Salud, Ciencia y Tecnología. 2025; 5:1716
doi: 10.56294/saludcyt20251716

ORIGINAL

Global Research Trends on Productive Struggle Students in Primary Scholl: Bibliometric Analysis (2016-2025) using VOSviewer

Tendencias Globales de Investigación Sobre La Lucha Productiva de Los Estudiantes de Primaria: Análisis bibliométrico (2016-2025) Con VOSviewer

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Cite as: Mufliva R, Turmudi, Prabawanto S, Rakhmat Riyadi A. Global Research Trends on Productive Struggle Students in Primary Scholl: Bibliometric Analysis (2016-2025) using VOSviewer. Salud, Ciencia y Tecnología. 2025; 5:1716. https://doi.org/10.56294/saludcyt20251716

Submitted: 06-11-2024 **Revised:** 02-03-2025 **Accepted:** 24-07-2025 **Published:** 25-07-2025

Editor: Prof. Dr. William Castillo-González

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ABSTRACT

This study focusses on trends in existing research and creates a bibliometric map of articles discussing the productive struggle of elementary school students using the VOSviewer application from a psychological perspective. It also examines the influence of productive struggle on the quality of elementary school students' mathematics learning. Data collection was conducted using reference management software, specifically Publish or Perish, to facilitate a literature review focused on the topic of productive struggle. This approach provides insights into the scope and depth of existing studies, highlighting patterns and gaps for further investigation. The keywords "elementary school students" and "productive struggle" were used throughout the data collection process. For the analysis, 175 articles published between 2016 and 2025 were selected. The results show that research on productive struggle has become a global trend from 2016 to 2018. However, from 2019 there was a decline, this trend increased again from 2020 to 2022. However, in 2023 there was a drastic decline to only 11 publications. The peak of research on productive struggle occurred in 2024 with 30 publications, and then it declined again in 2025 with only 7 publications. Based on the results of the bibliometric analysis, the term productive struggle has 143 links. It can be concluded that research publications on productive struggle are still limited to research and have great potential for further studies on students' productive struggle from a psychological perspective in the future, especially on emotional intelligence, motivation, learning, and anxiety in mathematics learning.

Keywords: Bibliometric; Productive Struggle; Students; Primary School; Vosviewer.

RESUMEN

Este estudio se centra en las tendencias de la investigación existente y crea un mapa bibliométrico de artículos que discuten la lucha productiva de los estudiantes de primaria utilizando la aplicación VOSviewer desde una perspectiva psicológica. También examina la influencia de la lucha productiva en la calidad del aprendizaje de matemáticas de los estudiantes de primaria. La recopilación de datos se llevó a cabo utilizando software de gestión de referencias, específicamente Publish or Perish, para facilitar una revisión de la literatura centrada en el tema de la lucha productiva. Este enfoque proporciona información sobre el alcance y la profundidad de los estudios existentes, destacando patrones y lagunas para una investigación adicional. Las palabras clave "estudiantes de primaria" y "lucha productiva" se utilizaron durante todo el proceso de recopilación de datos. Para el análisis, se seleccionaron 175 artículos publicados entre 2016 y 2025. Los resultados muestran que la investigación sobre la lucha productiva se ha convertido en una tendencia global desde 2016 hasta 2018. Sin embargo, a partir de 2019 hubo una disminución, esta tendencia aumentó nuevamente de 2020 a 2022. Sin embargo, en 2023 hubo un drástico descenso a solo 11 publicaciones.

El pico de la investigación sobre la lucha productiva ocurrió en 2024 con 30 publicaciones, y luego volvió a disminuir en 2025 con solo 7 publicaciones. Basado en los resultados del análisis bibliométrico, el término lucha productiva tiene 143 enlaces. Se puede concluir que las publicaciones de investigación sobre la lucha productiva aún están limitadas y tienen un gran potencial para futuros estudios sobre la lucha productiva de los estudiantes desde una perspectiva psicológica, especialmente en relación con la inteligencia emocional, la motivación, el aprendizaje y la ansiedad en el aprendizaje de las matemáticas.

Palabras clave: Bibliometría; la Lucha Productiva; Estudiantes; Escuela Primaria; Vosviewer.

INTRODUCTION

Mathematics learning at the elementary school level presents its own challenges, especially in developing deep conceptual understanding in students. One of the pedagogical approaches that is gaining increasing attention is productive struggle, which is a condition where students are faced with challenging tasks that are still within their capability, thus encouraging active engagement, critical thinking, and reflective processes during learning.[1,2] This approach is believed to enhance learning resilience, problem-solving skills, and students' confidence in tackling complex mathematical material.[3,4]

For elementary school students, productive struggle holds great value. At this stage, children are forming the foundation of their logical thinking structure and numerical skills. Exposure to controlled challenges in mathematics learning helps them develop perseverance, independent cognitive strategies, and the ability to reflect on mistakes as part of the learning process.[5] Moreover, productive struggle has proven effective in reducing math anxiety because students become accustomed to facing difficulties as part of the learning experience, rather than as an indicator of failure.[5,6,7]

However, the application of this concept is still relatively limited in the context of primary education in Indonesia and globally, especially from a psychological perspective. However, factors such as emotional intelligence, intrinsic motivation, and emotion regulation have a significant impact on students' success in completing challenging math tasks.[8,9] Therefore, it is important to further examine how productive struggle can be effectively applied by considering these psychological aspects in the design of learning.

In an effort to understand the development of the literature related to this topic, this study uses a bibliometric approach to map the research trends of productive struggle among elementary school students from 2016 to 2025. The analysis was conducted with the help of VOSviewer and Publish or Perish software to identify research directions, collaboration patterns, and existing research gaps. The main focus is directed towards the relationship between productive struggle and psychological aspects in mathematics learning.

The findings from this study are expected to provide a broader understanding of the scope and direction of productive struggle research, as well as identify opportunities for further exploration to enrich mathematics teaching strategies that favour the cognitive and emotional development of elementary school students. Research on students' productive struggle remains an important trend in mathematics education and psychology.[1,2] This research explores the factors that influence the productive struggle of elementary school students, the positive or negative impact of productive struggle on the quality of students' mathematics learning outcomes, and the development of effective strategies to enhance students' productive struggle. This study aims to identify effective learning strategies and teaching materials to help elementary school students develop productive struggle when solving mathematics problems, in order to improve their mathematical cognitive flexibility in a measurable way through tests that include indicators such as the ability to switch between problem-solving strategies, adapt to new situations or contexts in math problems, and generate and consider various alternative solutions. Productive struggle in this context is indicated by several indicators, namely persistence in solving problems, the ability to reflect on mistakes, the use of various problem-solving strategies, and the improvement of conceptual understanding.

The connection between productive struggle and cognitive flexibility lies in how the process of struggling productively enables students to develop adaptive and flexible thinking skills. When students continuously try and reflect on different strategies in solving mathematical problems, they train their cognitive flexibility to switch and adjust approaches as needed. Thus, an increase in productive struggle directly contributes to enhancing cognitive flexibility, which in turn strengthens overall mathematical thinking ability. In conclusion, supporting students in developing productive struggle not only helps them become more persistent and creative in solving problems but also significantly improves their cognitive flexibility, resulting in more effective and sustainable improvements in mathematical thinking skills.

Recent research on productive struggle in mathematics learning, particularly at the elementary school level, encompasses various interrelated important dimensions. One of the main focusses is the role of the teacher and the learning environment, where teachers who encourage students to face challenges constructively, without

fear of making mistakes, have been proven to enhance students' conceptual understanding.[10] In this context, emotional and instructional support from teachers becomes crucial. In addition, the study also highlights the impact of remote learning, especially during the COVID-19 pandemic, which presents obstacles in optimally implementing productive struggle due to limited direct interaction and intensive guidance.[11] Therefore, adapting this approach to digital platforms has become one of the challenges that must be addressed.

Furthermore, the professional development of teachers also becomes an important focus. Research shows that training emphasising direct experience in tackling mathematical problems reflectively can help teachers understand and apply productive struggle more effectively in the classroom.[12] Additionally, student involvement in mathematical modelling activities is also an emerging area of research, considering that many students struggle to build accurate mathematical representations. The productive struggle strategy has proven to encourage deep exploration in such activities.[13] Other research highlights the importance of a justice-based teaching approach in supporting all students, including those from disadvantaged backgrounds, to fully engage in challenging yet meaningful learning experiences.[14] Overall, research trends indicate that productive struggle is not only an effective teaching strategy but also has the potential to strengthen both the cognitive and affective dimensions of students in mathematics learning.

Efforts to enhance students' productive struggle in elementary school mathematics learning are very important because at this stage, students are building cognitive and affective foundations that are crucial for their success in deeply understanding mathematical concepts. Productive struggle helps students learn to face challenges without giving up easily, encouraging them to think critically, explore various strategies, and reflect on mistakes as part of the learning process.[15,16] This not only strengthens conceptual understanding but also fosters a positive attitude towards mathematics, boosts self-confidence, and cultivates perseverance and learning resilience.[17] Furthermore, when students are trained to struggle productively from an early age, they will be better prepared to tackle more complex material at the next level. In the long term, this contributes to the overall improvement in the quality of mathematics learning and reduces the common anxiety towards mathematics in children.[18,19] Therefore, creating a safe, supportive, and cognitively challenging learning environment is key to fostering constructive productive struggle.[20]

Using Vosviewers, this study investigates the publications on students' productive struggle from 2016 to 2025 from a psychological perspective. Students' productive struggle in elementary school mathematics learning encompasses several important interrelated aspects that support the development of deep mathematical understanding. First, productive struggle includes student engagement in problem-solving that is challenging yet still within their capability range, which forces them to think critically, explore various strategies, and reflect on their thinking process.[21,22] Second, it also includes students' ability to face mistakes and confusion as part of the learning process, not as a sign of failure, thereby building mental resilience and a positive attitude towards learning difficulties.[23] Third, productive struggle includes timely teacher support that does not directly solve problems for students, but rather facilitates open-ended questions, guidance, and feedback that guide students to find solutions on their own.[24] Fourth, this aspect also includes social interaction in the classroom, where students can share thoughts, discuss strategies, and learn from each other, thereby strengthening their understanding through collaborative discussions.[25] Fifth, productive struggle encompasses the development of affective aspects such as intrinsic motivation, self-confidence, and anxiety management towards mathematics, which greatly influence students' willingness to keep trying despite facing difficulties.[26] Thus, productive struggle is not just about the difficulty itself, but about how students confront it constructively with appropriate support to build a deeper and more sustainable understanding of mathematics.

Several reasons why research on productive struggle remains relevant and continues to develop include several important factors. First, with the increasing emphasis on the importance of conceptual understanding in mathematics learning, productive struggle has proven effective in helping students build a deeper understanding of mathematical concepts through exploration and challenging problem-solving. The emphasis on 21st-century competencies, such as critical thinking and problem-solving skills, also makes productive struggle increasingly relevant, as this approach positions students as the main actors in their learning.[27,28] Additionally, productive struggle helps students develop learning resilience and self-regulation skills, which are crucial in the fast-paced information era, where students need to become independent learners who can effectively overcome challenges.[29,30] However, research on productive struggle is still limited, especially in developing countries, providing opportunities to expand the understanding of the application of this strategy in various social and cultural contexts.[31] This research is also relevant for addressing the high levels of math anxiety among students, as productive struggle experiences can reduce anxiety and boost their confidence in learning mathematics.[32] Finally, with the advancement of educational technology, research is now beginning to explore how digital platforms and adaptive learning can support the implementation of productive struggle, expanding the reach and effectiveness of this strategy.[33] So it is important to map the research related to productive struggle from its psychological perspective.

METHOD

This research uses bibliometric analysis methods due to their ability to systematically measure and evaluate publications in targeted databases. This method facilitates the search, recording, analysis, and visualisation of documents related to a specific topic.[8] This research uses the Google Scholar database, which is a commonly used indexing platform and has analytical tools deemed sufficient to obtain the necessary data. The Harzing's Publish or Perish application assists in conducting a literature review on the topic of Teacher Welfare. The research process includes the following stages:

1. Using Harzing's Publish or Perish to collect publication data from the Google Scholar database.
2. Using the Numbers application to process bibliometric data.
3. Using VOSviewer to perform computational mapping.
4. Analysing the results of computational mapping to identify trends and insights related to students' productive struggle.

Data collection conducted in April 2025 using the keyword "Student Productive Struggle" included articles published between 2016 and 2025. Data files in *.csv and *.ris formats were exported for analysis. The *.csv files are processed using the Numbers application, while the *.ris files are visualised with VOSviewer. VOSviewer plays an important role in generating bibliometric maps that visually represent and analyse trends in three different formats: network visualisation, density visualisation, and overlay visualisation. These maps depict co-citation networks and highlight the relationships between various articles, offering a detailed overview of research themes and connections in the field of teacher well-being. By using this visual tool, this research is able to identify patterns, trends, and key topics emerging from the literature on students' productive struggle, providing valuable insights into the status of research in this field. This research can identify patterns, trends, and key topics from the literature on students' productive struggle using this visual tool. This provides an important overview of the development of research in this field.

RESULTS

Publications Data Search Result

The Harzing Publish or Perish application collects data on Students' Productive Struggle from the Google Scholar database. The results include 175 articles that meet the research criteria. Information such as the author's name, title, year of publication, publisher, number of citations, DOI, and relevant URL are included in the metadata of each article. Example data used for VOSviewer analysis for this study is shown in table 1. This shows the twenty best articles with the highest citation counts over the past ten years. All articles in this study received a total of 1435 citations, with an average of 159,44 citations per year. The average citation rate per article is 8,20, and the average citation rate per author is 785,95. These figures indicate the impact of the research and the relevance of the articles selected for analysis.

Table 1. Students' Productive Struggle Publication Data Based on Citation

Cites	Authors	Title	Year	Publisher
133	C Granberg	Discovering and addressing errors during mathematics problem-solving—A productive struggle?	2016	Elsevier
87	D Murdoch, AR English, A Hintz, K Tyson	Feeling Heard: Inclusive Education, Transformative Learning, and Productive Struggle	2020	Wiley Online Library
73	CP Trinter, HE Hughes	Teachers as Curriculum Designers: Inviting Teachers into the Productive Struggle	2021	Taylor & Francis
69	J Russo, J Bobis, A Downton, S Livy, P Sullivan	Primary Teacher Attitudes towards Productive Struggle in Mathematics in Remote Learning versus Classroom-Based Settings	2021	Mdpi.com
66	SD Lynch, JH Hunt, KE Lewis	Productive Struggle for All: Differentiated Instruction	2018	Pubs.nctm.org
65	HK Warshauer, C Starkey, CA Herrera	Developing prospective teachers' noticing and notions of productive struggle with video analysis in a mathematics content course	2021	Springer
64	S Livy, T Muir, P Sullivan	Challenging Tasks Lead to Productive Struggle	2018	Search.informit.org

62	YC Chen	Epistemic uncertainty and the support of productive struggle during scientific modeling for knowledge co-development	2022	Wiley Online Library
51	K Vanlehn, H Burkhardt, S Cheema	Can an orchestration system increase collaborative, productive struggle in teaching-by-eliciting classrooms?	2021	Taylor & Francis
46	Z Zeybek	Productive Struggle in a Geometry Class	2016	ERIC
46	K Baker, NA Jessup, VR Jacobs	Productive Struggle in Action	2020	Pubs.nctm.org
44	C Towsend, D Slavit, AR McDuffie	Supporting All Learners in Productive Struggle	2018	Pubs.nctm.org
39	JJ sanGiovanni, S Katt, KJ Dykema	Productive Math Struggle: A 6-points action plan for fostering perseverance	2020	Corwin
31	AB Moraitis, J Copley	Productive and unproductive labour and social form: Putting class struggle in its place	2017	Journals.sagepub.com
30	B Freeburn, F Arbaugh	Supporting Productive Struggle with Communication Moves	2017	Pubs.nctm.org
25	AT Barlow, NE Gerstenschlager, JF Strayer	Scaffolding for Access to Productive Struggle	2018	Pubs.nctm.org
23	DB Roble	Communicating and Valuing Students' Productive Struggle and Creativity in Calculus	2017	Academia.edu
23	J Ewing, GJ Gresham, B Dickey	Pre-Service Teachers Learning to Engage All Students, Including English Language Learners, in Productive Struggle	2019	ERIC
19	JM Murawska	Seven Billion People: Fostering Productive Struggle	2018	Pubs.nctm.org
18	J Amidon, A Monroe, D Rock, C Cook	Shame, Shame, Go Away: Fostering Productive Struggle with Mathematics	2020	Taylor & Francis

Research Development in the Field on Students' Productive Struggle

Table 2. Students Productive Struggle Publication Data in 10 Years

Year	Number of Publications
2016	13
2017	15
2018	17
2019	12
2020	18
2021	26
2022	26
2023	11
2024	30
2025	7

Table 2 shows the development of research on productive conflict. 175 articles discussing this topic were published in journals indexed in the Google Scholar database over ten years (2016–2025). For research on productive struggle, the year 2024 is the most productive year, with 30 publications released. On the other

hand, in 2021 and 2022, 26 publications were published, and in 2023, 15 publications were published. Although the number of publications increased in 2024, the number of publications decreased to 7 in 2025.

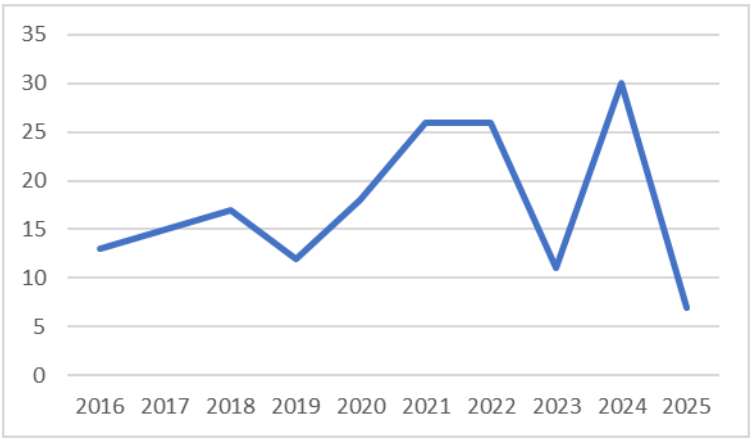

Figure 1. Level of Research Development in Students Productive Struggle

Figure 1 shows the research trend on productive struggle over the past ten years (2016–2025). The number of research activities related to this topic changes every year, and the level of interest and focus on the topic also changes every year. In 2024, there were 30 research publications on students' productive struggles. However, in 2023, there was a significant decline, with only 11 publications. In the previous years, 2021 and 2022, the research publications were quite numerous, each with 26 articles. However, in 2025, the publication also decreased to only 7 publications.

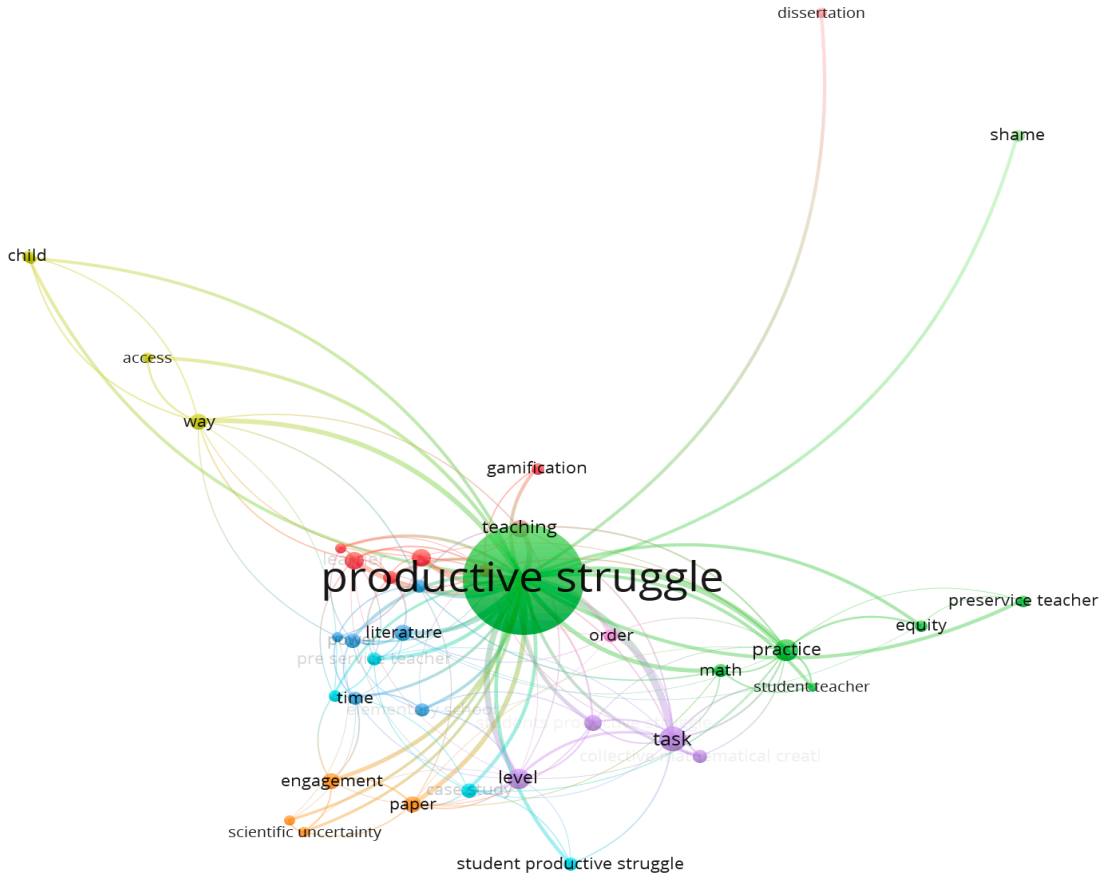

Figure 2. Network Visualization of Research about Student Productive Struggle

Cluster shows the relationship between datasets. Each term is displayed in a coloured circle. Depending on how many times the term appears, the circles have different sizes. The article titles have more terms with larger circles, indicating that the research topics are used more frequently. Figure 2 illustrates the three main

categories of computational mapping visualisation for analysis: network visualisation, overlay visualisation, and density visualisation. All these visualisations show the relationships and relevance of terms in the field of research.

Figure 2 shows the relationship between various terms in an interconnected network. This network shows groups of terms that are frequently studied and related to the topic of students' productive struggles. Figure 3 shows an overlay that illustrates the relationship between terms and research trends in this field. Figure 4 shows how to view density. From 2016 to 2025, research on students' productive struggles was conducted. During this period, research on students' productive struggles became very popular, but its popularity later declined. This shows that there is still plenty of room for new research in this field. Figure 4 shows the density, which indicates the level of research conducted on specific terms.

Brighter colors indicate terms that have been thoroughly studied, while darker colors indicate terms that have received only minimal research. There is no in-depth discussion of the terms and research topics related to students' productive struggle, as shown by the overlay visualization in figure 3. This opens up opportunities for further research. However, the scale for temporally locating the clusters needs to be made clearly visible, for example by using specific time ranges (years or decades) and consistent color indicators to mark the development of research over time. Thus, research clusters can be accurately positioned according to their period of emergence, facilitating the analysis of trends and the evolution of research topics. Overall, this visualization provides an in-depth overview of current research, while also identifying how new research differs from earlier studies.

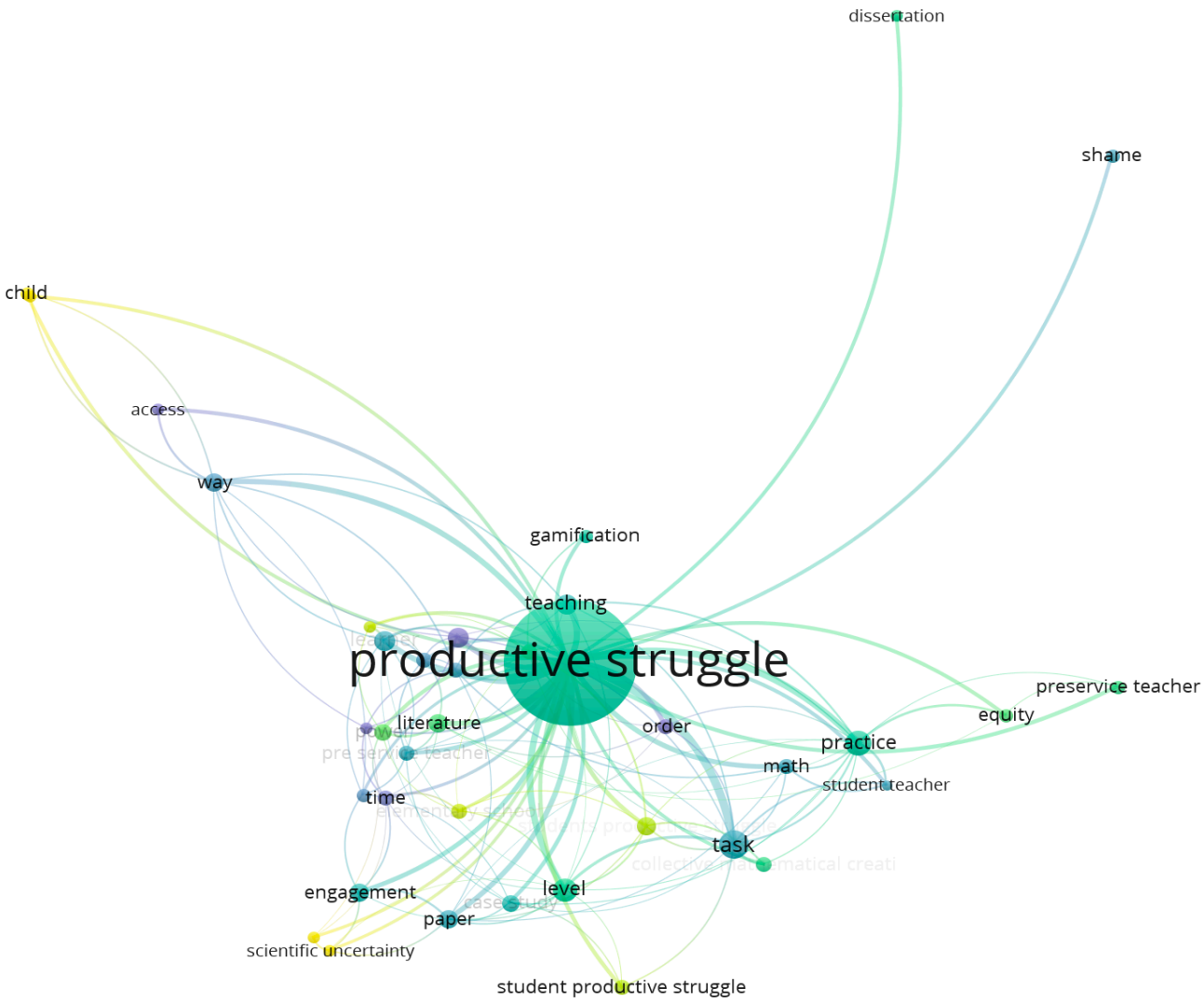

Figure 3. Overlay Visualization of Research about Student Productive Struggle

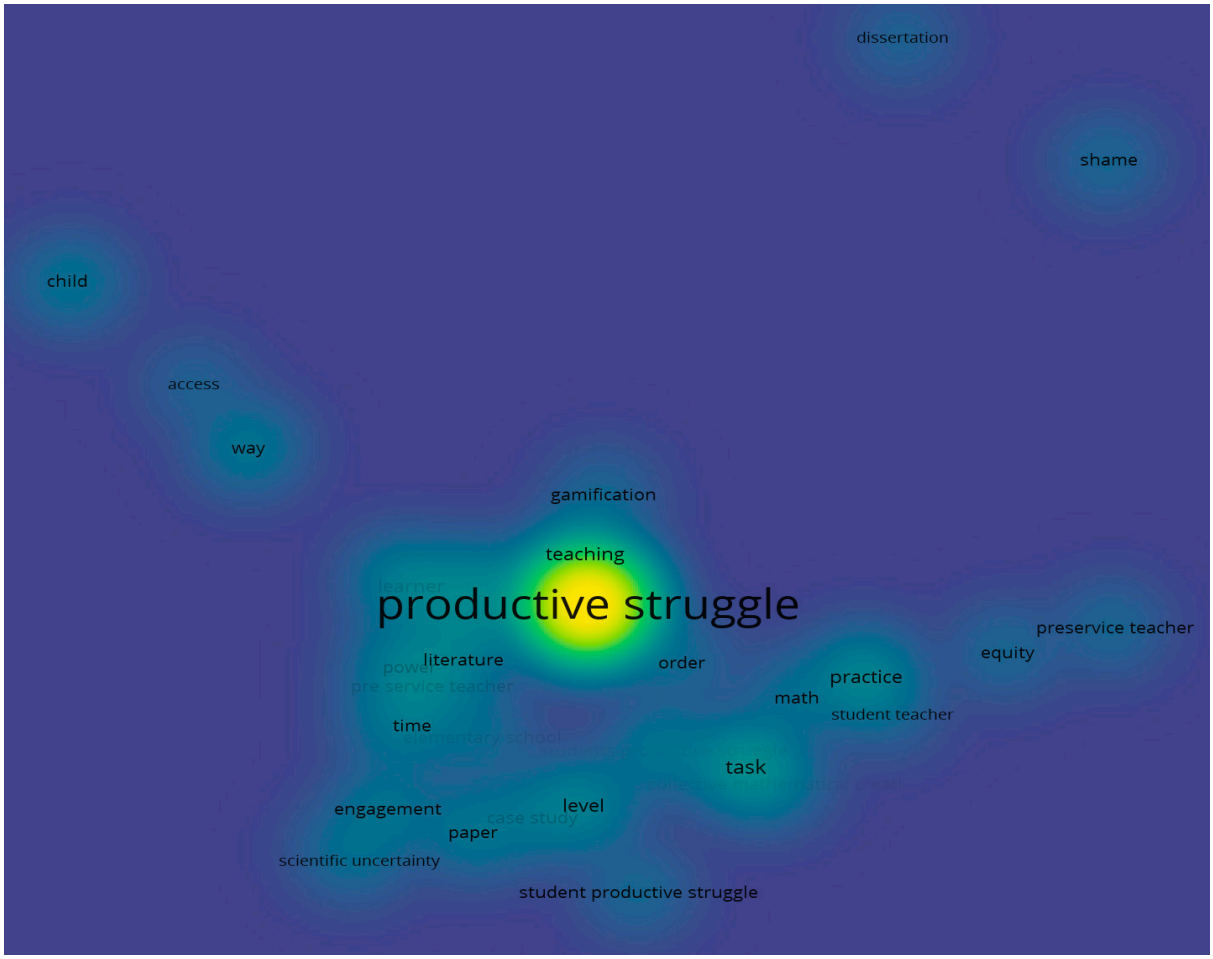

Figure 4. Density Visualization of Research about Student Productive Struggle

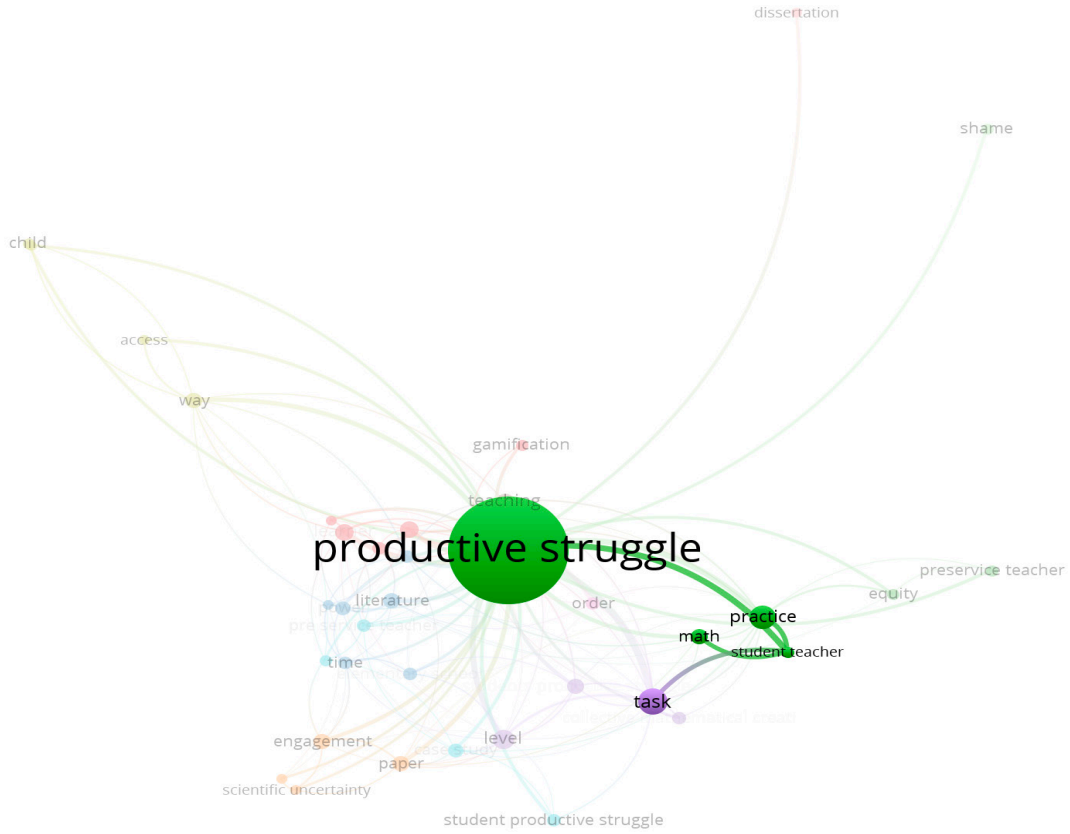

Figure 5. Network Visualization of Research about Students

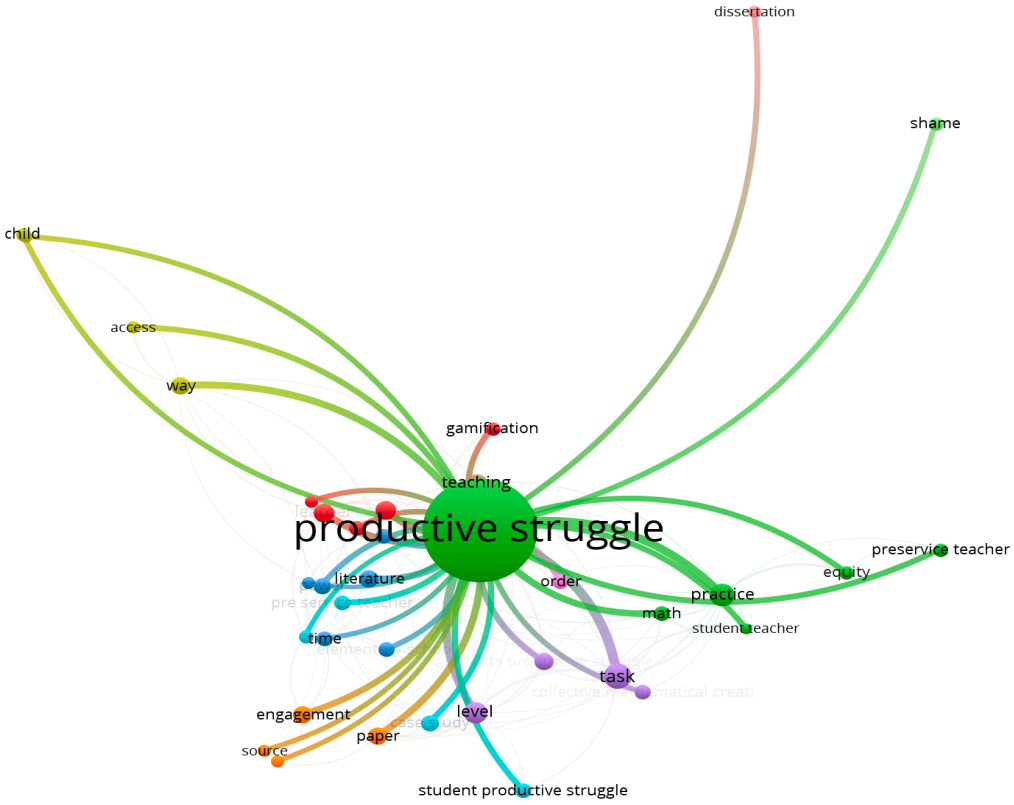

Figure 6. Network Visualization of Productive Struggle

The data shows a correlation between the term "student productive struggle" and other relevant terms within the field of mathematics research. Conceptual network mapping reveals that Cluster 2 has 8 links with a link strength of 97, while Cluster 5, which includes the term "students," has 143 links with a much greater link strength of 2663. This analysis indicates that although the term "student productive struggle" is connected to other terms, the relationship and connection between this term and others are relatively weak compared to more general terms like "students." This situation suggests that research on student productive struggle remains limited and has not received sufficient attention in the academic literature. Therefore, more in-depth and extensive research in this area is urgently needed to strengthen understanding and produce significant new knowledge regarding how students develop resilience and effective strategies when facing challenges in mathematics learning. Such research has the potential to open new insights that can improve the quality of education and enhance students' learning success more comprehensively.

DISCUSSION

Research Development in the Field on Students'Productive Struggle

Table 2 illustrates the development of research on students' productive struggle. 175 articles discussing the topic were published in journals indexed in the Google Scholar database over ten years (2016–2025). The peak of research activity on this topic occurred in 2023, when 30 publications on production struggles were published. This became the most productive year for research on this subject. For comparison, 11 articles were published in 2023 and only 7 in 2025. This shows a trend of declining publications over the past few years.

Visualisation of the Productive Struggle Topic Area Using VOSViewer

The application of VOSviewer software produces a computational mapping of articles related to students' productive struggle. The mapping categorises all items into 11 different groups, consisting of a total of 35 items. These groups provide an organised visualisation of the research landscape on this topic.

1. Group 1 is indicated by the colour red, consisting of 6 items: approach, educator, gamification, influence, instruction, and learner.
2. Group 2 is indicated by the colour green, with 6 items: equity, math, practice, preservice teacher, productive struggle, and teacher.
3. Group 3 is indicated by the colour blue, its 6 items are aspect, elementary school, implication, literature, power, and time.
4. Group 4 is indicated by the colour yellow, with 5 items: access, child, confusion, teaching, and way.

5. Group 5 is indicated by the colour purple, its 4 items are collective mathematical, level, student productive struggle, and task.
6. Group 6 is represented by the sky blue colour, with 4 items: case study, context, preservice teacher, and student productive struggle.
7. Group 7 is indicated by the colour orange, its 4 items are engagement, paper scientific uncertainty, and source.

Bibliometric research on productive struggle in mathematics learning is very important because it can provide a comprehensive overview of the evolution, trends, and scientific contributions in the topic. Researchers can identify the main journals used for publishing this research, as well as the number of influential researchers or institutions studying the concept of productive struggle. This research can also reveal gaps in the literature, such as a lack of studies at certain educational levels or in local contexts like Indonesia. This is important because productive struggle is a proven learning strategy that encourages students to think critically, independently, and improve their mathematical understanding through appropriate challenges. By understanding how this topic develops and is used in various contexts, educators and policymakers can make better decisions when creating curricula and teaching strategies. Bibliometric analysis also helps strengthen academic networks in the field of mathematics education and encourages research collaboration.[34,35] Therefore, this research plays an important role in supporting the improvement of mathematics learning quality by focussing on a learning process that is challenging yet meaningful for students.

At the elementary school age, students are in the concrete operational stage of cognitive development according to Piaget's theory, so they greatly benefit from being given the opportunity to explore problems through a directed trial and error process.[36,37,38] Research shows that students who experience productive struggle tend to have a more meaningful and lasting understanding compared to those who only receive direct instruction or answers from the teacher.[39,40] In addition, productive struggle also contributes to the formation of a growth mindset, which is the belief that abilities can develop through effort and learning from mistakes.[41,42] However, the challenges given must be adjusted to the students' ability levels to avoid causing excessive frustration that actually hinders the learning process. Therefore, teachers need to design learning activities that encourage students to think independently, provide timely support, and create a safe environment for trying and failing.[43,44,45] The proper implementation of productive struggle at the elementary school level will help students develop a solid learning foundation and a positive attitude towards future academic challenges.

The emergence of productive struggle in mathematics learning is influenced by a number of interrelated supporting factors. One of the main factors is the design of tasks that are challenging yet still within the students' ability range.[46,47,48] Tasks like these encourage students to think more deeply without feeling overwhelmed, as they are within their zone of proximal development. Additionally, the role of the teacher is very important in providing strategic support through prompting questions, guidance, or clarification without directly giving the answer, so that students remain active in the problem-solving process.[49] A safe and supportive learning environment is also a key factor, as students will be more willing to take intellectual risks if they are not afraid of making mistakes and understand that mistakes are part of the learning process.[49,50] Sufficient time to explore various strategies and engage in reflection is also necessary for students to be truly involved in the deep thinking process.[49,50,51] Learning approaches such as problem-based learning have proven effective in encouraging students to experience productive struggle, as they are challenged to find solutions on their own before receiving explanations from the teacher.[50,52] Additionally, strengthening a growth mindset through encouragement that effort and perseverance can enhance abilities makes students more resilient to difficulties and less likely to give up. Collaboration among students also contributes, as group discussions allow for the exchange of ideas and problem-solving strategies that enrich the learning process. By paying attention to and optimising these factors, teachers can create a challenging yet meaningful mathematics learning experience for students.

CONCLUSIONS

This study highlights the importance of effective learning strategies and teaching materials to help elementary students develop productive struggle in mathematics, aiming to measurably improve their cognitive flexibility. Productive struggle, characterized by persistence, error reflection, use of diverse strategies, and conceptual understanding, plays a key role in fostering students' adaptive and flexible thinking. The role of teachers and the learning environment—especially through emotional and instructional support—is crucial in encouraging this productive struggle. However, remote learning during the COVID-19 pandemic posed challenges due to limited direct interaction and guidance, necessitating the development of productive struggle strategies adapted for digital platforms. Bibliometric analysis shows that although research on productive struggle is growing, its scope remains limited and holds significant potential for further development, particularly from psychological perspectives involving emotional intelligence, motivation, and anxiety in mathematics learning.

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FINANCING

The source of funding for this research is from further study cos assistance of Indonesia University of Education.

CONFLICT OF INTEREST

There is no conflict of interest.

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