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A half century of didactic design in mathematics education: A bibliometric analysis

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Abstract
This study aims to examine the results of studies on didactic design in mathematics education as a contribution to the advancement of study concerning didactical design research. 1413 research articles on didactic design in mathematics education indexed in Scopus over the past 50 years, from 1973 to 2024, were collected and analyzed using bibliometric analysis. The results show increased studies related to didactic design in mathematics education. Based on the bibliometric analysis using VOSviewer and RStudio, there was a significant increase in publication between 2016 and 2022 but a decrease in 2023. The most frequently appearing keywords in the VOSviewer and RStudio search are “mathematics education," “teaching," and “mathematics." However, a relationship exists between didactic design and elementary education, secondary school, and higher education. The correlation on these labels is small, presenting opportunities for research on didactic design. From the visualization using VOSviewer and RStudio, research related to didactic design in algebra, calculus, and geometry has not been done much, and it is very urgent to do so because the potential research on didactic design in these areas is up-and-coming.

Keywords: didactic design; bibliometric analysis, VOSviewer, RStudio

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I. Introduction

In recent years, didactic design has emerged as a prominent trend in mathematics education (Dasari et al., 2024; Putri, Yerizon et al., 2024). Didactic design is one of the education design research models (Gravemeijer & Prediger, 2019). Didactic design is construed as the organized exploration of conceiving, designing, and assessing educational interventions, programs, pedagogical strategies, educational materials, products, and systems. These endeavors are not only solutions to address the intricate challenges within the educational domain but also a means to augment

our comprehension of the attributes inherent to these interventions (Fiedler & Väljataga, 2009; Putri, Juandi, Jupri et al., 2024). Moreover, they shed light on the intricate procedures required for conception and development (Plomp & Nieveen, 2010). Didactic design is a specific form of design research encompassing validation and developmental studies (Lidinillah, 2012). Within the systematic design research framework, didactic design offers a methodological approach to tackling complex issues within educational practice. These issues can be effectively addressed through meticulous design and development efforts integrated into the learning process (Fardian, Suryadi et al., 2024; Putri et al., 2024; Ruthven et al., 2009).

Two models for the development and implementation of didactical design research have been formulated by Hudson (2011) and Suryadi (2019). In addition, Hudson's model stands out due to its strong focus on significance, meaning, and intentionality right from the initiation of the teaching preparation process. The didactical design process, which Hudson adopts, encompasses five stages: analysis, design, development, implementation, and evaluation. In Indonesia, Suryadi introduced the concept of didactic design as an educational research model in 2019. This introduction aimed to provide support for the *metapedadidactics* theory, which had been previously developed in the subject of mathematics education. In the learning process, there must be three relationships between teacher and student (HP), teacher and instructional materials (HD), and student and instructional materials (ADP). The model developed by Suryadi emphasized the analysis of *metapedadidactics*, which is the teacher's ability to analyze the didactic triangle to produce a didactical design.

Furthermore, studies focusing on bibliometric analysis in the context of mapping research of didactic design have not been carried out in the past. Bibliometrics is a statistical methodology employed to evaluate and measure the number of publications within a particular research field (Fellnhofer, 2019; Khodabandelou et al., 2019). Using websites or applications, Bibliometrics can help researchers quickly identify research trends (Palupi et al., 2023). This approach has garnered increasing recognition recently due to its capacity to reduce the impact of individual perspectives and potential bias (Jiang et al., 2019). Bibliometric analysis has become a powerful method for studying research trends and developments across various academic fields. It is a valuable resource for gaining insights into research boundaries and trends (Oktavio & Harsono, 2024; Thomas et al., 2023). Consequently, the present study was undertaken to delineate and visualize the results of published articles derived from the use of bibliometric analysis, employing Scopus as the primary data source and subsequently refining the data with VOSviewer and RStudio software (Fardian & Dasari, 2023; Putri, Juandi, & Turmudi, 2024a; Sari et al., 2024). This research endeavor aims to provide a valuable resource for researchers by offering insights into potential research topics, particularly in the realm of didactic design.

In light of these considerations, the primary aim of this study is to delve into the trends within the field of didactic design by employing bibliometric analysis. To achieve this objective, we investigate four research questions: (1) what is the temporal distribution of articles pertaining to didactic design? (2) how are articles related to didactic design spread among various countries? (3) what is the spread or allocation of articles related to didactic design across various academic sources? (4) which keywords appear most frequently in articles related to didactic design, and how do these keywords change or develop over time?

II. Research Method

Research Design

Scopus and Web of Science (WoS) indisputably stand out as two of the most prominent and influential academic databases commonly employed in previous bibliometric analyses. However, for this specific study

focusing on the literature on didactic design, we have exclusively utilized data retrieved from Scopus. Scopus is a globally recognized reference database renowned for housing a vast repository of high-quality, peer-reviewed scholarly papers (Baas et al., 2020; Ballew, 2009; Schotten et al., 2017). Given its broader coverage compared to the Web of Science, Scopus is the preferred choice for conducting bibliometric analyses in this context. Bibliometrics, as a methodology, entails a methodical scrutiny of data extracted from the bibliographical components of scientific publications, employing rigorous quantitative analyses and statistical methodologies (Zan, 2019). Bibliometric analysis plays a pivotal role in discerning nascent domains and forthcoming trajectories within the research landscape, and aided by utilizing visualization tools; it stands as a primary objective (Pradhan, 2017). Notably, bibliometric analysis demonstrates its prowess in handling substantial quantities of unorganized data extracted from scientific databases, thereby furnishing factual and impartial insights through the exposition of citation metrics. The research design of this study encompasses several key phases, including exploration, visualization, identification, and verification. These phases collectively provide an organized process, beginning with searching for relevant articles and progressing to categorizing clusters formed by terms according to their frequency.

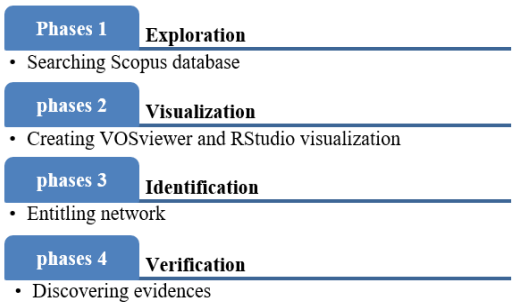

Figure 1. Research design of the current study

Data Collection

To gather data, this research adhered to the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Fardian & Dasari, 2023; Putri, Juandi, & Turmudi, 2024b) for document retrieval (Hallinger & Wang, 2020; Tran et al., 2019). In the identification step, keywords such as: 'didactic' or 'didactic design' or 'didactical design research' or 'didactic situation' and 'mathematics' and 'mathematics education' were executed on the Scopus database utilizing the specified keywords. All documents strongly associated with these specific keywords in their titles, abstracts, or keywords were subjected to a meticulous filtration process. This rigorous filtering process was undertaken to ensure the retrieval of the most pertinent documents essential for the study of didactic design. To be precise, the keywords employed were as follows: TITLE-ABS-KEY (didactic OR "didactic design" OR "didactical design research" OR "didactic situation" AND mathematics OR "mathematics education"). The initial search query produced a total of 1,413 documents. These documents then underwent a secondary screening process in the second step. During this screening phase, a predefined set of criteria and parameters were applied to identify and select the most relevant documents for the study.

Table 2. The categorization of effect size

Criteria	Descriptions
Publishing year	1973-2024
Subject area	Unlimited
Document	Articles
Language	English

During this step, 796 documents did not meet the specified criteria and were subsequently excluded. As a result, 617 documents proceeded to the third step, which involved an eligibility assessment. In this phase, each document's title and abstract were meticulously examined. At this juncture, 85 documents were disqualified due to incomplete or insufficient keywords. The ultimate dataset comprises 532 documents, all compiled and stored in a CSV file for subsequent bibliometric analysis.

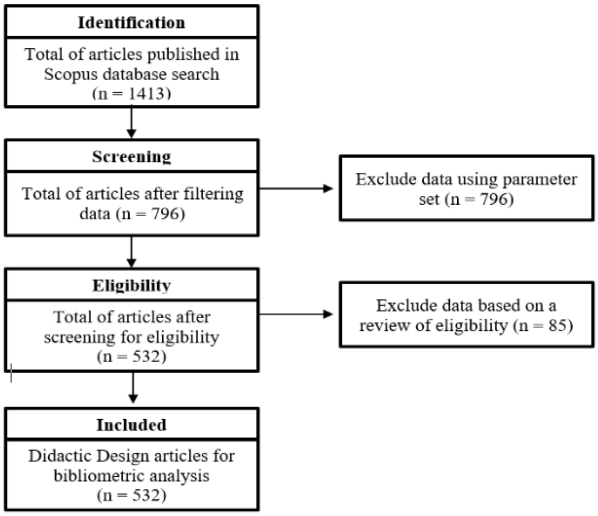

Figure 2. Preferred reporting items for systematic review and meta-analysis (PRISMA)

Data Analysis

VOSviewer and RStudio, renowned for their diverse visualization capabilities, are the predominant computer software tools. However, these software tools are pivotal in visualizing and analyzing data. VOSviewer and RStudio collected, analyzed, and visualized the bibliographic data. With the aid of these software tools, it becomes possible to generate bibliometric maps, including network maps that illustrate the interrelationships among items and categorize them into clusters based on the strength of their connections. Additionally, overlay maps can be created, featuring a color gradient that signifies changes over time. Moreover, density maps are another valuable output, showcasing the frequency of items associated with keywords that prominently appear in publications (Gökçe & Güner, 2022).

III. Results and Discussion

In this section of the paper, we expose the discovered results of descriptive and evaluative analyses. We have utilized VOSviewer and RStudio software to extract valuable insights from our data. Specifically, we have explored bibliographic coupling between sources, examined the co-occurrences of author keywords, delved into bibliographic coupling among countries, and scrutinized the bibliographic coupling of publications. These analyses provide a comprehensive view of the relationships and patterns within the dataset, contributing to a deeper understanding of our research topic.

Distribution of publications by years

Figure. 3 illustrates the annual scientific production related to didactic design over the past 50 years, between 1973 and 2024. The inception of didactic documents in the Scopus database dates back to 1987.

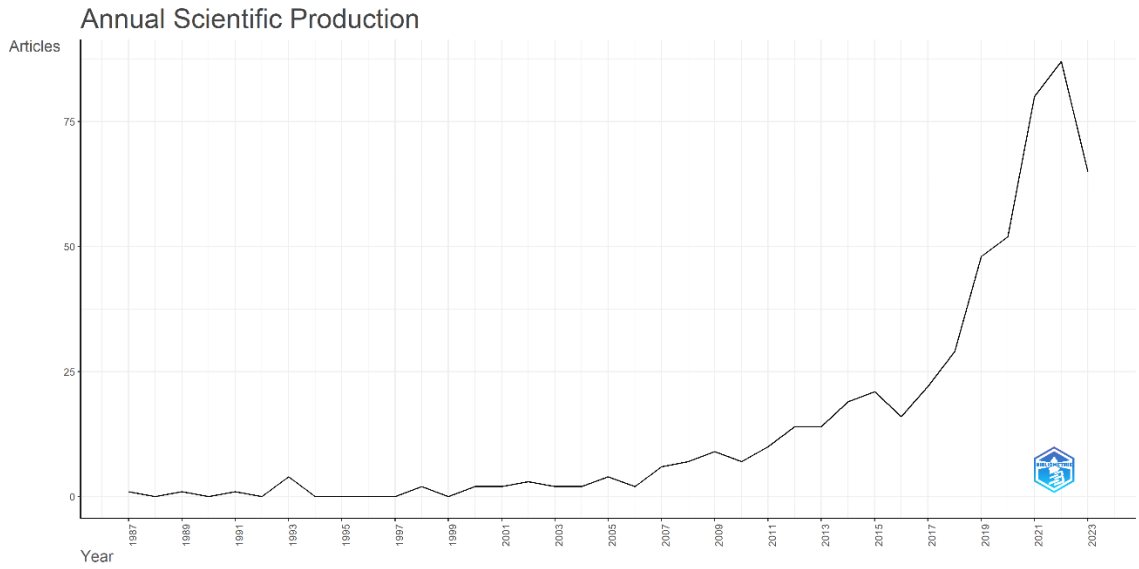

Figure 3. Article distribution related to didactic design from 1973 to 2024

Figure 3 shows that the period from 1987 to 2006, spanning 19 years, did not garner substantial attention from the research community, with only 26 documents related to didactic design being published during this timeframe. After 2006, the distribution of publications related to didactic design rose slightly. The span from 2016 to 2022, encompassing a duration of 6 years, witnessed a significant upsurge in research pertaining to didactic design. During this time frame, 334 documents were published, averaging approximately 55 papers per year, accounting for 62.7% of the total articles published. In 2022, the publications output accounted for 87 articles, which was the highest number of publications, but saw a decrease in 2023, accounting for 65 articles, the third-highest percentage of publications in the last 50 years. This is in line with (Sari et al., 2023), which stated that research on didactic design has shown significant growth in recent years. From 2016 to 2022, there was a substantial increase in publications, with 334 documents produced during this period.

Distribution of publications by country

Regarding the geographical distribution of articles related to didactic design, it is evident that Spain, Brazil, and Italy hold prominent positions within the field of didactic studies among 46 countries and 1212 authors (Figure 4). In 2023 alone, these countries contributed significantly to the literature with 303, 107, and 83 articles, respectively. Notably, there has been a marked upswing in the number of publications related to didactic design from the top 5 countries since 2017 (Figure 5).

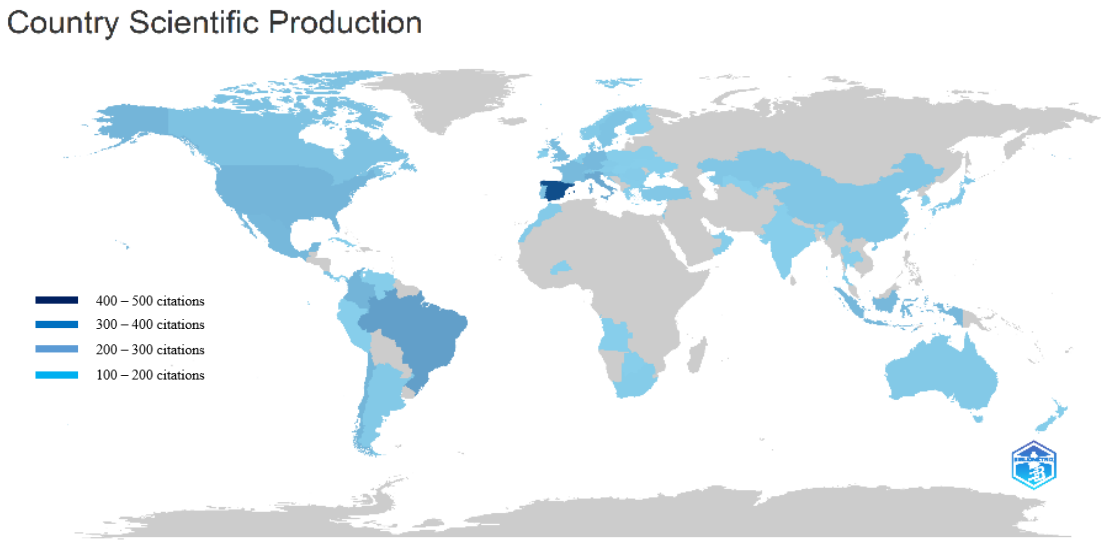

Figure 4. Article distribution related to didactic design by country

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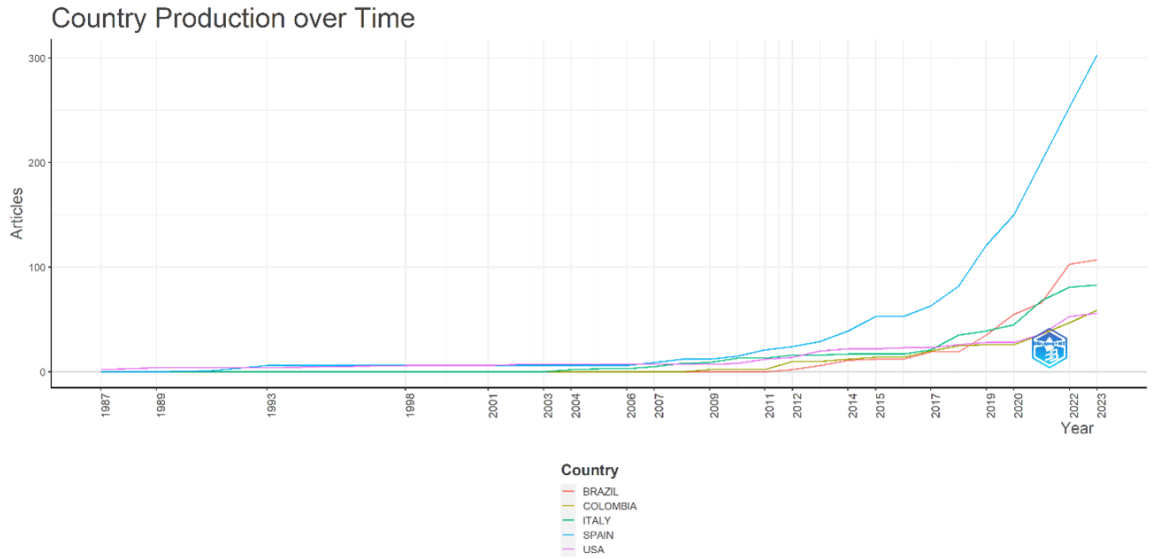

Figure 5. Country production related to didactic design

Distribution of publications by sources

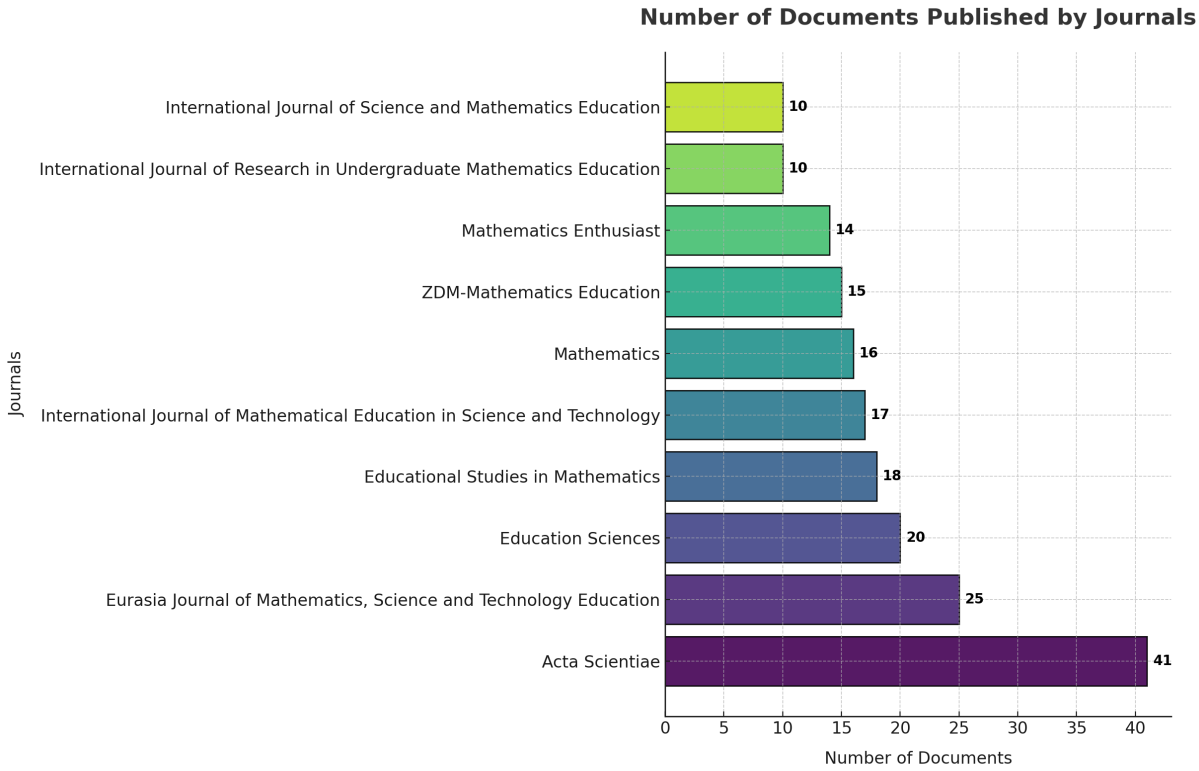

Figure 6. Sources production related to didactic design

Regarding the source distribution of articles related to didactic design (Figure 6), it appears that Acta Scientiae, Eurasia Journal of Mathematics Science and Technology, and Education Sciences are three important journals in didactic design (total of 217 sources). However, these journals published 41, 25, and 20 articles.

Co-occurrences of the author's keywords

The study employed three visualization schemes to analyze mapping: network visualization, overlay visualization, and density

visualization. In network visualization, the relationships between terms are represented as connections or lines that link one term to another. In the visualization, the connections or lines between terms illustrate their relationships. Figure. 7 depicts various circles, each distinguished by its unique color, size, and labels, interconnected by lines. The size of each labeled circle corresponds to the frequency of the term's occurrence in the title and abstract, signifying a positive correlation.

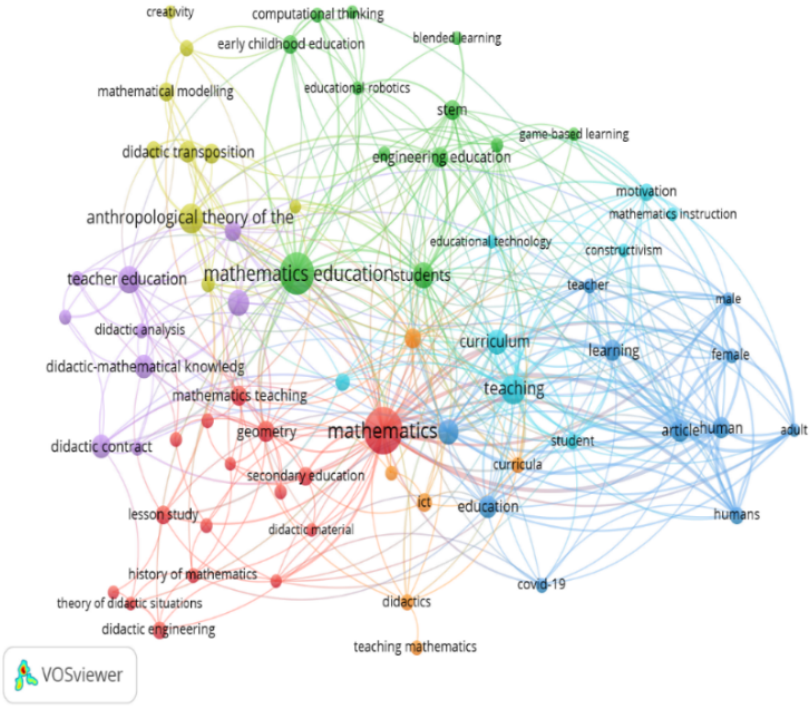

Figure 7. Co-occurrences of the author keywords (network visualization)

Figure 7 clearly illustrates the relationships and presents significant opportunities for recent studies. Additionally, there is a connection between didactic design and primary school education. The small correlation of the orange circle with the primary school label suggests opportunities for research in didactic design. The network visualization also reveals a lack of significant research on didactic design in middle and high schools, highlighting the need for urgent studies in this area.

Furthermore, from the visualization using VOSviewer and RStudio, research related to didactic design in algebra, calculus, and geometry has not been done much, and it is very urgent to do so because the potential research on didactic design in these areas is up-and-coming. Novianda and Turmudi (2021) investigated and identified common learning barriers in middle schools (SMP) related to several geometry topics over the past five years. Based on the analysis of six key articles in their study, it was found that one of the causes of didactic obstacles is didactic design. Therefore, addressing and improving the design of instructional materials and teaching strategies is crucial to overcoming these barriers and enhancing students' understanding of geometric concepts. By refining the didactic design, educators can create more effective learning environments that reduce obstacles and support students in mastering complex mathematical topics.

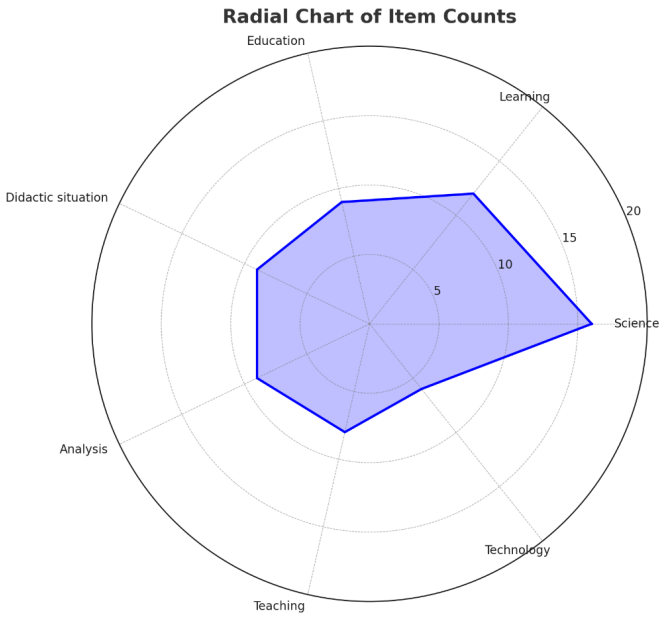

Figure 8. Radial chart on didactic design

The VOSviewer application successfully mapped numerous articles, helping researchers narrow selections based on specific criteria. From these results, 71 items related to didactic design were chosen and grouped into 7 clusters. The cluster mapping is outlined in Figure 8. The analysis has resulted in the identification of seven distinct clusters for the keywords. Each of these clusters highlights the keywords that exhibit the highest frequency of co-occurrence, which are interconnected within their respective clusters. There are seven items in the first cluster: These are science clusters (16 items), learning clusters (12 items), Education clusters (9 items), didactic situation clusters (9 items), analysis clusters (9 items), teaching clusters (8 items), and technology clusters (6 items). However, there is a need for improvement in the perspective of the technology cluster. This aligns with the findings of (Fardian, Herman, et al., 2024), who suggest that researchers should focus on designing didactic approaches that integrate technology. Integrating technology into learning can enhance the teaching process by providing teachers with greater resources and enabling them to better adapt to students' diverse learning styles (Hendriyanto et al., 2024). Integrating technology creates opportunities to increase student involvement, improve their understanding of mathematical concepts, and create a more engaging and enjoyable learning experience (Putri, Juandi, Jupri, et al., 2024).

The co-occurrence patterns of author keywords have been depicted in Figure 9. Only keywords that appeared at least five times were considered in this analysis. Out of the initial pool of 2211 terms, a total of 71 keywords met this threshold. The collective strength of co-occurrence links with other keywords was computed for all these keywords. Remarkably, "Mathematics" emerged as the most robust keyword, appearing in 56 instances with a total link strength 108. Evidently, "Mathematics" is the preferred term for conveying this concept, not only within the author keywords but also in the titles and abstracts of publications related to didactic design, where it enjoys frequent usage.

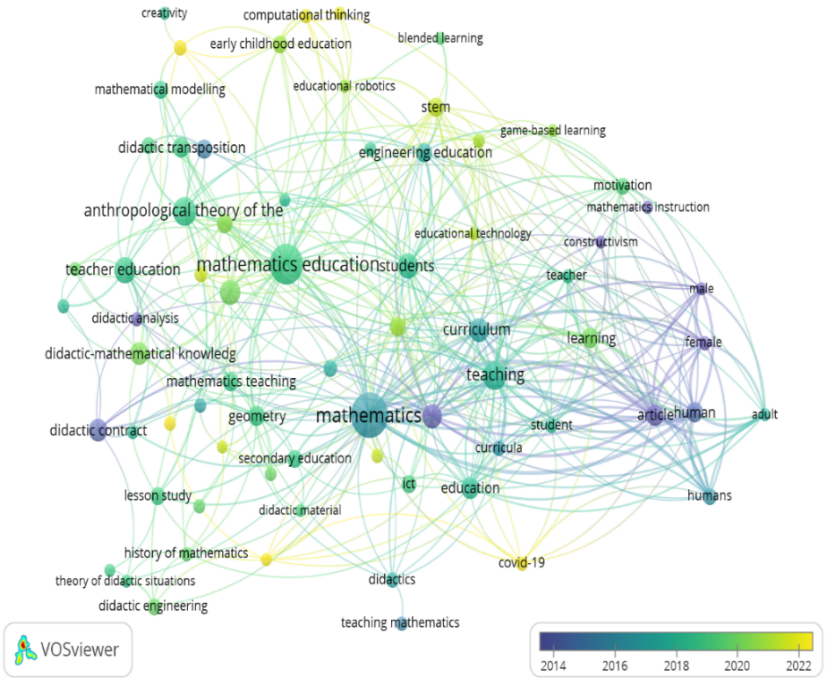

Figure 9. Co-occurrences of the author keywords (overlay visualization)

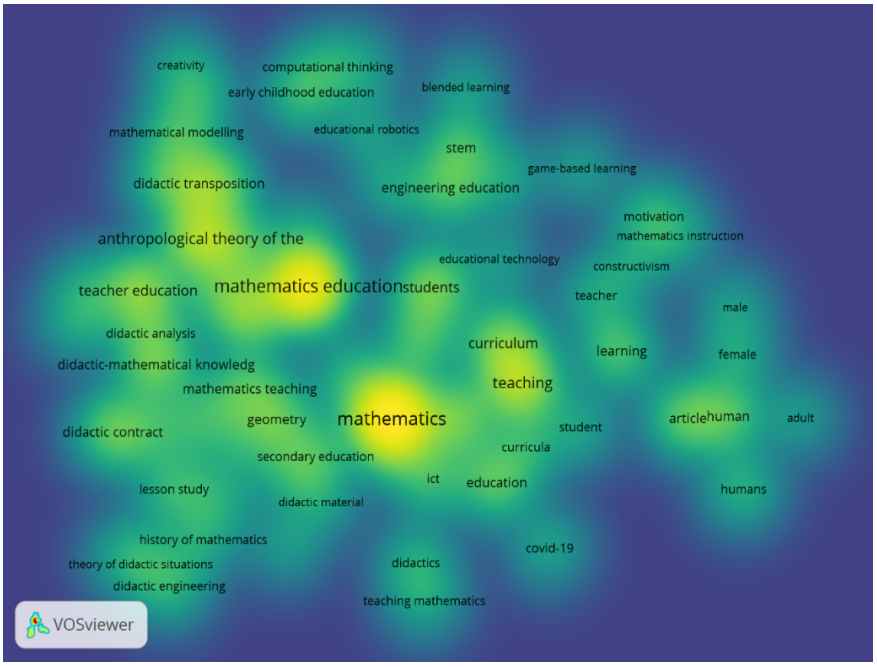

Figure 10. Co-occurrences of the author keywords (density visualization)

The density visualization shown in Figure 10 illustrates that a greater application of yellow indicates a high volume of research, whereas a dark or faded yellow, blending with the background, suggests limited research on the topic. This is in line with Deda and Disnawati (2024), who stated that there are four key clusters related to design research: the learning process, local instructional theory, realistic mathematics education, and didactical design research. As a consequence, scholars can pinpoint trends in design research and direct

future studies, as there has been a lack of recent research on design in the past three years (2020-2022).

IV. Conclusion

The research was conducted by analyzing the publication of articles with the keywords didactic OR "didactic design" OR "didactical design research" OR "didactic situation" AND mathematics OR "mathematics education," which was taken in the last 50 years (1973-2024). 532 articles were collected from Scopus and analyzed using VOSviewer and RStudio. Based on the outcomes of this analysis, it is evident that there has been an increase in publications about didactic design over the last 5 years now; it can be concluded that there is a significant opportunity for research on didactics, with a strong potential for connections to other related terms.

Several implications and recommendations can be drawn based on the research findings, which show an increase in publications related to didactic design over the past five years. The growing number of publications on didactic design indicates that this topic is receiving significant attention, especially in mathematics education. This trend suggests that effective instructional design is becoming increasingly recognized as crucial for improving learning outcomes, and this area is expected to continue evolving in future research. In terms of recommendations, future research should expand the exploration of didactic design beyond just mathematics education to include other subjects. This would provide a richer understanding of its applicability and effectiveness in different academic fields.

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