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Bibliometric Analysis: Artificial Intelligence (AI) in High School Education

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ABSTRAK

Salah satu teknologi yang dapat digunakan dalam dunia pendidikan adalah Artificial Intelligence (AI). Kecerdasan buatan (AI) adalah kemampuan mesin atau program komputer untuk meniru atau melakukan tugas yang biasanya membutuhkan kecerdasan manusia, seperti pengambilan keputusan, pengenalan ucapan atau gambar, dan pemecahan masalah. Tujuan dari penelitian ini adalah untuk menganalisis publikasi terkait Artificial Intelligence (AI) di Sekolah Menengah dan mendeskripsikan karakteristik dari penelitian ini. Metode yang digunakan adalah analisis bibliometrik deskriptif. Database Scopus digunakan untuk mendapatkan data yang diperlukan. Hasil riset menunjukkan bahwa publikasi meningkat dari 9 pada tahun 2021 menjadi 20 pada tahun 2020. Publikasi pada tahun 2010 paling banyak disitasi dibandingkan tahun lainnya. Cina adalah negara yang paling berpengaruh di bidang ini. Publikasi penelitian Artificial Intelligence yang diterapkan pada siswa SMA terbanyak berada pada peringkat Q1 yaitu sebanyak 25 jurnal. Tema baru di bidang ini adalah pembelajaran mesin dan pembelajaran mendalam. Kecerdasan Buatan belum berhubungan langsung dengan beberapa kata kunci kluster ketiga seperti Literasi Kecerdasan Buatan, pendidikan ilmu komputer, dan konsepsi.

ABSTRACT

One of the technologies that can be used in education is Artificial Intelligence (AI). Artificial intelligence (AI) is the ability of machines or computer programs to imitate or perform tasks that normally require human intelligence, such as decision-making, speech or image recognition, and problem-solving. The purpose of this research is to analyze publications related to Artificial Intelligence (AI) in Middle Schools and to describe the characteristics of this research. The method used is descriptive bibliometric analysis. The Scopus database is used to obtain the necessary data. The research results show that publications have increased from 9 in 2021 to 20 in 2020. Publications in 2010 have been cited more than any other year. China is the most influential country in this field. Most publications on Artificial Intelligence research applied to high school students are at the Q1 rank, namely 25 journals. New themes in this field are machine learning and deep learning. Artificial Intelligence has not been directly connected with some third clusters keywords such as Artificial Intelligence Literacy, computer science education, and conception.

1. INTRODUCTION

The digitalization era is when digital technology has changed how humans interact, work, and carry out their daily activities (Halid et al., 2020; Machkour & Abriane, 2020; Rahmatullah et al., 2022). The digital era began with the advent of information and communication technology (ICT), such as computers, the internet, smartphones, and social media, that changed how humans obtain information, communicate and interact with the world (Geelan, 2021; Prodani et al., 2019). This phenomenon has been happening since the 1950s, but its development is accelerating along with increasing technological capabilities and accessibility (Autor et al., 2020; Hantrais et al., 2021). The era of digitalization can also be interpreted as a stage where the tendency of life supported by digital technology is increasingly dominant.

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This era also created drastic changes that affected various aspects of human life, such as industry, government, society, economy, and culture (Alraouf, 2021; Robandi et al., 2019). Along with the development of the digital era, the term Industry 4.0 emerged, which refers to the use of digital technology in the industry, especially in manufacturing (Aheleroff et al., 2021; Núñez-Merino et al., 2020). Industry 4.0 enables the production of more efficient, fast, and quality goods and services, as well as expanding markets and business opportunities (Dutta et al., 2020; Sima et al., 2020). This creates substantial economic benefits and significant changes in industry and business due to adoption of digital technology and automation. Industries and businesses are taking advantage of technologies such as artificial intelligence, robotics, and big data to improve efficiency, productivity, and the quality of their products and services (Jagatheesaperumal et al., 2022; Misra et al., 2022).

In addition, the digital era has also brought changes to the social system, especially in terms of interaction and communication (Bak-Coleman et al., 2021; Yarchi et al., 2021). With social media, one can easily interact with other people from all over the world and obtain more and faster information. However, this phenomenon also causes polarization of opinion, the spread of false or harmful information, and privacy issues. The digital era has also changed the way of learning and getting an education (Bojović et al., 2020; Dhawan, 2020). Now, many educational institutions are using digital technology to improve the quality of learning and provide a more interactive and innovative learning experience. Students can also access learning materials and resources online from anywhere and anytime so that learning can be done flexibly. One of the technologies that can be used in education is Artificial Intelligence (AI). Artificial Intelligence (AI) is the ability of machines or computer programs to imitate or perform tasks that usually require human intelligence, such as decision-making, speech or image recognition, and problem-solving (Pettersen, 2019; Zhang & Lu, 2021). AI uses advanced algorithms and technologies, such as machine learning, natural language processing, and neural networks, to collect, analyze, and process data quickly and efficiently. Artificial Intelligence (AI) and education are closely linked because AI can positively impact how we learn and teach (Machmud et al., 2021; Rodríguez-García et al., 2021). As a technology that can process and analyze data with high speed and accuracy, AI can help identify patterns and trends in learning, provide recommendations tailored to student needs, and increase the education system's effectiveness as a whole. One of the positive impacts of using AI in education is the personalization of learning. By utilizing AI technology, teachers can provide learning experiences tailored to each student's needs and abilities. AI systems can recommend appropriate learning materials and provide personalized feedback by monitoring student performance and gathering data about their learning preferences (Lee et al., 2021; Ouyang et al., 2022).

In addition, AI can also help speed up the process of assessing and supervising exams. Using sound and image monitoring technology, AI can help oversee online exams and speed up grading (Babitha et al., 2022; Jagatheesaperumal et al., 2022). Teachers can administer exams safely and efficiently without spending time and effort checking and correcting every answer. AI can also help improve the overall quality of learning by enabling teachers and education stakeholders to collect and analyze learning data, such as student performance and curriculum progress. By systematically collecting data, AI systems can help identify patterns and trends in learning and provide tailored recommendations to improve the education system's effectiveness (Megahed et al., 2022; Sanjaya & Divayana, 2015). AI is also widely used in more specialized education such as secondary education. However, the use of AI in education also has challenges and risks, such as the inability of AI to replace complex human interactions and surveillance of student data and privacy, especially in secondary education (Berendt et al., 2020; Reis et al., 2020). Therefore, using AI in secondary education must be carried out carefully and responsibly to maximize its benefits and minimize its risks and negative impacts on students (Babitha et al., 2022; Seo et al., 2021). The results of research related to artificial intelligence need to be analyzed. Bibliometric analysis can be carried out to analyze the results of publications in certain fields, especially in the field of education, such as in the field of economics (Triansyah et al., 2022; Triansyah & Supardi, 2023), communication (Sanusi et al., 2023), and the field of mathematics education (Muhammad et al., 2022, 2023; Muhammad & Mukhibin, 2023) and other fields. The novelty of this study looks at how Artificial Intelligence (AI) is applied in middle schools through a bibliometric approach and is different from previous research which examined 35 students and eight teachers from secondary schools with the aim of Creation and Evaluation of a Pretertiary Artificial Intelligence (AI) Curriculum results showing that students perceive greater competence and develop more positive attitudes towards learning AI and the co-creation process increases teachers' knowledge of AI, as well as fosters teacher autonomy in bringing subject matter into their classrooms (Chiu et al., 2022). Furthermore research also conducted on Possibilities and Concerns in the Landscape of Artificial Intelligence in Education whose results show that AI (and related technological advances) will replace some professions (didactics are not needed), that other professions will change impressively (didactic materials need to be updated) , and a large number of new calls will be made (Alam,

2021). This study aims to analyze publications related to Artificial Intelligence (AI) in Middle School and describe the characteristics of this research. Bibliometric analysis was used in this study to explore the characteristics of the publications of Artificial Intelligence (AI) in Middle School and related factors and to analyze the trend of research focus in this field.

2. METHOD

This study uses a bibliometric analysis method. The bibliometric analysis research method answers research questions by looking at research developments and literature. The analysis used is evaluative and descriptive bibliometric analysis. The sample in this study were 50 publications obtained from the Scopus database that matched the specified keywords. Researchers used the Scopus database to search for data sources related to "Artificial Intelligence in high school students" because of its broad interdisciplinary coverage There are several steps in perfecting the data that has been collected. The first is identification, screening, eligibility and finally, the inclusion step (Moher et al., 2009). Data collection process is show in Figure 1.

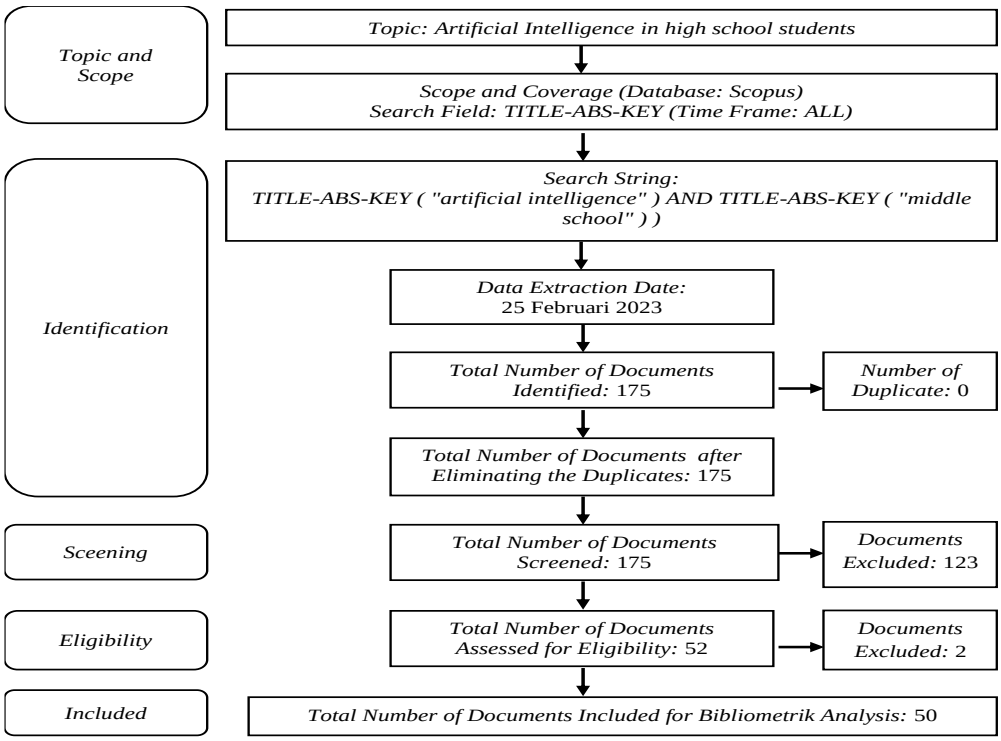

Figure 1. Data Collection Process

In Figure 1, it can be seen that the first step in the data collection process is the identification process. The researcher enters keywords in the search on the Scopus database. The keywords entered are ("Artificial Intelligence ") AND ("middle school"). The results of this identification obtained publication data for 175 articles. The next step is the screening process. Namely, the researcher screens according to the criteria. Namely, publications must be in English and must be in the form of articles published in journals. From the results of this screening, 52 publications were obtained that met the above criteria. This means 123 publications have been discarded and not continued in the next process.

Publication of screening results then carried out the feasibility process. In this process, the researcher does it manually regarding publications that are eligible to be included in the included stage. The researcher looked at the abstracts and titles of 52 publications and assessed publications that contained or included the Artificial Intelligence variable in high school students. At the end of this third phase, 50 publications were obtained that were eligible for inclusion in the next stage. The trend of publications related to Artificial Intelligence applied to high school students is carried out by descriptive analysis taken from the Scopus database using bibliometric analysis. The number of publications and a linear line of publication trends each year from 1997 to 2023 will be displayed in a graph using Microsoft excel software. Publication trends and citation trends related to Artificial Intelligence for high school

students are separated by the year starting from 1997 to 2023. The number of publications each year is displayed with diagrams with the help of Microsoft Excel software. Then the average publication citations are also calculated using Microsoft Excel software. PoP software is used to calculate the h-index and g-index of publications easily. The geographical distribution of countries and subject areas is displayed with the help of Microsoft Excel software. However, to see cooperation between countries, researchers use the VOSviewer application. Researchers use Microsoft Excel software to display journal rankings based on quartile values to display journal ranking diagrams. The data that has been obtained from the Scopus database of 50 publications will be grouped based on (Q1), (Q2), (Q3), and (Q4). This shows that 50 publications obtained related to Artificial Intelligence applied to high school students have been published in the journal ranking above. The focus of research related to Artificial Intelligence which is applied to high school students, is carried out with the help of the Vosviewer application by analyzing events with keywords. The researcher sets a threshold for displaying the research focus. Namely, the researcher sets a minimum of 2 publications that use the keywords together.

3. RESULT AND DISCUSSION

Result

Publications related to Artificial Intelligence were applied to high school students who had gone through a data collection process so that 50 publications were obtained from 1997 to 2023, which met the criteria, then carried out a descriptive bibliometric analysis. Publication trends, citation trends, distribution of countries and journals and research focus will be discussed further.

What are the trends in publications and citations related to Artificial Intelligence applied to high school students?

The trend of publications related to Artificial Intelligence applied to high school students from 1997 to 2023. A total of 50 publications are grouped by year of publication which can be seen in Figure 2.

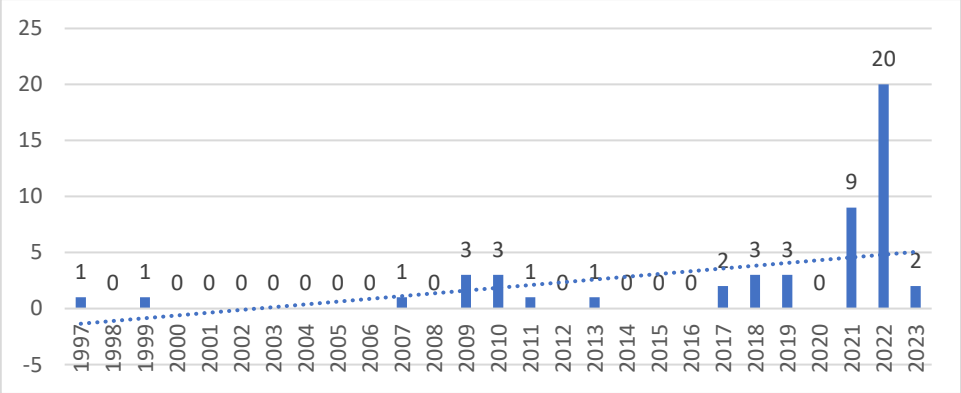

Figure 2. Publication Trends (1997-2023)

Base on Figure 2 it can be seen that in 2022 there were 20 articles published. This is the highest number of publications compared to other years. Judging from the trend line, it can be seen that publications go up and down every year. It can also be seen that in 2020 there has been no publication regarding Artificial Intelligence at the high school level. A rapid increase in the number of publications occurred from 2021 to 2022, namely from initially only nine publications increased to 20. The trend of citations related to Artificial Intelligence applied to high school students from 1997 to 2023. As with publication trends, as many as 50 publications are grouped by year of publication which will then be seen based on total publications per year, NCP, TC, C/P and others which can be seen in Table 1.

Tabel 1. Citation Analysis of Publications

Year	TP	NCP	TC	C/P	C/CP	h	g
2023	2	0	0	0	0	0	0
2022	20	8	29	1.45	3.6	3	5
2021	9	7	30	3.33	4.3	4	5
2020	0	0	0	0	0	0	0
2019	3	3	68	22.7	23	3	3

Year	TP	NCP	TC	C/P	C/CP	h	g
2018	3	1	18	6	18	1	3
2017	2	2	16	8	8	2	2
2016	0	0	0	0	0	0	0
2015	0	0	0	0	0	0	0
2014	0	0	0	0	0	0	0
2013	1	1	15	15	15	1	1
2012	0	0	0	0	0	0	0
2011	1	1	102	102	102	1	1
2010	3	3	132	44	44	1	3
2009	3	3	19	6.33	6.3	2	3
2008	0	0	0	0	0	0	0
2007	1	1	4	4	4	1	1
2000-2006	0	0	0	0	0	0	0
1999	1	1	127	127	127	1	1
1998	0	0	0	0	0	0	0
1997	1	1	1	1	1	1	1

Base on Table 1 shows that the value (NCP) in 2022, which is 8, is the year with the highest NCP compared to other years. Then if seen from the number of citations, publications in 2010 have been cited more than any other year, namely with 132 citations. Even though the number of publications and NCP in 2022 is greater than in other years, 2021 will provide a large research impact due to the highest h-index and g-index values. Many years had few citations, namely from 2000 to 2006. This was because, in those years, no publications related to Artificial Intelligence in middle school met the researcher's inclusion criteria. The highest h-index and g-index values were published in 2017, with h-index = 4 and g-index = 5. So it can be said that 2021 will greatly impact this research. Nine publications in 2021 have 30 citations. To see citation trends related to this field, researchers sort publications based on the number of citations which can be seen in Table 2.

Table 2. Articles with the Most Citations

No	*Author (year)*	*Citation*
1	(Grimes & Warschauer, 2010)	130
2	(Lester et al., 1999)	127
3	(Vattam et al., 2011)	102
4	(Bin & Mandal, 2019)	56
5	(Sahin et al., 2018)	18

How is the geographical distribution of publications and patterns of cooperation between countries in research related to Artificial Intelligence applied to high school students?

The country shown in Figure 2 below is the country of origin of the publication author. Geographically, the distribution from the author's country of origin can be seen in Figure 3.

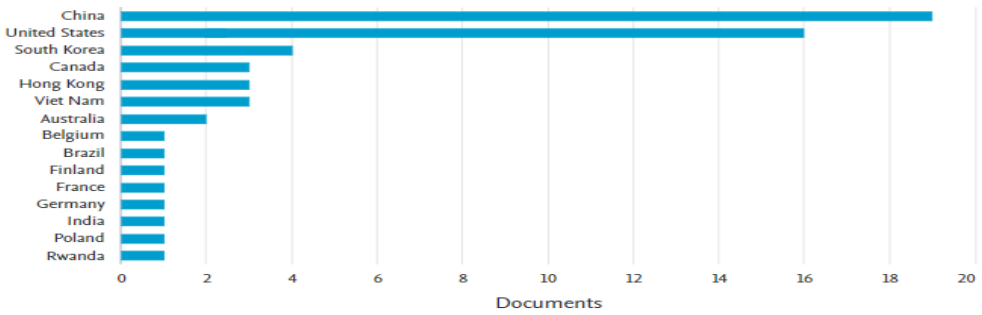

Figure 3. Geographic Distribution

Figure 3 shows that China is the most influential country in relation to Artificial Intelligence research applied to high school students. This can be seen in the many publications from China, which have published 19 documents related to this field. In second place is the United States which is the country that has the second influence on Artificial Intelligence research on high school students, namely with 16 documents that have been published. The Americas, Asia, Australia and Europe and Africa are continents that have published documents related to Artificial Intelligence for high school students. This means that all continents contribute to research in this field. The Asian continent is the most influential in this field because it has published 27 documents. This number is higher than publications from other continents. This means that China is the country that has the greatest impact on research in this field. The pattern of collaboration between countries can be seen in Figure 3 below. Researchers do not set a threshold at this stage. This means that countries that only have 1 document related to this field will be displayed, but if that country has no cooperative relations with other countries, it will not be displayed. The pattern of relations between countries is show in Figure 4.

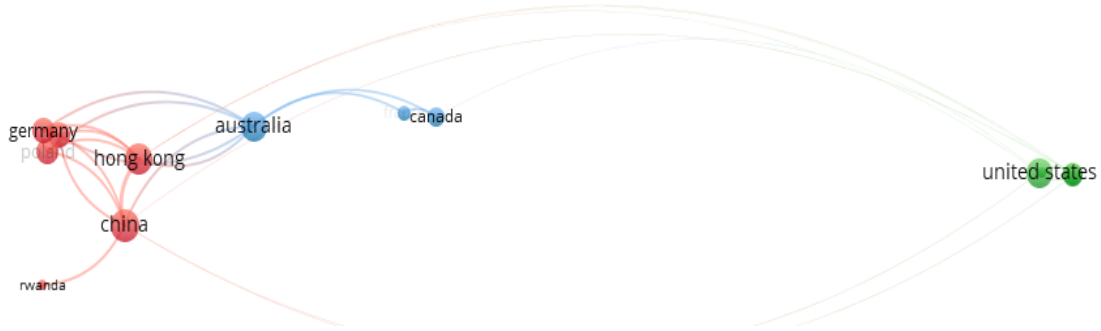

Figure 4. The Pattern of Relations Between Countries

From Figure 4, it can be seen that the Chinese circle has the largest circle diameter when compared to other countries. This shows that the country has the highest level of cooperative relations. Then followed by Hong Kong. The VOSviewer display shows that China has collaborated with nine other countries, followed by Hong Kong with a total of 8 links, meaning that Hong Kong has collaborated with eight other countries.

How is the distribution of journal rankings based on quartile scores related to Artificial Intelligence which is applied to high school students?

The distribution of journal rankings can be seen from the quartile (Q) value of journals related to publications related to Artificial Intelligence in high schools. Journal rankings can be seen on the scimagojr website. Ranking based on Journal quartile values is show in Figure 5.

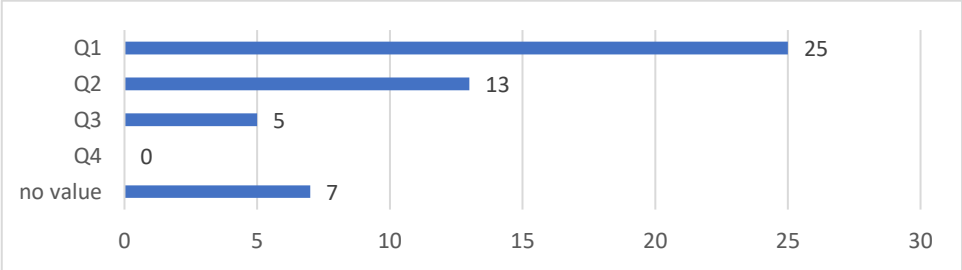

Figure 5. Ranking Based on Journal Quartile Values

Figure 5 shows that most publications in journals related to Artificial Intelligence research applied to high school students are mostly at the Q1 ranking, namely 25 journals. In second place is a journal with a Q2 rating of 13 articles. Journals that still need to have quartiles are seven articles each. Seven articles are still published in journals that do not have a quartile value. This means that writing articles still need to be improved so that authors of articles related to this field can publish them in

journals with a quartile value. Of the 50 articles, 37 journals have a quartile value or not, which can be seen in Table 3.

Table 3. Articles Related to This Field Can Publish Them in Journals with A Quartile Value

Journal Name	Quartile Value	Amount
Agro Food Industry Hi-Tech	-	1
AI Magazine	Q2	1
Applied Bionics and Biomechanics	Q3	1
Archives of Design Research	Q1	1
Asia Life Sciences	-	1
Asia-Pacific Science Education	Q2	1
Complexity	Q1	1
Computers and Education: Artificial Intelligence	Q1	2
Decision Support Systems	Q1	1
Education and Information Technologies	Q1	5
Educational Technology and Society	Q1	1
Environmental Research	Q1	1
Frontiers in Education	Q2	1
Frontiers in Psychology	Q1	3
Interactive Technology and Smart Education	Q2	1
International Journal of Artificial Intelligence in Education	Q1	4
International Journal of Emerging Technologies in Learning	Q1	1
International Journal of Engineering Education	Q2	1
International Journal of Social Robotics	Q1	1
IT - Information Technology	Q3	1
Journal of Computational Information Systems	-	1
Journal of Educational Multimedia and Hypermedia	Q3	1
Journal of Engineering Education Transformations	Q3	1
Journal of Environmental and Public Health	Q2	1
Journal of Intelligent and Fuzzy Systems	Q2	1
Journal of Research in Science Teaching	Q1	1
Journal of Supercomputing	Q2	1
Journal of Technology, Learning, and Assessment	-	1
Journal of the American Society for Information Science and Technology	-	1
KI - Kunstliche Intelligenz	Q2	2
Mobile Information Systems	Q2	2
Participatory Educational Research	Q3	1
PeerJ	Q1	1
Sustainability (Switzerland)	Q1	1
User Modeling and User-Adapted Interaction	Q1	1
Wireless Communications and Mobile Computing	Q2	1
World Academy of Science, Engineering and Technology	-	2

From Table 3, the journal that has published the most articles, namely "Education and Information Technologies", has a Q1 quartile value. The publisher of the journal is Kluwer Academic Publishers from the United States. The journals in table 3 can be a reference for researchers who want to publish articles related to Artificial Intelligence, especially in education.

How is the distribution of subject areas related to Artificial Intelligence, especially among high school students?

Research related to Artificial Intelligence, especially in Education, has been carried out a lot. In this study 50 articles were collected according to predetermined inclusion criteria. Of the 50 articles various subject areas were identified, this can be seen in Figure 6.

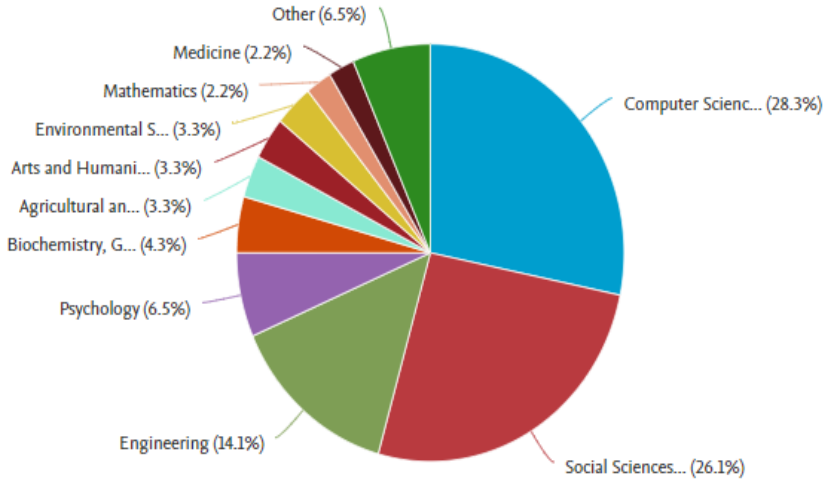

Figure 6. Documents by Subject Area

Base on Figure 6, Computer Science is the subject area with the highest number of documents, with 26 documents, followed by Social Sciences, with 24 documents. These two subject areas contain half the entire documents (Computer Science, 28.3% and Social Sciences, 26.1%. The citation trends section has discussed examples of research on subject areas such as (Grimes & Warschauer, 2010). As for research in Social (Vattam et al., 2011), which understands complex natural systems by articulating a structure-behaviour-function model Artificial Intelligence Research on creative design has led to the Structure-Behavior-Function (SBF) model, which emphasizes function as an abstraction for governs the understanding of physical systems.

What is the focus of research related to Artificial Intelligence especially in high school students?

Researchers do not set a threshold at this stage because the keywords that appear are few. Of the 50 keyword articles, after the screening stage, keywords that go far off the mark will be removed, and in the end, 22 keywords, as shown in Figure 7.

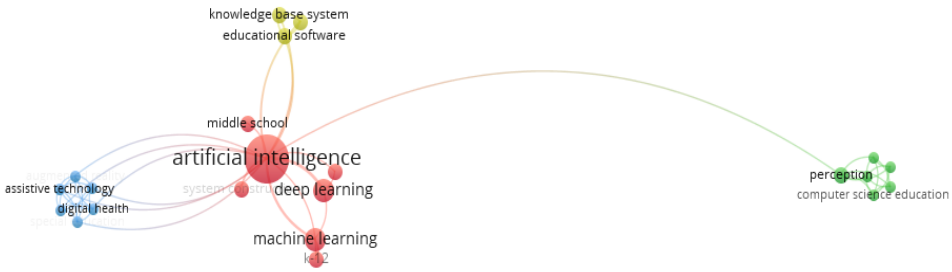

Figure 7. Keyword Co-Occurrence (Occurrence Threshold ≥ 3)

The research focus can be seen from the clusters shown in Figure 7. It can be seen that there are several different colours. This colour indicates a research cluster related to Artificial Intelligence in secondary schools. There are four clusters. Namely, red is the largest cluster, followed by green, blue and yellow. This means that the research focus is divided into four parts, namely 1) The first cluster (in red) consists of 7 items. When viewed from the circle size in this first cluster, the keywords with the largest diameter are Artificial Intelligence, deep learning, and machine learning. These keywords are the focus of the first research together with middle school; 2) The second cluster (coloured green) consists of 6 items. The keywords perception and computer science-education are the largest circle in the cluster, meaning that these keywords are the focus of the second research together with Artificial Intelligence; 3) The third cluster (coloured blue) consists of 6 items; all four keywords have the same occurrence; 3) The fourth cluster (yellow) consists of 3 items, the three keywords also have the same number of occurrences.

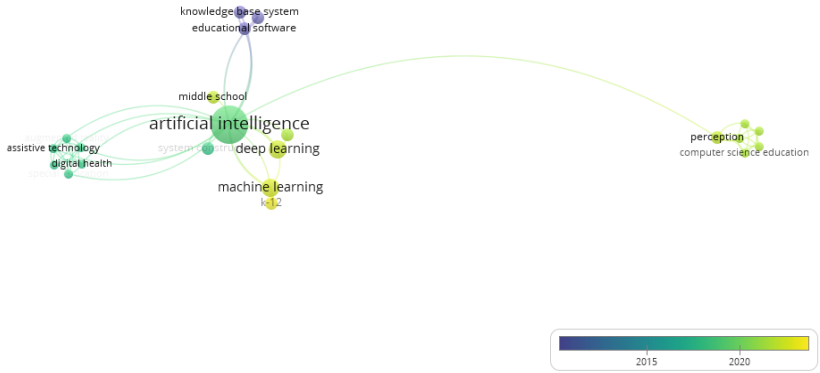

Figure 8. Overlay Visialization

Base on Figure 8, yellow circles indicate keywords that are the new theme. In figure 8, the keywords that are new themes in this field are machine learning, deep learning, and middle school. Novelty can be seen from the relationship between keywords. In Figures 7 and 8, the keywords Artificial Intelligence are not directly connected with some of the third clusters keywords such as Artificial Intelligence Literacy, computer science-education, and conception. This new and novel theme is very useful for further research in setting research themes related to this field.

Discussion

Base on the result publications have increased from 9 in 2021 to 20 in 2020. Publications in 2010 have been cited more than any other year, with 132 citations. China is the most influential country in this field. Most publications on Artificial Intelligence research applied to high school students are at the Q1 rank, namely 25 journals. The research focus is divided into four parts. Computer science and social science are the subject areas with the highest number of documents. New themes in this field are machine learning and deep learning. Artificial Intelligence is not directly connected with some third clusters keywords such as Artificial Intelligence Literacy, computer science education, and conception. The first research focus is deep learning and machine learning, along with research themes, namely Artificial Intelligence and middle school. Previous study have conducted research related to Artificial Intelligence which links with deep learning (Rong et al., 2022; Wang et al., 2021; Wu & Wang, 2022). Other study evaluates the practical application value of teaching methods under the guidance of educational psychology and Artificial Intelligence (AI) design, using deep learning theory as a basis for teaching design (Wang et al., 2021). The research object of this research involved all teachers, students, and parents of Ningbo Middle School students. Meanwhile other study innovatively looks at deep learning and Artificial Intelligence applied to statistics and analysis of collected data (Wu & Wang, 2022).

Base on the result it the article with the title "Utility in a fallible tool: A multi-site case study of automated writing evaluation" (Grimes & Warschauer, 2010), has been cited 130 times, this is the document with the highest number of citations. The research examined automatic writing evaluation software (AWE) using Artificial Intelligence (AI) to assess student essays and support improvement. The article became the most cited because the researchers studied how an AWE program called MY Access was used in eight middle schools in Southern California over three years. Although many teachers and students find automated assessment unreliable, and teachers' use of AWE is limited by a desire to use conventional writing methods, the software still brings important benefits. Observations, interviews, and surveys show that using AWE simplifies classroom management and increases students' motivation to write and revise. For this reason, training is needed for teachers in using the software, and further research can pay more attention to teachers related to Artificial Intelligence (AI).

In this study also found that China is the most influential country regarding Artificial Intelligence (AI) in secondary schools, and this is because China has the largest number of documents and the highest level of cooperation. This follows by previous study who state that from the publishing trend, the number of papers published in the field of Artificial Intelligence (AI) is growing rapidly (Rong et al., 2022). China and the United States are among the top countries in scientific research paper results, and India has the fastest cumulative growth rate. The limitation of this study is that data was taken only from the Scopus database on February 25, 2023, meaning that data or articles published after that date are not included in this analysis and may experience slight differences.

4. CONCLUSION

Based on the results and discussion, it can be concluded that publications have increased from 9 in 2021 to 20 in 2020. Publications in 2010 have been cited more than any other year, with 132 citations. China is the most influential country in this field. Most publications on Artificial Intelligence research applied to high school students are at the Q1 rank, namely 25 journals. The research focus is divided into four parts. Computer science and social science are the subject areas with the highest number of documents. New themes in this field are machine learning and deep learning. Artificial Intelligence is not directly connected with some third clusters keywords such as Artificial Intelligence Literacy, computer science education, and conception.

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