Charting the Course of Active Learning Methods Research: A Comprehensive Bibliometric Analysis

Nurul Latifatul Inayati[1], Vanneza Diva Ariona[2]

[1,2] Universitas Muhammadiyah Surakarta, Indonesia

[1]nl122@ums.ac.id

Abstract

The purpose of this study was to describe the development map and research direction of active learning methods in publications indexed by the Scopus database. The technique in this study was to use bibliometric analysis to review all publications indexed in the Scopus database about active learning methods starting from 2000 to 2024. The data that has been obtained, is then analyzed using Microsoft Excel and R/R-Studio. VOSviewer is used to visually analyze the occurrence of keywords and document excerpts done stimulantly. The author finds 318 publications. Publications found correspond to predetermined subjects, functions, and criteria. The results of this study show that research with the theme of active learning methods was mostly carried out in 2020. The country that contributes to having the most publications is China, then in second place is the United States. The Sharif University of Technology is the highest affiliate with the most influence in publishing research on the theme. Shouraki, S.B. is the most relevant author. Iee Access is the most widely published writing source on active learning methods. The bibliometric analysis performed was limited to the Scopus database. Other national and international databases were not taken into account in the study. This study provides an overview of the literature available to researchers in the field of education and recommendations for future research.

Keywords: *Active learning, Methods, Bibliometric*

Introduction

Active learning in general is a method that encourages students to actively participate in learning process activities (Studi et al., 2018). Active learning is different from the traditional approach where in this approach students tend to be more passive and only listen and receive information obtained from teachers or other learning sources (Al-Qahtani & Higgins, 2013). In active learning methods, students will be more involved in analyzing, understanding, and applying their knowledge (Izzatul Yuanita, 2020). Active learning methods encourage a wide variety of ways of participating, such as collaborative projects, groups, experimentation, and problem-solving (Takmiliyah & Kota, 2020). This is because each student must have a variety of learning styles and different levels of understanding. Active learning tends to place more emphasis on problem-solving and the practical application of knowledge in real situations (Albar, 2023).

Active learning methods can promote a deeper understanding, develop critical skills, increase student motivation and engagement, and hone the ability to solve a problem (Salehizadeh & Behin-Aein, 2014). This is because this approach focuses more on student engagement, problem-solving, collaboration, and reflection. In addition, learning methods also

have many functions that are relevant in the context of analysis or research, namely encouraging active involvement, increasing understanding of concepts, and empirical data collection for example, experiments that involve active participants in an action or simulation can produce important data for analysis, problem solving and much more (Consorti et al., 2012; Hong et al., 2023). Active learning methods can be used as a tool to obtain better data or information, as well as an approach to developing relevant skills and knowledge (Fazakis et al., 2020). Therefore, this method can have significant value in analysis or research across multiple disciplines.

In the phenomenon that occurs, trends in education continue to change. Some phenomena associated with active learning methods are such as the increasing use of technology (Ataie et al., 2018). As the use of e-learning platform applications, mobile applications, and online collaborative tools has experienced rapid development, teachers are also increasingly utilizing technology to enable more engaged and interactive learning experiences (Ghani et al., 2022). Then, during the Covid-19 pandemic, schools implemented distance and hybrid learning (Alsubaie, 2022). With the development of technology, active learning has become increasingly relevant in the context of hybrid and distance learning. Blended learning allows teachers to combine active learning methods with the help of technology, to create a more flexible learning experience (Ali, 2023). These phenomena reflect developments in education that recognize the importance of active learning, student engagement, and the use of technology to improve teaching quality (Oliveira et al., 2022). From the explanation above, it is very necessary to conduct further study, especially about active learning method research, research that can develop research on active learning methods. Research on the theme has also seen a significant increase from 2000 to 2024.

In the field of education, research on active learning methods entitled Active Teaching-Learning Methods for Improving Students Engagement in the Classroom shows that active learning methods are needed to create interactive lecture learning and increase interest among students. The active learning method is an innovative learning technique because it can increase critical, independent, and creative thinking among students, as well as increase student interest in lectures, motivation, and performance in exams (Mane, 2020).

The previous research entitled Motivational Impact of Active Learning Methods in Aerospace Students showed that active learning methods such as project learning applied by students from the Master of Aerospace Engineering degree confirmed the positive impact of the application of active learning methods and showed the key factors inartistically and extrinsically in the motivation of aerospace engineering students. Active learning methods further increase the motivation of aerospace students and help them survive in the face of heavy and challenging workloads (López-Fernández et al., 2019). From these two previous studies, the bibliometric analysis research method is still not used as an effort to map scientific publications, especially those related to active learning methods.

Critical analysis is important to be carried out on existing research results to pave the way for researchers in the future and provide predictions as a suggestion to policymakers regarding research fields that need to obtain a greater portion of accelerated development. The evaluation process relies entirely on the availability of accurate and reliable data. Bibliometric analysis research has become a tool that serves to map data on published research (Bayram, 2020).

Bibliometric indicators are tools used to evaluate the results of scientific research, study, and study the interaction between technology and science, make mapping of scientific fields,

explore the development of new knowledge in certain fields, and as indicators of strategic planning in the future (Abd. Wahab et al., 2022; Djeki et al., 2022). This research will serve as a guide for future researchers collaborating with authors from various institutions and countries to further deepen their knowledge of active learning methods on Scopus-indexed publications from 2000 to 2024.

Method

In this study, bibliometric analysis methods were used thoroughly in the form of document analysis and networking. The Boolean search engine is used to obtain data by combing through the Scopus database of the years 2000-2024. The data search will be conducted on October 8, 2023. The tools used in this study are VOSviewer, R and Rstudio applications, and Microsoft Excel to analyze citations, document content, and networking. The stages taken by researchers are:

In the first stage, researchers ensure that the research to be carried out is relevant to the bibliometric topic by conducting a literature review or literature review of related themes. In addition, literature review is used to determine and identify appropriate keywords and represent the scope of research.

In the second stage, researchers searched Scopus using the boolean operator KEY (learning AND methods) and produced 260,216 documents. Then, researchers performed filtration with boolean operators (KEY (learning AND methods) AND KEY (active AND learning AND methods) AND (LIMIT-TO (DOCTYPE, "ar") AND (LIMIT-TO (SRCTYPE, "j") AND (LIMIT-TO (LANGUAGE, "English") AND (LIMIT-TO (EXACTKEYWORD, "active learning methods") and produced a final document of 318 documents. Filtration is carried out to limit only English documents, journals as document sources, articles as document types and focus active learning methods keywords in data search.

In the third stage, researchers use Scopus analyzer and R and Rstudio to analyze the final document so that researchers can find out the number of documents per year, relevant authors, documents by journal, affiliation, subject/field, and country. Next, analyze the document network level using VOSviewer to visualize data and perform data processing using Microsoft Excel. The procedure in this study can be seen in the following figure:
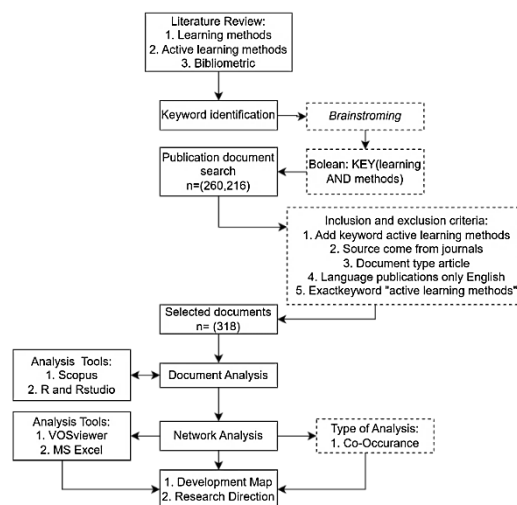

Figure 1. Research procedure

Results

A. Document Analysis

Main Information

Table 1. Main information about data

Description	Results
Main Information About Data	
Timespan	2000:2024
Sources (Journals, Books, Etc)	188
Documents	318
Annual Growth Rate %	0
Document Average Age	4,71
Average Citations Per Doc	19,89
References	12244
Document Contents	
Keywords Plus (Id)	2402
Author's Keywords (De)	804
Authors	
Authors	957
Authors Of Single-Authored Docs	10
Authors Collaboration	
Single-Authored Docs	10
Co-Authors Per Doc	3,89
International Co-Authorships %	25,16
Document Types	
Article	318

Table 1 shows an overview of 318 documents collected over 24 years. Covering 957 authors, 10 single authors, 25.16% international authorship collaborations, and 12244 references with an average citation per document of 19.89 citations.
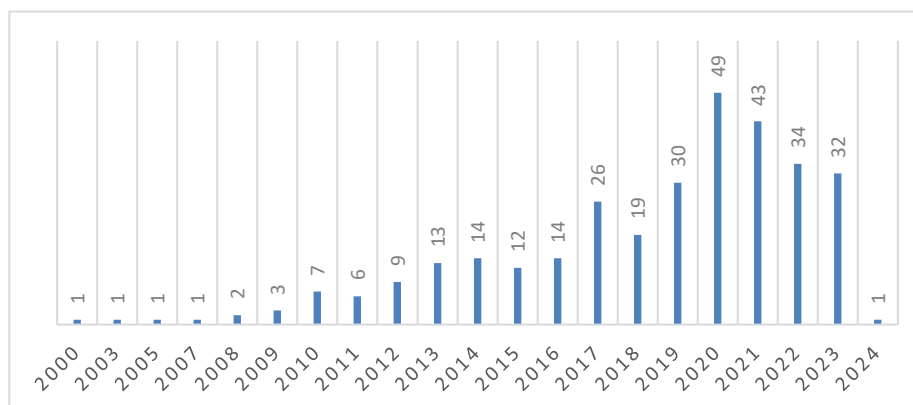
Documents by Year

Figure 2. Documents by year

Figure 2 shows that research with the theme of active learning methods was first conducted in 2000 with 1 document and did not increase until 2007. Research on active learning methods began to increase in 2009 with a total of 3 documents. Research with the

theme of active learning methods was most conducted in 2020 with a total of 49 documents and decreased in 2021 with a total of 43 documents. Meanwhile, in 2023, publications related to active learning methods will only number 32 documents. Based on data, there is 1 document found in 2024 related to research on active learning methods. The document found in 2024 is an article with a print that has been published in January 2024. The article was written in 2023 under the title An Efficient and Versatile Kriging-Based Active Learning Method for Structural Reliability Analysis published by the journal Reliability Engineering & System Safety in volume 241.
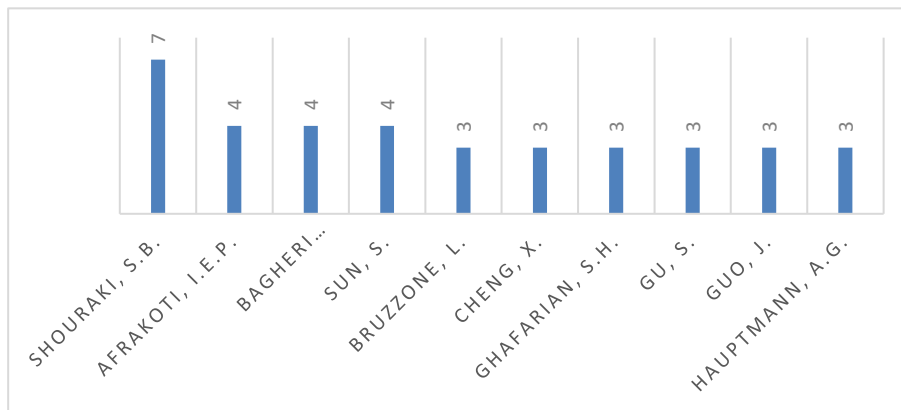
Most Relevant Authors

Figure 3. Documents by the most relevant authors

Figure 3 shows an analysis of the most relevant authors, i.e. authors whose work was successfully published and indexed by Scopus. The image with the highest bar chart is the most influential author. Based on figure 3, Shouraki, S.B. is the author who has the highest bar chart, which shows the number 7, followed by other authors with a fairly good impact with a bar chart showing the number 4, including Afrakoti, I.E.P., Bagheri Shouraki, S., Sun. S.
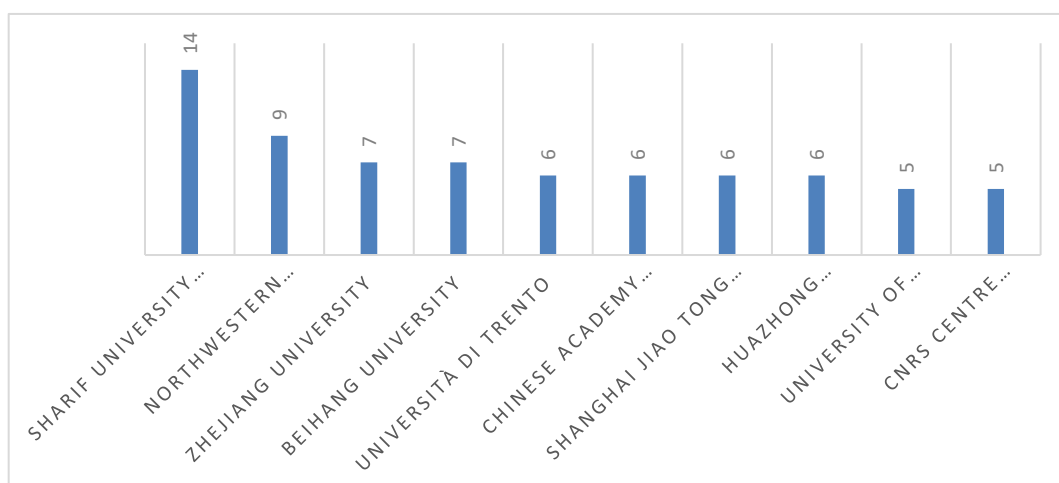
Documents by Affiliation

Figure 4. Documents by affiliation

Figure 4 shows that Sharif University of Technology is the most influential institution in publishing research in the field of active learning methods, with 14 publications. Then followed by a large institution Northwestern Polytechnical University which published research results

in the field of active learning methods as many as 9 publications. Then there are Zhejiang University and Beihang University institutions that are no less far contributing to research related to this discussion, with a total of 7 publications.
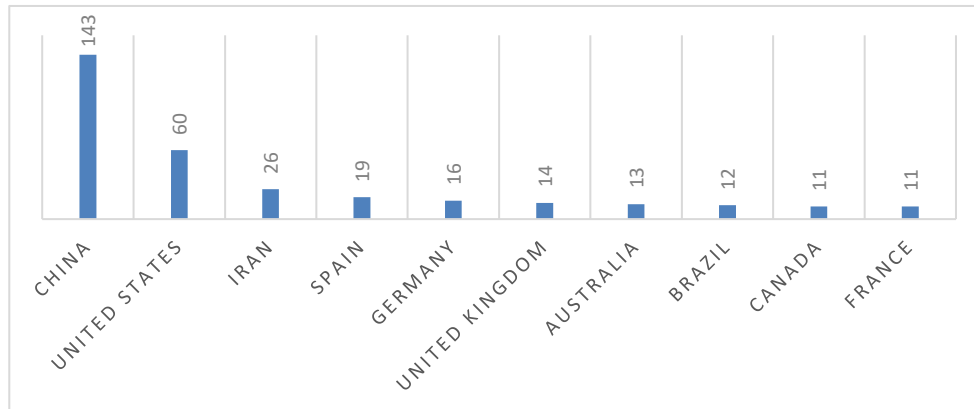
Documents by Country

Figure 5. Documents by country

Figure 5 shows that the country that publishes the most scientific publications with the theme of active learning methods is China with a total of 143 documents. Then the second country with the most scientific publications is the United States with a total of 60 documents. Ranked third is Iran with a total of 26 documents.
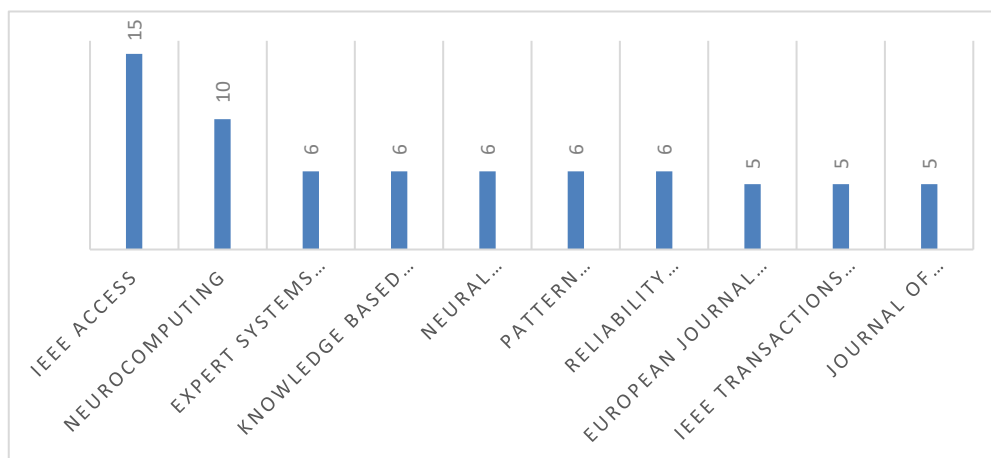
Documents by Source

Figure 6. Documents by source

Figure 6 shows that 10 publication journals occupy the top position in publishing research results related to active learning methods. The height of the bar chart shows how many publications were carried out, while the lower the bar chart, the fewer the number of publications of the research results carried out. In the journal Iee Access there are 15 publications. Then the journal Neurocomputing numbered 10 publications. Five journals have the same number of publications, as many as 6 publications, including Expert Systems with Applications, Knowledge Based Systems, Neural Computing and Applications, Pattern Recognition, and Reliability Engineering and System Safety.

https://jurnaldidaktika.org
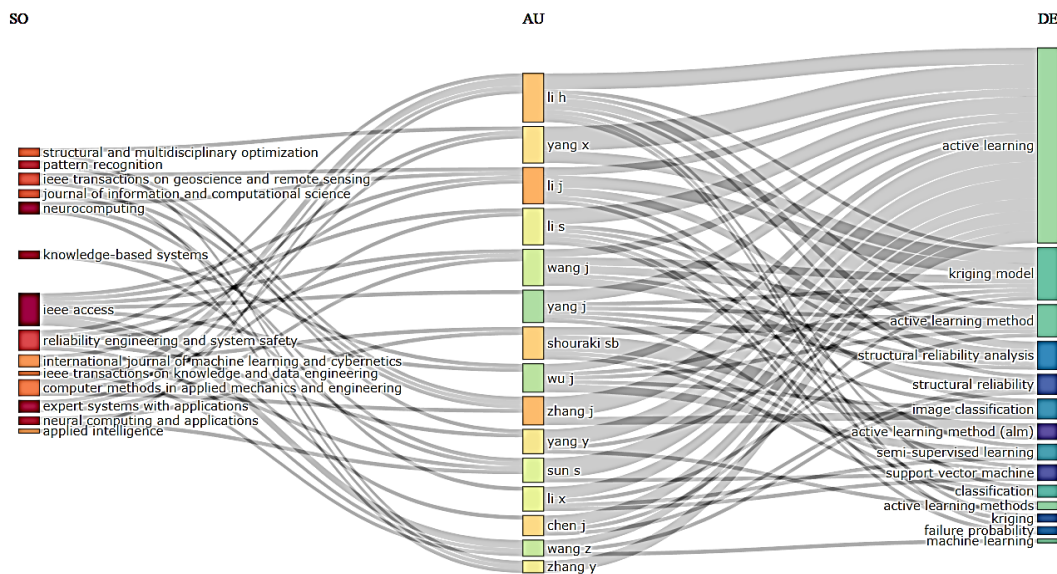
Three Field Plot

Figure 7. Three-field plot

Figure 7 shows three observable elements, namely the name of the journal, the name of the author and the theme or subject matter used. The elements are then connected by gray plot lines that relate to each other. Each journal lists the names of authors who often contribute to their publications based on the name of the journal, especially those with the theme of active learning methods.

The size of the plot indicates the magnitude of the distribution associated with the subject. Figure 7 shows there are 14 journals. The journal that publishes the most research with the theme of active learning methods is Iee Access which is displayed in dark red and connected to the authors Li, J., Li, S., Wang, J., Yang, J., Wu, J., Chen. J., Wang, Z.

Based on figure 7, there are 15 authors who have published research results related to active learning methods. The size of the bar chart shows how much research results each author has published. Of the 15 authors who wrote the most articles with the theme of active learning methods are Li, H. Then in second place is Yang, X.

In the third element, each research topic is connected to the author who writes many research articles with the theme of active learning methods. From the results of the analysis, it was found that 14 keywords with active learning, kriging model, and active learning method were in the top three positions. This shows that these keywords are closely related to research topics, especially those related to active learning methods.
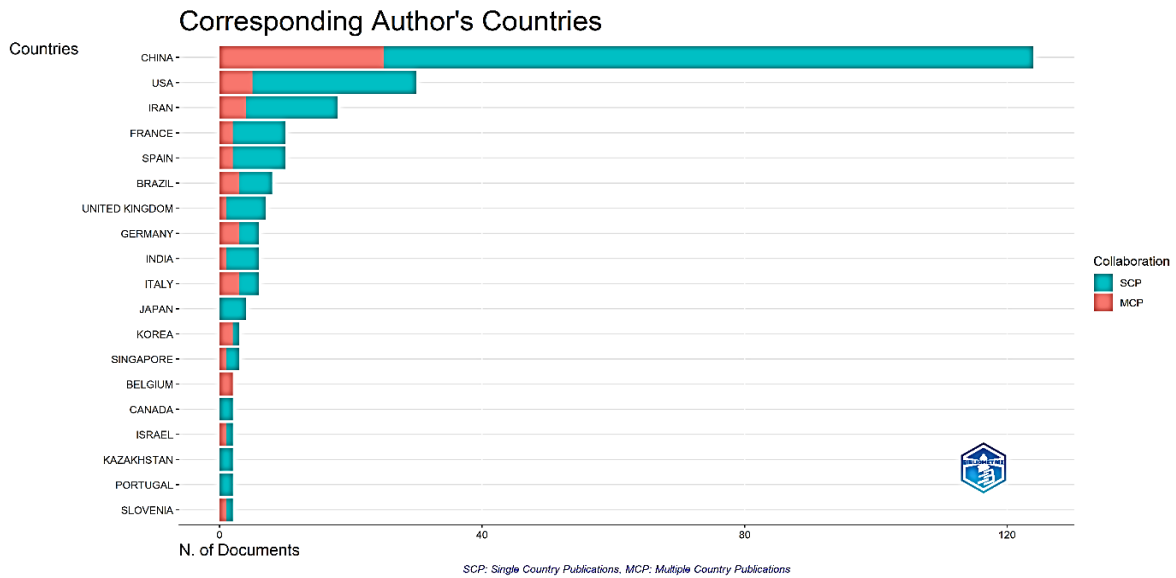
Corresponding Author's Countries

Figure 8. Document corresponding author's countries

Figure 8 shows data on corresponding author's countries, where there are several blocks that have two colors, namely red and blue. In collaboration there is SCP which is single country publications where only the sole author in the country. Then MCP is multiple country publications where there are authors in that country and also other countries. Based on the results of image analysis, 8 countries China is the country that has the most MCP and SCP, followed by the USA and Iran.

Most Global Cited Document

Table 2. Most global cited document

Paper	Total Citations	Tc Per Year
Yi L, 2016, Acm Trans Graphics	592	74,00
Huang X, 2016, Struct Saf	257	32,13
Lv Z, 2015, Comput Math Appl	236	26,22
Dopido I, 2013, Ieee Trans Geosci Remote Sens	170	15,45
Menekse M, 2013, J Eng Educ	163	14,82
Zhang J, 2018, Comput Methods Appl Mech Eng	123	20,50
Goudjil M, 2018, Int J Autom Comput	119	19,83
Demir B, 2015, Ieee Trans Geosci Remote Sens	119	13,22
Consorti F, 2012, Comput Educ	117	9,75
Hoi Sch, 2009, Acm Trans Inf Syst	115	7,67

Table 2, shows the most global cited document which shows that there are 10 authors and their citations. Based on table 2, it can be known that the papers with the largest total citations are Yi L paper, 2016, Acm Trans Graphics with a total citation of 592 citations. Then in second place is Huang X paper, 2016, Struct Saf with a total citation of 257. The paper with the largest TC per Year is the paper in 2016 with a TC per Year of 74.00, namely Yi L, 2016, Acm Trans Graphics. The year of publication does not affect the total citations because the more recent the year published, it does more recent the total citations are the most. Hoi's paper, Sch. published in 2009 had fewer total citations than Yi, L.'s paper published in 2016 with a total of

592 citations. Then Zhang, J.'s paper published in 2018 had fewer total citations than Huang, X.'s paper published in 2016 with a total of 257 citations.

B. Network Analysis
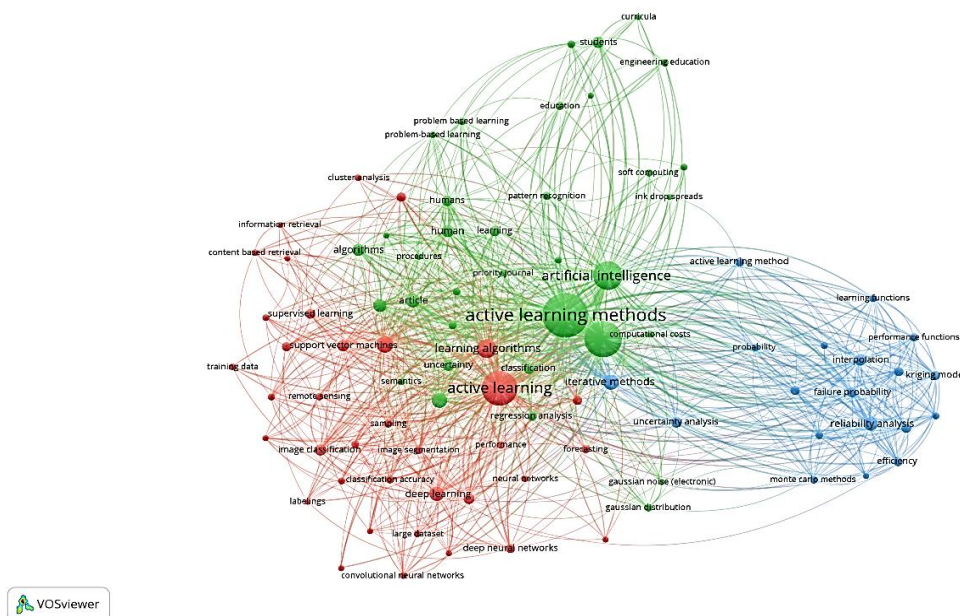
Network Analysis

Figure 9. Network analysis

Figure 9 is the result of network analysis (VOSviewer) from research related to the theme of active learning methods, with a minimum cluster of 18. Figure 9 shows that there are 3 clusters formed, namely red, green, and blue. In cluster 1 marked in red has 36 keyword items with the main keyword is active learning. Cluster 2 marked in green has 36 keyword items with the main keyword being active learning methods. Cluster 3 is marked in blue and has 19 keyword items with the main keyword iterative methods.

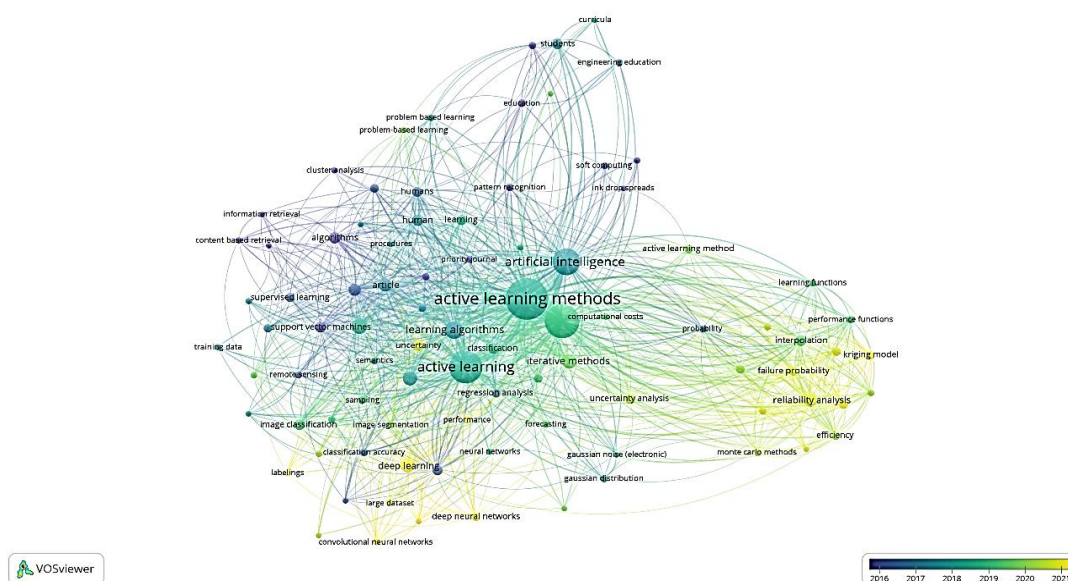### Overlay Network Analysis

Figure 10. Overlay network analysis

Figure 10 shows an analysis of keyword networks based on overlays marked with colors. The brighter the network color in the keyword, the keyword is the latest keyword in the current year. Meanwhile, the darker the network color in the keyword, indicating that the keyword is a keyword with relatively long use. Based on figure 10, the keywords deep learning, kriging model, reliability analysis are keywords with the latest usage, namely 2021, while the keywords supervised learning, teaching, cluster analysis are keywords with relatively long usage, namely 2016.
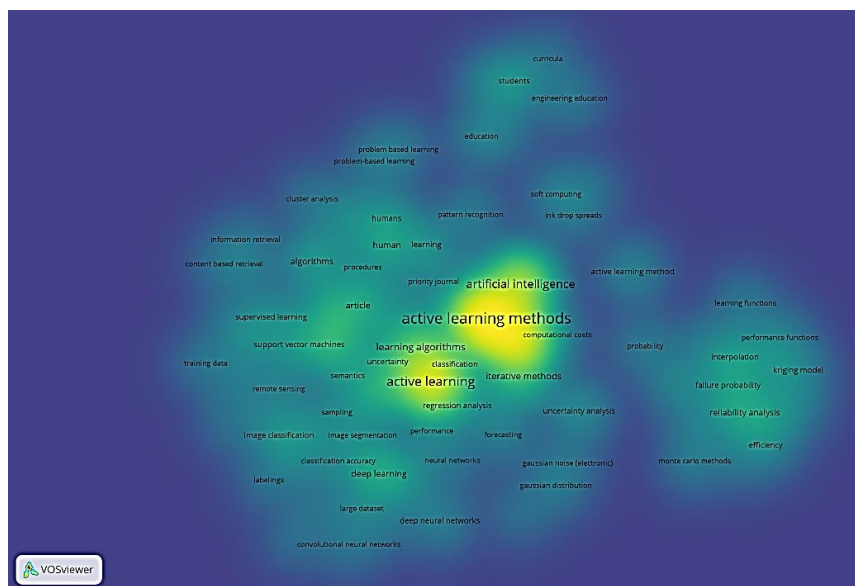
Network Density Analysis

Figure 11. Network density analysis

Figure 11 is the result of density analysis which is still included in network analysis using VOSviewer, so it can be seen that there are light-colored and dark-colored keywords. Keywords with light colors are many keywords and are often researched such as the words active learning methods, learning systems, and artificial intelligence. While keywords with dim colors and low density are keywords that are rarely researched such as cluster analysis, pattern recognition, and learning functions.

The Occurrence in Each Cluster

Table 3. Occurrence in each cluster

No	Keyword	Occurrence	Cluster
1.	Active learning	197	1
2.	Active learning algorithm	20	1
3.	Classification (of information)	45	1
4.	Cluster analysis	8	1
5.	Deep learning	34	1
6.	Learning algorithms	57	1
7.	Supervised learning	17	1
8.	Batch mode active learning	9	1
9.	Performance	11	1
10.	Semi-supervised learning	15	1
11.	Active learning methods	318	2
12	Active learning strategies	12	2
13.	Algorithm	27	2
14.	e-learning	7	2

15.	Education	13	2
16.	Learning	20	2
17.	Learning system	213	2
18.	Machine learning	39	2
19.	Students	22	2
20.	Teaching	11	2
21.	Active learning methods	15	3
22.	Iterative methods	39	3
23.	Kriging model	15	3
24.	Learning functions	10	3
25.	Numerical methods	10	3
26.	Kriging	14	3
27.	Performance functions	12	3
28.	Efficiency	14	3
29.	Probability	11	3
30.	Reliability analysis	31	3

Table 3 shows the occurrence in each cluster that represents the main theme of research in the field of active learning methods. The first cluster has a theme related to learning. The second cluster is still in the context of themes related to active learning in education. While the theme in the third cluster is related to learning methods.

Discussion

Based on the research results, cluster one covers a variety of keywords. The keyword "Active learning algorithm" on cluster one refers to a specific set of procedures and techniques used to implement active learning. Active learning algorithms determine how data points are selected for labeling and how the model learning process is guided by iteratively selecting the most informative data points. The word "Learning algorithm" encompasses the various techniques and methodologies used to train machine learning models. These algorithms determine how models adjust their parameters based on input data to make predictions. The word "Deep learning" is a subfield of machine learning that deals with neural networks consisting of several layers (deep neural networks). The word "Active learning" is a machine learning approach in which the model actively selects data points for labeling. It's an iterative process that leverages human or automated labeling to focus on the most informative data. The word "batch mode active learning" is a special approach to active learning that chooses to label data points in groups or groups instead of individually. This method is used if bulk labeling of data is more efficient. The word "Supervised learning" is a type of machine learning in which models are trained on labeled datasets. It involves mapping input data to known output labels. It is commonly used in tasks such as image classification, spam detection, and sentiment analysis. The keyword "Semi-supervised learning" is a learning paradigm that combines elements of supervised and unsupervised learning. It involves training the model on a dataset that contains a mix of labeled and unlabeled data. The keywords on cluster one cover a broad spectrum of machine learning concepts, ranging from the basic building blocks of learning algorithms to specialized techniques such as active learning, deep learning, and semi-supervised learning.

In cluster two, it can be analyzed that the keyword "Active learning method" refers to teaching and learning techniques that involve students in learning poses. This theme emphasizes the importance of fostering a dynamic and interactive educational environment, as this method generally encourages students to participate, collaborate, and apply what they

have learned. The keyword "Active learning strategies" includes a variety of techniques and approaches designed to increase student engagement in learning. Strategies can include problem-based learning, group discussions, hands-on activities, and more. The word "Algorithm" is a collection of step-by-step instructions used in e-learning and machine learning. In the context of active learning, algorithms play an important role in selecting the most informative training examples for machine learning models. The word "E-learning" refers to electronic learning, which involves the use of digital technology and the internet for educational and training purposes. This theme highlights the role of e-learning platforms and technologies in facilitating active learning and enhancing the educational experience. The keyword "Machine learning" is a subset of artificial intelligence that focuses on developing algorithms and models that allow computers to learn from data and make predictions or decisions. In an educational context, machine learning can be used to personalize the learning experience and adapt to student needs, aligning with the theme of active learning. The theme analysis in cluster two revolves around the intersection of active learning methods, strategies, and technology-based components such as algorithms and machine learning in a broader educational context.

In cluster three, the term "Active learning method" is an educational strategy that always involves students in the learning process, and encourages their interaction and participation. If understood in the context of probabilistic modeling, active learning can involve students actively participating in the decision-making process, thereby improving their understanding of probability analysis and reliability. The word "Iterative method" is a mathematical technique used to estimate solutions to complex problems through successive refinements. In the context of numerical analysis, iterative methods can play an important role in improving the efficiency and accuracy of probabilistic modeling techniques such as krigging models. The word "Kriging model" can be known as a statistical interpolation method used to estimate values in spatial or temporal data. This theme emphasizes the application of kriging models in probabilistic modeling, especially for spatial data analysis, where active learning and iterative methods can be used to improve prediction. Later, the word "Numerical method" encompassed various techniques for solving mathematical and statistical problems using computers. This method is essential for probabilistic modeling and may involve an iterative process to accurately calculate probabilistic results. Probability is a basic concept in probabilistic modeling, representing the likelihood of various outcomes. Active learning can be used to enhance students' understanding of probability theory and its role in reliability analysis. The theme analysis in cluster three focuses on the convergence of active learning methods, iterative techniques, and numerical methods in the context of probabilistic modeling, especially to improve efficiency, understand probabilities, and perform reliability analysis.

The results of this study show that bibliometric analysis by investigating the latest research, namely research with the keywords deep learning, kriging model, reliability analysis can have implications in helping the development of more effective active learning methods, namely by using deep learning, the system can identify unique learning patterns and student tendencies. This allows for a better learning process, by tailoring learning materials according to individual needs and levels of understanding. Reliability analysis can help gauge the extent to which learning outcomes are reliable. It helps teachers and students to understand the extent to which test or evaluation results reflect students' true knowledge. Kriging can help in modeling students progress over time and provide predictions regarding their future achievements. It can be a useful tool for individual learning planning. Identifying research trends can help develop more effective active learning methods. Recent research investigations can provide

insight into the best techniques and strategies for applying active learning methods. Through this bibliometric analysis, variations and innovations can be found in the application of active learning methods in various contexts and subjects. The results of bibliometric research can also be helpful in identifying concepts or topics that are most often emphasized in the context of active learning methods. Teachers and educators can also use research findings to improve their understanding of active learning methods and incorporate them into their teaching practices.

Further research is needed because of the limitations in this study, namely the author only takes publication data that has been successfully indexed by Scopus. This research is limited to only English documents with document types, namely articles and journals as document sources so that the final document amounts to 318 documents. Therefore, the scope of search can be expanded by taking meta data derived from WoS (Web of Science). Researchers can also expand the scope of search by not limited to only English documents, article document types and journals as document sources so that understanding of active learning methods can be more comprehensive and in-depth.

Conclusion

Based on the results of the analysis above, it can be concluded that there are 318 research documents with the theme of active learning methods collected for 24 years. Research with this theme was the most researched in 2020 with a total of 49 documents. Shouraki, S.B is the most influential author and his work was successfully published and indexed by Scopus. Sharif University of Technology is the most widely and influential institution in publishing research in the field of active learning methods. China is the country that publishes the most scientific publications with the theme of active learning methods. Iee Access Journal is the journal that publishes the most research on this theme. Based on the three-field plot, Li, H. is the author who writes the most articles with the theme of active learning methods. China is the country that has the most MCP and SCP. Paper Yi L, 2016, Acm Trans Graphics is the paper that has the most total citations, with a total citation of 592. Based on the results of network analysis, research occurs with the theme of active learning methods, there are 3 clusters formed. Research with the keywords deep learning, kriging model, reliability analysis are keywords with the latest usage, namely 2021. The keywords active learning methods, learning systems, and artificial intelligence are keywords that have a high level of density and are often researched.

This research contributes to the research of mapping active learning methods by dividing three main themes in each cluster. The limitation in this study is that the author only took publication data that was successfully indexed by Scopus. This research is limited to only English documents with document types, namely articles and journals as document sources so that the final document amounts to 318 documents. Therefore, there needs to be a further research that is not limited to Scopus. The scope of the search can be expanded by retrieving meta data derived from WoS (Web of Science). Researchers can also expand the scope of search by not limited to only English documents, article document types and journals as document sources so that understanding of active learning methods can be more comprehensive and in-depth.

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