# Augmented Reality Research in Middle Schools: Bibliometric Review

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## ARTICLE INFO

## ABSTRACT

Augmented Reality is a technology that helps 3D virtual objects to be viewed interactively in the real world. Implementing Augmented Reality into the learning process has a great opportunity to get various benefits. The purpose of this study is to capture research landscapes related to Augmented Reality in high school learning from 2009 to 2023. The method used is bibliometric analysis. The database used in collecting the necessary related information is the Scopus database. Augmented Reality research publications in secondary schools from 2009 to 2023 have experienced an increase in recent years. The highest number of citations was in 2013. The United States and China are the most influential countries in this field. The focus of research related to Augmented Reality in secondary schools is 1) technology, motivation, and environment; 2) games and interests; 3) achievement and development. The keyword Augmented Reality is not directly related to science learning. The game keywords are not directly related to the outcomes keywords. This novelty can be useful for further research examining a theme similar to this research. The new themes related to this field are science learning, mathematics education, concepts, and spatial abilities.

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## 1. INTRODUCTION

Augmented Reality (AR) is the latest technology that can link digital information to a real environment (Castañeda et al., 2018; Hussein, 2022). According to (Hsiao & Chang, 2016), besides combining the virtual and real worlds, Augmented Reality also adds virtual objects such as images, videos, and three-dimensional (3D) objects into the real world. Meanwhile, according to (Dutta, Mantri, & Singh, 2022), Augmented Reality is a technology that helps 3D virtual objects to be viewed

interactively in the real world. So, Augmented Reality is a technology in learning that displays digital information and objects in the real world.

Augmented Reality (AR) has become a trend for many developer applications. Besides that, it also increases users' insight into the real world (Alamäki et al., 2021; Borgohain et al., 2022; Chen et al., 2019; Sungkur et al., 2016). Augmented Reality is a technology that is increasingly being used in Education (Hanid et al., 2020; Hedenqvist et al., 2021; Medina & Ferrer, 2022). Augmented Reality can be used in learning, increasing the effectiveness of classroom teaching and mobile learning (Garrett et al., 2015; Li & Liu, 2022; Lorenzo et al., 2022).

Implementing Augmented Reality into the learning process has a great opportunity to get various benefits (Almenara & Vila, 2019; Patzer et al., 2014). The benefits of Augmented Reality in learning are that it can increase student attention and make students feel satisfied with what they have learned (Santos et al., 2016). Augmented Reality can improve students' computational thinking, students' visualization skills, and achievement of material topics that have been studied (Hanid et al., 2022). Augmented Reality can encourage students to cooperate and discuss concepts together (Sarkar et al., 2020).

In recent years, there has been an increase in the popularity of research interests related to Augmented Reality, and this is because mobile devices have provided users with simpler, cheaper, and more efficient access to using Augmented Reality than before (Dutta et al., 2022). So it is necessary to analyze studies related to Augmented Reality, especially among high school students. Bibliometric analysis can be used to analyze studies related to Augmented Reality in high school students.

Bibliometrics is a statistical method for analyzing publications (Muhammad, Marchy, et al., 2023; Phoong et al., 2022; Wang et al., 2021; Zhang et al., 2019; Zyoud et al., 2015). Bibliometrics is the basis for determining the most popular and significant publications in certain fields (Zyoud et al., 2022). This bibliometric research has been widely carried out, especially in the field of education (Muhammad, Himmawan, et al., 2023; Muhammad, Samosir, et al., 2023; Raidil et al., 2023; Triansyah et al., 2022; Triansyah & Supardi, 2023). Bibliometrics is a research method that has complete information by combining science, mathematics, and statistics in analyzing knowledge quantitatively (Muhammad, Mukhibin, et al., 2022; Zhang et al., 2019). So, bibliometrics is a statistical method that contains information related to publications used to analyze publications in certain fields.

Augmented Reality in learning can profoundly change Education (Bower et al., 2014). Research related to Augmented Reality in secondary schools is like research conducted by (Muhammad, Marchy, et al., 2022) regarding bibliometric analysis in learning, but this research focuses more on learning mathematics. This is the same as research conducted by (Kesim & Ozarslan, 2012) which also discusses bibliometric analysis in Augmented Reality research, which focuses on learning physics. In research conducted by (Karakus et al., 2019) regarding bibliometric analysis in Augmented Reality research in Education, the database used in this study was the web of science database, while the range of years analyzed in this study was from 1999 to 2018 Of the three previous studies related to this field, none has specifically discussed Augmented Reality research, especially in high schools, and no one has used the Scopus database to find the data needed.

The purpose of this study is to capture the research landscape related to Augmented Reality in high schools from 2009 to 2023 as follows:

a. What are the current trends in publications and citations related to Augmented Reality research in secondary schools?
b. What is the geographic distribution of publications and collaboration patterns between countries?
c.  What is the focus of research and novelty related to Augmented Reality in secondary schools?

## 2. METHODS

The method used in this research is bibliometric analysis. The database used to collect the required data is the Scopus database. According to (Moher et al., 2009), to improve data acquisition,

several processes must be carried out, namely, 1) identification; 2) screening; 3) eligibility 4) inclusion. The data acquisition process can be seen in Figure 1 as follows.
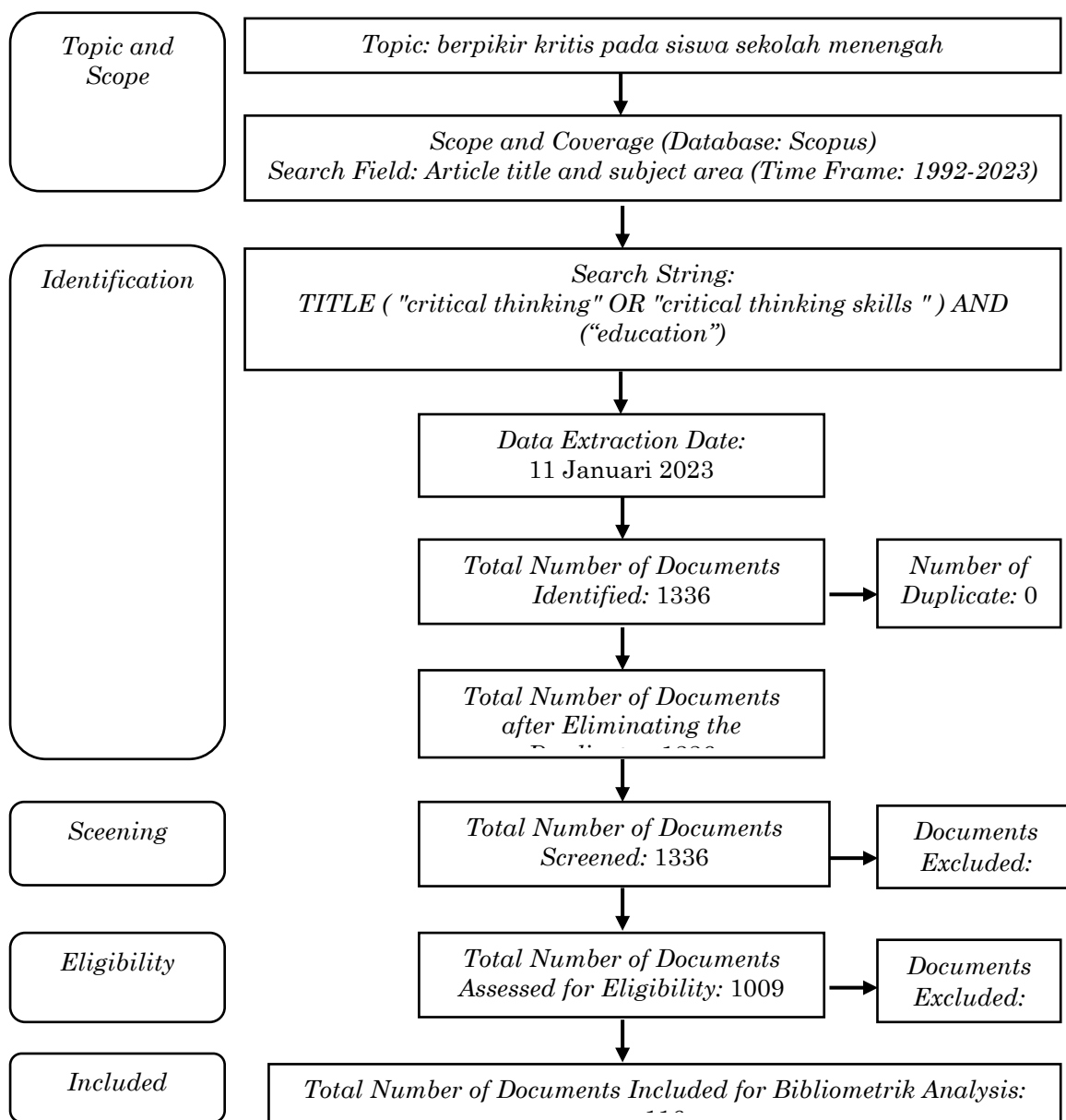


**Gambar 1.** Proses Pengumpulan Data

Identification was made by entering the appropriate keywords in the Scopus database. In this study, the keywords used were "Augmented Reality" and "education." From this process, the researchers obtained 469 publications according to the criteria. Next, the researcher screened the criteria, namely, 1) Publications must be in English; 2) Publication in the form of articles; 3) researchers take publications from the year of first appearance 417 publications met these criteria. Eligibility is carried out by looking at the abstract and title of the document, whether the title and abstract contain Augmented Reality in high schools or not. From this process, 43 documents were obtained matching the established criteria, and 43 were included in the stage.

**Data Analysis Method**

Researchers use several supporting applications in data analysis, such as VOSviewer, Harzing's Publish or Perish Software, and Microsoft Excel Software. The analysis was carried out to answer the

research questions. The included data is then stored in the form of RIS and CSV. RIS data is used to view publication and citation trends using Harzing's Publish or Perish Software. CSV data is used to view geographic mapping distribution, patterns of cooperation between countries, and research focus using the VOSviewer application.

Publication trends are seen based on the year of publication displayed with the help of Microsoft excel software. The quote trend is calculated from several values, such as NCP, TC, C/CP, and others. The distribution of geographic mapping is displayed on a flat map so that the distribution can be seen clearly with the help of Microsoft Excel software. State cooperation patterns are displayed to see relations between countries. The research focus is analyzed from the Network visualization and Overlay Visualization views. The novelty of research can be seen from the interrelationships between the keywords.

## 3. RESULT AND DISCUSSION

From figure 1 above, publications related to Augmented Reality in high schools have increased from 2019 to 2021. Most publications occurred in 2021. Judging from the linear line, the publication trend has increased from year to year. However, no documents were published in 2011, 2012, 2014, and 2015. The increase from 2019 to 2021 is 300%, or three times the previous year. Next, we will see the trend of citations related to Augmented Reality research in high schools from 2009 to 2022. Publications related to Augmented Reality in secondary schools from 2009 to 2023 are displayed geographically based on the author's country of origin. From Figure 2, it can be seen that the United States is a country that has published a lot, namely with 15 publications. in second place is Turkey, with 8 documents. Publications are spread across the Americas, Asia, Europe, Africa, and Oceania. Only the Australian Continent has yet to publish articles related to Augmented Reality in secondary schools. Furthermore, the pattern of cooperation between countries will be seen as follows.

The pattern of cooperation between countries can be seen from the circle's color shown in figure 3. From figure 3, it can be seen that there are 3 colors, meaning that there are three clusters. The country with the most links is China, with 17 links. Second place is two countries with 16 links, namely Taiwan and Turkey. This means that the country has cooperated a lot with other countries. Even though the United States has the highest number of publications, the United States only has 12 links of cooperation with other countries

The research focus is displayed from Network Visualization. The total keywords displayed are 28 items. The focus of the research is seen from the clusters marked with the circle color shown in Figure 4 above. The first research focuses on a red circle consisting of 11 items. The keywords with the largest circles are Augmented Reality, technology, motivation, and environment. This means that in addition to the keywords Augmented Reality, the keywords that are the focus of the first research are technology, motivation, and environment. The second research focus (green circle) consists of 9 items, with the education keyword having the largest circle. Besides, the other keywords with the largest circle are the game and interest keywords, meaning that these keywords are the second research focus. The third research focus (blue circle) consists of 8 items with the middle school student keywords that have the largest circle. Besides that, the keywords with the other largest circles are the achievement and development keywords, meaning that these keywords are the third research focus.

The new theme can be seen in figure 5 above, and the new theme is a keyword in a recently published document. The new theme and the old theme are marked with a circle color. The blue color indicates the old theme, while the yellow color indicates the newest theme. The new theme related to Augmented Reality research in secondary schools is science learning, mathematics education, concepts, and spatial abilities. Novelty can be seen from the interrelationships between keywords. As seen from Figure 4 above, the keywords that are the focus of research and new themes will take precedence in this section. The keyword Augmented Reality is not directly related to science learning. The game keywords are not directly related to the outcomes keywords. Middle school student

keywords are not directly related to science learning. Then, the keywords Spatial ability is not directly related to outcomes, mathematics education, and science learning.

**Discussion**

**What Are The Current Publication Trends And Citation Trends Regarding Augmented Reality Research In Secondary Schools?**

The trend of publications related to Augmented Reality in secondary schools is seen from the trend line, which has increased. There has been an increase in the last few years. This follows what was conveyed by (Dutta et al., 2022) that the interest in Augmented Reality research has been in recent years. Furthermore, the trend of citations is seen in the number of citations from publications each year. Publication in 2013 has been cited as many as 1081 with three publications. The publications in 2013 that have been widely cited are as follows.

Publication in 2013 with the highest number of citations was research conducted by  (Di Serio et al., 2013) entitled "Impact of an Augmented Reality system on students'students' motivation for a visual art course," discussing that Augmented Reality technology has a positive impact on the motivation of high school students. However, this technology still needs to be mature enough to be used massively in education. The enthusiasm of high school students removes most of the obstacles found. The research has been widely cited because it considers four motivational factors: attention, relevance, confidence, and satisfaction. The above journals, such as Computers and Education and the Journal of Computer Assisted Learning, can be used as a reference for researchers who use this field's theme to publish their articles in these journals.

**What Is The Geographical Distribution Of Publications And Patterns Of Collaboration Between Countries?**

Geographic distribution of Publications related to Augmented Reality in secondary schools from 2009 to 2023 based on their country of origin with a total of 20 countries. The United States of America has published the most in this field, with 15 publications. China is a country with a high level of cooperation with other countries. This means that America and China are the most influential in this field. This follows what was conveyed by (Hincapie et al., 2021) that the United States has influenced Augmented Reality research in education. The difference with this research is that this research focuses more on high schools.

**What Is The Focus Of Research And Novelty Related To Augmented Reality In Secondary Schools?**

The focus of Augmented Reality research in secondary schools is divided into three parts, namely, 1) technology, motivation, and environment; 2) games and interests; 3) achievement and development. The first research focus is technology, motivation, and the environment. Research conducted by (Portillo & Portillo, 2019) has discussed the impact of augmented reality technology on the academic achievement and motivation of students from Mexican public and private schools, where research findings imply that in Mexico, augmented reality technology can be utilized as an effective learning environment to help secondary school students from public and private schools to practice the basic principles of Geometry. Therefore this research suggests that this research examines augmented reality in high schools associated with technology and motivation in other countries.

The second research focus is games and interests. Research conducted by (Pranoto & Panggabean, 2019) has examined increasing interest in game-based augmented reality. This research suggests future research for the expected features in this application are virtual 3D objects that are expected to be able to interact and must be more complex and have more information about the object. The third research focus is achievement and development. Research conducted by (Huda et al., 2021) as examined the development of augmented reality on achievement, this research suggests that further research should pay attention to the impact or empirical review of augmented reality

application technology that has not been studied through this research, so this study invites researchers to conduct future research on the impact of augmented reality application technology. The focus of this research can be used as a reference for future researchers who want to research related to this field in determining the focus of research.

The new theme related to Augmented Reality research in secondary schools is science learning, mathematics education, concepts, and spatial abilities. Novelty can be seen from the interrelationships between keywords. As seen from Figure 4 above, the keywords that are the focus of research and new themes will take precedence in this section. The keyword Augmented Reality is not directly related to science learning. The game keywords are not directly related to the outcomes keywords. Middle school student keywords are not directly related to science learning. Then, the keywords Spatial ability is not directly related to outcomes, mathematics education, and science learning. This novelty can be useful for further research that wants to examine something similar to the theme of this research.

## 4. CONCLUSION

Based on the results and discussion, the publication of Augmented Reality research in secondary schools from 2009 to 2023 has experienced an increase in recent years. The highest number of citations was in 2013. The United States and China are the most influential countries in this field. The focus of research related to Augmented Reality in secondary schools is 1) technology, motivation, and environment; 2) games and interests; 3) achievement and development. The focus of this research can be used as a reference for future researchers who want to research related to this field in determining the focus of research. The keyword Augmented Reality is not directly related to science learning. The keyword game is not directly related to the keyword outcomes. The keyword Middle school student is not directly related to science learning. Then, the keywords Spatial ability is not directly related to outcomes, mathematics education, and science learning. This novelty can be useful for further research that wants to examine something similar to the theme of this research.

Research limitations is the limitation of this research is that the data taken from the Scopus database needs to be fully representative of all existing publications. Many other databases, such as the Google Scholar database and others, can be used as references. The data in this study were taken on January 10, 2023. Therefore publications after that date are not included in the discussion of this study.

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