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 &
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](image)

Table 1. The amount of research data obtained

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Years</th>
<th>Number found</th>
</tr>
</thead>
<tbody>
<tr>
<td>TITLE-ABS-KEY (confirmatory AND factor AND analysis AND in AND education)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>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))</td>
<td>All Years</td>
<td>4,961 Document Results</td>
</tr>
<tr>
<td>TITLE-ABS-KEY (confirmatory AND factor AND analysis AND in AND education) AND (LIMIT-TO (PUBYEAR, 2012-2021))</td>
<td>2012-2021</td>
<td>3,846 Document Results</td>
</tr>
</tbody>
</table>

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**

<table>
<thead>
<tr>
<th>Year</th>
<th>Cited</th>
<th>Paper</th>
<th>ACPP</th>
<th>ACPPY</th>
<th>Citable Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>1,836</td>
<td>17</td>
<td>108</td>
<td>10.8</td>
<td>10</td>
</tr>
<tr>
<td>2013</td>
<td>2,781</td>
<td>18</td>
<td>154.5</td>
<td>17.2</td>
<td>9</td>
</tr>
<tr>
<td>2014</td>
<td>2,801</td>
<td>20</td>
<td>140.1</td>
<td>17.5</td>
<td>8</td>
</tr>
<tr>
<td>2015</td>
<td>1,648</td>
<td>16</td>
<td>103</td>
<td>14.7</td>
<td>7</td>
</tr>
<tr>
<td>2016</td>
<td>1,077</td>
<td>10</td>
<td>107.7</td>
<td>17.9</td>
<td>6</td>
</tr>
<tr>
<td>2017</td>
<td>1,059</td>
<td>10</td>
<td>105.9</td>
<td>21.2</td>
<td>5</td>
</tr>
<tr>
<td>2018</td>
<td>224</td>
<td>3</td>
<td>74.7</td>
<td>18.7</td>
<td>4</td>
</tr>
<tr>
<td>2019</td>
<td>317</td>
<td>4</td>
<td>79.3</td>
<td>26.4</td>
<td>3</td>
</tr>
<tr>
<td>2020</td>
<td>278</td>
<td>2</td>
<td>139</td>
<td>69.5</td>
<td>2</td>
</tr>
<tr>
<td>2021</td>
<td>0</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>830,202</td>
<td>100</td>
<td>1012.2</td>
<td>213.9</td>
<td></td>
</tr>
</tbody>
</table>
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
Top 100 Cited Research of Confirmatory Factor Analysis (CFA) in Education From 2012 to 2021

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

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

[Diagram of network visualization]
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 United 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).
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

<table>
<thead>
<tr>
<th>Document Type</th>
<th>Cited</th>
<th>Mean</th>
<th>Median</th>
<th>S.D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Article</td>
<td>9,759*</td>
<td>110.9</td>
<td>85.5</td>
<td>72.9</td>
</tr>
<tr>
<td>Book</td>
<td>71</td>
<td>71</td>
<td>71</td>
<td>-</td>
</tr>
<tr>
<td>Conference Paper</td>
<td>713</td>
<td>142.6</td>
<td>138*</td>
<td>93.4</td>
</tr>
<tr>
<td>Note</td>
<td>195</td>
<td>195</td>
<td>1</td>
<td>-</td>
</tr>
<tr>
<td>Review</td>
<td>1,283</td>
<td>256.6*</td>
<td>125</td>
<td>295.3*</td>
</tr>
</tbody>
</table>

*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

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

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

**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 you 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.

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