Bibliometric Analysis of Research Developments on Differentiated Instruction

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Abstract: This research attempts to map the trend of research related to differentiated instruction (DI). The research was conducted in May 2023 by researching research articles in the Scopus database. The search data from Scopus used title, abstract, and keyword searches. Research articles were analyzed descriptively based on year of publication, journal name, affiliation, country, and researcher name. The article database from Scopus was analyzed through VOSviewer and RStudio software so that a bibliometric map could be depicted in research related to DI. Based on the Scopus analysis results, it showed that publications of articles related to DI had increased from 2011 to 2021, although it decreased in 2016. The journal with the largest contributor to the publication of research articles related to DI was the Teaching and Teacher Education Journal. Vrije Universitiet Brusel was the university with the most published articles on DI. The country that contributed the most to the research articles related to DI was the United States. Struyven was the most productive scholar related to DI. Through network visualization, it was revealed that the evolution map of research related to DI was divided into five clusters.

Keywords: *Differentiated instruction, Scopus data, RStudio, VOSviewer.*

Introduction

Humans have physical or non-physical characteristics that are unique and different from one human to another. Students of the same age have different interests, hobbies, intelligence, and characteristics (Algozzine & Anderson, 2007; Tomlinson, 2001). That difference is what makes the diversity of students in the learning classroom (Pozas et al., 2023). The diversity of students in the classroom should not allow teachers to teach the same way to all students (Bondie & Zusho, 2018; Tomlinson, 1999, 2001). Teachers must accommodate all student needs in learning by conducting differentiated learning (Hogan, 2014; Reis et al., 1998; Tomlinson, 2001) is important for teachers to master how to improve students' academic, social, and emotional achievement (Pozas et al., 2021; Smale-Jacobse et al., 2019; Yavuz, 2020; Ziernwald et al., 2022) The importance of differentiated instruction (DI) in learning has given rise to many studies related to DI which have been developed by researchers. Existing DI research includes teachers' perceptions of DI (Ginja & Chen, 2020; Santoso et al., 2022; Shareefa et al., 2019; Zaier & Maina, 2022), DI impact (Iterbeke et al., 2020; Krishan & Al-rsa'I, 2023; Yavuz, 2020), DI effectiveness (Magableh & Abdullah, 2020), as well as other studies which have not yet been classified. In the early years of DI, there was a lot of research on the concept of the DI (Kuznetsova, 1974; Vendrovskaia, 1992), the application of the DI (Mel'nikov, 1963; Ogurtsov, 1992) and DI for children with special needs (Irvine, 1991; Thurlow et al., 1983).

Bibliometric research related to DI has been conducted by scholars (AM et al., 2023; Dal & Abu, 2023; Kamarulzaman et al., 2018; Shareefa & Moosa, 2020; Sun & Xiao, 2021). Bibliometric research on existing DI certainly differs from this study. In the method carried out by AM et al. (2023) and Sun and Xiao (2021), eligibility was not obtained by browsing

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one of the documents. As such, it was possible that DI keywords did not discuss DI as the main topic. The article by Dal and Abu (2023) bibliometric was taken from the Web of Science (WoS) database. The article by Kamarulzaman et al. (2018) only discusses the context of DI research, the DI area, and the methodology used by DI researchers. As such, the novelty of this study is to take Scopus data from the beginning of the year, namely 1961-2022, using relevant bibliometric research methods and VOSviewer and RStudio software in the data analysis.

Aim and Research Question

This research aims to quantitatively explore the current state of research related to DI and identify major themes and trends that have emerged over the past decade. Specifically, we aim to answer the following research questions.

1. How has DI research developed over the years?

2. Which journals have been the most prominent in publishing research on DI?

3. What are the prominent affiliations and countries have contributed to publishing articles on DI?

4. Which researchers have been the most prolific in terms of publishing articles on DI?

5. What are the most highly cited articles in the field of DI?

6. What is the co-occurrence network of keywords associated with DI research, and how do these keywords cluster and interact within the research literature?

Literature Review

DI initially focused on teaching gifted students, then this focus expanded into a series of teaching practices targeted at inclusive education classrooms and further developed into a primary teaching approach to fulfill the needs of all learners in regular classrooms (Langelaan et al., 2024). The definition of DI is still ambiguous but has the same meaning about the differences in the character of each student (Graham et al., 2021; Jager et al., 2022; Zerai et al., 2023).

DI is an effort by teachers to meet the needs of each participant in the process of teaching and learning activities where their students learn the subject matter according to the needs of each student (Chien, 2012; Godor, 2021; Tomlinson et al., 2003) so that they do not feel that they have failed in learning and frustration can be avoided (Navrátilová, 2019; Tomlinson, 2001). Providing fair learning opportunities for students does not mean equating one learning method for all students. Instead, it is based on the student development (Wormeli, 2023, p. 8). Students with high abilities will be bored if given learning treatment that follows low-ability students. On the other hand, if they follow the methods of high-ability students, low-ability students will find it difficult to follow and even reduce their self-efficacy (Barbier et al., 2023; Porta & Todd, 2024). DI accommodates the diversity of student learning needs so that all students get the same appropriate way to absorb, use, develop, and present concepts in the learning process as part of daily life (Osuafor & Okigbo, 2013) to maximize student growth and success (Adare et al., 2023; Wong et al., 2023), and positive impact on student learning outcomes (Deunk et al., 2018; Liou et al., 2023; Mićanović et al., 2023), social-emotional development of students (Herset et al., 2023), motivation (Ismail et al., 2021; Sapan & Mede, 2022), and student self-efficacy (Cholsakorn & Piamsai, 2022; Pozas et al., 2022).

The diversity of students in the classroom that needs to be considered before conducting DI includes student readiness, interests, and student learning profiles (Bondie & Zusho, 2018; Hockett, 2018; Tomlinson, 1999, 2001) Student readiness is not about the level of intellect (IQ) but rather the level of students' current understanding, or previous knowledge, about a topic or concept and reflects their current level of ability to provide the right challenge (Elyas et al., 2020; Tomlinson, 2001). The purpose of interest-based teaching is to help students realize that there is a match between school and their own desire to learn (Tomlinson, 2001; Tomlinson et al., 2003). Student learning profiles can be seen in terms of learning styles, intelligence preferences, gender, and culture (Tomlinson, 2017). A learning profile refers to an individual's learning style and preferred mode of learning that is responsive to their needs (Sebihi, 2016).

DI can be done by differentiating content, processes, products, and learning environments (Smith & Throne, 2011; Tomlinson, 2001). Content is "what" students learn, as well as the materials and sources used to learn it (Börnert-Ringleb & Wilbert, 2018), so differentiating content allows for using the same curriculum but perhaps quantitatively or qualitatively different (Adami, 2004; Levy, 2008). Referring to process differentiation, teachers can help students understand and interpret the information or material they learn by providing tiered activities, asking guiding questions, challenging them, creating individual agendas for each student, utilizing different times, developing varied activities, and using flexible groupings (Tomlinson, 2001). Product differentiation is an expected bill from students focusing on understanding and learning objectives (Hogan, 2014; Tomlinson, 2001). The learning environment includes personal, social, and physical class arrangements that must be adjusted to students' learning readiness, interests, and learning profiles so that they have high motivation in learning (Tomlinson, 2001). Personality can include managing students' emotions because positive emotions affect life satisfaction (Hidayat et al., 2020).

DI in learning has sometimes been applied by some teachers even though they are not aware of it, and there are many

positive teacher perspectives on DI (Baumoel & Schmidlein, 2023; Crisologo et al., 2023; Dorfberger & Eyal, 2023). However, research that focuses on the challenges of DI for teachers illustrates that the challenges of DI for teachers are resources (Letzel et al., 2023), making materials and evaluation (Yuen et al., 2023), takes a lot of time (De Jager, 2023; Mardhatillah & Suharyadi, 2023), large class sizes and lack of DI training for teachers (Adare et al., 2023).

Methodology

The method in this study was a systematic literature review (SLR) with a bibliometric approach. One way to find out research trends in the field to be studied is to use bibliometric analysis. Bibliometric applications can be separated into three elements: bibliometric calculations (performance), behavioral indicators, and bibliometric network view analysis. Bibliometrics are descriptive or evaluative Fields(Donthu et al., 2021).

Tools that allow the design and visualization of bibliometric networks are VOSviewer and RStudio. VOSviewers can create and browse bibliometric maps featuring fantastic visualizations (Moral-Muñoz et al., 2020). It offers text mining functionality to generate and show networks/relationships in article excerpts, showing overlays and densities of emerging keywords (Arruda et al., 2022). The VOSviewer display map can be enlarged to drill down into the in-depth mapping in an easy-to-read way (van Eck & Waltman, 2010). Performance analysis in this study used RStudio software (R 4.2.2) due to its flexibility and fast scale and integration with other statistical R-packages as well as being suitable for mapping science with an emphasis on empirical contributions resulting in a large, fragmented, and controversial research stream (Aria & Cuccurullo, 2017).

This study used online Scopus data from international publications in the field of education, especially about differentiated learning. Searching for data related to differentiated learning in Scopus was done using search options with title, abstract, and keyword categories. A search about differentiated learning in Scopus on May 15, 2023, used the keyword 'differentiated instructions.' This bibliometric research procedure used data collection, data screening, and data analysis steps. Data collection and screening steps utilized the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA, 2020) framework. We examined this method as an example in the studies conducted by Pham et al. (2023) and Wei et al. (2022). The data analysis utilized VOSviewer and RStudio software.

The process of data collection and data screening using PRISMA was carried out on the scopus.com web until an accurate article about DI was obtained. The utilization of PRISMA ensures a systematic and transparent approach to conducting the bibliometric analysis, following the various stages outlined in Figure 1.
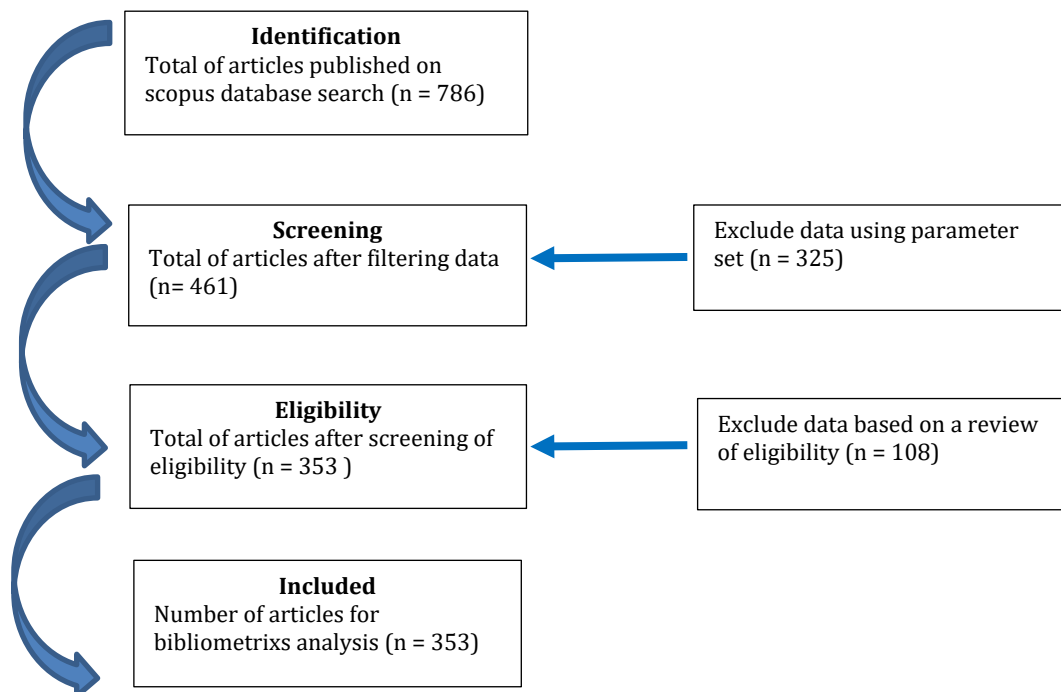

Figure 1. Results of Article Search Using PRISMA

Based on Figure 1, the identification stage was done by searching for document searches on Scopus using article titles, abstracts, and keywords. Next, the keyword "Differentiated Instruction" was entered into the document search without limiting or excluding data. Based on these keywords, 786 documents were obtained. Furthermore, screening was carried out by limiting or excluding the year, subject area, document type, source type, and language so that 461 documents in the form of articles were obtained. In the search view in Scopus, these words were displayed: TITLE-ABS-KEY

("differentiated instruction") AND (EXCLUDE (PUBYEAR, 2023)) AND (LIMIT-TO (PUBSTAGE , "final")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "ARTS") OR LIMIT-TO (SUBJAREA , "MATH")) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (SRCTYPE , "j")).

In the screening stage, 325 documents were excluded because they were unsuitable. The eligibility stage was carried out by looking at the documents one by one in the screening stage. There were as many as 461 documents, and the researchers assessed the suitability of the article's content through abstracts and full text. At the eligibility stage, there were 108 articles issued. This was because, after being traced in the discussion using the abstracts and full texts, the articles did not discuss DI as a major topic in the discussion. Instead, the emphasis was more on other topics, such as state policies for teacher learning in the classroom (Valli & Buese, 2007), the results of parental evaluations of teacher competence (Letzel et al., 2022), students' understanding of concepts related to the material (and other articles were not yet mentioned. The corresponding articles were exported as *Ris, *Csv and *Bibtex. Furthermore, bibliometric analysis using RStudio and VOSviewer was performed.

The bibliometric analysis conducted in this study encompassed a total of 353 articles. These articles were selected and included in the analysis based on predetermined criteria and rigorous screening processes. VOSviewer was used to see maps of relationships between countries and between authors, as well as interrelated keyword maps, the most dominant keywords used, and those still relevant for further research. Analysis using VOSviewer was conducted using a map based on bibliographic data as a type of data, selecting read data from bibliographic database files as a data source, selecting Scopus file, conducting VOSviewer analysis by selecting the necessary indicators such as co-authorship, countries, or others by selecting full counting, fill in thresholds and continue until visible analysis and map bibliographic. RStudio was used to analyze the development of DI from year to year, journals that publish edDI articles, affiliations and countries that had DI articles, authors of the most DI articles, and the most citations. RStudio analysis was done by selecting raw files from Scopus data and performing analysis according to expected indicators such as overviews, sources, authors, or others.

Results

The Development of DI Research From Year to Year

Scopus data collection for the year filter was only excluded in 2023 because researchers took data in mid-2023; the year 2023 cannot describe the real number of articles. The development of research articles related to differentiated learning based on Scopus data from 1961-2022 can be seen in Table 1.

Table 1. Differentiated Learning Research Publications by Year of Publication

Year	Number of Articles	Year	Number of Articles	Year	Number of Articles	Year	Number of Articles
2022	41	2006	2	1990	2	1974	1
2021	47	2005	3	1989	0	1973	0
2020	44	2004	1	1988	0	1972	0
2019	33	2003	1	1987	0	1971	0
2018	30	2002	1	1986	0	1970	1
2017	25	2001	0	1985	1	1969	0
2016	12	2000	3	1984	0	1968	0
2015	24	1999	1	1983	1	1967	0
2014	15	1998	2	1982	0	1966	0
2013	14	1997	0	1981	0	1965	0
2012	11	1996	0	1980	0	1964	1
2011	7	1995	2	1979	0	1963	2
2010	7	1994	0	1978	0	1962	0
2009	5	1993	0	1977	0	1961	2
2008	7	1992	2	1976	0		
2007	1	1991	1	1975	0		

Table 1 illustrates the fluctuating trends in the number of articles pertaining to DI over the years 1961 to 2021. While there was a notable decrease in the number of articles in 2016, an overall increasing trend can be observed during the period from 2011 to 2021. In the earlier period, from 1961 to 2006, the number of articles published in journals exhibited fluctuations. Notably, the first articles related to differentiated learning published in Scopus-indexed journals emerged in 1961, comprising a total of two articles. Subsequently, the number of articles concerning differentiated learning varied throughout the years. The peak in the number of articles occurred in 2021, with a remarkable count of 47 articles dedicated to the subject matter.

Journals That Publish Research on DI

A comprehensive collection of 353 articles pertaining to DI was published across 202 distinct journals. The journal data presented was from the top 10 journals to get a clear and comprehensive picture using RStudio. Among these journals, the top ten which published the highest number of DI-related articles are as follows: Teaching and Teacher Education (n = 11), Cogent Education (n = 8), Journal of Advanced Academics (n = 8), International Journal of Instructions (n = 7), Kappa Delta Pi Record (n = 7), Frontiers In Education (n = 6), Journal for The Education of The Gifted (n = 6), Soviet Education (n = 6), Teacher and Teaching: Theory and Practice (n = 6), and Education Leadership (n = 5). Figure 2 visually represents the data concerning the number of articles addressing DI within these ten journals.
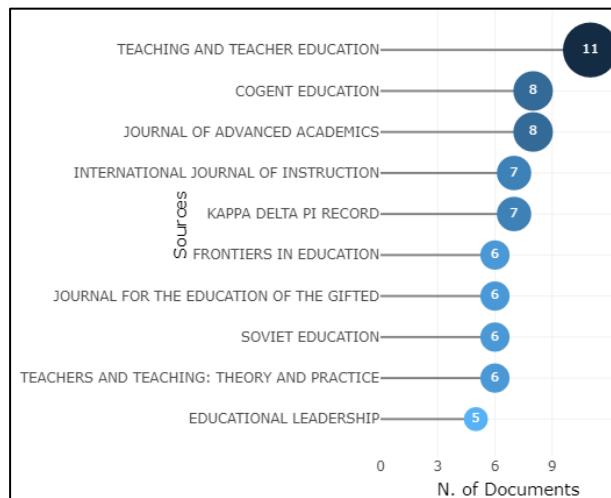

Figure 2. Top Ten Journals for Publications on DI

According to the information depicted in Figure 2, it is evident that the journal 'Teaching and Teacher Education' was the primary publisher of articles related to DI. The prominence of this journal suggested its significant contribution to the field in terms of publishing DI-related research. Furthermore, by examining the distribution of publication years in Figure 3, it was possible to identify several other journals that also published a substantial number of articles on DI. The spread of publication years provided insight into the presence and continuity of DI research across different journals, highlighting their involvement in disseminating knowledge in this area.
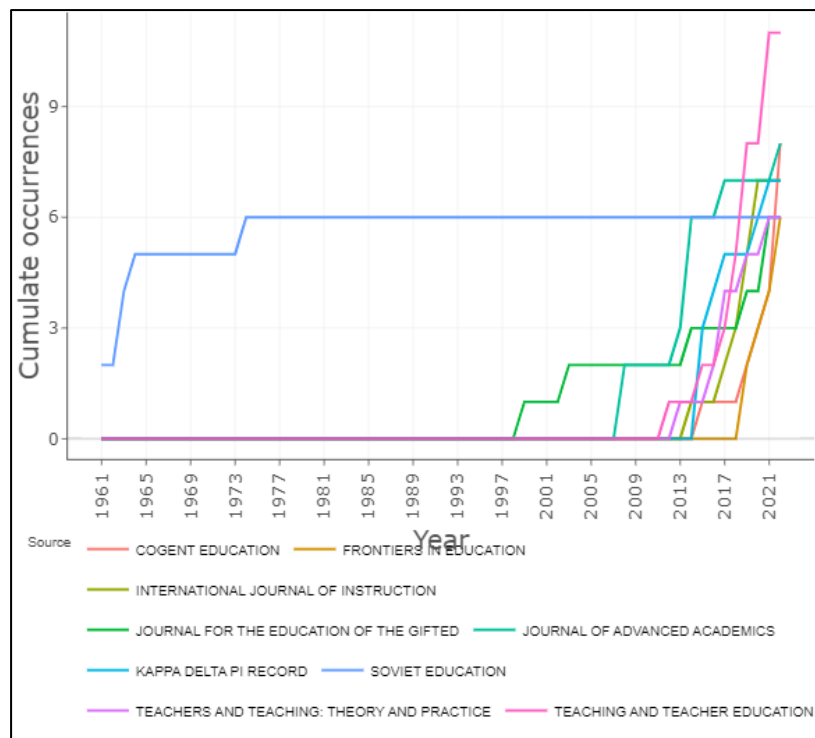

Figure 3. Source Dynamics Publications About DI

Figure 3 reveals that not all journals which published a substantial number of articles related to DI exhibited consistent dynamics over time. For instance, the journal "Teaching and Teacher Education" published a total of 11 articles, with its publication history showing variations. It began publishing DI articles in 2012, with one article each in 2012, 2015, and 2017. In 2018, it published 2 articles, and the highest number of articles, 3 each, were published in 2019 and 2021. Similarly, the journal "Cogent Education" published 8 articles, but the distribution across years showed fluctuations. One article each was published in 2015, 2019, 2020, and 2021, while 4 articles were published in 2022. In the case of the "Journal of Advanced Academics," 8 articles were published. The publication pattern included one article each in 2013, 2017, and 2022 and 2 articles in 2008. The highest number of articles, 3, was published in 2014. It is worth noting that the Soviet journal "Education" started publishing DI articles in 1961 but ceased publication in 1974. These observations indicated that while certain journals had published a considerable number of DI-related articles, their publication dynamics varied across different years, highlighting fluctuations in research activity and interest in the field of DI.

Affiliations and Countries That Have DI Article Publications

The affiliations and countries referred to in this study are affiliates and countries that publish related DI articles. According to the ranking of affiliated institutions and organizations, the order of the institutions with the most article publications on DI can be seen in Table 2.

Table 2. Number of Research Documents on DI by Affiliation

Affiliation	Nation of Journal	Number of Articles
Vrije Universitiet Brusel	Belgium	18
Ghent University	Belgium	14
University of Virginia	United Stated	9
University of Connecticut	United Stated	7
University of Nicosia	Cyprus	7
University of Antwerpen	Belgium	6
University of Trier	Germany	6
University of Monterrey	United Stated	5
University of Nort Carolina at Charlotte	United Stated	5
University of Thessaly	Greece	5

Vrije Universiteit Brussel and Ghent University emerged as the top two affiliations which contributed significantly to international journal publications in Scopus related to DI, with a total of 18 and 14 publications, respectively. These universities demonstrated their commitment to advancing DI research through their substantial contributions to the field. Additionally, several other universities which ranked among the top ten institutions with a significant number of published DI-related articles also played a crucial role in contributing to the overall publication output in the field. Their contributions contributed to the collective body of knowledge on DI. For a comprehensive overview of the countries with the highest number of publications related to DI, the results can be seen in Table 3. This table presents valuable insights into the countries that made notable contributions to DI research, highlighting their prominence and engagement in the field.

Table 3 presents a comprehensive overview of research article contributions in the field of DI from various countries. The United States emerged as the leading country, having made the most significant contribution with 220 research articles related to DI. Following closely behind was Belgium, with a substantial number of 56 articles, predominantly authored by Vrije Universiteit Brussel and Ghent University. This placed Belgium at a notable distance from the United States in terms of publication output. To gain a visual understanding of the countries which made substantial contributions to DI research, Figure 4 provides a graphical representation. By examining this figure, one can easily identify the countries which played a prominent role in generating research articles in the field of DI.

Table 3. Number of Research Documents on DI by Country

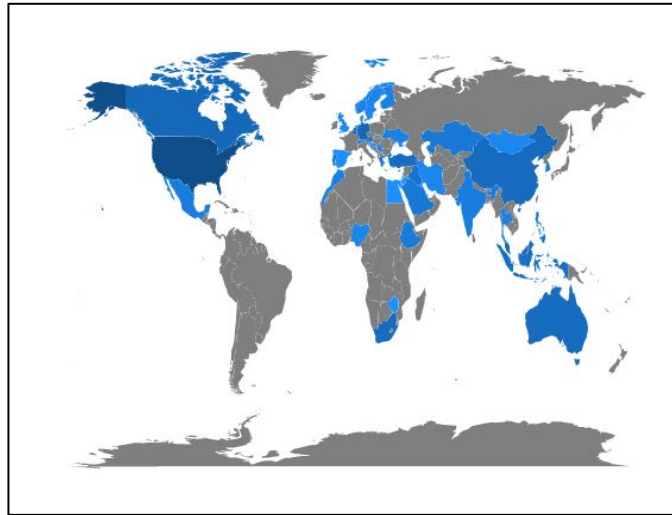| Country	Number of Articles
United States	220
Belgium	56
Netherlands	26
Germany	23
Canada	22
Malaysia	21
South Africa	18
Australia	17
China	17
Greece	16

Figure 4: Country Scientific Production of DI

Based on Figure 4, it can be seen that the darker blue color indicates the country that was most productive in contributing to DI articles and vice versa. The brighter the blue color, the fewer DI articles were produced in that country, and the gray color showed that the country did not contribute to writing DI-related articles. From Figure 4, it appears that the United States dominated the productivity of DI articles the most. Collaboration between countries was carried out in contributing articles related to DI. The collaboration between these countries can be seen in Figure 5.
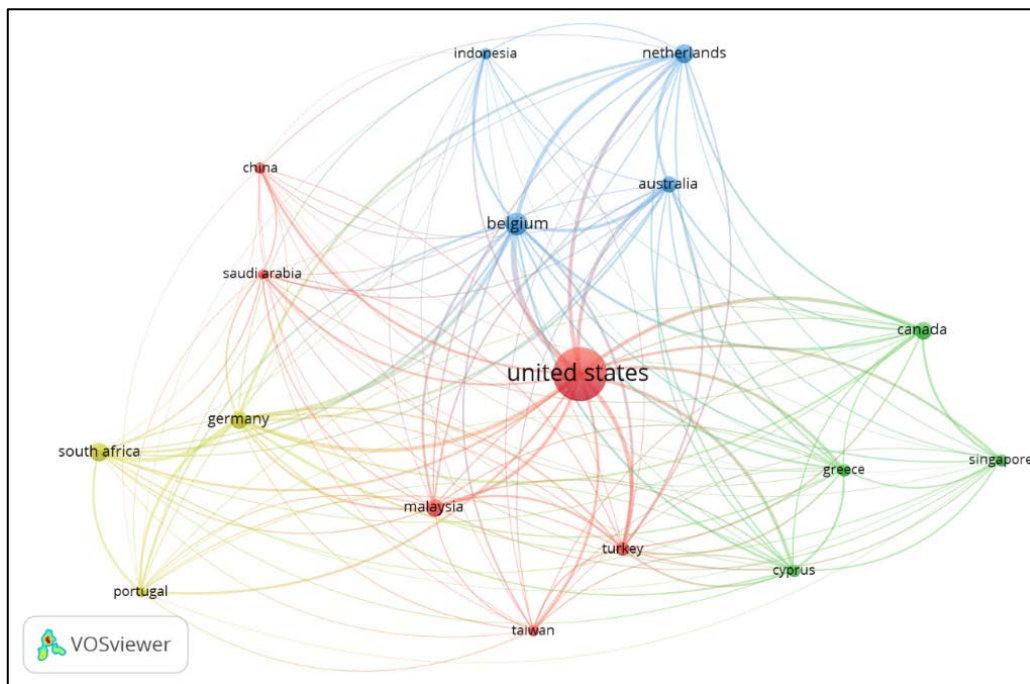
Figure 5. Map of Collaborations Between Countries

There were 4 collaboration clusters between countries based on Figure 5. Collaborations in Cluster 1 occurred in China, Saudi Arabia, Turkey, Malaysia, Taiwan, United States. Cluster 2 included Canada, Cyprus, and Greece. Cluster 3 includes Australia, Indonesia, Netherlands, and Belgium. Cluster 4 included Germany, South Africa, and Portugal. This can be seen on VOSviewer software at https://bit.ly/mapkolaborasi to see the collaboration network more clearly.

Researchers Who Most Actively Published DI Articles

Table 4 displays the ranking of authors who published articles related to DI in the Scopus database, highlighting the top ten contributors in terms of publication output.

Table 4. Name of Prolific Writer

Author Name	Number of Articles	H-indeks*	G-indeks*	M-index	TC	PY start
Struyven, K	11	6	11	0.857	177	2017
Pozas, M	8	3	6	0.750	54	2020
Letzel, F	5	3	5	0.750	54	2020
Abdullah, A	5	2	4	0.500	47	2020
Consuegra, E	5	3	4	0.600	18	2018
Gheyssens, E	5	3	5	0.750	29	2020
Shareefa, M	5	4	4	0.800	32	2019
Valiandes, S	5	3	5	0.333	33	2015
Vanderlinde, R	5	4	4	0.667	113	2018
Dack, H	4	4	4	0.667	47	2018

According to Scopus date 15 Mey 2023

In Table 4, Struyven had the highest number of DI-related articles with 11 articles followed by Pozas with 8 articles. For the third group, there were 7 authors who each had 5 DI articles, namely Letzel, Abdullah, Consuegra, Gheyssens, Shareefa, Valiandes and Vanderlinde. The dissemination of articles related to DI every year from productive writers can be seen in Figure 6.
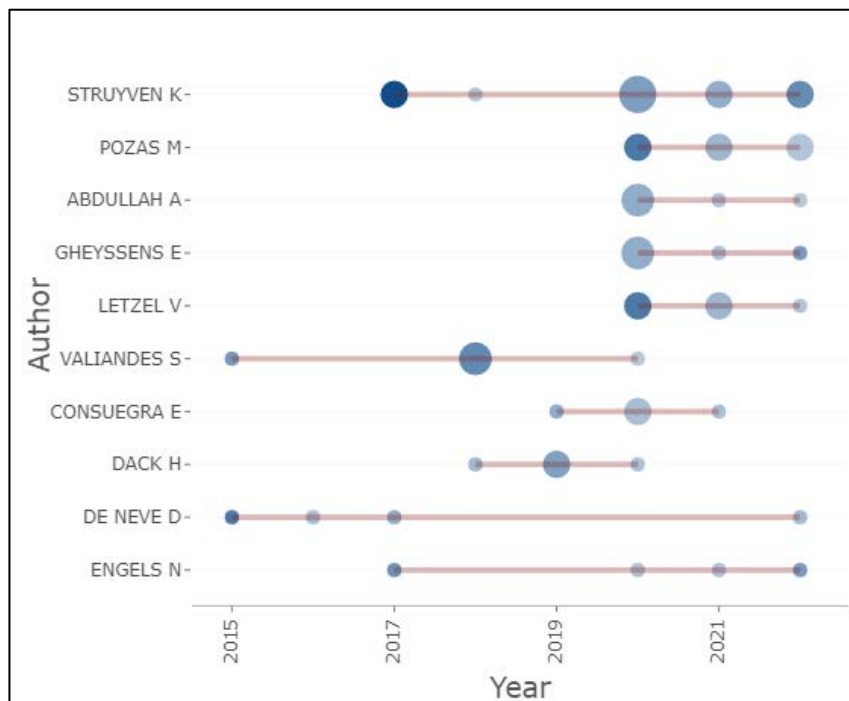
Figure 6. Top Author's Production Over the Time

In Figure 6, the darkest color showed the number of citations per year, while the lighter color showed the small number of citations per year from the article written by the author. The smallest circle showed the least number of articles published, while the large circle showed the greatest number of articles. Struyven wrote 11 DI-related articles published in 2017, 2018, 2020, 2021 and 2022. There were no articles published in 2019. While the next four writers in the order, namely Pozas, Abdullah, Gheyssens and Letzel, wrote articles related to DI in 2020. Writers who were prolific in writing DI articles also collaborated in writing their articles. Based on the analysis of VOSviewer by selecting the minimum number of documents of an author 5, the author collaboration network was obtained, as shown in Figure 7.

Figure 7. Author Collaboration Map
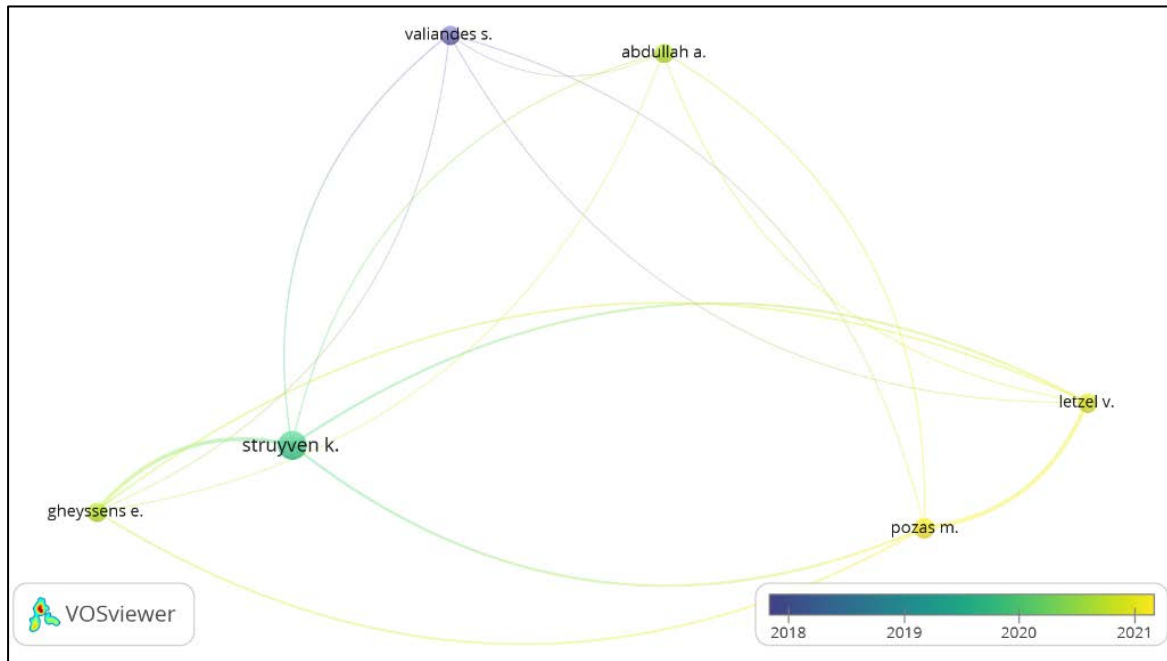
In Figure 7, it can be seen that two collaboration groups were formed. Cluster 1 is Abdullah, Valiandes, Struyven, and Gheyssens. Cluster 2 is dominated by Pozas and Letzel. Pozas and Letzel are a new collaboration based on the color gradation of the network. To see the network connection between authors in more detail can be seen at https://bit.ly/mapkolabauthor. Three field plots between journals, authors, and keywords can also be considered as relationships in the form of visualizations. Consider the following Figure 8.
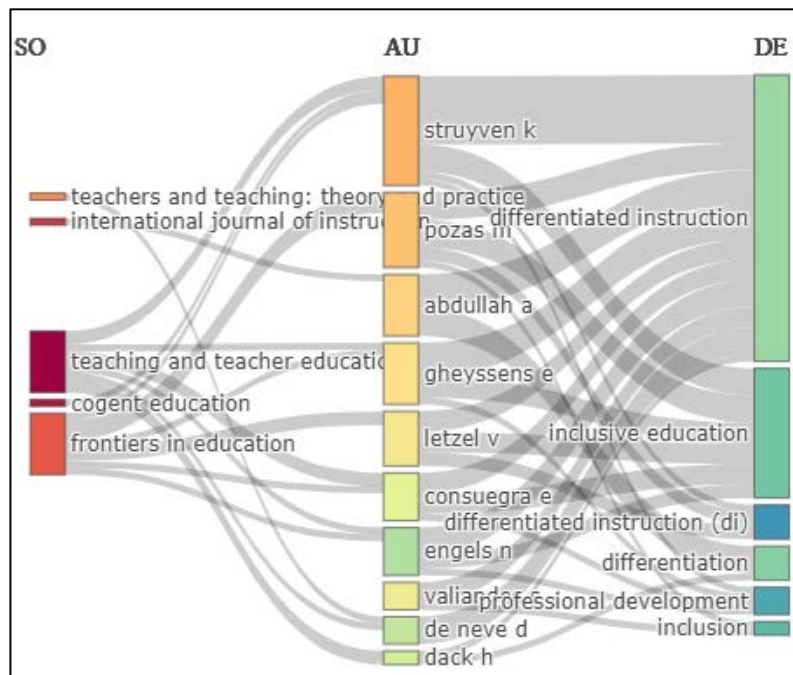
Figure 8. Three Field Plots

Figure 8 shows the three components i.e., journal, author name, and keyword. These components are related to each other by gray lines, showing their interconnectedness. The element located on the left is the name of the journal name, while the middle of each journal indicates authors who frequently contributed to their publications. The right side of each author indicates topics that were often used for the study of DI. Based on Figure 8, the first element included 5 journals from the Scopus database in the Three Fields Plot that published DI articles. Teaching and Education and Cogent Education were the top 2 journals that published the highest number of articles on DI. The Teaching and education were represented by a maroon rectangle directly connected to several authors, including Struyven, the most prolific author.

The author's name was the second element in the center of the three-plane plot. The most prolific author, Struyven, published DI articles in the journals Teaching and Teacher Education, Cogent Education, and Frontier in Education. All writers netted in a three-field plot used differentiated instruction keywords.

Most Cited DI Articles

In articles netted in Scopus with the keyword "differentiated instruction", not all use titles that mentioned words related to DI, but there were DI-related words in abstracts and keywords. Based on the analysis results in Scopus data, the articles with the most citations can be sorted. The order of the most cited articles can be seen in Table 5.

Table 5. Highest Citation DI

Title articles	Name author and year	N.of cited	TC per year
Flipping the classroom and instructional technology integration in a college-level information systems spreadsheet course	Davies et al.(2013)	535	48.64
Differentiated instruction: A research basis	Subban (2006)	147	8.17
The effects of differentiated instruction and enrichment pedagogy on reading achievement in five elementary schools	Reis et al.(2011)	147	11.31

Based on Table 5, the article titled "Flipping the classroom and instructional technology integration in a college-level information systems spreadsheet course" was cited the most at 535 times. The article aimed to explore how technology can be used to teach technology skills and to determine the benefits of flip classrooms for college students. The term DI appears in the abstract with the results of research showing that improved flipped classroom technology was effective and scalable, it could facilitate learning better than simulation-based training and students found this approach more motivating because it allows for a more dominant DI.

Co-Accurance Network With Keyword

The researcher used the Scopus meta data related to DI articles and exported documents to * CSV format, then the data was imported into VOSviewer software. Later, the analysis was later performed. The results of the co-word map network visualization of research developments on DI in Scopus were divided into 5 clusters, as shown in Figure 9.

Figure 9. Visualization of Network Map of Research Development on DI

In Figure 9, 5 clusters formed from keywords often appeared. Cluster 1 in red contained 11 keywords: article, child, curriculum, education, human, learning, motivation, student, student, teacher, and teaching. Cluster 2 green color consisted of 8 keywords: differentiation, diversity, early childhood, formative assessment, inclusive education,

instruction, secondary education, and teachers. Cluster 3 blue consisted of 7 keywords: assessment, differentiated instruction, literacy, mathematics, pedagogy, primary education, and professional development. Cluster 4 yellow consisted of 4 keywords, including inclusion, special education, teacher education, and technology. Cluster 5 purple consisted of 3 keywords: reading, reading comprehension, and self-efficacy. The relationship between clusters can be seen at https://bit.ly/networkDI.

Based on the five clusters, the dominating topics in clusters 1, 2, 3, 4, and 5 were differentiated instruction, differentiation, and inclusive education. The three topics were directly connected. Keywords that were not directly related between clusters can be a topic for further research by combining keywords between clusters such as curriculum (cluster 1), mathematics (cluster 3), differentiated instruction (cluster 3), using technology (cluster 4) to improve self-efficacy (cluster 5) or others. Based on the overlay visualization of the latest topic, several color gradations showed the novelty of the topic under study. The darker the color, the longer the topic had been researched and the lighter the color, the more recent the topic had been researched. The overlay visualization of the DI study can be seen in Figure 9 (https://bit.ly/overlayDI).
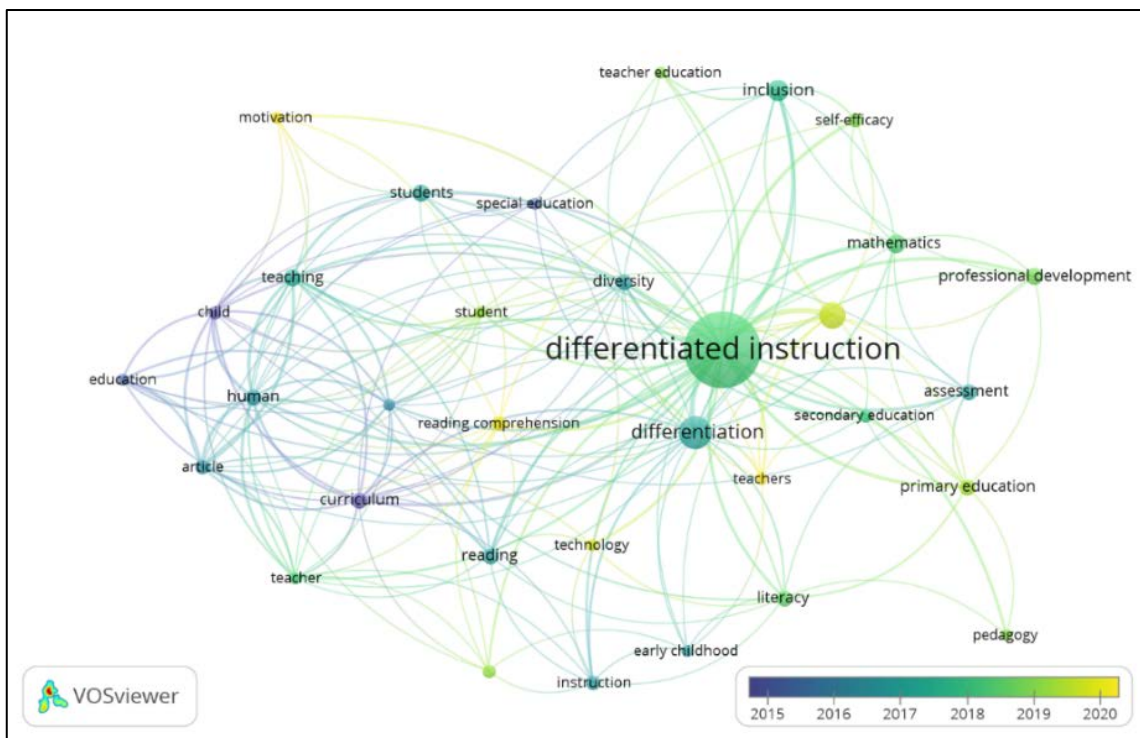

Figure 10. Overlay Visualization Research on DI

Based on Figure 10, it can be seen that there were six color gradations, namely purple, greenish purple, bluish green, green, yellowish green, and yellow. Yellow indicated the most recently researched topics related to differentiated learning. The latest topics related to differentiated learning were *instrument, competence, inclusive education, English, significant differences, gender, experimental group, present study,* and *country.* This can be an interesting topic to make a literature review study and meta-analysis related to keywords related to the last year.

The density of research topics related to differentiated learning can also be seen in the density visualization on the VOSviewer. The following is a picture of the density of research related to differentiated learning.
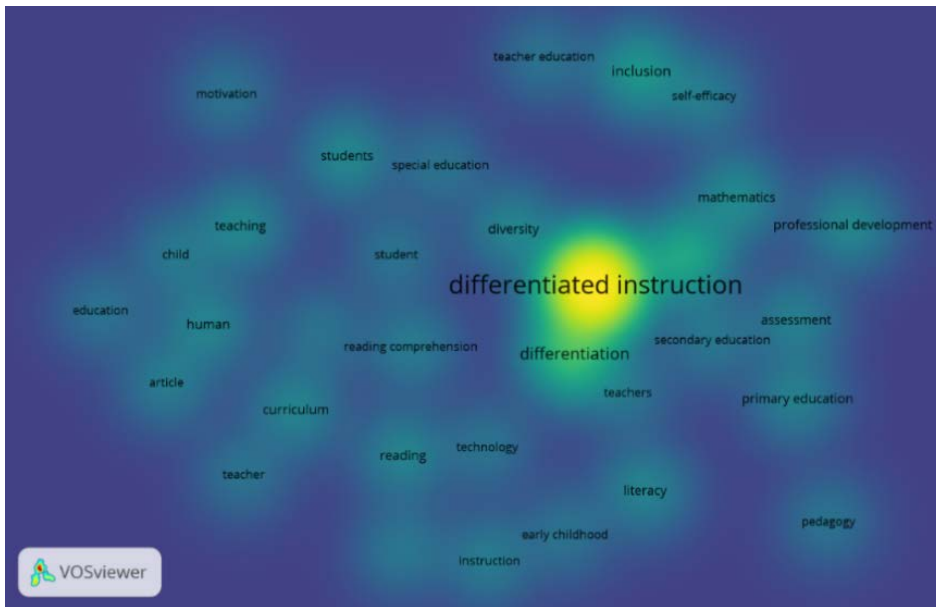
Figure 11. Visualization of Research Development Density on DI

The density of clusters is displayed as a label for visible items, with the color of each item point varying according to its density level. The sharpness of the color of a location on a map depends on its relationship. Density visualization interprets the most frequently used publication keywords. Figure 11 shows a map of research density related to differentiated learning. The yellower the color, the more research that addressed the topic; the greener the color, the rarer. In accordance with the keywords taken in metadata, the topics that were still hotly studied were differentiated instruction and differentiation. The picture can be seen more clearly at https://bit.ly/densityDI. In addition to looking at keywords that often appear and their distribution, topics often discussed in DI articles can be categorized, as shown in Figure 12.
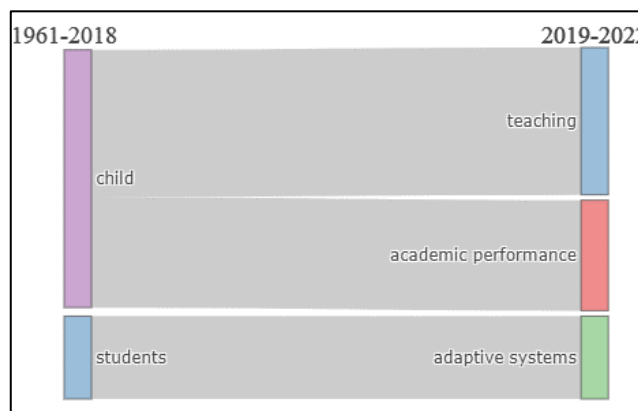

Figure 12. Trending Topics

Based on Figure 12, it can be seen that there is a shift in the main topic discussed in the DI article. From 1961 to 2018, the topic that was often discussed by DI was related to children and students. From 2019 to 2022, the topics discussed in DI were teaching, academic performance, and adaptive systems.

Conclusion

Research on DI has demonstrated an increasing trend since 2011. A similar result was also found by AM et al. (2023). This finding contrasts with the results reported by Sun and Xiao (2021) based on WoS data spanning 2000-2020 and results from Shareefa and Moosa (2020) from Scopus data from 1990-2018, where DI research tended to fluctuate. The steady growth of DI research can be attributed to the emphasis on education policies related to DI in various countries (Ali et al., 2024; Hasanah et al., 2022; Heng, 2023; Maulana et al., 2020; Sun & Xiao, 2021). These policies reflect a recognition of the importance of addressing the diverse learning needs of students and promoting inclusive educational practices. In response to the growing awareness of learner variability, many countries have implemented policies that advocate for integrating DI principles and strategies in educational settings. Furthermore, DI research has a long history, as evidenced by records in the Scopus database dating back to 1961. The earliest articles on DI, "An Experiment in Differentiated Instruction in the Secondary General-Education Schools" by Mel'nikov (1961) and "Differentiated

Instruction in the Physics Technology Department of secondary school no. 710, Moscow" by Peryshkin (1961), were published in different volumes of the journal Soviet Education, specifically volume 3 and volume 4. These early contributions highlight the longstanding interest and exploration of DI in educational contexts.

Teaching and Teacher Education is the journal that published the most articles related to DI. Journal Teaching and Teacher Education coverage by Scopus from 1985 until now and is a Quartile 1 (Q1) journal from 1999 until now. In accordance with the journal's name, Teaching and Teacher Education focuses on teachers and teaching in schools so that many disciplines can be covered. The results of research by Dal and Abu (2023) corroborate this finding that the Journal of Teaching and Teacher Education was also a journal that was widely cited about DI even though, according to its analysis, the European Journal of Educational Research was the most cited journal about DI articles. Different results were also found by AM et al. (2023), who wrote the International Journal of Inclusive Education as the most published journal for DI articles. This difference was due to the existence of different database sources and the limited number of years taken to collect data.

The most affiliated university that published DI is Vrije Universitiet Brusel. The same findings also listed Vrije Universitiet Brusel as the affiliate that published the most DI articles (AM et al., 2023; Dal & Abu, 2023; Shareefa & Moosa, 2020), although this result was different, as stated by Sun and Xiao (2021). According to these authors, Arizona State University was the affiliate that published the most DI articles because the database was taken from WoS. The United States had the most research related to DI. Other research findings on bibliometric DI also stated that the USA had the most distribution of articles about the DI (AM et al., 2023; Dal & Abu, 2023; Kamarulzaman et al., 2018; Shareefa & Moosa, 2020; Sun & Xiao, 2021). The United States is the country that is most aggressively conducting differentiated learning because there is a policy that every school in the US must be able to show that children can use their minds well so that they are ready to be good citizens, ready to enter higher education, and also ready for productive jobs in the modern economy so that this is a challenge for every teacher and researcher to do learning with students who more diversity (Hogan, 2014).

Struyven is the author of the most prolific article related to DI from Universiteit Hasselt, Belgium. The same results are also stated by Dal and Abu (2023) from WoS data 1981-2019 and AM et al. (2023) from Scopus data, but the results are different if the data was taken from WoS 2000-2020, which stated that Wendelien Vantieghem was the most prolific author related to DI (Sun & Xiao, 2021). The article written by Struyven related to DI, which is widely cited, is entitled "Higher education students with disabilities speaking out: perceived barriers and Opportunities of the Universal Design for Learning Framework" with 61 citations. This qualitative study explores the compatibility between differentiated learning design frameworks and the needs of inclusive children (Griful-Freixenet et al., 2017). Tomlinson, who has always been a reference for differentiated learning, especially in Indonesia, has only been detected publishing 3 articles in Scopus, namely "Deciding to differentiate instruction in middle school: One school's journey" (Tomlinson, 1995), "Teacher educators' perceptions and use of differentiated instruction practices: An exploratory investigation" (Santangelo & Tomlinson, 2012) and "Equal does not mean identical" (Reis et al., 1998). This is because this study was limited to articles that were finally published, while Tomlinson was more productive in writing books about DI.

The most cited DI article, entitled "Flipping the classroom and instructional technology integration in a college-level information systems spreadsheet course" written by Davies et al. (2013), was 353 times cited, the same as the results in the study (AM et al., 2023), although with a different number of citations due to the different years in Scopus data collection. Other bibliometric studies on DI, which were not limited by data sources from articles alone, provided different analyses from this study; Tomlinson is a widely cited author (Dal & Abu, 2023; Shareefa & Moosa, 2020).

The keyword that often appears in DI articles is "differentiated instruction". This is also evident in bibliometric analysis by other researchers, which showed that "differentiated instruction" was the most common keyword in the DI research (AM et al., 2023; Dal & Abu, 2023; Shareefa & Moosa, 2020).

The bibliometric analysis provides valuable insights into the landscape of differentiated learning research. The findings highlight the growth of research over time, prominent contributors, and emerging areas of interest within the field. These conclusions can guide and inspire future studies, encouraging further advancements in the field of differentiated instruction. DI remains a prominent and widely discussed topic in diverse classroom learning contexts. Numerous studies have been conducted on DI, and bibliometric analysis is a valuable tool to map and analyze the existing research, providing insights for future DI-related studies. Several key conclusions can be drawn based on the findings and discussions presented. Firstly, the number of Scopus-indexed articles on the development of differentiated learning research has been growing since 1961, with a consistent increase observed from 2011 to 2021, despite a slight decline in 2016. Among the journals publishing research articles on differentiated learning, Teaching and Teacher Education emerged as the leading contributor. Vrije Universitiet Brusel was identified as the institution with the most published articles on differentiated learning. Regarding country contributions, the United States stood out as the primary source of research articles on differentiated learning. The prolific researcher Struyven has made notable contributions to the field. The evolutionary map of research on differentiated learning can be divided through network visualization techniques into five distinct clusters, revealing the interconnectedness and development of research themes within the field. The latest keywords studied in relation to differentiated learning include "differentiated instruction" and "differentiation." Several relevant topics warrant further exploration in future DI research, such as teaching methodologies, academic

performance outcomes, and adaptive systems. The results of this study can be utilized by other researchers who focus on DI to find journal targets, research collaborations, and affiliations and look for topics that are still relevant.

To enhance future research in this area, it is recommended to employ a larger sample size by expanding the range of keywords used and accessing multiple databases. A more comprehensive collection of relevant articles can be obtained by broadening the scope of the search and providing a more representative sample for analysis. Furthermore, to ensure robustness and validity, comparing the analysis results obtained using different bibliometric analysis software would be beneficial. Utilizing alternative software, such as HistCite, can help validate and cross-validate the findings, offering a more comprehensive understanding of the research landscape on DI. Expanding the article database search beyond Scopus is also a valuable suggestion. Including additional databases such as Web of Science, Google Scholar, and ERIC can provide a broader coverage of relevant literature. These databases may contain articles not captured in the initial search, enriching the analysis and ensuring a more comprehensive overview of DI research. By incorporating these recommendations, future research endeavors can overcome some of the limitations posed by restricted sample sizes, limited keywords, and database-specific biases. Using larger sample sizes, expanded keyword sets, and multiple databases will give researchers a more accurate and comprehensive understanding of the DI research landscape. Moreover, incorporating different bibliometric analysis software and additional databases will contribute to the validation and robustness of the findings, strengthening the overall research outcomes.

There are three main limitations to consider in this study. Firstly, the study relies on a restricted set of keywords, which may have limited the search scope and potentially omitted relevant articles. Additionally, using a specific database for article collection introduces the possibility of database-related limitations, such as incomplete coverage or excluding certain articles from the analysis. Secondly, despite using formal tools such as RStudio, VOSviewer, and Mendeley applications, the subjective judgments made by the authors during the analysis process could introduce errors or biases. Despite efforts to ensure objectivity, subjective interpretations or inadvertent mistakes might still occur, affecting the accuracy or comprehensiveness of the findings. Thirdly, it should be acknowledged that the Scopus database used to collect data may contain author names or affiliations errors. Unfortunately, the inability to manually correct these errors within the database limits the accuracy of author information and country affiliations reported in the study. Lastly, it is important to recognize that the number of cited articles can change rapidly over time, as new publications are constantly added and existing articles receive new citations. This means that the data analyzed in the present study may become outdated or less relevant as time progresses. Therefore, the findings should be interpreted within the context of the specific time period when the analysis was conducted.

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Authorship Contribution Statement

Utami: Conceptualization, analysis, writing, securing funding. Sujarwo: Editing/reviewing, supervision, securing funding, final approval. Fauziyah: Analysis, design, final approval. Mustadi: Editing/reviewing, writing. Hidayat: Editing/reviewing, technical support. Rofiki: Analysis, writing, critical revision of manuscript, technical support.

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