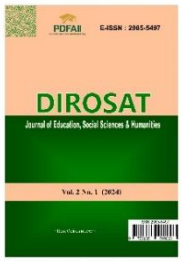

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Research Article

The Using Confirmatory Factor Analysis as Construct Validity in Education Research: A Analysis with Biblioshiny

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Abstract. This research aims at bibliometric analysis on the topic of confirmatory factor analysis in the field of education. Researchers used the RStudio and Vosviewer applications to map bibliometrics results. From the results of the analysis that has been carried out, it is concluded that overview of the bibliometric analysis of 203 research documents, published between 1987 and 2023, from various sources in the Scopus database. Publication growth shows an increase of 7.61% every year. In contrast, it saw a peak in growth in 2018, with 24 publications, reflecting significant research interest and focus.

The University of Tasmania from Australia dominates with 13 articles. Nurse Education Today was the highest contributing journal, contributing 7 articles, highlighting the important role of nursing in this research. This analysis illustrates the diversity of contributions of researchers from various institutions in Thailand in the exploration of CFA in education. The highest document citation is "(Marsh et al., 2014)" regarding exploratory structural equation models. There are five clusters that discuss CFA in the education sector. There are keywords multivariate analysis, exploratory factor analysis, surveys and questionnaires, reliability, and construct validity as the latest keywords that can be used as recommendations for further research in the field of CFA in education.

Keywords: Confirmatory Factor Analysis, Education, Bibliometrics

INTRODUCTION

Education is a key aspect in a country's development, and its development is very important to ensure the best quality (Zafrullah, Bakti, et al., 2023; Zafrullah, Suyanto, et al., 2023). Along with advances in all aspects, including technology, education is also experiencing a significant transformation. This creates new challenges for educators, such as how to integrate technology into the learning process and how to produce students who are able to adapt to change (Hakim & Angga, 2023; Zafrullah, Hardi, et al., 2024; Zafrullah, Meisya, et al., 2024). Quality education provides broad opportunities to individuals, prepares them to face the demands of the times, and makes a positive contribution to the quality of life in society. Therefore, efforts to improve the quality of education must be the main focus for every country in facing the dynamics of global change (Ulwiyah, 2023; Ulwiyah et al., 2023). Thus, education that continues to develop will become a strong foundation for the progress of a country (Zafrullah, Fitriani, et al., 2023; Zafrullah & Zetriuslita, 2021).

The school has experienced significant development in recent times. Apart from being a place of learning, the role of schools is also increasingly prominent as a place to channel creativity (Dedek Andrian et al., 2020; Muhamad Yunus et al., 2022). This emphasizes the important role of education in forming a comprehensive individual. Quality education provides broad opportunities to individuals, prepares them to face the demands of the times, and makes a positive contribution to society's quality of life. Thus, efforts to improve the quality of education must be the main focus for every country in facing the dynamics of global change (Mukminin et al., 2023; Reyna et al., 2017). Digital transformation also plays an important role in post-pandemic educational recovery, but the challenges of access to technology and the availability of teacher competence in using technology also need attention. Therefore, collaboration between society, government and educators is very necessary to create an educational environment that is inclusive and adaptive to change (Sinaga et al., 2021; Vhalery et al., 2022).

The quality of a school does not only depend on its physical facilities, but also on the curriculum and learning approaches used (Peck, 2005; Richards & Wilson, 2006; Robinson & Aronica, 2015). Therefore, carrying out innovation and continuous improvement in this matter is very important. This renewal process includes

reviewing and improving the curriculum and learning methods, so that schools can maintain high educational standards and be in line with the latest developments (Gaston, 2023; Maki, 2023; Shen, 2023; Vhalery et al., 2022). Thus, a quality school will always strive to update and improve these aspects in order to provide an optimal learning experience for students (Muis et al., 2022).

Optimal learning is always closely related to supporting factors, including the availability of quality facilities and human resources. Adequate facilities, such as comfortable classrooms, complete libraries, and modern educational technology, can create a conducive learning environment (Harahap et al., 2017; Hazimah et al., 2021). Apart from that, the role of human resources, such as qualified and competent teachers, also plays an important role in determining the quality of learning (Nurstalis et al., 2021). Good learning has the main goal of achieving optimal learning quality, and therefore, must pay attention to various aspects. Aligning the curriculum with the latest developments, utilizing innovative learning methods, and paying attention to the diversity of student learning styles are some of the many factors that must be considered. By paying attention to and integrating all these factors, learning can be improved, creating a learning environment that is dynamic, inspiring, and in line with students' developmental needs.

Effective learning not only depends on providing quality facilities and human resources, but also requires a regular evaluation mechanism (Ngoc & Tien, 2023). Evaluations carried out regularly are an important basis for educational institutions in identifying points of error and shortcomings, as well as being the first step to improving the quality of education. By conducting regular evaluations, institutions can review the curriculum implemented, improve learning methods that may be less effective, and assess the performance of teachers and students. Evaluation is not just a tool for measuring achievements, but also a means of reflection and continuous improvement. In this way, educational institutions can design improvement strategies that are more targeted, create a dynamic learning atmosphere, and improve overall education quality standards.

In carrying out learning evaluations, the use of instruments that have proven validity and reliability has a crucial role in determining the success of an education system (Keinänen et al., 2018). Validity which is a basic element, plays a central role in improving the quality of learning. A quality evaluation instrument is an instrument whose validity has been tested, both in content and construct aspects, thus ensuring that the data obtained is relevant and accurate. Understanding the importance of validity is a first step that cannot be ignored in developing learning evaluation instruments (Wafudu et al., 2022). By carrying out regular evaluations, institutions can precisely identify points of error or deficiencies in the learning system and take necessary corrective action . Therefore, the validity of evaluation instruments is not only a guarantee of learning quality, but also a foundation for developing more effective improvement strategies to achieve higher educational standards in a sustainable manner.

Confirmatory Factor Analysis (CFA) is a multivariate analysis method used to verify the suitability of the measurement model to the initial hypothesis. The CFA testing process involves several steps, such as Kaisyer-Meisyer-Olkin (KMO) as a

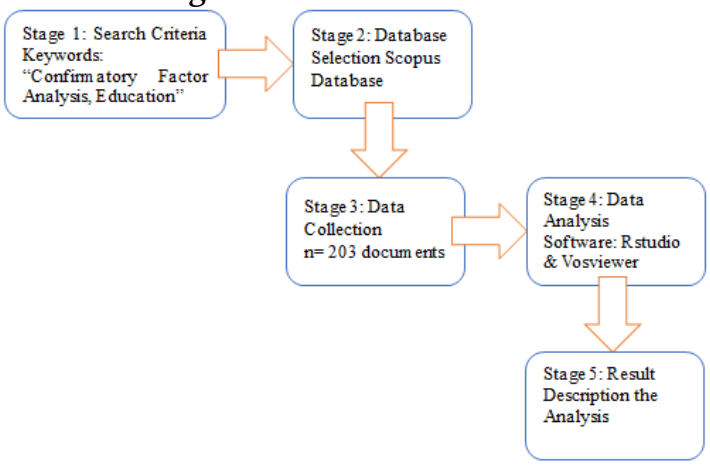
measure of sample adequacy, Barlett Test of Spericity, calculating the anti-image matrix, forming factors with Total Variance Explained, determining the component matrix, calculating Communalities values, making a scree plot, and matrix rotation (Lumbantobing, 2023). Confirmatory Factor Analysis (CFA) is an element that involves construct validity, a crucial dimension in evaluating the quality of evaluation instruments. Through concrete steps in the CFA, the applicability of each aspect of the instrument can be confirmed (Istiyono, 2018). This validity plays an important role in determining whether an instrument is reliable and consistent. The success of instruments whose validity and reliability have been tested not only creates quality standards, but also provides a strong basis for the use of these instruments in making accurate decisions and making a real contribution to improving the learning system.

Confirmatory Factor Analysis (CFA) analysis has become the main choice for many researchers as a crucial analytical technique or integral element in evaluating the validity of instruments in the educational domain. Therefore, the author's interest in carrying out bibliometric research focused on CFA analysis emerged as a response to the significance and prevalence of the use of this method in research related to the validity of instruments in the field of education.

METHOD

This bibliometric research aims to broadcast previous academic work that has been carried out in the context of Confirmatory Factor Analysis in research in the field of Education. Bibliometric analysis is an approach to examining the evolution of a research domain, including topics and authors, based on social structures, intellectual structures, and disciplinary contexts (Supinah & Soebagyo, 2022). Bibliometric analysis is commonly used in scientific disciplines and focuses on the quantitative study of journal papers, books, or other types of written communication (Sidiq, 2019). The overall analysis of the article mapping was carried out through R-Studio, which is the Bibliometric platform used (Saifudin, 2013). Researchers also use Vosviewer in mapping research groups and keyword novelty.

Figure 1. Bibliometrics Flow



In the initial stages of the research, the focus was on the use of scientific sources related to Confirmatory Factor Analysis in an educational context. Two main

keywords, "Confirmatory Factor Analysis" and "Education," were used to ensure relevance and maintain the focus of the study. The second stage involved searching the Scopus database, resulting in 202 documents for analysis. The next stage includes document evaluation using Bibliometrix and Vosviewer software for bibliometric analysis and research novelty mapping. The final stage presents the results, conclusions and quantitative assessment of the data analysis.

RESULTS AND DISCUSSION

Main Information

Once the metadata has been exported to the Biblioshiny application, the initial display of the software is basic information about all the articles that have been imported and are ready for analysis. The main information about the documents to be analyzed using bibliometric methods can be found in Figure 2.

Figure 2. Main Information

Figure 2 provides an overview of the bibliometric analysis of 203 research documents, published between 1987 and 2023, from various sources in the Scopus database. Publication growth shows an increase of 7.61% every year. Bibliographic analysis also reveals the author's contribution, where of the 688 authors involved, 21 of them are single authors, showing the diversity of writing. Only 14.78% of author collaborations are international, with an average of 3.61 authors per document. There are 651 keywords and 8289 references, reflecting the diversity and depth of research in the field of Confirmatory Factor Analysis (CFA) in education. These documents had significant impact with an average of 22.9 citations per document.

Distribution Article by Years

This research describes the distribution of publications each year in Scopus. Data distribution starts from the year the article was first published to the year the

article was ready to be published. The results of the distribution of the number of article publications each year are presented in the following table.

Table 1. Distribution of Article by Years

Year	Articles	Percentage
1987	1	0.49%
1988	0	-
1989	2	0.99%
1990-1992	0	-
1993	1	0.49%
1994-1996	0	-
1997	3	1.48%
1998	3	1.48%
1999-2000	0	-
2001	3	1.48%
2002	1	0.49%
2003	2	0.99%
2004	0	-
2005	1	0.49%
2006	4	1.97%
2007	1	0.49%
2008	6	2.96%
2009	5	2.46%
2010	7	3.45%
2011	10	4.93%
2012	14	6.90%
2013	9	4.43%
2014	8	3.94%
2015	8	3.94%
2016	12	5.91%
2017	14	6.90%
2018	24	11.82%
2019	12	5.91%
2020	14	6.90%
2021	13	6.40%
2022	11	5.42%
2023	14	6.90%
Total	203	100%

Year analysis shows significant variation in research publications regarding Confirmatory Factor Analysis (CFA) in education. The year 1988 and the 1990–1992 span stand out as periods with zero publications, indicating minimal contributions at that time. In contrast, it saw a peak in growth in 2018, with 24 publications, reflecting significant research interest and focus. The steady growth trend from 2008 to 2018 indicates a continued increase in the exploration of CFA in educational contexts. Meanwhile, 2023 marks the most recent year with 14 publications, indicating that interest in this topic remains high. Overall, the year analysis highlights the evolution

of this research over time, illustrating significant trends in CFA-related publications in education.

Most Productive Affiliates

Below is presented data regarding the most productive affiliates which can be seen in the table below.

Table 2. Top Affiliation with the Highest Publications

No.	Affiliation	Country	Articles
1	University of Tasmania	Australia	13
2	The University of Hong Kong	Hong Kong	11
3	University of Turin	Italy	10
4	City University of Hong Kong	Hong Kong	9
5	Universidad de Granada	Spain	9

Data analysis shows that there are five university affiliates that contribute to Confirmatory Factor Analysis (CFA) research in the field of education. The University of Tasmania from Australia dominates with 13 articles, followed by The University of Hong Kong from Hong Kong with 11 articles, and the University of Turin from Italy with 10 articles. City University of Hong Kong and Universidad de Granada of Hong Kong and Spain each also made significant contributions with 9 articles. This analysis reflects the diversity of university affiliations from different countries involved in the exploration of CFA in educational contexts.

Most Productive Source

Citation analysis starts with the ten main sources that have the largest number of publications in the Scopus index which can be seen in Table 3.

Table 3. The Most Productive Source

Sources	Articles
Nurse Education Today	7
Frontiers in Psychology	5
BMC Medical Education	4
Journal of Interprofessional Care	4
Appetite	3

Data shows that a number of scientific journals contribute to research on Confirmatory Factor Analysis (CFA) in the educational context. Nurse Education Today was the highest contributing journal, contributing 7 articles, highlighting the important role of nursing in this research. Frontiers in Psychology and BMC Medical Education contributed 5 and 4 articles, respectively, demonstrating the diversity of multidisciplinary approaches and medical education in the exploration of CFA. The Journal of Interprofessional Care and Appetite also contributed with 4 and 3 articles,

respectively, highlighting the importance of interprofessional care and the psychological aspects of this approach. This analysis reflects the broad impact of CFA in various disciplines and educational contexts, reflected through these publications in leading journals.

Most Published Authors

Below are presented the ten most cited articles obtained from various sources and authors. The table below reveals the results of a bibliometric analysis highlighting the articles that have received the highest number of citations.

Table 4. The Most Productive Authors

Authors	Affiliation	Article	Articles Fractionalized
Sajjakaj Jomnonkwao	Suranaree University of Technology	3	1.25
Janet T. Y. Leung	City University of Hong Kong	3	0.62
Paitoon Pimdee	King Mongkut's Institute of Technology Ladkrabang	3	0.92
Vatanavongs Ratanavaraha	Suranaree University of Technology	3	1.25
Boonchan Sisan	King Mongkut's Institute of Technology Ladkrabang	3	1.67

The data shows the research contributions of five authors from various university affiliations in Thailand. Sajjakaj Jomnonkwao and Vatanavongs Ratanavaraha, from Suranaree University of Technology in Thailand, each contributed three articles with a fractionalization rate of 1.25, demonstrating significant contributions to Confirmatory Factor Analysis (CFA) research in educational contexts. Janet T. Y. Leung from City University of Hong Kong and Paitoon Pimdee from King Mongkut's Institute of Technology Ladkrabang in Thailand each contributed three articles with fractionalization rates of 0.62 and 0.92, reflecting sufficient participation in this knowledge development. Boonchan Sisan, also from King Mongkut's Institute of Technology Ladkrabang in Thailand, had a fractionalization rate of 1.67, indicating contributions greater than the number of articles he wrote. This analysis illustrates the diversity of contributions of researchers from various institutions in Thailand in the exploration of CFA in education as well as the relative levels of their participation in these research projects.

Highest Citation Publications

Below are presented the ten most cited articles obtained from various sources and authors. The table below reveals the results of a bibliometric analysis highlighting the articles that have received the highest number of citations.

Table 5. Top 10 the Highest Citation Publications

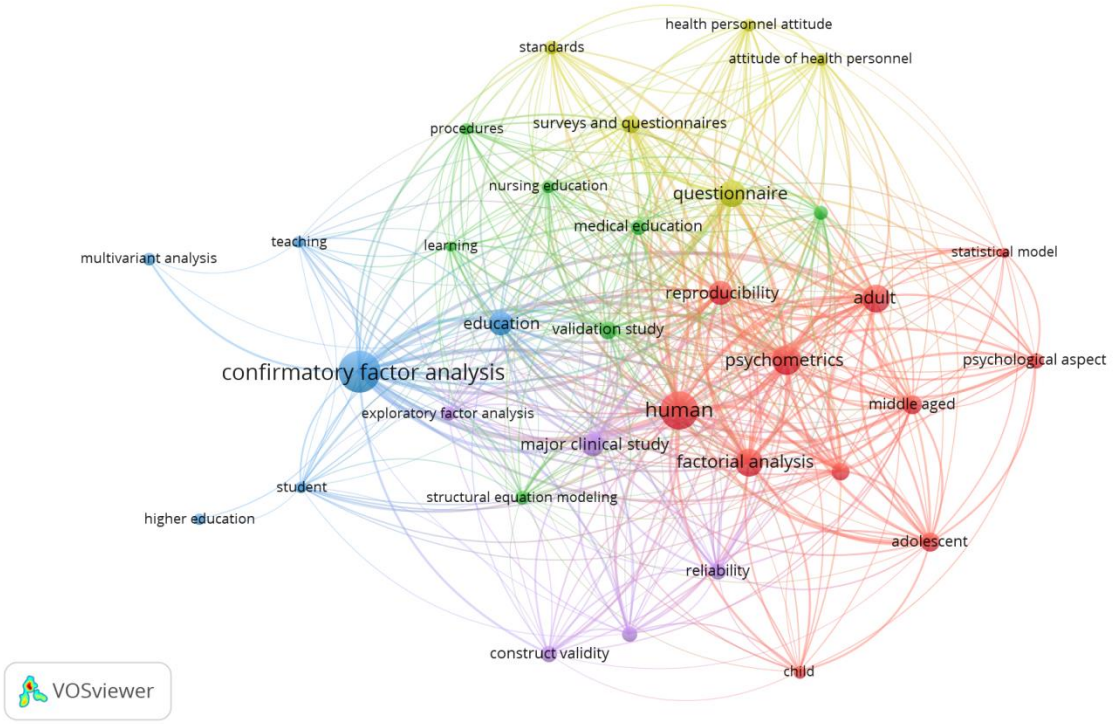
Paper	Title	Source	Total Citations
(Marsh et al., 2014)	Exploratory structural equation modeling: An integration of the best features of exploratory and confirmatory factor analysis	Annual review of clinical psychology	1038
(Veale, 2014)	Edinburgh handedness inventory–short form: a revised version based on confirmatory factor analysis	Laterality: Asymmetries of Body, Brain and Cognition	393
(Karaırmak, 2010)	Establishing the psychometric qualities of the Connor–Davidson Resilience Scale (CD-RISC) using exploratory and confirmatory factor analysis…	Elsevier	131
(Prosser & Trigwell, 2006)	Confirmatory factor analysis of the approaches to teaching inventory	Wiley Online Library	119
(King & Fisher, 2010)	The Self-Directed Learning Readiness Scale for Nursing Education Revisited: A Confirmatory Factor Analysis	-	110

Based on citation analysis of several studies that use Confirmatory Factor Analysis (CFA), it can be concluded that CFA has a very important role in scientific literature. Two examples of research mentioned, namely "(Marsh et al., 2014)" regarding exploratory structural equation modeling and research by Veale (2014) regarding the revision of the Edinburgh Handedness Inventory, show that CFA is used to measure, confirm, or revise conceptual models in various research context. The high number of citations from these two studies indicates that the contribution of CFA in validating and understanding the factor structure of a concept or measurement instrument is highly appreciated and recognized by the scientific community. Therefore, it can be concluded that Confirmatory Factor Analysis has a crucial role in strengthening the validity and reliability of research in various fields, enriching our understanding of the structure of concepts, and playing an important role in developing theories and research instruments.

Focus Research and Keywords Novelty

Apart from using RStudio, researchers also use Vosviewer to map research focus and see the novelty of keywords. The research focus can be seen in Figure 3.

Figure 3. Network Visualization (Keyword Occurrence≥ 7)



There are five clusters that discuss confirmatory factor analysis in the field of education. The red cluster is entitled "Developmental Stages and Psychometric Evaluation" with a research focus on the stages of human development, involving key words such as adolescent, adult, child, and young adult. The research carried out can focus on developing psychometric instruments that suit the unique psychological characteristics of each age group. For example, developing measuring instruments that can accurately measure psychological aspects relevant to children, adolescents and young adults. Confirmatory Factor Analysis (CFA) can be used to evaluate and confirm the structural validity of a developed instrument, ensuring that the psychological constructs measured effectively reflect the differences between that age group. The application of CFA in education is important in this context because it provides a strong scientific basis for measuring and understanding the psychological differences that emerge at each stage of development, which in turn can support the development of more appropriate and effective educational strategies.

Green cluster with the title "Educational Validation Through Cross-Sectional Analysis". This cluster combines key words such as cross-sectional studies, learning, medical education, nursing education, structural equation modeling, and validation study. Research in this cluster could focus on validating educational instruments in medical and nursing learning contexts. The application of Cross-Sectional Studies allows researchers to understand the dynamics of learning at a certain level, while Structural Equation Modeling (SEM) can be used to confirm the structural validity of measurement instruments. For example, validation studies can be conducted using

Confirmatory Factor Analysis (CFA) as part of SEM to verify and measure the effectiveness of learning instruments. The use of CFA in medical and nursing education is crucial because it ensures that the instruments used are reliable and appropriate to learning objectives, allowing for a more accurate evaluation of educational outcomes. Thus, this cluster summarizes efforts to validate educational measurement tools through cross-sectional studies and structural modeling, with a focus on learning effectiveness in the medical and nursing fields.

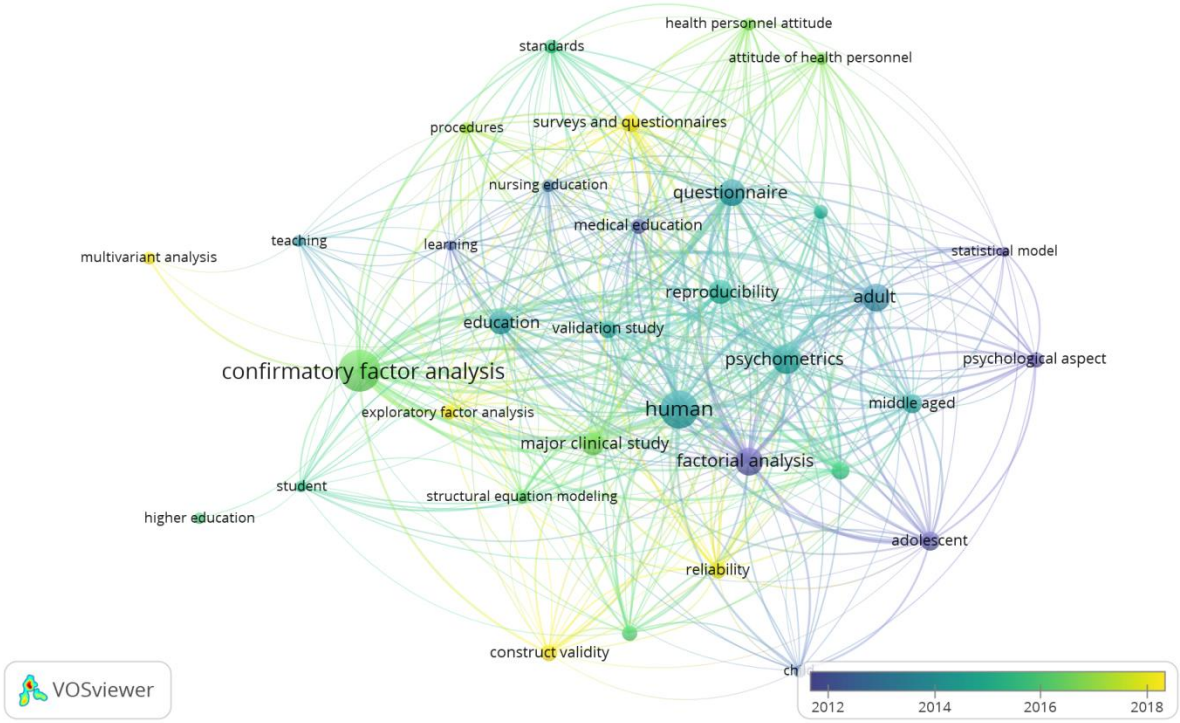
The blue cluster is entitled "CFA in Higher Education Teaching Evaluation". This cluster highlights the use of Confirmatory Factor Analysis (CFA) in teaching evaluation at the higher education level. With key words such as education, higher education, student, teaching, and multivariate analysis, This cluster includes research that focuses on confirmatory factor analysis to measure the validity and effectiveness of teaching methods in higher education contexts. Research in this cluster may involve evaluating dimensions of teaching that include teacher-student interactions, effectiveness of teaching methods, and student responses. CFA is used to measure and confirming the factor structure of the evaluation instrument that includes these variables, provides a strong basis for understanding the impact of teaching methods on student learning outcomes.The application of CFA in the context of higher education is important because it ensures that teaching is carried out in a measurable and reliable manner, so that improving the overall quality of higher education.

Yellow cluster with the title "Surveying Health Personnel Attitudes with CFA". This cluster relates to research on the attitudes of health workers which are studied through the use of questionnaires and standard surveys. In this cluster, research can focus on the development and validation of questionnaires to measure the attitudes of health personnel towards certain aspects, such as the implementation of certain standards in their practice. The application of Confirmatory Factor Analysis (CFA) in this cluster plays an important role in testing and confirming the structural validity of the survey instrument developed, ensuring that the questions in the questionnaire appropriately reflect the desired attitude dimensions. By applying CFA, research can ensure that survey instruments used in health education are reliable and valid, helping to improve understanding of health worker attitudes. Additionally, the use of CFA can strengthen the basis for assessment and evaluation of attitudes, providing a solid foundation for the development of educational strategies that are more effective in increasing positive attitudes and meeting standards in health practice.

Purple cluster with the title "Assessing Construct Validity in Clinical Studies". This cluster discusses research related to construct validity in controlled clinical studies, with elements such as exploratory factor analysis and reliability as the main focus. Within this cluster, research often involves developing assessment instruments or survey questions to measure specific constructs, such as clinical variables. Confirmatory Factor Analysis (CFA) can be used as the primary tool to test and validate the construct of the instrument, ensuring that the variables measured truly reflect the dimensions of interest in the clinical context. By integrating in-depth factor exploration and controlling for relevant variables in clinical research, these clusters can provide powerful insights into the validity and reliability of measurement instruments. The application of CFA in health education can increase understanding

of the validity of clinical evaluation instruments, helping to form more effective policies and guidelines in curriculum development and clinical education.

Figure 3. Overlay Visualization



The visualization displayed uses a color scheme to differentiate between research topics that have been researched for a long time, which are marked with darker colors, and newly researched topics, which are marked with lighter colors. Based on the visualization, in 2018, themes such as multivariate analysis, exploratory factor analysis, surveys and questionnaires, reliability, and construct validity became keywords in yellow. This indicates that this is a keyword that can be used as a recommendation for further research related to CFA in the field of education.

CONCLUSION

From the results of the analysis that has been carried out, it is concluded that overview of the bibliometric analysis of 203 research documents, published between 1987 and 2023, from various sources in the Scopus database. Publication growth shows an increase of 7.61% every year. In contrast, it saw a peak in growth in 2018, with 24 publications, reflecting significant research interest and focus. The University of Tasmania from Australia dominates with 13 articles. Nurse Education Today was the highest contributing journal, contributing 7 articles, highlighting the important role of nursing in this research. This analysis illustrates the diversity of contributions of researchers from various institutions in Thailand in the exploration of CFA in education. The highest document citation is "(Marsh et al., 2014)" regarding exploratory structural equation models. There are five clusters that discuss CFA in

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