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A Decade of Research Design Studies: A Bibliometric Analysis (2012-2022)

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Abstract

Research design is a didactic-oriented research method, predicting student responses before learning and paying attention to student conditions during and at the end of learning. However, comprehensive studies have yet to show trends in design research worldwide. This study investigates design research trends through bibliometric study of widespread and open-access databases, namely the Google Scholar and Scopus databases, from 2012 to 2022. We reviewed 997 documents from Google Scholar and 94 from the Scopus database on Harzing's Publish or Perish (PoP) 8.7.4245.8399 version on March 10, 2023. The descriptive analysis approach was employed to analyze the data; data from PoP was processed using Microsoft Excel and VoSViewer. The vizualitation show that there are four significant clusters related to design research are the learning process, local instructional theory, realistic mathematics education, and didactical design research. The findings can help scholars identify design research trends and guide future investigations because in the last three years (2020-2022), there aren't recent research related to design research. Future research should compare Google Scholar, Scopus, other sources to investigate more years, and deepen meta-analysis on design research.

Keywords: Bibliometric Analysis, Design Research, Scopus, Google Scholar

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INTRODUCTION

Research Design is a learning trajectory with the hope of what might happen, both in students' mental processes and in mathematics learning. Modern mathematics instruction requires pupils to learn from their thoughts and experience. If students find their knowledge, then students can connect concepts. Therefore, teachers are required to provide an appropriate plan for education. [1] revealed that when it comes to using mathematical knowledge, educators must prepare for all the things needed in learning. Good learning must have prepared for the learning process tailored to students' needs to achieve the learning objectives set by Isnawan and Wicaksono [2]. Aims, methods, resources, and evaluations are all part of an all-encompassing learning design.

A student-oriented learning approach requires teachers to design learning and need to pay attention to student learning trajectories [3]. learning trajectory describes the various

[1]Muhamad Galang Isnawan and Arief Budi Wicaksono, "Model Desain Pembelajaran Matematika Mathematics Learning Design Model," *Indonesian Journal of Mathematics Education* 1, no. 1 (2018): 31.

[2] Galang Isnawan and Budi Wicaksono.

[3] P. Holt Wilson, Gemma F. Mojica, and Jere Confrey, "Learning Trajectories in Teacher Education: Supporting Teachers' Understandings of Students' Mathematical Thinking," *Journal of Mathematical Behavior* 32, no. 2 (2013): 103–21, https://doi.org/10.1016/j.jmathb.2012.12.003; Agnes

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ideas that tend to emerge during student-centred learning and a series of tasks that successfully generate comprehending and strengthening the process of cognitive growth [4]. teachers can gain insight into their students' thought processes and knowledge acquisition through a learning trajectory [5]. the learning trajectory is still considered a hypothesis even though it has been validated by many students empirically [6] because the design is still in the form of a guess or hypothesis Nuraida & Arman [7]. The end result of the learning trajectory, which was tried out several times, was the acquisition of local instructional theory (ILT), which could be used in similar conditions elsewhere.

An example of research design (DR) is already interesting because it has used the RME approach. However, DR is less effective because it requires much time [8]. Refianti & Adha [9] suggest an ordered learning trajectory regarding the material students must go through in learning cubes and blocks. This research can be imitated because of the aspect of student activity, using cardboard, dice, pencil boxes or other objects in the form of cubes and blocks. However, this research still needs to contain pedagogic aspects.

Therefore, a comprehensive study is needed to pinpoint trends in design research worldwide. This study investigates design research trends through bibliometric analysis of widely distributed and open-access databases, namely the Google Scholar and Scopus databases, from 2012 to 2022. Through this research, researchers explore several parameters or interrelationships between variables that are often studied in design research, such as local instructional theory, realistic mathematics education, Learning process, educational design research, retrospective analysis and didactical design research.

Therefore, this study emphasizes research trends regarding design research during 2012-2022 with four investigative questions: i) How has the output of design research publications been trending by author, citation and document source in the last ten years?; ii) How to visualize the results of research trends related to design research?; iii) How does the author collaborate on research trends in design research?; and iv) what are the recommendations for future research in mathematics education?.

Ivana Hendrik, Christine K Ekowati, and Damianus D Samo, "Kajian Hypothetical Learning Trajectories Dalam Pembelajaran Matematika Di Tingkat SMP," *Fraktal: Jurnal Matematika Dan Pendidikan Matematika* 1, no. 1 (2020): 1–11, https://doi.org/10.35508/fractal.v1i1.2683.

[4] Jere Confrey et al., "Scaffolding Learner-Centered Curricular Coherence Using Learning Maps and Diagnostic Assessments Designed around Mathematics Learning Trajectories," *ZDM - Mathematics Education* 49, no. 5 (2017): 717–34, https://doi.org/10.1007/s11858-017-0869-1; Wilson, Mojica, and Confrey, "Learning Trajectories in Teacher Education: Supporting Teachers' Understandings of Students' Mathematical Thinking."

[5] Wahid Ibnu Zaman and Abdul Aziz Hunaifi, "Learning Trajectory Dalam Mengembangkan Kompetensi Berpikir Matematika," *Jurnal Pendidikan Surya Edukasi*, no. November (2017): 351–71, https://doi.org/10.1007/978-94-6300-549-4_29.

[6] Suwarto Suwarto and Agustina Sri Purnami, "Upaya Meningkatkan Pemahaman Konsep Matematika Melalui Hypothetical Learning Trajectory Pada Materi Vektor," *IndoMath: Indonesia Mathematics Education* 1, no. 2 (2018): 69, https://doi.org/10.30738/indomath.v1i2.2614.

[7] Ida Nuraida and Asep Amam, "Hypothetical Learning Trajectory in Realistic Mathematics Education To Improve the Mathematical Communication of Junior High School Students," *Infinity Journal* 8, no. 2 (2019): 247, https://doi.org/10.22460/infinity.v8i2.p247-258.

[8] Hening Windria, Zulkardi Zulkardi, and Yusuf Hartono, "Design Research to Support Fourth Grader Learn Addition of Mixed Numbers in RME Learning," *Mimbar Sekolah Dasar* 7, no. 1 (2020): 153–70, https://doi.org/10.17509/mimbar-sd.v7i1.23978.

[9] Rani Refianti and Idul Adha, "Learning Trajectory Pembelajaran Luas Permukaan Kubus Dan Balok," *JOURNAL of MATHEMATICS SCIENCE and EDUCATION* 1, no. 1 (2018): 24–37, https://doi.org/10.31540/jmse.v1i1.162.

METHOD

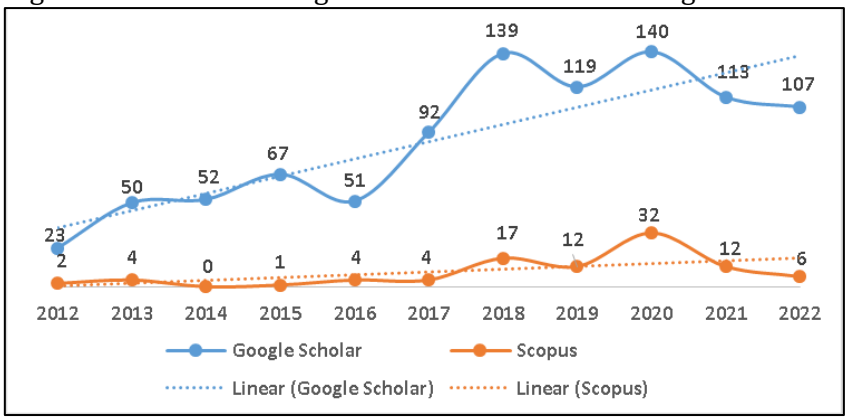
Bibliometric analysis of the article is the method used in this study, which will be useful for future research as a reference. [10]. Finding fresh, all-encompassing insights from prior research on current, relevant material is crucial in academic studies. Bibliographic research [11] profiles will serve as a roadmap for the global expansion of research. This study was conducted by searching the Scopus and Google Scholar databases. Design research, mathematics learning, and trajectory are used to look for abstracts and keywords from 2012 to 2022. The search strategy uses Scopus and Google Scholar search on Harzing's Publish or Perish (PoP) 8.8.4275.8412 version. The data was collected on March 10 2023. 997 documents on Google Scholar and 94 on Scopus were searched with time range 2012-2022.

Descriptive analysis is also employed for data analysis. The data was examined using Microsoft Excel. The research trends, physical properties, paper sources, top citations, authors, and years 2012–2022, as well as the research trends overall, were the subjects of the exploration. To identify study trends in design research, the VoSViewer tool was utilised [12].

RESULT AND DISCUSSION

Publication outputs, sources of the document, top cites, top author and top source in 2012-2022. Figure 1 below shows the number of studies related to design research in the last ten years (2012-2022).

Figure 1. Number of design research documents during 2012-2022



[10] Atik Kulakli and Valmira Osmanaj, "Global Research on Big Data in Relation with Artificial Intelligence (A Bibliometric Study: 2008-2019)," *International Journal of Online and Biomedical Engineering* 16, no. 2 (2020), https://doi.org/10.3991/ijoe.v16i02.12617; Yohanis Ndapa Deda, Hermina Disnawati, and Otaget Daniel, "Research Trends on Lesson Study Based on Google Scholar and Scopus Database: A Bibliometric Analysis" 35, no. 1 (2023): 54–75, https://doi.org/10.23917/varidika.v1i1.22663; Yohanis Ndapa Deda, "Bibliometric Analysis of Higher-Order Thinking Skills Based On," *Jurnal VARIDIKA* 35, no. 2 (2023): 127–36, https://doi.org/10.23917/varidika.v35i2.23223; Yohanis Ndapa Deda et al., "Global Trend of Ethnomathematics Studies of the Last Decade: A Bibliometric Analysis," *Infinity Journal* 13, no. 1 (January 2024): 233–50, https://doi.org/10.22460/infinity.v13i1.p233-250.

[11] Yohanis Ndapa Deda et al., "Research Trend on Dyscalculia by Bibliometric Analysis during 2017-2022," *International Journal of Evaluation and Research in Education (IJERE)* 13, no. 1 (February 2024): 69, https://doi.org/10.11591/ijere.v13i1.25992; Nadi Suprapto et al., "Research Trend on TPACK through Bibliometric Analysis (2015-2019)," *International Journal of Evaluation and Research in Education* 10, no. 4 (2021): 1375–85, https://doi.org/10.11591/IJERE.V10I4.22062; Deda, Disnawati, and Daniel, "Research Trends on Lesson Study Based on Google Scholar and Scopus Database: A Bibliometric Analysis."

[12] Nees Jan van Eck and Ludo Waltman, "Manual for VOSviewer Version 1.6.18," *Leiden: Univeristeit Leiden*, no. January (2022), https://doi.org/http://www.vosviewer.com/documentation/Manual_VOSviewer_1.6.1.pdf.

The trendline for design research documents based on Scopus and Google Scholar data in Figure 1 has tended to increase in the last ten years (2012-2022). Based on baseline data from 2012 to 2022, design research will continue to develop in the future.

Table 1. Top five authors of design research based on Google Scholar (2012-2022)

No.	Authors	Number of documents	Country Of Origin
1	A Fauzan	20	Indonesia
2	RII Putri	14	Indonesia
3	A Bakker	9	Belanda
4	F Nursyahidah	9	Indonesia
5	RCI Prahmana	9	Indonesia

Ahmad Fauzan from Indonesia is the top author with 20 documents from Google Scholar, followed by R.I.I. Putri 14 documents. Arthur Bakker from the Netherlands 9 documents, F Nursyahidah and R.C.I. Prahmana from Indonesia has nine documents, each of the five authors based on Google Scholar, dominated by Indonesia. Based on documents from Scopus, the top five authors of design research (2012-2022) are A. Fauzan (4 documents), F. Nursyahidah (4 documents), I. Risdiyanti (2 documents), R.C.I. Prahmana (2 documents), and R.I.I. Putri (2 documents). Overall, the top writer based on the Scopus and Google Scholar databases is Ahmad Fauzan from Indonesia.

Table 2. Most cited authors of articles based on Google Scholar all years

No.	Authors	Title	Source	Cites
1	[13]	"Conducting educational design research"	Educational Media International	2370
2	[14]	"Educational design research: An introduction"	Educational design research	1850
3	[15]	"Design research: What we learn when we engage in design	"The Journal of the Learning Sciences"	1785
4	[16]	Design research from a learning design perspective"	Educational design research	1380
5	[17]	Participating in classroom mathematical practices	"The Journal of the Learning Sciences"	1008

Furthermore, From 2012–2022, the five most referenced papers and their authors are displayed in Table 3.

Table 3. Top citation of the article design research from Scopus (2012-2022)

No.	Authors	Title	Source	Cites
1	[18]	"The hypothetical learning trajectory on research in mathematics education using research-based learning"	Pedagogika	37

[13] Susan Mckenney and Thomas C Reeves, *Conducting Educational Design Research*, *Educational Media International*, vol. 50, 2012, https://doi.org/10.1080/09523987.2013.843832.

[14] T Plomp and Nienke Nieveen, "An Introduction to Educational Design Research," 2007.

[15] Daniel C. Edelson, "Design Research: What We Learn When We Engage in Design," *Journal of the Learning Sciences* 11, no. 1 (2002): 105–21, https://doi.org/10.1207/S15327809JLS1101_4.

[16] Koeno Gravemeijer and Paul Cobb, "Design Research from a Learning Design Perspective," *Educational Design Research*, 2006.

[17] Paul Cobb et al., "Participating in Classroom Mathematical Practices," *Journal of the Learning Sciences* 10, no. 1–2 (2001): 113–63, https://doi.org/10.1207/S15327809JLS10-1-2_6.

[18] Rully Charitas Indra Prahmana and Yaya S Kusumah, "The Hypothetical Learning Trajectory on Research in Mathematics Education Using Research-Based Learning" 123, no. 3 (2016): 42–54.

2	[19]	“The didactic trajectory of research in mathematics education using research-based learning”	Journal of Physics: Conference Series	26
3	[20]	“The innovation of learning trajectory on multiplication operations for rural area students in Indonesia”	Journal on Mathematics Education (JME)	23
4	[21]	“Developing a local instruction theory for learning the concept of angle through visual field activities and spatial representations”	International Education Studies	21
5	[22]	Addition of fractions in the swimming context	Journal of Physics: Conference Series	15

The most widely referenced author based on Scopus document sources is R.C.I. Prahmana with 37 citations for his articles published in pedagogics. R.C.I wrote the second most cited article. Prahmana with 26 citations. Furthermore, H. Hendriana was referred to 23 times for his articles published in JME Unsri. Bustang's article published in International Education Studies is referenced 21 times, and the R.I.I. Putri entitled "Addition of fraction in swimming context" was cited 15 times. The top sites based on Scopus sources in design research are R.C.I. Prahmana. Meanwhile, based on Google Scholar documents, the most frequently referenced authors in the 2012-2022 period were S McKenney et al. with the paper titled "Conducting educational design research" (2321 citations), followed by T Plomp with his paper "Educational design research: An introduction" (1816 citations), W Sandoval with the paper title "Conjecture mapping: An approach to systematic educational design research" (715 citations), A Bakker with his paper entitled "What is design research in education?" Four hundred thirty-five citations, and A Bakker, D Van Eerde with the paper title "An introduction to design-based research with an example from statistics education" referenced 410 times.

Table 4. Number of documents of design research acrosswise source titles

No.	Source Title	Total documents
1	“Journal of Physics: Conference Series”	135
2	Journal on Mathematics Education	31
3	ZDM–Mathematics Education	19
4	International Conference Unsri, Learning and Education	14
5	AIP Conference Proceedings	11

Journals or proceedings that have contributed the most to publishing papers related to design research based on the Google Scholar database can be seen in Table 4. Journal of

[19] R C I Prahmana, Yaya S. Kusuma, and Darhim, “Didactic Trajectory of Research in Mathematics Education Using Research-Based Learning,” 2017.

[20] Heris Hendriana, Rully Charitas Indra Prahmana, and Wahyu Hidayat, “The Innovation of Learning Trajectory on Multiplication Operations for Rural Area Students in Indonesia,” *Journal on Mathematics Education* 10, no. 3 (2019): 397–408, https://doi.org/10.22342/jme.10.3.9257.397-408.

[21] Bustang et al., “Developing a Local Instruction Theory for Learning the Concept of Angle through Visual Field Activities and Spatial Representations,” *International Education Studies* 6, no. 8 (2013): 58–70, https://doi.org/10.5539/ies.v6n8p58.

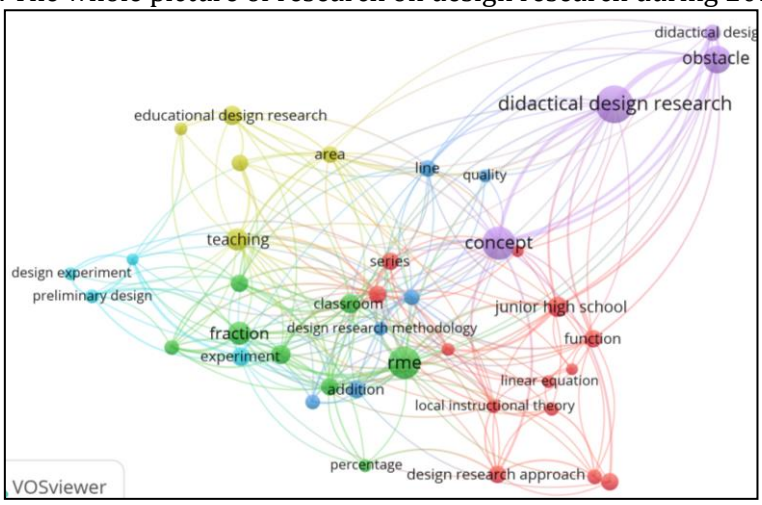
[22] R. I.I. Putri, M. S. Gunawan, and Zulkardi, “Addition of Fraction in Swimming Context,” *Journal of Physics: Conference Series* 943, no. 1 (2018), https://doi.org/10.1088/1742-6596/943/1/012035.

Physics: Conference Series (135 documents), Journal on Mathematics Education (31 documents), ZDM–Mathematics Education (19 documents), Unsri International Conference, Learning and Education (14 documents), and AIP Conference Proceedings (11 documents). At the same time, the search results on Scopus show that the Journal of Physics: Conference Series (54 documents), Journal on Mathematics Education (13 documents), AIP Conference Proceedings and Mathematics Teaching-Research Journal, each with four documents, followed by ACM International Conference Proceeding Series (3 documents).

Visualization of research tendencies on design research by using VoSViewer software

Visualization of the tendency of design research using the VoSViewer software can be seen in Figures 2 to Figure 6.

Figure 2. The whole picture of research on design research during 2012-2022

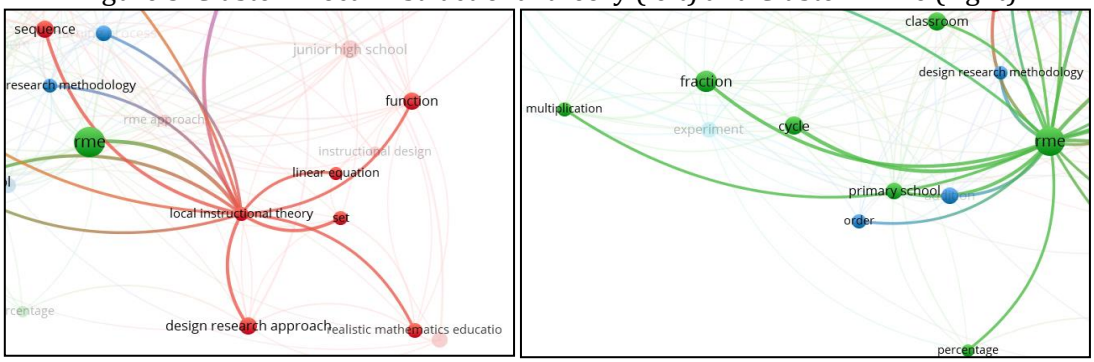


Visualization of design research in the last ten years using VosViewer in Figure 2 shows six clusters. However, only four clusters are significant: local instructional theory, rme, learning process, and didactical design research. Cluster 1 is the local instructional theory (LIT) which is produced through a realistic mathematics education (RME) approach and research design methods [23]. The most widely used mathematical material (see Figure 3) is algebraic, including functions, linear equations, and series at the junior high school level. The LIT produced for series and sequences material aims to improve students' problem-solving abilities [24].

[23] A. Fauzan, E. Musdi, and J. Afriadi, "Developing Learning Trajectory for Teaching Statistics at Junior High School Using RME Approach," *Journal of Physics: Conference Series* 1088 (2018), https://doi.org/10.1088/1742-6596/1088/1/012040.

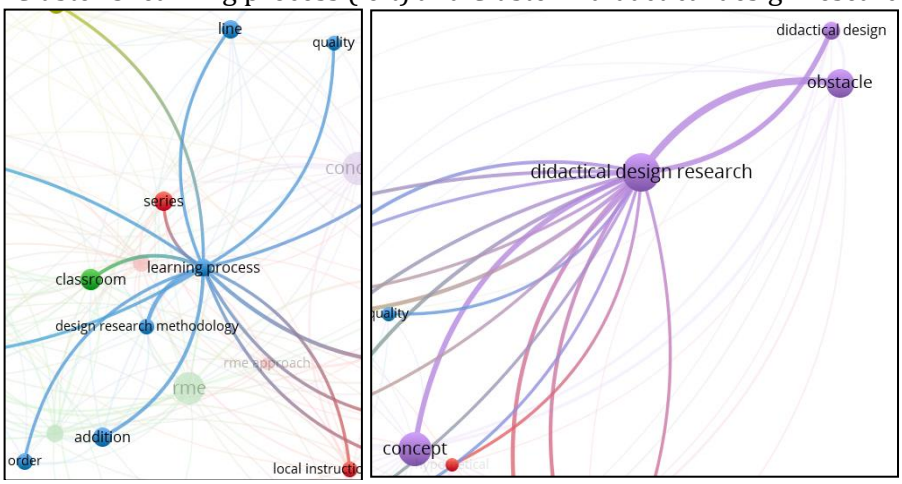
[24] E. Gee, A. Fauzan, and A. Atmazaki, "Designing Learning Trajectory for Teaching Sequence and Series Using RME Approach to Improve Students' Problem Solving Abilities," *Journal of Physics: Conference Series* 1088 (2018), https://doi.org/10.1088/1742-6596/1088/1/012096.

Figure 3. Cluster 1 local instructional theory (left) and Cluster 2 rme (right)



In cluster 2, in Figure 3 on the right side above, it can be seen that design research related to RME is mostly carried out in primary schools [25] on percentage, fraction, multiplication, and cycle material. The one approach, originating from the Netherlands, is most widely used in Indonesia. The Indonesian version of RME is known by the acronym PMRI (Indonesian realistic mathematics education).

Figure 4. Cluster 3 learning process (left) and Cluster 4 didactical design research (right)



Most research designs on learning process clusters are in order, addition, line and quality material (see Figure 4 on the left). The research design uses RME learning to support learning the process of addition operations on mixed numbers [26]. Furthermore, Murdiyani [27] developed ILT using one approach to support understanding the concept of subtraction. Design research that develops a local instructional theory to support students in broadening their understanding of the meaning of multiplying fractions by integers [28]. There are very few research designs related to special education based on my learning additional material for students with disabilities [29].

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[25] Ahmad Fauzan, T Plomp, and K. P. E. Gravemeijer, "The Development of an RME-Based Geometrycourse for Indonesian Primary Schools The Development of an RME-Based Geometry Course for Indonesian Primary Schools," *Educational Design Research*, no. 2013 (2013).

[26] Windria, Zulkardi, and Hartono, "Design Research to Support Fourth Grader Learn Addition of Mixed Numbers in RME Learning."

[27] Nila Mareta Murdiyani et al., "Developing a Model to Support Students in Solving Subtraction," *Journal on Mathematics Education* 4, no. 1 (2013): 95–112, https://doi.org/10.22342/jme.4.1.567.95-112.

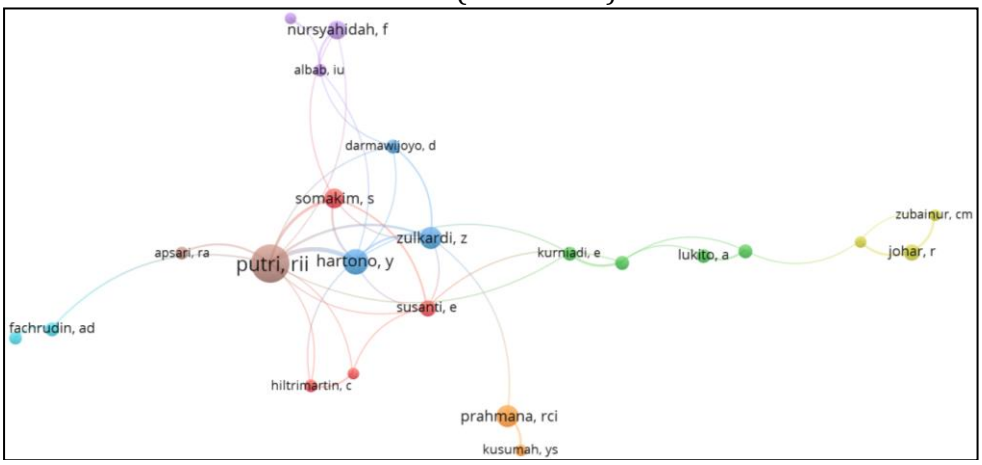
[28] Cut Khairunnisak et al., "Supporting Fifth Graders in Learning Multiplication of Fraction with Whole Number," *Journal on Mathematics Education* 3, no. 1 (2012): 71–86, https://doi.org/10.22342/jme.3.1.615.71-86.

[29] Ahmad Fauzan et al., "Developing RME-Based Learning Trajectory for Teaching Addition to A Dyscalculia Student in Elementary School," *Jurnal Didaktik Matematika* 9, no. 1 (2022): 39–58, https://doi.org/10.24815/jdm.v9i1.25340.

Figure 4 on the right shows the Didactical Design Research (DDR) cluster. DDR was introduced by Brousseau in 1972. DDR prioritizes didactic situations between teachers, students and material[30]. The starting point for DDR is a situational didactic theory [31] which has similarities with Design Research (DR). The similarities between DDR and DR are in the research phase: preliminary analysis and design, teaching experiments, and retrospective analysis [32]. Margolinas also stated the difference between French TDS and Dutch RME related to DR, namely DR aims to produce ILT, and TDS related to DDR has a more epistemic goal in establishing basic scientific knowledge about the teaching and learning of mathematics.

Author Collaborate on Research Trends in Design Research

Figure 5. Co-authorship in Design Research based on the database Scopus and Google Scholar (2012-2022)



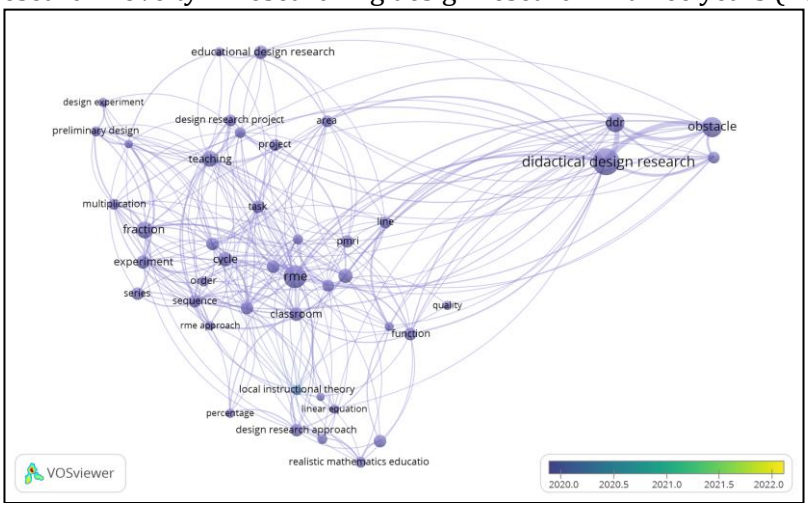
There are 1250 authors, but only 46 meet the threshold. The maximum number of authors per document is 25, and the minimum number of documents of an author is 5. For each of the 46 authors, the total strength of the co-authorship with other authors will be calculated. The following are the top 5 authors based on Scopus and Google Scholar Data Base (2012-2022) who have the most co-authored documents, and the most cited ones, as shown in Figure 5. R.I.I. Putri has 91 authorship documents with a total link strength of 36 Hartono, Y with 32 documents and a total link strength of 25. Somakin has a total link strength of 14 with 18 co-authored documents, Zulkardi, A with a total link strength of 12 and 23 co-authored documents; Fauzan, A has 35 co-authored documents with total link strength of 9.

[30] Irfan Fauzi and Didi Suryadi, "Didactical Design Research Untuk Mengembangkan Kompetensi Pedagogik Guru Di Sekolah Dasar," *Inventa* 4, no. 1 (2020): 58–68, https://doi.org/10.36456/inventa.4.1.a2207; Didi Suryadi, "Didactical Design Research (DDR) Dalam Pengembangan Pembelajaran Matematika," in *SEMINAR NASIONAL MATEMATIKA DAN PENDIDIKAN MATEMATIKA*, ed. Gida Kadarisma Adi Nurjaman, Ratna Sariiningsih, Indah Puspita Sasi (Jawa Barat: STKIP Sliwangi, 2013), 3–12.

[31] Claire Margolinas and Paul Drijvers, "Didactical Engineering in France; an Insider's and an Outsider's View on Its Foundations, Its Practice and Its Impact," *ZDM - Mathematics Education* 47, no. 6 (2015): 893–903, https://doi.org/10.1007/s11858-015-0698-z.

[32] Margolinas and Drijvers.

Figure 6. Research novelty in researching design research in three years (2020-2022)



If we break down the unique correlations between variables to identify patterns and new developments in the field of design study, we discover several things. The first is that in the last three years (2020-2022), there needs to be more recent research related to design research (see Figure 6). This shows that design research is a topic still new to research today. One unique aspect of design research is investigating the worth of traditional knowledge systems before incorporating them into the field.

There is no research on bibliometric analysis related to research design. However, the difference between this finding and other bibliometric analyses is that it touches slightly on the difference between French TDS and Dutch RME related to DR, namely DR aims to produce ILT, and TDS related to DDR has a more epistemic goal in establishing basic scientific knowledge about the teaching and learning of mathematics. In addition, DDR prioritizes didactic situations between teachers, students and material[33]. The starting point for DDR is a situational didactic theory [34] which has similarities with Design Research (DR). The similarities between DDR and DR are in the research phase: preliminary analysis and design, teaching experiments, and retrospective analysis [35].

The contribution of this research is to reveal the trend of design research through bibliometric analysis based on Scopus and Google Scholar. Scopus and Gs are popular databases used in this research. The forthcoming study may compare Google Scholar, PubMed, Semantic Scholar, Pubmed, and other sources. The researcher offers three future research suggestions as part of this study: A wider variety of years should be researched, and Web of Science, Google Scholar, and Scopus data should be compared. Consider 2002-2022 design research and deep study meta-analysis. However, the outcomes of this research may not help the eagle eye understand design research in the last decade (2020-2022).

CONCLUSION

Several important emphases points have been made on research trends in design research publications in the last ten years (2012-2022). The number of design research documents throughout the year experienced grown up every year. The top author based on the number of documents from Google Scholar and the Scopus database is Ahmad Fauzan, and the leading author based on the highest number of citations from Scopus is R.C.I. Prahmana, and from the Google Scholar database, is S McKenney. R.I.I. Putri has the

[33] Fauzi and Didi Suryadi, "Didactical Design Research Untuk Mengembangkan Kompetensi Pedagogik Guru Di Sekolah Dasar"; Suryadi, "Didactical Design Research (DDR) Dalam Pengembangan Pembelajaran Matematika."

[34] Margolinas and Drijvers, "Didactical Engineering in France; an Insider's and an Outsider's View on Its Foundations, Its Practice and Its Impact."

[35] Margolinas and Drijvers.

most co-authored documents and has the strongest author link trend. The Journal of Physics: Conference Series in the last ten years is the most source of design research documents from Scopus and google scholar databases. Judging from the Country of origin, Indonesia's dominance is clear. The topics most discussed were the learning process, local instructional theory, realistic mathematics education, and didactical design research. The findings can assist relevant researchers in understanding trends in design research trend and recommend guidelines for other studies. Some recommendations for future research are to compare data from the google scholar, PubMed, Semantic Scholar, Scopus and other sources. Scopus database, to research a more comprehensive range of years, and to deep study meta-analysis on design research.

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