



Research Article

Trends in Using Structural Equation Modeling in Education on the Scopus Database: Bibliometric Analysis (1984-2024)

Zafrullah, Anugrah Arya Bakti, Reza Kastara, Eko Sutrisno Riantoro

1. Universitas Negeri Yogyakarta, Yogyakarta, Indonesia; zafrullah.2022@student.uny.ac.id
2. Universitas Negeri Yogyakarta, Yogyakarta, Indonesia; anugraharya.2022@student.uny.ac.id
3. Universitas Negeri Yogyakarta, Yogyakarta, Indonesia; rezakastara.2022@student.uny.ac.id
4. Universitas Negeri Yogyakarta, Yogyakarta, Indonesia; ekosutrisno.2022@student.uny.ac.id

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Trends in Using Structural Equation Modeling in Education on the Scopus Database: Bibliometric Analysis (1984-2024)

Abstract. This analysis aims to see publication trends regarding the use of structural equation modeling in the field of education. By using predetermined keywords, researchers obtained 433 documents that had gone through the PRISMA method and analyzed using the R Program. From the analysis results, it can be concluded that research using the Structural Equation Modeling approach

in the field of education shows a positive trend from 1984 to 2024, with an annual growth rate of 11.58%, and the peak publication is expected to occur in 2024 with 80 documents. The country with the highest number of publications is China (Asia), with 54 publications (12.50%) and a total of 1,286 citations (12.27%). Jambi University from Indonesia is ranked first with the highest number of publications, namely 14 publications (3.24%). Sustainability Journal (Switzerland) was ranked first with an h-index of 9, recording 387 citations and 19 publications. Researcher Tsai Chin-Chung from National Taiwan Normal University was ranked first with an h-index of 8. The article with the highest number of citations was (Scherer et al., 2019) with 955 citations. The keyword "Structural Equation Modeling" is the most frequently used in research, with a total of 72 times, while the keywords "Confirmatory Factor Analysis" and "self-regulated learning" are also worthy of being a focus in further research.

Keywords: Structural Equation Modeling, Education, Bibliometric

Abstrak. Analisis ini bertujuan untuk melihat tren publikasi mengenai penggunaan pemodelan persamaan struktural atau *Structural Equation Modeling* pada bidang Pendidikan. Dengan menggunakan kata kunci yang telah ditentukan, peneliti mendapatkan 433 dokumen yang telah melalui metode PRISMA dan dianalisis dengan menggunakan R Program. Dari hasil analisis, dapat disimpulkan bahwa penelitian dengan pendekatan *Structural Equation Modeling* di bidang pendidikan menunjukkan tren positif dari tahun 1984 hingga 2024, dengan laju pertumbuhan tahunan sebesar 11,58%, dan puncak publikasi diperkirakan akan terjadi pada tahun 2024 dengan 80 dokumen. Negara dengan jumlah publikasi terbanyak adalah China (Asia), dengan 54 publikasi (12,50%) dan total 1.286 sitasi (12,27%). Universitas Jambi dari Indonesia menempati peringkat pertama dengan jumlah publikasi tertinggi, yakni 14 publikasi (3,24%). Jurnal Sustainability (Switzerland) menduduki peringkat pertama dengan h-index 9, mencatatkan 387 sitasi dan 19 publikasi. Peneliti Tsai Chin-Chung dari National Taiwan Normal University menduduki peringkat pertama dengan h-index 8. Artikel dengan jumlah sitasi terbanyak adalah (Scherer et al., 2019) dengan 955 sitasi. Kata kunci "Structural Equation Modeling" menjadi yang paling sering digunakan dalam penelitian, dengan total 72 kali, sementara kata kunci "Confirmatory Factor Analysis" dan "self-regulated learning" juga layak menjadi fokus dalam penelitian selanjutnya.

Kata Kunci: Pemodelan Persamaan Struktural, Pendidikan, Bibliometrik

INTRODUCTION

Education is an important process in forming individual character, knowledge and skills (Zafrullah, Hamdi, et al., 2024; Zafrullah, Ramadhani, et al., 2024). Education provides a foundation for someone to understand the world, develop their potential, and contribute to society. The existence of quality education is the key to creating a generation that is competent and ready to face the challenges of the times (Izzulhaq et al., 2024; Zafrullah et al., 2023). One form of quality education that can be realized is through schools, as places of structured learning that support students' holistic development. Schools not only play a role in providing knowledge, but also instilling

moral, social values and life skills (Andrian et al., 2020; Zafrullah, Gunawan, et al., 2024). Therefore, ensuring every individual has access to quality schools is a shared responsibility to create a better society. With quality education, future generations can develop optimally and become pillars of the nation's progress.

School is the main place for students to obtain education and develop their potential (Foley et al., 2024). Advanced schools create a supportive learning environment, both in terms of facilities, curriculum and competent teaching staff. Schools play an important role in forming a generation that is knowledgeable, has character and has skills that are relevant to the needs of the times (Sappaile et al., 2024). Thus, the quality of education provided at school greatly determines the future of students and the progress of the nation as a whole (AR et al., 2024). One of the important elements in a quality school is the classroom, which is the main interaction space between teachers and students for an effective and meaningful teaching and learning process.

The classroom is the main space where an in-depth and interactive learning process takes place (Beal & Steier, 2024). Classes are a means for students to interact with teachers and friends, as well as deepen various subject matter. The effectiveness of the learning process in the classroom really depends on teaching methods, student involvement, and a supportive atmosphere (Nwoko et al., 2024). To ensure learning runs optimally, directed and ongoing evaluation of student learning processes and outcomes is needed. This evaluation helps identify strengths as well as areas that need improvement, so students can continue to improve. Thus, one of the keys to successful learning in the classroom is evaluation that is carried out systematically and focuses on improving the quality of education.

Evaluation is an important process in assessing the effectiveness and success of a program or activity (Chaudhry et al., 2023). Evaluation not only aims to measure results, but also to understand the processes that occur so that necessary improvements can be made. In the educational context, evaluation is a tool to ensure that learning objectives are achieved well (Hamdi et al., 2024). In-depth evaluation can help improve the quality of learning, provide constructive feedback, and design more effective strategies. One evaluation method that is often used to analyze complex relationships between various variables in education is Structural Equation Modeling, which is able to provide a comprehensive and in-depth picture of the dynamics of the educational process.

Structural Equation Modeling (SEM) is a statistical technique used to analyze the relationship between interacting variables in a complex model (Sheykhfard et al., 2024). Structural Equation Modeling plays an important role in testing theories or hypotheses involving many interconnected variables, allowing researchers to understand the causal and correlation relationships that occur (Rahim et al., 2024). The need for more in-depth and comprehensive analysis in various fields, such as education, psychology, and economics, makes SEM a very useful tool. Using SEM,

researchers can test theoretical models, measure the strength of relationships between variables, and determine how well the data supports the model (Nadella et al., 2024). Structural Equation Modeling helps reduce uncertainty in research and provides more accurate and reliable results. Therefore, SEM is increasingly becoming the first choice in the analysis of complex and structured data.

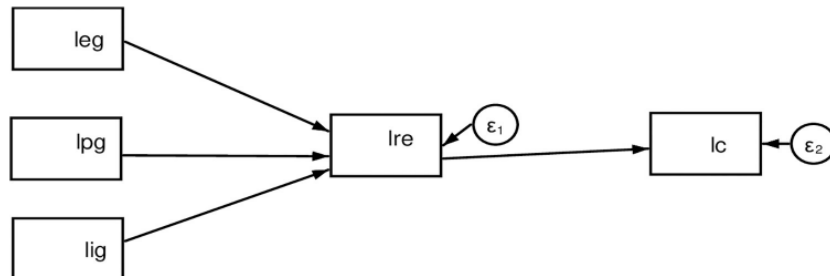


Figure 1. One of the Structural Equation Modeling Models (Source: Gyimah et al., (2024))

The popularity of SEM has made many people conduct research using SEM in various fields, including education. However, previous research focused more on mathematics education and was still limited until 2023 (Lim et al., 2023). This was proven by one of the researchers who conducted a bibliometric analysis of 1,017 papers published in the Scopus database which specifically studied the use of SEM in mathematics education. The analysis shows a growing trend of publications, but with a narrow focus on one scientific discipline. Therefore, the author feels it is necessary to conduct a broader bibliometric analysis of SEM in the field of education in general, to provide guidance for researchers who wish to explore the use of SEM in a more diverse range of educational contexts.

METHOD

This analysis aims to see research trends in structural equation modeling in education using bibliometric analysis. Bibliometric analysis is a method to analyze and measure scientific publications and research trends based on available data. Before analyzing, the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) method is used to filter and select relevant articles, ensuring the quality and eligibility of the research to be analyzed further. With this approach, the analysis can be conducted systematically and thoroughly, providing a clear picture of the development and direction of research in the field.

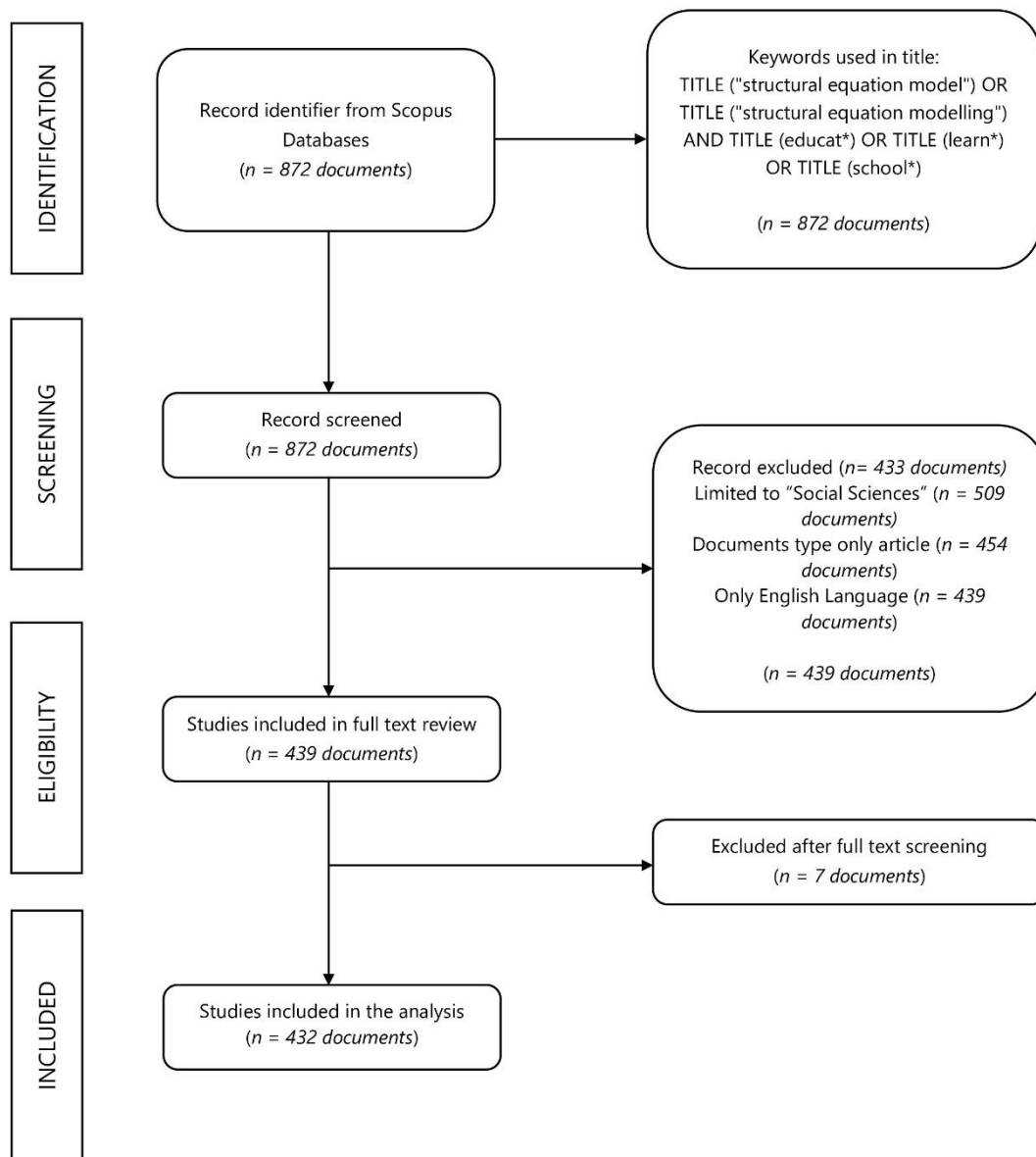


Figure 2. PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Flow

In the Identification stage, we started by using predetermined keywords, which resulted in 872 documents. Next, in the screening stage, the authors limited the documents to those that belonged to the Social Sciences category, were articles only, and were in English. This process caused 433 documents to be eliminated, leaving 439 documents that met the initial criteria. In the eligibility stage, the author manually checked the remaining documents. As a result, 7 documents were eliminated, leaving 432 documents ready for analysis. The analysis used in this study is bibliometric analysis using the R Program, which allows researchers to explore and visualize trends and relationships in existing research data.

RESULTS AND DISCUSSION

Main Information

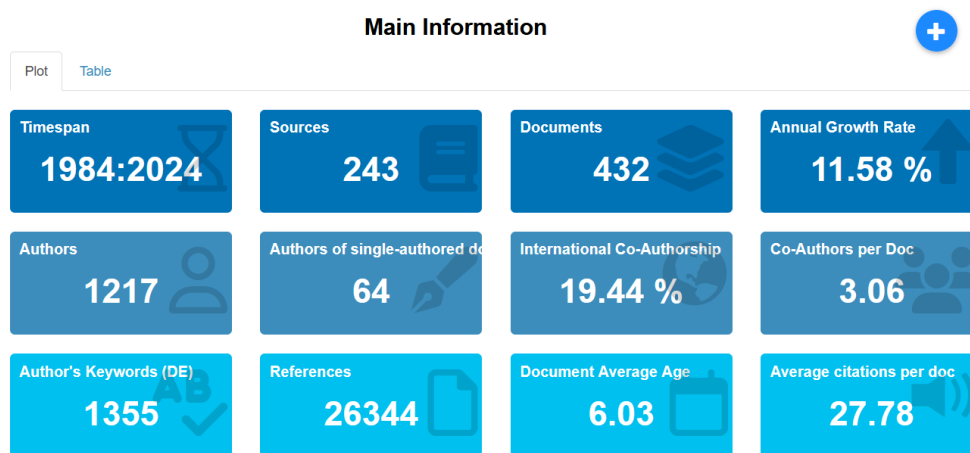


Figure 3. Main Information

The results in Figure 1 show that research on Structural Equation Modeling (SEM) in Education has grown rapidly from 1984 to 2024, with an annual growth rate of 11.58%. Of the 432 documents analyzed, the average document age was 6.03 years, indicating that the research is quite recent. Each document had an average of 27.78 citations, with a total of 26,344 references used, indicating significant influence in the academic literature. This topic involved 1,217 authors, with international collaboration on 19.44% of documents, and an average of 3.06 authors per document. The diversity of keywords, such as 637 Keywords Plus and 1,355 keywords from the author, reflects the broad scope of SEM research in education. Collaboration between authors is dominant, although there are 69 documents written by a single author.

Publications Trend

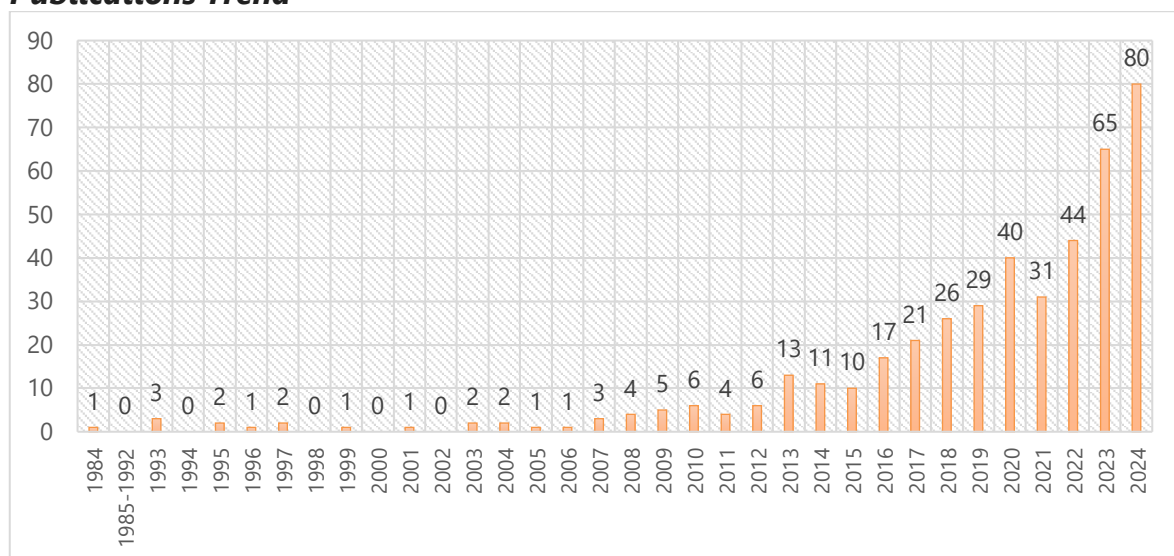


Figure 4. Trends in Number of Publications from Year to Year

Data shows that publication trends related to Structural Equation Modeling (SEM) in Education experienced fluctuating development from 1984 to 2024. In the initial period, publications tended to be sporadic, with only one document in 1984 and several publications spread out until 1997. However, there is a gap publications over several years, such as in the period 1985-1992 and several subsequent years, reflecting the lack of attention or development in this field at that time. Until the early 2000s, the number of publications remained low with an average of less than two documents per year.

However, the trend began to change significantly from 2010, with a steady increase in the number of publications. Publications increased sharply in 2013 with 13 documents, and continue to grow consistently, reaching 40 documents in 2020. Peak publications will occur in 2024 with 80 documents, reflecting the increasing interest and attention towards SEM in education. This acceleration shows that SEM is becoming an increasingly relevant and widely used analytical method in educational research, especially in understanding complex relationships between variables. This trend underscores the importance of SEM as a popular research tool in a variety of modern educational contexts.

The Productive Country

Table 1. Top 10 The Productive Country

Rank	Country (Continent)	TP	%	TC	%
1 st	China (Asia)	54	12.50%	1286	12.27%
2 nd	USA (North America)	38	8.80%	1283	12.24%
3 rd	Turkey (Asia/Europe)	35	8.10%	595	5.68%
4 th	Iran (Asia)	19	4.40%	391	3.73%
5 th	Malaysia (Asia)	18	4.17%	278	2.65%
6 th	Saudi Arabia (Asia)	16	3.70%	703	6.71%
7 th	Australia (Oceania)	13	3.01%	1078	10.29%
8 th	Thailand (Asia)	13	3.01%	117	1.12%
9 th	Hong Kong (Asia)	11	2.55%	166	1.58%
10 th	India (Asia)	11	2.55%	385	3.67%

Description: TP= Total of Publication, TC= Total of Citations

Table 1 shows that the country with the highest number of publications is China (Asia), with 54 publications (12.50%) and a total of 1,286 citations (12.27%). The second position is occupied by the USA (North America) with 38 publications (8.80%) and almost equal citations, namely 1,283 (12.24%). Followed by Turkey (Asia/Europe) with 35 publications (8.10%). This indicates that Asia dominates in the number of publications, with five countries in the top 10 list, namely China, Turkey, Iran, Malaysia and Saudi Arabia. The dominance of the Asian continent shows the high contribution of this region in research that utilizes Structural Equation Modeling (SEM) in the field of education.

In terms of citations, Australia (Oceania) stands out with a very high citation rate, namely 1,078 (10.29%), even though the number of publications is only 13 (3.01%). This reflects that research from Australia has significant quality and impact. Overall, global contributions to SEM research are fairly evenly distributed, with different continents contributing, although Asia dominates in number of publications. The USA's large role in citations and publications shows the importance of international collaboration and dissemination of research results at the global level. This analysis underlines the strategic role of the Asian and American continents in developing SEM research in education.

The Productive Affiliations

Table 2. Top 10 The Productive Affiliations

Rank	Affiliation	City	Country	TP	%
1 st	Universitas Jambi	Jambi	Indonesia	14	3.24%
2 nd	Central China Normal University	Wuhan	China	11	2.55%
3 rd	Michigan State University	East Lansing	USA	11	2.55%
4 th	University of Granada	Granada	Spain	11	2.55%
5 th	National Taiwan Normal University	Taipei	Taiwan	10	2.31%
6 th	National Taiwan University of Science and Technology	Taipei	Taiwan	10	2.31%
7 th	Abu Dhabi Education Council	Abu Dhabi	United Arab Emirates	9	2.08%
8 th	Islamic Azad University	Tehran	Iran	9	2.08%
9 th	University of Calabar	Calabar	Nigeria	9	2.08%
10 th	East China Normal University	Shanghai	China	8	1.85%

Description: TP= Total of Publication

Table 2 shows that Universitas Jambi from Indonesia is ranked first with the highest number of publications, namely 14 publications (3.24%). The next position is occupied by three universities with the same number of publications, namely Central China Normal University (China), Michigan State University (USA), and University of Granada (Spain), each with 11 publications (2.55%). The dominance of these universities highlights the significant contribution of academic institutions in Structural Equation Modeling (SEM) research in the field of education. In addition, two universities from Taiwan, namely National Taiwan Normal University and National Taiwan University of Science and Technology, show the important role of Taiwan with 10 publications each (2.31%).

Overall, contributions to SEM research in education are spread across different regions of the world, but some countries show a strong dominance, such

as China with two institutions on the list (Central China Normal University and East China Normal University). Other countries such as Indonesia, USA, Spain, Taiwan, and the United Arab Emirates also make significant contributions through their university affiliations. This reflects the geographic diversity in the development of SEM research, while emphasizing the importance of cross-country collaboration to advance relevant and impactful studies in education.

The Productive Source

Table 3. Top 5 The Productive Sources

Rank	Name	h-index	TC	%	TP	%
1 st	Sustainability (Switzerland)	9	387	4,35	19	4,40
2 nd	Computers and Education	8	2019	22,68	8	1,85
3 rd	Education and Information Technologies	8	393	4,42	12	2,78
4 th	System	7	321	3,61	8	1,85
5 th	Egitim Ve Bilim	6	56	0,63	7	1,62

Description: TP= Total of Publication, TC= Total of Citations

Based on Table 3, the journal Sustainability (Switzerland) was ranked first with an h-index of 9, recording 387 citations and 19 publications, with a contribution of 4.35% to total citations and 4.40% to total publications. This journal shows quite a significant influence in research, with a number of publications generating many citations. Computers and Education is in second place with an h-index of 8 and 2019 citations (TC), but only has 8 publications (TP), which means it has a huge impact on research with fewer publications. This journal's contribution percentage to citations reached 22.68%, showing that even though the publications are few, their impact is very large.

On the other hand, the journals Education and Information Technologies and Systems have a more balanced contribution between the number of publications and citations, with an h-index of 8 and 7, respectively. The Education and Information Technologies journal with 393 citations and 12 publications contributed 4.42% to citations and 2.78% to publications, showing good influence in the field. Meanwhile, System, with an h-index of 7, contributed 3.61% to citations and 1.85% to publications. The Egitim Ve Bilim journal recorded the lowest contribution in terms of citations and publications, but still showed a relevant role with an h-index of 6, recording 56 citations and 7 publications. Overall, these journals demonstrate the importance of striking a balance between number of publications and citation impact in measuring contributions to relevant research fields.

The Productive Authors

Table 4. Top 5 The Productive Authors

Rank	Name	Affiliation	Country	h	TC	%	TP	%
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1st	Tsai Chin-Chung	National Taiwan Normal University	Taiwan	8	435	4.89	8	1.85
2nd	Liang Jyh-Chong	National Taiwan Normal University	Taiwan	7	275	3.09	7	1.62
3rd	Al Rashedi Asma	Abu Dhabi Department of Education & Knowledge	UAE	3	51	0.57	3	0.69
4th	Anastasiadou Sofia D.	University of Western Macedonia	Greece	3	18	0.20	3	0.69
5th	Badri Masood	Abu Dhabi Department of Education & Knowledge	UAE	3	51	0.57	3	0.69

Description: h=h-index, TP= Total of Publication, TC= Total of Citations

Based on existing data, Tsai Chin-Chung from National Taiwan Normal University ranked first with an h-index of 8, recording 435 citations (TC), which contributed 4.89% to the total citations, as well as 8 publications (TP), contributing 1, 85% of total publications. This shows that Tsai Chin-Chung has had considerable influence in his field with a relatively high number of citations. Liang Jyh-Chong, who also comes from National Taiwan Normal University, is ranked second with an h-index of 7, recording 275 citations (TC) and 7 publications (TP). Although his contribution is slightly lower than that of Tsai Chin-Chung, his contribution is still significant with a percentage of 3.09% for citations and 1.62% for publications.

In third to fifth place, there are two researchers from the Abu Dhabi Department of Education & Knowledge, namely Al Rashedi Asma and Badri Masood, who each have an h-index of 3 and recorded 51 citations (TC) and 3 publications (TP). Their contribution to citations is 0.57%, while to publications it is 0.69%. Anastasiadou Sofia D. from the University of Western Macedonia is in fourth place with similar contributions, having an h-index of 3, 18 citations (TC), and 3 publications (TP), which contributes 0.20% to citations and 0.69% to publications. Overall, although many of these researchers have lower h-indexes, their contributions to citations and publications in the field still have a significant impact.

Documents with the Highest Citations

Table 5. Top 5 Documents with the Highest Citations

Rank	Citations	Title	Total Citations
1st	(Scherer et al., 2019)	The technology acceptance model (TAM): A meta-analytic	955

		structural equation modeling approach ..	
2nd	(Hair & Alamer, 2022)	Partial Least Squares Structural Equation Modeling (PLS-SEM) ...	489
3rd	(Lee et al., 2010)	How does desktop virtual reality enhance learning outcomes? A structural equation modeling approach	424
4th	(Makransky & Lilleholt, 2018)	A structural equation modeling investigation of the emotional value of immersive virtual reality in education	388
5th	(Ballantyne et al., 2011)	Visitors' learning for environmental sustainability: Testing short-and ...	384

Based on existing data, the article with the highest number of citations is (Scherer et al., 2019) entitled "The Technology Acceptance Model (TAM): A Meta-Analytic Structural Equation Modeling Approach to Teachers' Explanations of Digital Technology Adoption in Education" with 955 citations. This article shows the enormous influence in research related to the adoption of digital technology in education, especially using the Structural Equation Modeling (SEM) approach to understand the acceptance of technology by teachers. This indicates that this research has very high relevance in the literature discussing technology integration in education.

Furthermore, (Hair & Alamer, 2022), with 489 citations, focuses on the use of Partial Least Squares Structural Equation Modeling (PLS-SEM) in second language research and education. This research provides practical guidance and examples of the application of PLS-SEM, demonstrating the importance of this methodology in educational research focused on language development. In third place, (Lee et al., 2010) examines how desktop virtual reality can improve learning outcomes through the SEM approach, with 424 citations. This research offers insight into the impact of virtual reality technology in educational contexts, which is an area of research that continues to grow as technology advances.

The article (Makransky & Lilleholt, 2018) examining the emotional value of immersive virtual reality in education, with 388 citations, makes an important contribution to understanding the impact of immersive technology on emotional learning in education. Meanwhile, (Ballantyne et al., 2011) who studied the short and long term impact of animal tourism experiences on sustainable learning using SEM, contributed 384 citations. This article highlights the importance of experiential

learning outside the classroom in the context of environmental education. Overall, these studies make a major contribution to the development of SEM applications in various aspects of education and technology, and highlight the importance of technology-based approaches in improving learning outcomes.

Focus Research and Keyword Novelty

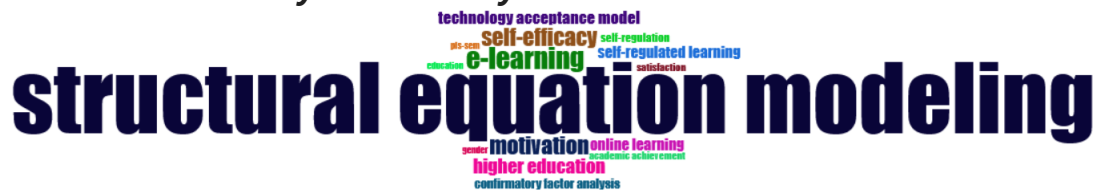


Figure 5. Frequently Used Keyword Analysis

Based on Figure 5, "Structural Equation Modeling" is the keyword most frequently used in research, with a total of 72 times. This shows that SEM is the dominant approach in research related to education, especially in analyzing complex relationships between variables. Apart from that, other frequently used keywords were e-learning and motivation, which recorded 22 and 18 uses respectively. This reflects this topics such as online learning and factors that motivate learning are highly relevant and often a focus in educational research.

Meanwhile, keywords recorded lower, such as self-regulation (9 times) and confirmatory factor analysis (10 times), indicate that although these topics are also relevant, their use is still limited in more specific research contexts. Keywords such as technology acceptance model, online learning, and self-regulated learning represent important topics but have a lower frequency compared to SEM, indicating that despite their importance, these topics may appear more frequently in research with a more focused approach or in a narrower field. Therefore, the use of these keywords can be recommended to enrich and expand the scope of existing research.

Apart from that, Confirmatory Factor Analysis (CFA) and self-regulated learning are also worthy of being a focus in further research. CFA, although it has a lower frequency (10 times), is a very important statistical technique for validating measurement models in SEM, and can be used to test the extent to which the measured construct is in accordance with existing theory. Therefore, researchers can more often integrate CFA in their analyzes to obtain more robust and valid results. Meanwhile, self-regulated learning, which is related to students' ability to manage their learning process independently, also needs to expand the use of keywords. With more and more students learning independently, especially in online learning contexts, further research on self-regulated learning could provide deeper insight into effective learning strategies and how to support the development of these skills among students.

CONCLUSION

From the results of the analysis, it can be concluded that research using the Structural Equation Modeling (SEM) approach in the field of education shows a positive trend from 1984 to 2024, with an annual growth rate of 11.58%, and the peak of publications is expected to occur in 2024 with 80 documents. The country with the highest number of publications is China (Asia), with 54 publications (12.50%) and a total of 1,286 citations (12.27%). Universitas Jambi from Indonesia is ranked first with the highest number of publications, namely 14 publications (3.24%). Sustainability Journal (Switzerland) was ranked first with an h-index of 9, recording 387 citations and 19 publications. Researcher Tsai Chin-Chung from National Taiwan Normal University was ranked first with an h-index of 8. The article with the highest number of citations was (Scherer et al., 2019) with 955 citations. The keyword "Structural Equation Modeling" is the most frequently used in research, with a total of 72 times, while the keywords "Confirmatory Factor Analysis" and "Self-regulated Learning" are also worthy of being a focus in further research.

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