Top 100 Cited Research of Confirmatory Factor Analysis (CFA) in Education From 2012 to 2021

Mila Candra Pristianti[1]
[1]Universitas Negeri Surabaya, Surabaya, Indonesia

Sections Info	ABSTRACT
	The aim of this research is to analyze the trends and future research opportunities related to confirmatory factor analysis in education. This research uses a descriptive bibliometric analysis and literature review to determine research trends. The data in this research used the Scopus database during 2012-2021. Data in form .CSV was analyzed using Ms. Excel and data in form .RIS was analyzed using VOSviewer. The conclusion from this research are the trend of research on this topic has increased every year in the last ten years. The most widely used keyword is confirmatory factor analysis. Research related to CFA in education has a wide and good opportunity to be carried out for several reasons including: (1) the trend shows a good graph and continues to increase; (2) the number of citations per paper per year shows a number with a high average; (3) From many studies, it is stated that CFA has a contribution in educational research. For future research, we can focus on discussing CFA in a multidisciplinary manner or discussing CFA trends in education using databases other than Scopus.

INTRODUCTION

In research on education requires a research instrument that is in accordance with the variables used. The instrument itself is intended to measure the achievement of student learning outcomes (Langer et al., 2022; Chekichev et al., 2021; Ruschenpohler & Markic, 2019; Cor, 2018; Artino et al., 2018). In addition, the instrument can also be used to determine the factors that have an influence on student learning outcomes to the success of a learning program given by the teacher (Tokarev et al., 2021). An instrument is said to be really good at measuring symptoms and producing valid data if the instrument has good validity and reliability (Rovigati, 2021). Reliability itself can show whether an instrument is consistent if it is used to measure the same symptoms in various places (Castro-Rodriguez, 2021). So that researchers can determine whether the instrument used several times to measure the same object will produce the same data.

In general, to test the reliability of the instrument using the Cronbach Alpha coefficient. The definition of Cronbach's Alpha is a measure of reliability with values ranging is 0-1 (Alkhadim, 2022; Barbera et al., 2021; Astivia et al., 2020; Emerson, 2019). Besides Cronbach Alpha, another method that can be used is Confirmatory Factor Analysis (CFA) (Taber, 2018). This CFA is used to test the unidimensional, validity and reliability of the construct measurement model which cannot be measured directly (Fauzi et al., 2022). This CFA can also show the operationalization of research variables or constructs into measurable indicators formulated in the form of certain equations and or path diagrams (Effendi et al., 2022). The main purpose of the CFA is to confirm or test the model, i.e. a measurement model whose formulation is derived from theory. The CFA has two focuses including: (1) whether the conceptualized indicators are

unidimensional, precise, and consistent; (2) what are the dominant indicators forming the construct under study (Fu et al., 2022).

CFA is often used to determine the level of validity and reliability of an instrument, both a test instrument and a non-test instrument. CFA aims to evaluate and confirm several types of variables on certain variables which have been developed in the previous map (Mahat et al., 2021). In conducting CFA analysis, statistical programs such as SPSS, AMOS, LISREL and PhysPort are needed by paying attention to the value of test indicators such as CMIN/DF, AGFI, RMR, and others (Qiu & Qi, 2020; Chen et al., 2020; Ping, 2017). CFA refers to Reflective Measurement Theory (RMT) (Riedel et al., 2021; McGeough et al., 2021). So that the first step that must be done in the CFA is to examine the theory of the construct being measured. Furthermore, from the theory obtained theoretical concepts and constitutive definitions of the construct to be measured (Liu & Keating, 2021). Then the dimensions or measurable indicators can be identified as a reflection or manifest of the construct (Watt et al., 2021).

CFA can be used to validate instruments in education. According to research by Bastias & Garcia, (2021); Mungchu et al. (2021) the complex CFA process causes this analysis to be rarely used by the general public. So that research related to CFA needs to be reviewed for trends to see opportunities for this topic in the future. To see research trends related to CFA, bibliometric studies can be used. Bibliometrics can map studies to find out trends in keywords, authors, countries, etc. and then visualize them into overlays or something else (Wang et al., 2022; Su et al., 2022; Raman et al., 2021; Lopez & Rodriguez, 2020; Ye, 2018). The aim of this research is to analyze the trends and future research opportunities related to confirmatory factor analysis in education. This goal is strengthened research by Suprapto, (2018) which recommends describing trends from CFA for physics education. This research contains several research objectives including:

1. Analyzing trends from research on confirmatory factor analysis in education during 2012-2022
2. Analyzing the year-wise distribution of research on confirmatory factor analysis in education during 2012-2022
3. Analyzing the most widely used keywords from research on confirmatory factor analysis in education during 2012-2022
4. Describe the authors and countries with the most publications on confirmatory factor analysis in education during 2012-2022
5. Describe the most widely used document types, the source titles and publishers who most contributed on research of confirmatory factor analysis in education during 2012-2022
6. Analyzing the future research opportunities on confirmatory factor analysis in education

RESEARCH METHOD
General Background
This research uses a descriptive bibliometric analysis to determine research trends regarding Confirmatory Factor Analysis (CFA) in education from 2012 to 2021. This research uses the Scopus database in the form of .RIS and .CSV. Scopus is the largest database that includes abstracts to literature citations that can be searched and organized based on the needs of researchers (Henriquez et al., 2022; Stefanis et al., 2022; Thelwall & Sud, 2022). Scopus is under the auspices of Elsevier (Purnell, 2022; Caputo &

Kargina, 2022). In addition to bibliometric studies, this research also uses literature review. The literature review aims to synthesize and obtain new perspectives, as well as determine the meaning and relationships between variables (Sabharwal & Miah, 2022; Kruse et al., 2022; Pablos et al., 2022).

Sample

The sample of this research is Scopus data through keyword filtering. The reason for using this database because Scopus is the largest academic paper database in global and displays abstracts from various literatures that have been filtered and reviewed so that it is effective for tracking the trend of a topic, visualizing to analyzing publications (Deta et al., 2021; Xie et al., 2020). The data was taken on June 20, 2022. In bibliometrics there are five stages, namely determining keywords; initial search results, refinement research; initial statistical data; data analysis (Gao et al., 2022; Heredia et al., 2022). The keywords in this research were searched based on title-keyword-abstract about CFA in education.

Procedures

The procedures or research process can be seen in Figure 1, while the results can be seen in Table 1.

Figure 1. Flowchart in research procedures

Table 1. The amount of research data obtained

Keyword	Years	Number found
TITLE-ABS-KEY (confirmatory AND factor AND analysis AND in AND education)	All Years	4,961 Document Results
TITLE-ABS-KEY (confirmatory AND factor AND analysis AND in AND education) AND (LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016) OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012))	2012-2021	3,846 Document Results

Data Analysis

The data obtained from Scopus, will first be analyzed using Microsoft Excel, this data is in the form of .CSV. Subsequent analysis of the data in .RIS format will use VOSviewer to obtain the visualization. And finally, the literature will be reviewed. Analysis using VOSviewer will produce data that is grouped into several clusters, each cluster will describe the related relationships between variables (Munir et al., 2022; Liu et al., 2021; Velmurugan & Ramasamy, 2021).

RESULTS AND DISCUSSION

Trend and Year Wise Distribution of Confirmatory Factor Analysis in Education Research from 2012 to 2021

Research trends related to CFA over the last ten years are shown in Figure 2 below. It can be concluded that research related to CFA is increasing from year to year, especially in 2020 experiencing the highest increase, namely 122 documents from 2019. This result is in accordance with research by Ponce et al. (2021); Laupper et al. (2020); Imani et al. (2019) that CFA research is increasing every year. With this it can be seen that the CFA research in the following year will have a great opportunity to be carried out. This provides information for future researchers that CFA has a high level of attractiveness to study and pay attention to.
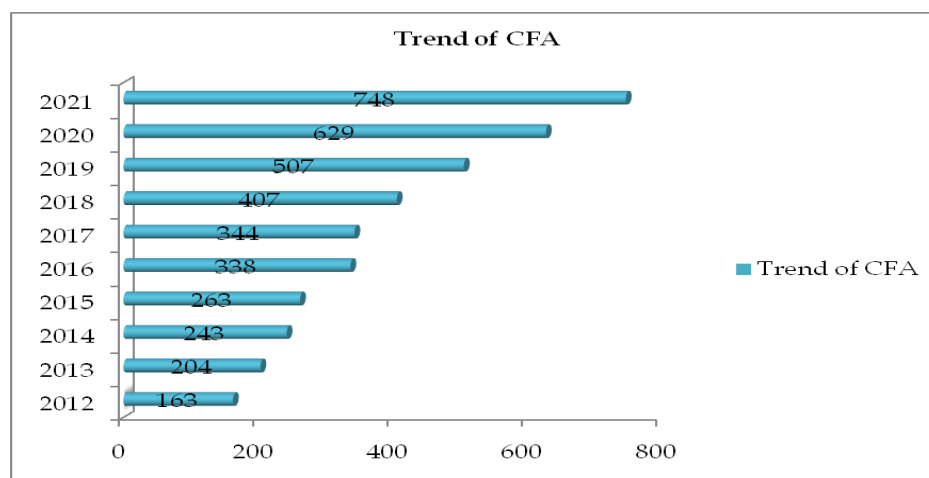

Figure 2. Trend of CFA in the last ten years

In contrast to the publication trend, the year-wise distribution uses selected data, namely the top 100 cited research from 2012-2021. Table 2 shows that in 2014 there were the highest number of papers and citations. This means that in that year CFA research was on the rise among researchers. The number of citations per year shows a number with a high average proving that research on the topic of CFA has great benefits. So this analysis strengthens the results that the topic of CFA in the future has great opportunities and will provide more benefits.

Table 2. Year wise distribution of top 100 cited research of CFA in education from 2012-2021

Year	Cited	Paper	ACPP	ACPPY	Citable Years
2012	1,836	17	108	10.8	10
2013	2,781	18	154.5	17.2	9
2014	2,801	20	140.1	17.5	8
2015	1,648	16	103	14.7	7
2016	1,077	10	107.7	17.9	6
2017	1,059	10	105.9	21.2	5
2018	224	3	74.7	18.7	4
2019	317	4	79.3	26.4	3
2020	278	2	139	69.5	2
2021	0	0	-	-	1
Total	830,202	100	1012.2	213.9	

Keyword, Top Author and Country with The Most Publications on Confirmatory Factor Analysis in Education During 2012-2022

The results of the most widely used keyword analysis can be seen in the visualizations of Figures 3 and Figure 4. It can be concluded that the keywords that have the highest occurrences and total link strength are confirmatory factor analysis of 23 and 206. This clearly proves that confirmatory factor analysis is the main keyword in the study. CFA in education. Then the keyword that occupies the second place is educational status with occurrence 10 and total link strength 200. For the third place, namely factor analysis with occurrence 27 and total link strength 185. Next is followed by keyword cross-sectional study, self report, validation study, controlled study, questionnaires, construct validity, statistics and numerical data. This is in accordance with research by Rahmatina, (2018) with the findings of the most widely used keywords, namely confirmatory factor analysis and educational status.

Figure 3. The most widely used keywords of top 100 cited research of CFA in education from 2012-2021

(a)

(b)

(c)

Figure 4. Map visualization of keywords (a) all of top 100 cited research of CFA in education from 2012-2021; (b) focus on CFA; (c) Focus on educational status

From Figure 4a visualize the most used keywords in CFA topics in education. Where confirmatory factor analysis has the largest point, means that this keyword is used the most by researchers. From the results of network visualization through VOSviewer, three clusters are generated. This cluster shows a close relationship through keyword mapping (Li & Zhou, (2021). The first cluster is red (n=16 items) with the focus on the keyword educational status. The second cluster is green (n=12 items) with the focus on confirmatory factor analysis keywords. The third cluster is blue (n=9 items) with a focus on the keyword questionnaires.

Figure 4b is a visualization that is focused on seeing the relationship between the dominant keywords in the green cluster (confirmatory factor analysis). From the visualization, we can see that CFA relates to students. This means that CFA can show the results of the influence of an instrument used on student learning outcomes or other variables sought in a study (Lee et al. 2019). In addition, CFA is also related to e-learning, learning strategy, teaching, measurement, and others, all of which are related to education. Next, for Figure 4c is a visualization that is focused on educational status. Where this keyword is dominant in the red cluster. From this figure we can know several things. One of them is educational status can be known through socioeconomic factors (Varughese & Aswathy, 2021). Educational status can determine income, health

knowledge, attitudes, and others (Green, 2022). Thus, we found important points to include: (1) the CFA determines educational status; (2) CFA can analyze survey instruments, questionnaires (Teng & Zhang, 2016); (3) CFA can demonstrate validity and reliability; (4) CFA relates to e-learning and teaching.
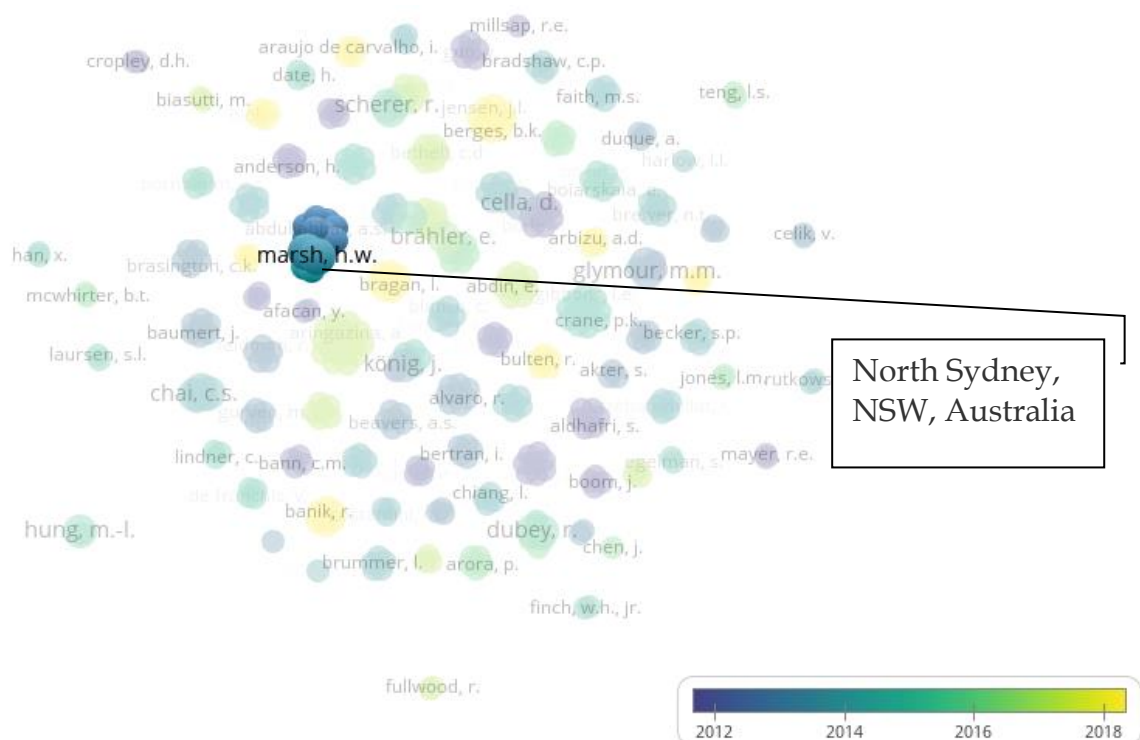
Figure 5. Overlay author visualization of top 100 cited research of CFA in education from 2012-2021

The top author visualized in the form of an overlay like Figure 5 resulted in 435 items, 89 clusters, 1,134 links and 1,141 total link strength. The most dominant author is Marsh, H.W with 2 documents and 14 total link strength. Marsh, H.W comes from Australia with a total of 446 documents and a total of 56,618 citations. One of his studies on CFA cited as many as 780, he found that CFA can largely replace Exploratory Factor Analysis (EFA), and exploratory SEM (ESEM) combines a thorough integration of the best aspects of traditional CFA/SEM and EFA, provides a confirmatory test of a priori factor structure, the relationship of the multigroup test with latent factors (Marsh et al. 2014).

The top 10 countries which are visualized through the datawrapper as Figure 6 are produced by the most dominant countries, namely Unites States with 881 documents. These results are relevant to the results of research by Mason et al. (2018) which states that the United States has the most articles on the topic of measurement, where one of them contains CFA. The next countries include Spain (401); China (278); Turkey (261); Australia (228); United Kingdom (191); Germany (172); Taiwan (151); Malaysia (137); Netherlands (128).
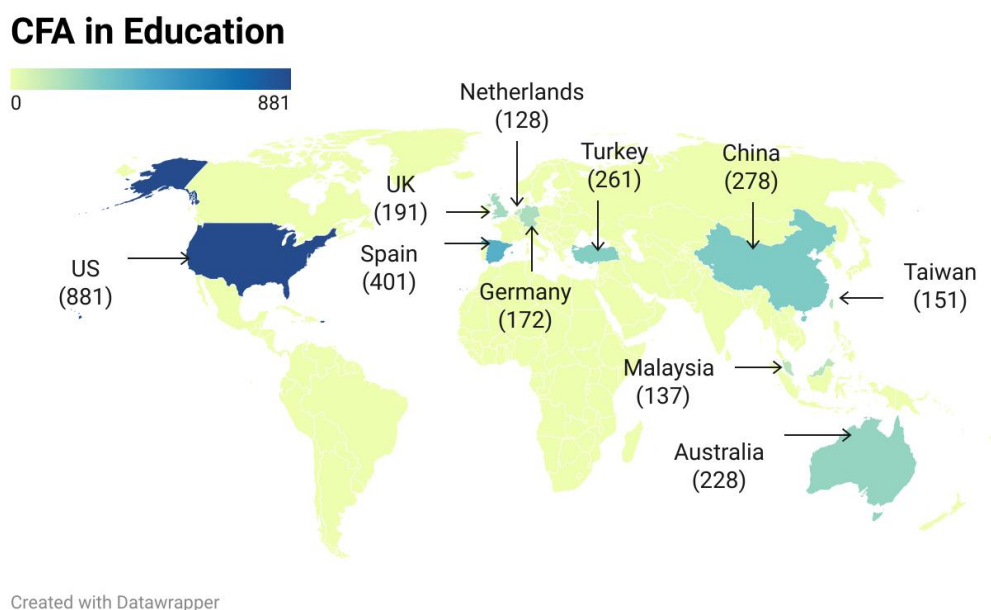
CFA in Education

Figure 6. Top 10 countries that have the highest publications related to CFA in education from 2012 to 2021

Document Type, Source Titles, Publisher with The Most Publications on Confirmatory Factor Analysis in Education During 2012-2022

From the top one hundred cited paper data in the form of .CSV which was processed using Ms. Excel, then obtained the document type from the topic of CFA in education with the most articles, namely 88% (88 documents). Furthermore, there are conference papers and reviews, which are as much as 5%, each of which contains 5 documents. In addition, there are 1% document types in the form of books and notes, each of which has 1 document. Many researchers choose to publish their writings in journals because the quality is better and higher than other sources (Prahani et al., 2022).
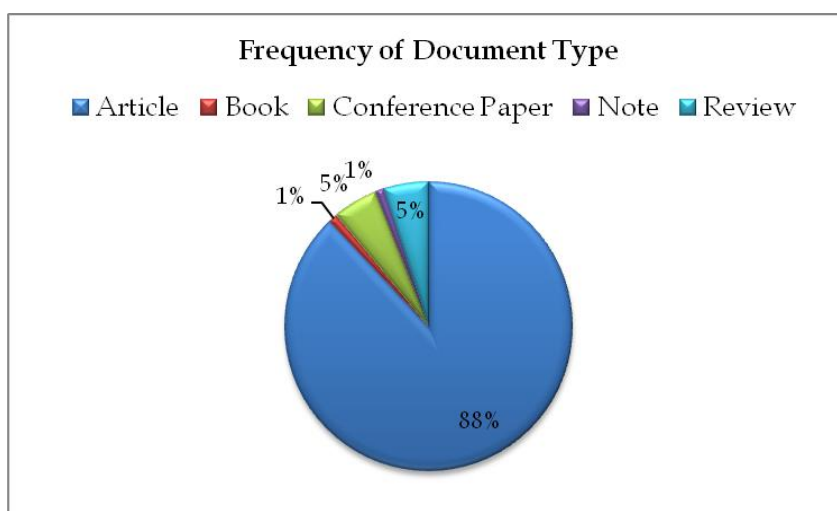
Figure 7. Frequency of document type

In Table 3, it can be seen that from several types of documents, the one with the highest number of citations is in the form of articles (n=9,759 cited). The highest mean

and standard deviation are in the form of a review, namely 256.6 and 295.3. Meanwhile, the one with the highest median value is 138 conference papers. All documents from the top one hundred cited papers in the topic of CFA in education are in English. This clearly proves that the researcher uses English because it is a language that can be understood by all people in the world so that the reach of readers can reach various countries (Yu & Xu, 2019).

Table 3. Document type of top 100 cited research of CFA in education from 2012-2021

Document Type	Cited	Mean	Median	S.D
Article	9,759*	110.9	85.5	72.9
Book	71	71	71	-
Conference Paper	713	142.6	138*	93.4
Note	195	195	1	-
Review	1,283	256.6*	125	295.3*
*The Highest Number				

The top source titles from research related to CFA in education are mostly published in Computers and Education, which are 7 papers. Then followed by Computers in Human Behavior and PLoS ONE where there are 4 papers each. However, the largest number of citations was owned by the Annual Review of Clinical Psychology, which was 778 citations. Furthermore, regarding the publisher who received the most CFA topics in education, namely Elsevier Ltd with 20 papers. This publisher also has the highest number of citations, namely 2,122. Next occupied by SAGE Publications Inc. as many as 10 papers. And third place by Blackwell Publishing Inc. as many as 8 papers. The number of publications of a topic in a source title describes the relevant field of interest (Yu et al., 2018). For more details can be seen in Table 4.

Table 4. Top 10 source titles and publisher of top 100 cited research of CFA in education from 2012-2021

Source Title	Paper	Cited	Publisher	Paper	Cited
Computers and Education	7*	636	Elsevier Ltd	20*	2,122*
Computers in Human Behavior	4	467	SAGE Publications Inc.	10	1,203
PLoS ONE	4	316	Blackwell Publishing Inc.	8	885
Psychological Assessment	3	484	Emerald Group Publishing Ltd.	6	537
Journal of Enterprise Information Management	2	503	BioMed Central Ltd.	5	620
Vaccine	2	260	Public Library of Science	5	471
Epidemiology	2	234	Routledge	5	472
Teaching and Teacher Education	2	174	Emerald Group Holdings Ltd.	4	1,059
Educational Technology and Society	2	130	MDPI AG	4	592
Annual Review of Clinical Psychology	1	778*	International Forum of Educational Technology and Society	2	199
*The Highest Number					

Literature Review and The Future Research Opportunities Research of Confirmatory Factor Analysis in Education

In research by Brown, (2015) it is stated that CFA (Confirmatory Factor Analysis) is one of the quantitative analyzes in survey research. This step is aimed at checking the validity and reliability of the questionnaire and testing the explanation of research questions in education (Toraman et al., 2022). Generally, survey designs are used to describe trending problems in education (Abraham & Barker, 2015), to determine students' individual opinions on pedagogical issues (Cho et al., 2022), to understand relationships between variables or factors, and to provide useful information for evaluating educational programs (Yang & Saad, 2021; Harerimana & Mtshali, 2020). This survey design can be tested in test and non-test instruments (Suwanroj et al., 2019).

CFA has a contribution in educational research. CFA can categorize questions related to force concept inventory (Eaton & Willoughby, 2018). By using CFA analysis, you can find out STARA's competence so that can find out the next step to improve competence in technology, smart technology, artificial intelligence, robotics, and algorithms (Ogebeibu et al., 2021; Yudiatmaja et al., 2021; Oktasari et al., 2019; Hidayat et al., 2018). The student's skill analysis instrument can use the LISREL program to determine the relationship between fit indicator items (Hanghon & Rinthaisong, 2018). The goodness of fit test for the results of construct validation was determined by CFA based on the load factor > 0.3. By looking at the many contributions of CFA in the world of education, there is a great opportunity for research using CFA topics in the coming year.

CONCLUSIONS

From the research that has been done on the topic of confirmatory factor analysis (CFA) it can be concluded that the trend of research on this topic has increased every year in the last ten years. Research related to CFA in education has a wide and good opportunity to be carried out for several reasons including: (1) the trend shows a good graph and continues to increase; (2) the number of citations per paper per year shows a number with a high average; (3) From many studies, it is stated that CFA has a contribution in educational research.

The most widely used keyword is confirmatory factor analysis. The author who has the most total link strength or is dominant in the research topic of CFA in education is Marsh, H.W from Australia. Meanwhile, the countries that discussed the topic the most were the United States, Spain, and China. On this topic, the most widely used document type is in the form of articles. For source titles, the most contributing to this topic are computers and education, while the publisher is Elsevier Ltd.

The implications of this research can be felt directly by future researchers to provide an overview of trends and opportunities for research topics regarding CFA in education. This research can provide information about the development of research topics regarding CFA in education from 2012 to 2021. This research has limitations where access to references is limited. For future research, we can focus on discussing CFA in a multidisciplinary manner or discussing CFA trends in education using databases other than Scopus.

ACKNOWLEDGEMENTS

REFERENCES

Abraham, J., & Barker, K. (2015). Exploring gender difference in motivation, engagement and enrolment behaviour of senior secondary physics students in New South Wales. *Research in Science Education*, 45, 59–73.10. Doi: 1007/s11165-014-9413-2

Alkhadim, G.S. (2022). Cronbach's alpha and semantic overlap between items: A proposed correction and tests of significance. *Frontiers in Psychology*, 13(1), 1-6. https://doi.org/10.3389/fpsyg.2022.815490

Andrea, C., & Kargina, M. (2022). A user-friendly method to merge scopus and web of science data during bibliometric analysis. *Journal of Marketing Analytics*, 10(1), 82-88. https://doi.org/10.1057/s41270-021-00142-7

Artino, A.R., Philips, A.W., Utrankar, A., Ta, A.Q., & Durning, S.J. (2018). "The questions shape the answers": Assessing the quality of published survey instruments in health professions education research. *Academic Medicine*, 93(3), 456-463. https://doi.org/10.1097/ACM.0000000000002002

Astivia, O.L.O., Kroc, E., & Zumbo, B.D. (2020). The role of item distributions on reliability estimation: the case of cronbach's coefficient alpha. *Educational and Psychological Measurement*, 80(5), 825-846. https://doi.org/10.1177/0013164420903770

Barbera, J., Naibert, N., Komperda, R., & Pentecost, T.C. (2021). Clarity on cronbach's alpha use. *Journal of Chemical Education*, 98(2), 257-258. https://doi.org/10.1021/acs.jchemed.0c00183

Bastias, M.P., & Garcia, C.M. (2021). Use of digital technologies to meet special educational needs in the teaching training of differential teachers. *Pixel-Bit, Revista de Medios y Educacion*, 61, 231-256. https://doi.org/10.12795/PIXELBIT.78020

Brown, T.A. (2015). Confirmatory factor analysis for applied research, 2nd ed. *Guilford Press: A Division of Guilford Publications, Inc.*, New York, 72–75.

Castro-Rodriguez, Y. (2021). Systematic review of the instruments for measuring research skills in higher medical education. *Revista Habanera de Ciencias Medicas*, 20(2), 1-17.

Chekichev, A.H., Shehova, D.A., Asenov, S.M., & Asparuhova, K.K. (2021). Research and teaching of amplitude modulation using matlab and emona instrument trainer in engineering education. *2021 30th International Scientific Conference Electronics*, 173511. https://doi.org/10.1109/ET52713.2021.9579626

Chen, H.Y., Lee, C.F., & Tai, T. (2020). The joint determinants of capital structure and stock rate of return: A LISREL model approach. *Handbook of Financial Econometrics, Mathematics, Statistics, and Machine Learning (In 4 Volumes)*, 1345-1397. https://doi.org/10.1142/9789811202391_0035

Cho, S., Kwon, S.H., & Jang, S.J. (2022). Validity and reliability of the gender equity scale in nursing education. *Nursing and Health Sciences*, 24(2), 447-457. https://doi.org/10.1111/nhs.12940

Cor, M.K. (2018). Measuring social science concepts in pharmacy education research: From definition to item analysis of self-report instruments. *Currents in Pharmacy Teaching and Learning*, 10(1), 112-118. https://doi.org/10.1016/j.cptl.2017.09.015

Deta, U.A., Arika, A., Lentika, D.L., Al Lathifah, S.A.S., Suliyanah, S., Admoko, S., & Suprapto, N. (2021). Research trend of socio scientific issues (ssi) in physics learning through bibliometric analysis in 2011-2020 using scopus database and the

contribution of Indonesia. Jurnal Penelitian Pendidikan IPA, (7)4, 682–692. https://doi.org/10.29303/jppipa.v7i4.862

Eaton, P., & Willoughby, S. D. (2018). Confirmatory factor analysis applied to the force concept inventory. *Physical Review Physics Education Research*, 14, 1-11. https://doi.org/10.1103/PhysRevPhysEducRes.14.010124

Effendi, M., Mohd-Matore, E., & Osman, S.S.K. (2022). Exploratory and confirmatory factor analysis for disposition levels of computational thinking instrument among secondary school students. *European Journal of Educational Research*, 11(2), 639-652. https://doi.org/10.12973/eu-jer.11.2.639

Emerson, R.W. (2019). Cronbach's alpha explained. *Journal of Visual Impairment and Blindness*, 113(3), 13-27. https://doi.org/10.1177/0145482X19858866

Fauzi,A., Saefi, M., Adi, W.C., Kristiana, E., & Lestariani, N. (2022). Instrument evaluation of conspiracy theory about covid-19: exploratory factor analysis and confirmatory factor analysis. *International Journal of Evaluation and Research in Education*, 11(2), 491-498. https://doi.org/10.11591/ijere.v11i2.22339

Fu, Y., Wen, Z., & Wang, Y. (2022). A comparison of reliability estimation based on confirmatory factor analysis and exploratory structural equation models. *Educational and Psychological Measurement*, 82(2), 205-224. https://doi.org/10.1177/00131644211008953

Gao, Y., Wong, S.L., Khambari, M.N.M., & Noordin, N. (2022). A bibliometric analysis of the scientific production of e-learning in higher education (1998-2020). *International Journal of Information and Education Technology*, 12(5), 390-399. https://doi.org/10.18178/ijiet.2022.12.5.1632

Green, G. (2022). Seniors' eHealth literacy, health and education status and personal health knowledge. *Digital Health*, 8(1), 1-9. https://doi.org/10.1177/20552076221089803.

Hanghon, P., & Rinthaisong,I. (2018). Confirmatory factor analysis of collaboration model in non-formal higher education management in southern Thailand. *Kasetsart Journal of Social Sciences*, 39(3), 472-477. https://doi.org/10.1016/j.kjss.2018.06.012

Harerimana, A., & Mtshali, N.G. (2020). Using Exploratory and Confirmatory Factor Analysis to understand the role of technology in nursing education. *Nurse Education Today*, 92(1), 1-9. https://doi.org/10.1016/j.nedt.2020.104490

Henriques, C.S., Cano, A.J.R, Galam, J.H., & Robles, Y.M.D.L.F. (2022). The past, present, and future of accessible tourism research: a bibliometric analysis using the scopus database. *Journal of Accessibility and Design for All*, 12(1), 26-60. https://doi.org/10.17411/jacces.v12i1.350

Heredia, N.M., Robles, S.C., Gijon, G.G., & Martin, M.S. (2022). Exploring inequality through service learning in higher education: a bibliometric review study. *Frontiers in Psychology*, 13(1), 1-10. https://doi.org/10.3389/fpsyg.2022.826341

Hidayat, R., Zamri, S.N.A.S., & Zulnaidi, H. (2018). Exploratory and confirmatory factor analysis of achievement goals for indonesian students in mathematics education programmes. *Eurasia Journal of Mathematics, Science and Technology Education*, 14(12), 1-9. https://doi.org/10.29333/ejmste/99173

Xie, L., Chen, Z., Wang, H., Zheng, C., & Jiang, J. (2020). Bibliometric and Visualized Analysis of Scientific Publications on Atlantoaxial Spine Surgery Based on Web of Science and VOSviewer. *World Neurosurgery*, 137, 435-442. https://doi.org/10.1016/j.wneu.2020.01.171

Imani, S., Goradel, J.A., Mousavi, S., & Noroozi, A. (2019). Internal consistency and confirmatory factor analysis of smartphone addiction inventory (SPAI). *Iranian Journal of Psychiatry and Behavioral Sciences*, 13(2), 1-7. https://doi.org/10.5812/ijpbs.55958

Kruse, J.A., Collins, J.L., & Vugrin, M. (2022). Educational strategies used to improve the knowledge, skills, and attitudes of health care students and providers regarding implicit bias: An integrative review of the literature. *International Journal of Nursing Studies Advances*, 4(1), 1-19. https://doi.org/10.1016/j.ijnsa.2022.100073

Langer, W., Bruns, J., & Erhorn, J. (2022). Correction to: Development and validation of a video-based test instrument to measure noticing with regard to processes of recognition in inclusive physical education. *German Journal of Exercise and Sport Research*, 10(1), 1-12. https://doi.org/10.1007/s12662-022-00834-x

Laupper, E., Balzer, L., & Berger, J.L. (2020). Online vs. offline course evaluation revisited: testing the invariance of a course evaluation questionnaire using a multigroup confirmatory factor analysis framework. *Educational Assessment, Evaluation and Accountability*, 32(4), 481-498. https://doi.org/10.1007/s11092-020-09336-6

Lee, J., Song, H.D., & Hong, A.J. (2019). Exploring factors, and indicators for measuring students' sustainable engagement in e-learning. *Sustainability (Switzerland)*, 11(4), 1-9. https://doi.org/10.3390/su11040985

Li, Y., & Zhou, W. (2021). Knowledge mapping of global value chain: a visual analysis using vosviewer and citespace. *Proceedings - 2021 International Conference on Management Science and Software Engineering*, 4(2), 77-82. https://doi.org/10.1109/ICMSSE53595.2021.00025

Liu, X., & Keating, X.D. (2021). A reexamination of pre-service physical education teacher attitudes toward school-based health-related fitness testing in the USA. *European Physical Education Review*, 27(4), 981-999. https://doi.org/10.1177/1356336X211005800

Liu, Y., Cao, Y., Ding, Y., & Zhang, Y. (2021). A βibliometric analysis of intelligent agent researches during 2010–2020 based on vos viewer. *Lecture Notes in Computer Science*, 12(1), 208-219. https://doi.org/10.1007/978-3-030-77820-0_16

Lopez, I.C., & Rodriguez, B.L. (2020). The relevance of transversal competences in vocational education and training: a bibliometric analysis. *Empirical Research in Vocational Education and Training*, 12(1), 1-14. https://doi.org/10.1186/s40461-020-00100-0

Mahat, H., Najib, S.A.M, Norkhaidi, S.B., & Baharuddin, N.H. (2021). Construct validity of the knowledge and skills in a geography stem education instrument among prospective teachers: confirmatory factor analysis. *Indonesian Journal of Geography*, 53(3), 424-432. https://doi.org/10.22146/ijg.47486

Marsh, H.W., Morin, A.J.S., Parker, P.D., & Kaur, G. (2014). Exploratory structural equation modeling: an integration of the best features of exploratory and confirmatory factor analysis. *Annual Review of Clinical Psychology*, 10(1), 85-110. https://doi.org/10.1146/annurev-clinpsy-032813-153700

Mason, D.L., Wentling, W.A., Englert, N.C., George, L., Hampe, H.M., Hellier, S., Kaufmann, J.A., Locasto, L.W., & McDermott, D.S. (2018). Supporting the quality of measurement and evaluation in education. *Journal of Nuclear Medicine Technology*, 46(4), 384-390. https://doi.org/10.2967/jnmt.118.210385

McGeough, J., Gallagher-Mitchell, T., Clark, D.P.A., & Harrison, N. (2021). Reliability and confirmatory factor analysis (cfa) of a paper-versus app-administered resilience scale in scottish youths: comparative study. *JMIR mHealth and uHealth*, 9(12), 32-43. https://doi.org/10.2196/11055

Munir, F., Yani, Y.M., Nizmi, Y.W., & Suyastri, C. (2022). State of the art para-diplomacy: a systematic mapping studies and a bibliometric analysis vos viewer in scopus database. *Academic Journal of Interdisciplinary Studies*, 11(2), 129-141. https://doi.org/10.36941/ajis-2022-0040

Mungchu, A., Teemueangsa, S., & Jedaman, P. (2021). Science educational management of "sIAOE model" for sustainability the quality improving a Thai's Basic education, Thailand. *Journal of Physics: Conference Series*, 1835(1), 410-423. https://doi.org/10.1088/1742-6596/1835/1/012096

Ogbeibu, S., Jabbour, C. J. C., Gaskin, J., Senadjki, A., & Hughes, M. (2021). Leveraging STARA competencies and green creativity to boost green organisational innovative evidence: A praxis for sustainable development Bus. *Strateg. Environ*, 1(1), 1-20.

Oktasari, D., Ismet., & Siahaan, S. M. (2019). Validation construct: Confirmatory Factor Analysis (CFA) instruments scientific communication skills students in learning physics. *Journal of Physics: Conference Series*, 1567, 1-6. https://doi.org/10.1088/1742-6596/1567/3/032095

Pablos, V.B.G., Matarranz, M., Aranda, L.A.C., & Otto, A. (2022). Teachers' digital competencies in higher education: a systematic literature review. *International Journal of Educational Technology in Higher Education*, 19(1), 1-9. https://doi.org/10.1186/s41239-021-00312-8

Ping, R.A. (2017). EQS and LISREL examples using survey data. *Interaction and Nonlinear Effects in Structural Equation Modeling*, 2(1), 63-100. https://doi.org/10.4324/9781315092614-4

Ponce, R.S., Bertolin, A.G., & Lujan, E.L. (2021). Proposal for a pedagogical leadership model for principals of charter primary schools. Application of confirmatory factor analysis [Propuesta de un modelo de liderazgo pedagógico para directores de centros concertados de Educación Primaria. Aplicación del análisis factorial confirmatorio]. *Estudios Sobre Educacion*, 40, 173-193. https://doi.org/10.15581/004.40.173-193

Prahani, B.K., Rizki, I.A., Jatmiko, B., Suprapto, N., & Amelia, T. (2022). Artificial intelligence in education research during the last ten years: a review and bibliometric Study. *International Journal of Emerging Technologies in Learning*, 17(8), 169-188. https://doi.org/10.3991/ijet.v17i08.29833

Purnell, P.J. (2022). The prevalence and impact of university affiliation discrepancies between four bibliographic databases—Scopus, Web of Science, Dimensions, and Microsoft Academic. *Quantitative Science Studies*, 3(1), 99-121. https://doi.org/10.1162/qss_a_00175

Qiu, L., & Qi, Linkai. (2020). E-learning assessment for tourism education LISREL assisted intercultural tourism perception and data integrated satisfaction perspectives. *Journal of Computing in Higher Education*, 32(1), 89-108. https://doi.org/10.1007/s12528-019-09223-0

Rahmatina, D. (2018). Application of confirmatory factor analysis for correlate of students attitude, self-belief, students engagement in mathematics lessons and

mathematics achievement. *International Journal of Engineering and Technology(UAE)*, 7(2), 535-539.

Raman, A., Thannimalai, R., Don, Y., & Rathakrishnan, M. (2021). A bibliometric analysis of blended learning in higher education: perception, achievement and engagement. *International Journal of Learning, Teaching and Educational Research*, 20(6), 126-151. https://doi.org/10.26803/IJLTER.20.6.7

Riedel, P., Horan, W., Lee, J., Hellemaann, G.S., & Green, M.F. (2021). The factor structure of social cognition in schizophrenia: a focus on replication with confirmatory factor analysis and machine learning. *Clinical Psychological Science*, 9(1), 38-52. https://doi.org/10.1177/2167702620951527

Ruschenpohler, L., & Markic, S. (2019). Self-concept research in science and technology education–theoretical foundation, measurement instruments, and main findings. *Studies in Science Education*, 55(1), 37-68. https://doi.org/10.1080/03057267.2019.1645533

Rovigatti, P. (2021). Retake rancitelli: The regeneration of the urban common goods as an instrument of social inclusion and empowerment of the communities. experiences of research, participation, education for active criticism of the urban inequalities in the southern periphery of pescara. *Smart Innovation, Systems and Technologies*, 178(1), 2109-2122. https://doi.org/10.1007/978-3-030-48279-4_199

Sabharwal, R., & Miah, S.J. (2022). An intelligent literature review: adopting inductive approach to define machine learning applications in the clinical domain. *Journal of Big Data*, 9(1). https://doi.org/10.1186/s40537-022-00605-3

Stefanis, C., Giorgi, E., Kalentzis, K., Tselemponis, A., Tsigalou, C., Nena, E., Kontogiorgis, C., Kourkoutas, Y., Voidarou, C., Chatzaki, E., Dokas, I., & Konstantinidis, T. Assessing worldwide research activity on ict in climate change using scopus database: a bibliometric analysis. *Frontiers in Environmental Science*, 10(2), 86-97. https://doi.org/10.3389/fenvs.2022.868197

Su, J., Ng, D.T.K., Yang, W., & Li, H. (2022). Global trends in the research on early childhood education during the covid-19 pandemic: a bibliometric analysis. *Education Sciences*, 12(5), 331-345. https://doi.org/10.3390/educsci12050331

Suprapto, N. (2018). Demographic sources as a local wisdom: Potency of Indonesian physics education researchers in conducting survey research. *Journal of Physics: Conference Series,* 1171, 1-10. https://doi.org/10.1088/1742-6596/1171/1/012003

Suwanroj, T., Leekitchwatana, P., & Pimdee, P. (2019). Confirmatory factor analysis of the essential digital competencies for undergraduate students in thai higher education institutions. *Journal of Technology and Science Education*, 9(3), 340-356. https://doi.org/10.3926/JOTSE.645

Taber, K.S. (2018). The use of cronbach's alpha when developing and reporting research instruments in science education. *Research in Science Education*, 48(6), 1273-1296. https://doi.org/10.1007/s11165-016-9602-2

Teng, L.S., & Zhang, L.J. (2016). A questionnaire-based validation of multidimensional models of self-regulated learning strategies. *Modern Language Journal*, 100(3), 674-701. https://doi.org/10.1111/modl.12339

Thelwall, M., & Sud, P. (2022). Scopus 1900–2020: Growth in articles, abstracts, countries, fields, and journals. *Quantitative Science Studies*, 3(1), 37-50. https://doi.org/10.1162/qss_a_00177

Tokarev, A., Skobelin, I., Tolstov, M., Tsyganov, A., & Pak, M. (2021). Development of VR educational instruments for school pre-professional education in a research

university. *Procedia Computer Science*, 190, 750-754. https://doi.org/10.1016/j.procs.2021.06.088

Toraman, C., Karadag, E., & Polat, M. (2022). Validity and reliability evidence for the scale of distance education satisfaction of medical students based on item response theory (IRT). *BMC Medical Education*, 22(1), 94-102. https://doi.org/10.1186/s12909-022-03153-9

Varughese, A.R., & Bairagya, I. (2021). Interstate variation in household spending on education in India: Does it influence educational status?. *Structural Change and Economic Dynamics*, 59(1), 405-415. https://doi.org/10.1016/j.strueco.2021.09.015

Velmurugan, C., & Ramasamy, G. Nephrology publications of bibliographic coupling and co-authorship network using vos viewer: a scientometric profile. *Library Philosophy and Practice*, 15(2), 1-12.

Wang, Y., Li, X., Liu, Y., & Shi, B. (2022). Mapping the research hotspots and theme trends of simulation in nursing education: A bibliometric analysis from 2005 to 2019. *Nurse Education Today*, 4(1), 1-10. https://doi.org/10.1016/j.nedt.2022.105426

Watt, S.K., Mueller, J.A., Parker, E.T, Neel, R., Pasquesi, K., Kilgo, C.A., Mollet, A.L., & Mahatmya, D. (2021). Measuring privileged identity in educational environments: Development and validation of the privileged identify exploration scale. *Frontiers in Education*, 6(1), 62-72. https://doi.org/10.3389/feduc.2021.620827

Yang, L., & Saad Mohd, R.B. (2021). Exploratory and confirmatory factor analysis of PERMA for Chinese University EFL students in higher education. *International Journal of Language Education*, 5(2), 51-62. https://doi.org/10.26858/ijole.v5i2.16837

Ye, C. (2018). The research development of big data in education: A bibliometric analysis based on citespace. *Proceedings - 2018 7th International Conference of Educational Innovation through Technology*, 7(1), 116-122. https://doi.org/10.1109/EITT.2018.00031

Yu, D., & Xu, Z. (2019). Characteristics of fuzzy researches: A bibliometric analysis based on essential science indicators. *Journal of Multiple-Valued Logic and Soft Computing*, 32(1), 1-25.

Yu, D., Wang, W., Zhang, W., & Zhang, S. (2018). A bibliometric analysis of research on multiple criteria decision making. *Current Science*, 114(4), 747-758.

Yudiatmaja, W. E., Salomo, R. V., & Prasojo, E. (2021). Smart technologies, artificial intelligence, robotics, and algorithms (STARA) competencies during covid-19: A confirmatory factor analysis using SEM approach. *Journal of Physics: Conference Series*, 2049, 1-9. https://doi.org/10.1088/1742-6596/2049/1/012014

*Mila Candra Pristianti
Department of Physics Faculty of Mathematics and Science,
Universitas Negeri Surabaya,
Jl. Ketintang, Surabaya, East Java, 60231, Indonesia
Email: mila.19029@mhs.unesa.ac.id