed for bibliometric and scientometric analysis. Developed by a team from the Federal University of Fluminense, this library offers a variety of features and capabilities that researchers can use to conduct bibliometric analysis. The comparison of pyBibX, which enables advanced artificial intelligence features such as

citation, collaboration, and similarity analysis, as well as topic modeling and text summarization, with other bibliometric analysis applications is given in Figure 1 (Pereira et al., 2023).

Name	Data Manipulation	EDA	Wordcloud	N-Gram	Projection	Evolution Plot	Sankey Diagram	Treemap	Bar Plot	Citation Analysis	Collaboration Analysis	Similarity Analysis	World Collab. Analysis	Topic Modeling	Embeddings	Text Summarization	chatGPT
pyBibX	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bibexcel		X								X		X					
Bibliometrix	X	X	X		X	X	X		X	X	X	X	X				
BiblioTools		X								X		X					
CiteSpace										X	X	X	X				
CitNetExplorer										X	X	X	X				
CRExplorer										X	X	X					
Litstudy		X							X	X	X	X	X	X			
Metaknowledge										X	X	X	X				
Publish or Perish		X															
Sci2 Tool		X								X	X	X	X				
Scientopy	X	X	X			X			X	X	X	X	X	X			
SciMat		X							X	X	X	X	X				
Tethne										X	X	X	X	X			
VOSviewer										X	X	X	X				

Figure 1. Comparison of Features in Bibliometric Tools.

Figure 1 provides a comparative analysis of the selected bibliometrics tools. A comparison is made in three categories: data preprocessing, focusing on data visualization, network analysis, and AI capabilities. Data preprocessing capabilities include the tools' ability to query data, identify trends and patterns, and visualize data. Network analysis capabilities demonstrate the tools' ability to examine and visualize complex relationships between elements such as authors, citations, and keywords. Deep learning techniques strengthen AI capabilities. Data preprocessing capabilities include the tools' ability to query data, identify trends and patterns, and visualize data. Network analysis capabilities demonstrate the tools' ability to examine and visualize complex relationships between elements such as authors, citations, and keywords. Deep learning techniques strengthen AI capabilities. Capabilities such as topic modeling, text summarization, and general language processing make the tools more effective. As shown in Figure 1, the common features of the tools include

citation analysis, collaboration analysis, and global collaboration analysis. pyBibX and Scientopy offer a wide range of features, while CiteSpace, CitNetExplorer, CRExplorer, Metaknowledge, Tethne, and VOSviewer focus more on citation-based analysis. Other tools focus on data preprocessing and visualization. The standout innovation is pyBibX's large feature set and AI integration.

pyBibx can process data from Web of Science (WoS), Scopus, and PubMed databases. It can also perform analysis by combining data from these three databases. However, some difficulties may arise in this process. Each database may use different formats and standards for its metadata; the coverage and selection criteria of the databases may differ; the level of completeness and accuracy of the data received from the database may vary; and the data may contain errors, duplicates, or missing values, which complicates the merging process. In the merging process, a database (e.g., PubMed) can be selected as a reference, and data from other databases can be added to this reference. This method avoids overwriting existing metadata and improves the quality of the merged dataset by adding only new information.

Research with the pyBibx library

Since its first release in 2023, the pyBibx library has been used in a variety of research studies in many disciplines. For example, Aksoy and Bush (2024) conducted a bibliometric analysis focusing on chatbots and used a combination of Microsoft Excel, VOSviewer, and the pyBibx library to facilitate their analysis. Similarly, Kökçam et al. (2024) used VOSviewer and pyBibx as well as Bibliometrix (Aria & Cuccurullo, 2017) to perform a bibliometric analysis in the field of geotechnical engineering. In another study, Ramos et al. (2024) included the pyBibx library in their systematic literature review on the identification of plastic waste through machine learning methodologies. Also, Uysal et al. (2024) have leveraged the capabilities of the pyBibx library in their bibliometric analyses, providing an overview of the role of AI in education. Collectively, these studies demonstrate the versatility and applicability of the pyBibx library in conducting comprehensive bibliometric analyses in various research areas.

Methodology

In this study, a bibliometric analysis of articles published in the Journal of National Education was conducted using pyBibX application. We analyzed the data from the Scopus database within the framework of the research questions. The tools provided by pyBibX include various bibliometric analysis methods such as data visualization, citation analysis, and author collaboration maps. We believe this approach enhances our understanding of the general trends and characteristics of the journal's publications.

Using the pyBibx library

The Python-based pyBibx library can be run in Jupyter Notebook, an application accessible through the Anaconda Navigator application. Alternatively, they can also run the pyBibx library through the Google Colab web interface, which allows users to write Python code in a browser. Using Google Colab can be advantageous as it runs in a virtual environment, thus reducing the need for a high-capacity local computer.

This flexibility allows researchers and practitioners to take advantage of the capabilities of the pyBibx library without hardware limitations.

The pyBibx library is available at the following web address: https://pypi.org/project/pyBibX/. To use this library effectively with data from Scopus, Web of Science (WoS), and PubMed databases, certain document formats must be followed. For both Scopus and WoS, the required format is "BibTeX," while for PubMed, the documents must be in ".txt" format. This adherence to the specified formats ensures seamless integration and functionality within the pyBibx library.

In this study, the publications in the journal "Milli Eğitim" indexed in the Scopus database were examined in order to exemplify the use of the pyBibx library and the creation of visualizations obtained from its use. In this context, the "Source Title" option was selected in the search section of the Scopus database, and the term "milli AND egitim" was entered in the search box. This query led to the retrieval of a total of 1650 studies. The obtained studies were then exported in "BibTeX" format, and the following steps were followed for further analysis and visualization using the pyBibx library:

1. https://colab.research.google.com/ opens a new notebook on the platform.
2. You must first write and execute the following commands in the opened notepad.

!pip install pyBibX: command installs the pyBibx library on Google Colab.

!pip install tabulate: command installs the library that allows tabular representation of data on Google Colab.

3. For data analysis, visualization and bibliometric analysis using the pyBibx library, the following codes are pasted into notepad and run.

```
# Required Libraries
import numpy as np
import pandas as pd
import textwrap

from google.colab import data_table
from google.colab import files
from tabulate import tabulate
from prettytable import PrettyTable
from pyBibX.base import pbx_probe
```

The numpy library for numerical data and array manipulation, the pandas library for data processing and analysis, the data_table module from google.colab for displaying interactive data tables in Colab, the tabulate library for creating formatted tables and PrettyTable for creating visually appealing ASCII tables.

4. At this stage, the document with the extension "bib" previously downloaded from the Scopus database is uploaded to the Google Colab environment by running the codes given below.

```
# Upload your own .bib file
files.upload()
```

By running this code pasted into Google Colab, the file upload menu becomes active and the document with the extension "bib" is uploaded to the system. The "meb.bib" document previously saved in the system is uploaded.

5. At this stage, the following codes are used to start interacting with the loaded document.

Table 2. Establishing Interaction with the Uploaded Document.

byBibx Codes	Screen Output

# Load .bib 	
# Arguments: file_bib = 'filename.bib'; db = 'scopus', 'wos', 'pubmed'; del_duplicated = True, False 	
file_name = 'YOUR FILE NAME.bib'
#database = 'scopus'
#database = 'wos'
#database = 'pubmed'
bibfile = pbx_probe(file_bib = file_name, db = database, del_duplicated = True)
	A Total of 1616 Documents were Found (1634 Documents and 18 Duplicates)
	Article = 1601
	Conference paper = 1
	Editorial = 5
	Note = 1
	Review = 8

1. In the code lines, the lines starting with # and colored in green are comment lines and give information about the operations to be performed.

2. file_name = 'YOUR FILE NAME.bib': This line requires you to enter the name of your .bib file.'YOUR FILE NAME.bib' should be replaced by the actual file name 'meb.bib'.

3. bibfile = pbx_probe(file_bib = file_name, db = database, del_duplicated = True): In this line, the document name ('meb.bib') should be written in the file_name section and 'scopus' should be written since Scopus is used as database.

By interacting with the uploaded document, the distribution of 1616 studies according to publication types is given in Table 2. Although 1634 studies were exported from the Scopus database, 1616 studies were included in the analysis because 18 studies were uploaded twice in the database. After interacting with the document downloaded from the Scopus database, code examples of the representation of the data suitable for the research purpose to be used in bibliometric mapping can be accessed via the pyBibx web page. In addition, links to related case studies that can also be accessed through the pyBibx web page are also presented.

- Example 01: Case study using Scopus database and documents available on github (Colab Demo)
- Example 02: WOS case study using the database and the documents in the github system (Colab Demo)
- Example 03: Case study using the PubMed database and documents in the github system (Colab Demo)
- Example 04: Case study using Scopus + WOS databases and documents in the github system (Colab Demo)

- Example 05: Case study using WOS + Scopus databases and documents in the github system (Colab Demo)
- Example 06: Case study using Scopus + WOS + Pubmed databases and documents in the github system (Colab Demo)
- Example 07: Example of work done by uploading documents transferred from databases to the desktop (Colab Demo)
- Example 08: Example of analysis by asking a question to ChatGPT (Colab Demo)

Ethics Committee Permission: Since the data used in the study were obtained from an online database open to access and examined through a program, Ethics Committee Permission was not obtained.

Findings

This section presents the findings obtained by analyzing the studies downloaded from the Scopus database and interacted with in the method section in the context of the research questions.

1. The descriptive distribution of the studies published in the Journal of National Education according to the findings of Exploratory Data Analysis (EDA) in the context of the research question is given in Table 3.

Table 3. Descriptive Distribution of Studies Published in the Journal of National Education

	Main information	Findings
0	Timespan	2006-2024
1	Total Number of Countries	17
2	Total Number of Institutions	894
3	Total Number of Sources	1
4	Total Number of References	0
5	Total Number of Languages	2
6	--english (# of docs)	488
7	--turkish (# of docs)	1128
8	-//-	-//-
9	Total Number of Documents	1616
10	--Article	1601
11	--Conference paper	1
12	--Editorial	5
13	--Note	1
14	--Review	8
15	Average Documents per Author	1.22
16	Average Documents per Institution	3.44
17	Average Documents per Source	1616.0
18	Average Documents per Year	85.05
19	-//-	-//-
20	Total Number of Authors	2427
21	Total Number of Authors Keywords	4260
22	Total Number of Authors Keywords Plus	0
	Main information	Findings
23	Total Single-Authored Documents	631
24	Total Multi-Authored Documents	985
25	Average Collaboration Index	1.83
26	Max H-Index	3
27	-//-	-//-
28	Total Number of Citations	1464
29	Average Citations per Author	0.6
30	Average Citations per Institution	1.64
31	Average Citations per Document	0.91
32	Average Citations per Source	1464.0
33	-//-	-//-

According to the information given in Table 3, the summary of the studies published in the Scopus database of the Journal of National Education is shown. It is seen that the studies published in the Journal of National Education in the Scopus database cover the period between 2006-2024 and bilingual publications are accepted. It is seen that the highest number of publications were made in Turkish language (n=1188) and English language (n=488), as well as the highest number of publications were made in article type (n=1601).

2.   According to the research question, which topics are mostly covered in the studies published in the Journal of National Education? The word cloud graph was used for this research question and the visual obtained from the analysis is given in Figure 2.

Figure 2. Distribution of Keywords According to Their Frequency in the Word Cloud

In Figure 2, the word cloud was created from the keywords of the published studies. In the code content 'abs', abs stands for study abstracts, title stands for study titles, kwa stands for study keywords and kwp stands for keywords determined by WoS. The arguments size_x = 15 and size_y = 10 in the script specify the size of the word cloud graph. The argument wordsn = 500 specifies the maximum number of words to display in the word cloud. In other words, this code creates a 15x10 word cloud using the 500 most frequent words in the articles' keywords. The more frequent the words appear in the word cloud, the larger it appears. Accordingly, terms such as 'education', 'teacher', 'learning', and 'school' are among the most frequently used and therefore focused themes, as they are shown in larger sizes. This shows that the magazine focuses on core education topics such as teaching, learning and school. The image also provides important information about which sub-themes in education the magazine prioritizes.

A query to the AI about the word cloud using the pyBibx library:

Query: 'give me insights about the following information'

The given information presents a frequency analysis of certain words related to education.   1. The term "education" appears to be the most frequently used word, reflecting its centrality to the overall topic.   2. Words like "teacher", "school", and "teaching" are also very common, showing that these are key components of the education concept. 3. The presence of terms such

as "turkish", "science", "language" and "mathematic" signifies that these are significant subjects or areas in the education sphere. 4. Words like "student", "learning", "curriculum", "primary", and "social" all suggest topics related to methods and levels of education, as well as social aspects connected to education. 5. Words including "covid" and "pandemic" indicate contemporary issues that have affected the education sector. 6. Presence of country-specific term like "turkish" suggests that the analysis might be based on text data concerning Turkish education system. 7. Various academic skills and techniques are referred to such as "reading", "writing", "analysis", and "problem solving". 8. The list contains a mix of nouns (like "teacher", "student") and verbs or gerunds that describe actions associated with education (like "teaching", "learning"). 9. The frequency with which the words appear may suggest the relative importance or prominence of these topics in the context from which the data was derived. 10. The diversity of the words used suggests that the education sector is complex and multifaceted, dealing with a variety of subjects, methods, and challenges.

3. The research question is about the trends of the keywords of the studies published in the Journal of National Education over the years. A graph showing the change in the most frequently used words (abstract, title, journal, author keywords or keywords plus) of the studies published in the Journal of National Education can be created with the pyBibx library. The graph created according to the distribution of keywords in the last 5 years is given in Figure 2.
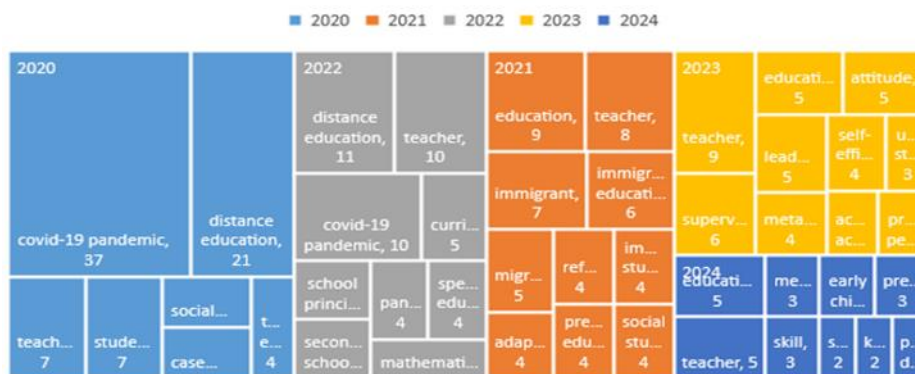

Figure 3. Yearly Changes in the Most Frequently Used Keywords in Keywords in the Last 5 Years

Figure 3 shows the trends according to the frequency of use of keywords in the Journal of National Education between 2020 and 2024. The response received as a result of an artificial intelligence-supported query in Turkish for this graph created through the pyBibx library:

Query: 'Give me an idea about the information provided'

Answer: *This data can reveal which keywords certain period-specific events, such as pandemics, are emphasized in the field of education. - In 2020, the keywords "distance education", "covid-19" and "pandemic" are prominent. This may be a reflection of the global pandemic and the rise of distance education as a result. - In 2021, we can observe the prominence of the words "immigrant", "immigrant education" and "migration". This may perhaps indicate an increased focus on migration movements and the education of migrant students around the world. - In 2022, the keywords "distance education" and*

"covid-19" are still popular, while other educational concepts such as "curriculum" and "school principal" are also included. This shows that education systems are affected in many different dimensions during the pandemic process and these effects are being examined. - In 2023, the concepts of "supervision", "attitude", "leadership" and "self-efficacy" came to the fore. This may indicate an increased interest in educators and educational leaders and the importance of personal characteristics such as self-efficacy and attitude in educational approaches. - In 2024, the words "metaverse", "skill" and "early childhood" were popular. This may represent new trends in educational technologies and the growing importance of early childhood education. In conclusion, these data show how research and debates in education can change over time. In particular, events such as the pandemic can have a marked impact on educational trends and issues highlighted.

With the artificial intelligence API connected to the pyBibx library, English queries can be made as well as Turkish queries. When the visual given in Figure 3 and the query made through the library are examined, the effect of the pandemic is seen in the studies conducted in 2020. This effect also shows its effect in education. It was observed that studies with the keyword distance education came to the fore.

1.   The research question is about the thematic groups formed according to the cluster analysis of the articles published in the Journal of National Education and the similarities or differences in these groups. Accordingly, the thematic groups into which the articles published in the journal were divided as a result of cluster analysis are given in Figure 3.
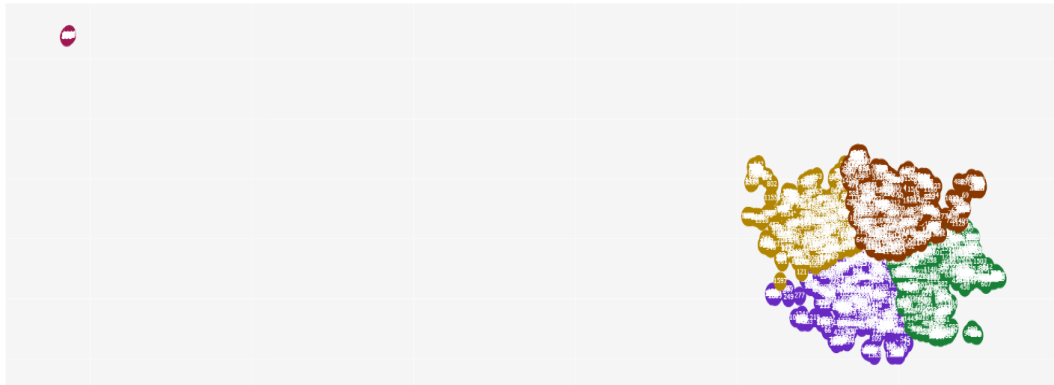

Figure 4. Distribution of Studies Published in the Journal by Cluster Analysis

Figure 4 shows the thematic distribution of articles shown in clusters of different colors. The clusters represent articles organized around specific topics or approaches. The clusters in the image show that the work in the journal is concentrated on certain topics and that there are similarities between certain topics. The pink cluster standing alone represents a less covered, rare topic or a separate discipline. These analyses made through Google Colab can be accessed from the link (https://colab.research.google.com/drive/1aJxXTPsvVDwjyZ-uQcAwxGSbJe_NOd4I#scrollTo=b-udDTzN3Wfy) and can be examined interactively.

Discussion, Conclusion and Recommendations

The integration of artificial intelligence into bibliometric analysis method makes significant contributions to research processes. The PyBibX application has accelerated and facilitated bibliometric analysis processes. Traditional bibliometric tools such as Vosviewer and CiteSpace are widely used to map scientific literature and analyze publication trends. However, these tools exhibit limitations, especially in handling data from multiple databases and merging duplicate publications (Pereira et al., 2023). In this study, studies published in the Journal of National Education were analyzed in terms of various variables using data obtained from the Scopus database. This analysis provided important findings on academic productivity and research trends.

With the first research question, descriptive statistics about the journal were presented and it was seen that the studies in the journal were concentrated in two languages. The average of collaboration between authors is given as 1.83. This ratio shows that the studies in the journal have more than one author. This situation is also seen in the bibliometric analysis conducted by Batur et al. (2022) on Turkish Education in the Journal of National Education. This situation emphasizes the importance of cooperation in the academic field.

In the second research question, a big picture of the studies published in the journal was given with the word cloud based on the keywords in the published studies. Accordingly, it shows that the journal contributes to the academic community and reflects the changing education agenda. Especially the prominence of the COVID-19 pandemic and distance education themes with the pandemic reveals that educational research can quickly adapt to current issues. This can be seen more clearly in the trend of keywords according to years, especially in the third research question. The rise of keywords such as distance education, Covid-19, and digital learning, especially with the pandemic period, reveals how research topics in the field of education are affected by environmental and social factors. In addition, the prominence of themes such as migration and migrant education shows that the journal contributes to these areas by focusing on social dynamics in education. Furthermore, it has shown that education-oriented themes are shaped by basic concepts such as "teacher," "student," and "learning". This situation points to the continuity of certain topics in educational research and reinforces the pioneering role of the journal in the field.

The findings for the fourth research question reveal that when the studies published in the Journal of National Education are analyzed in thematic clusters (n=5), they show concentration and diversity in certain areas. The visualization of these thematic clusters shows that the prominent topics in the journal offer different approaches to both teaching and learning processes and educational policies. At the same time, the fact that one cluster stands alone, independent of the others, suggests that these topics are less studied or require special expertise.

In conclusion, this study has revealed the academic trends in the journal and the level of focus on current issues through a bibliometric analysis of the research published in the Journal of National Education. The findings show that the journal shows a rapid adaptation to new and critical themes in the field of education such as pandemic, digital transformation,

migration, as well as a continuous academic contribution around key concepts in education. Thanks to the contribution of the artificial intelligence-supported pyBibX library in the bibliometric analysis processes, how these themes have changed over the years has been examined in detail. Bibliometric analyses are a critical tool for evaluating and guiding academic research. These AI-enhanced analyses provide researchers with deeper insights and encourage interdisciplinary interactions. By effectively utilizing the available tools, researchers can better understand the literature in their field and identify future research directions.

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