International Journal of
Disabilities Sports and Health Sciences
e-ISSN: 2645-9094

REVIEW

Bibliometric Study of Analytical Thinking Skills in Physical Education from Scopus Database

Magdalena Rambu P. WASAK*[1]

[1]Universitas Kristen Artha Wacana, Faculty of Teacher Training and Education, Physical Education, Health and Recreation Study Program, Kupang / Indonesia
*Corresponding author: rambuwasak@ukaw.ac.id

Abstract
This research reports the publication trend of analytical thinking skills (ATS) in physical education (PE) from the Scopus database for 1983-2023 (the last 40 years). On October 4, 2023, the data was inspected using the title, abstract, and keyword "*Analytical and Thinking and Skills and Physical and Education*," which succeeded in finding 30 published documents, and 1 article was eliminated because it was duplicated. The 29 bibliographies represent four types of documents, namely articles (55%), conference papers (35%), book chapters (7%), and reviews (3%). In the last 40 years, only in 2023 were up to 6 documents successfully published, whereas in other years <3 Documents were published. The highest citations were in 2012, with 90 citations (for two documents), while the articles with the highest citations were 42. There was no dominant author or affiliate in ATS publications because neither author nor affiliate succeeded in contributing >1 article. The results of the VOSviewer analysis prove that network, overlay, and density do not have a high item load, so they do not give rise to large-term patterns in the visualization. Finally, research on ATS in PE is, in fact, still very limited, thus providing potential opportunities for future researchers to develop ATS research themes in various aspects to support the implementation of quality PE to support students surviving in the 21st century.

Keywords
Analytical thinking, Analytical thinking skills, Analytical skills, Physical edcuation, Bibliometric study

INTRODUCTION

In conventional learning (teacher center), teachers do not give students wider opportunities to optimize their high-level thinking. This condition makes it difficult for students to solve problems when they are faced with learning experiences (theory and practice) that require higher-order thinking skills (HOTS) (Suhadi et al., 2022). Integrating thinking skills such as focus, information gathering, and organization into all subjects becomes increasingly crucial in primary school, and PE is no exception (Ennis, 1991). Rink (2014) suggested that cognitive goals relate to the knowledge that students must have (including how to develop joint flexibility) and outcomes related to problem-solving and creativity or the transfer of knowledge from a situation to other situations (for example, how to implement a zone defense in a six-on-six football game). The above statement underlines that to integrate analytical thinking, students can be initiated in a "simple" way, such as by "provoking" students to be able to explain the functioning of a system, the reasons why something happens, or the procedures for solving a problem so that they can transfer this experience to sports activity situations or other activities. Thus, teachers who pay attention to HOTS (analysis, evaluation, or creation) can train students to apply the knowledge and abilities they have learned in different circumstances by developing their thinking skills (Suhadi et al., 2023).

Research exploring HOTS in PE has been initiated since ancient times through critical

Received: 09 October 2023 ; **Revised** ; 25 October 2023 ; **Accepted:** 07 March 2024; **Published:** 25 March 2024

How to cite this article: Wasak, M.R.P. (2024). I Bibliometric Study of Analytical Thinking Skills in Physical Education from Scopus Database. *Int J Disabil Sports Health Sci*;7(2):482-493.https://doi.org/10.33438/ijdshs.1373196

thinking skills (CTS) (Cleland & Pearse, 1995; Humphries, 2014; Lodewyk, 2009; McBride, 1992; Pill & SueSee, 2017; Schwager & Labate, 1993). Several publication results attempt to improve CTS using play-based learning (Bayu et al., 2013), cooperative learning and concept mapping (Huang et al., 2017), problem-based learning (PBL) (Dupri et al., 2019), peer-observation, self-assessment, and circuit training (Bayu et al., 2022), HOTS-based blended learning CTS (Williyanto et al., 2022), and Team Games for Understanding (TGfU) (Usra et al., 2023). More specifically, the results of a bibliometric study using the Google Scholar database, Ridwan et al. (2022) found that from 2000 to 2021 (the last 11 years), there were 91 articles discussing CTS in PE. According to Spaska et al. (2021), analytical thinking skills (ATS) are usually associated with CTS because, before conceptualizing information, they first evaluate its relevance, quality, and suitability. However, if the reader looks closely at Bloom's cognitive taxonomy table (revised version), ATS is an effort to break down material or information into main parts and determine how these parts relate to each other and the overall structure. Meanwhile, CTS includes evaluative thinking (for example, assessing which of two methods is the best way to solve a particular problem) (Anderson et al., 2001), so even though they are similar, in fact, ATS and CTS are different in their reasoning processes. If ATS builds reasoning to explore material or information in detail based on the relevance of its structure, then CTS uses reasoning to select the information to be explored when solving certain problems.

In contrast to CTS, researchers have not yet optimally discussed ATS in discussing its integration and contribution to PE. New ATS publication documents have appeared recently, as confirmed in Phuseengoen & Singhchainara (2022), which seeks to integrate STEM into students' movement and ATS activities. Most recently, Blegur, Rajagukguk, et al. (2023) developed an ATS instrument for throwing-catch learning, and Blegur, Yustiana, et al. (2023) integrated ATS in PE using a scientific learning model to improve student learning outcomes. Seeing the limitations of ATS investigations, the question is whether ATS is not significant in supporting students' self-development. ATS is needed by students when facing ambiguous situations. Students must be skilled at identifying unclear and global problems; based on their identification results, they try to solve the problem (Robbins, 2011). ATS is manifested in the reasoning activities of differentiating, organizing, and attributing certain information or material. Differentiation is differentiating a relevant part from irrelevant and unimportant parts; organization determines the suitability of an element to its structure, and attribution determines the point of view, value, or purpose that underlies the existence of an element (Ad'hiya & Laksono, 2018; Anderson et al., 2001; Blegur, Rajagukguk, et al., 2023). Thus, ATS is necessary to prepare students to face a more complex life and work environment in the 21st century (Thaneerananon et al., 2016).

When organizing learning, teachers must selectively select the skills their students need to help them survive in the future (21st century), one of which is analytical thinking skills (ATS). Designing and internalizing ATS in student learning activities is very necessary, considering that ATS is one of the HOTS groups (Astuti et al., 2021; Blegur, Mahendra, et al., 2023; Blegur, Rajagukguk, et al., 2023; Mayarni & Nopiyanti, 2021; Sundari et al., 2020; Suyatman et al., 2021b) which can help students develop meaningful learning activities (Areesophonpichet, 2013). ATS refers to a person's ability to collect and analyze information, solve problems, and make decisions (Ramadani et al., 2021) so that it has an impact on increasing productivity and overall individual success every day (Aksu & Eser, 2020; Phuseengoen & Singhchainara, 2022; Susiaty et al., 2022; Suyatman et al., 2021a). Individuals with good ATS can solve problems by understanding parts of the situation, attributing other meanings to the overall structure or goal (Anderson et al., 2001), and being able to research and explain the facts (Kesorn et al., 2020). Concretely, four indicators can be seen in individuals who use ATS well, namely 1) being able to sort a problem and understand its parts, 2) being able to explain the functioning of a system, the reasons why something happens, or the procedure for solving a problem, 3) able to compare and contrast two or more problems, or 4) able to evaluate and criticize the characteristics of a problem (Perdana et al., 2019; Sternberg, 2006).

Currently, researchers are trying to carry out bibliographic metadata tracking that discusses the theme of analytical thinking in PE from the Scopus

database. Researchers use the Scopus database because it is one of the most significant publication platforms from several world-standard publication platforms, including Springer, Emerald, Taylor & Francis, and others. This study seeks to diagnose the development of ATS research in PE to fill the gap while offering a new perspective to future researchers to discuss the integration and development of ATS in PE. Bibliometric studies are useful as decision support tools in setting research priorities and tracking evolution as well as highlighting emerging science and technology in a particular field (Donthu et al., 2021; Mejia et al., 2021), such as examining publication patterns such as subject, author, quote, title, and other factors (Hanief, 2021b, 2021a; Li & Zhao, 2015; Puspita et al., 2023). Thus, bibliometric mapping findings will provide useful and meaningful contributions for future researchers and find opportunities and updates to contribute more (Blegur, Ma'mun, et al., 2023; Marmoah et al., 2022) in the development of science and technology in supporting the creation of quality PE for students.

MATERIALS AND METHODS

The quantitative examination of the bibliography was carried out using the bibliometric methodology. Bibliometric analysis is part of scientometrics that uses statistical and mathematical techniques to examine scientific activity in a particular study topic (Callon et al., 1991; Sreenivasan & Suresh, 2023), which helps measure, track, and analyze the structural relationships between various components of the literature more accurate scientific knowledge (Donthu et al., 2021; Rojas-Sánchez et al., 2023).

Five research procedures were used, starting with study determination and ending with data reporting. First, the researcher determined the title, abstract, and keywords "*Analytical and Thinking and Skills and Physical and Education*" for tracking from the Scopus database. In addition, set October 4, 2023 as the time for data collection.

Second, inspect documents from the Scopus database. Researchers found 30 documents from 1983-2023 (the last 40 years) and continued by analyzing using the Scopus application to record publication metrics (such as year, doctype, authorship, affiliation, and citations). It includes doctype articles, conference papers, book chapters, and reviews, and there are 12 subject areas, including engineering, social sciences, computer science, medicine, health professions, psychology, multidisciplinary, and so on.

The verification results still found one duplicate article. The article written by Mathers et al. (2011) entitled "*Robotic mission to Mars: Hands-on, minds-on, web-based learning*" was first published in the 62nd International Astronautical Congress 2011, pp. 8406-8412. With the same title and author, the article was again published in the Acta Austonautica issue in volume 80, pages 124-131, in 2012. Thus, the article for the 2011 issue was eliminated, and the researcher only used the article published in 2012 as the output form from the previous year's publication (2011).

Third, import Scopus data inspection results into Comma Separated Values (CSV) format for calculations to make data collection easier. Scopus data to Research Information Systems (RIS) format to make it easier to calculate publication metrics using Publish or Perish (PoP) and visualization using VOSviewer.

Fourth, analyze publication trend metrics (year, doctype, authorship, affiliation, country, and citations) using Excel, analyze data metrics (general) using Publish or Perish (see Table 1), and analyze CSV or RIS format data visualizations using VOSviewer (network, overlay, density).

Table 1. Citation metrics

Citation metrics	Analytical and thinking and skills and physical and education
Publication years	1983-2023
Citation years	40 (1983-2023)
Papers	29
Citations	176
Cites/years	4.40
Cites/paper	6.07
Author/paper	2.97
h-index	8
g-index	13
hl, norm	5
hl, annual	0.13
hA-index	2

VOSviewer analysis was carried out to find a graphical representation of a large bibliometric map in a way that is easy to interpret (Jan van Eck & Waltman, 2010). Furthermore, Jan van Eck & Waltman (2023) explain three ways of interpreting VOSviewer visualizations. First, network

visualization, where items are represented by their labels (default or circles). The item's weight determines the label's size and circle of an item. The distance between two items in the visualization indicates the relatedness of the items (two close items describe a strong relatedness). Second, overlay visualization: If an item has a score, the item's color is determined by the item's score, where, by default, the color ranges from blue (lowest score) to green to yellow (highest score). Third, density visualization shows the density of items at a certain point. By default, colors range from blue to green to yellow. The more items there are around a point and the higher the weight of the items around it, the color of the point is closer to yellow, and vice versa.

Fifth, report and discuss PoP data metrics in table format, report and discuss publication metrics (trends) in diagram format (lines and columns), and report and discuss VOSviewer data visualizations in image format (PNG).

RESULTS

Publication Trend

Science publication trends from the Scope database using search within article title, abstract, and keyword "*analytical and thinking and skills and physical and education*" (from now on referred to as ATS in PE) found 29 articles from 1983-2023. In the last 40 years, publications were only randomly filled in 15 years (37.5%), while there were no publications in the remaining 25 years (62.5%) (see Figure 1). The highest publication was in 2023 with six documents (37.5%), followed by 2012, 2021, and 2022 with three documents (18.8%), 2001, 2007, and 2016 with two documents (12.5%), and the remaining years only contributed one documents (6.3%).

The first publication discussing analytical thinking based on inspection results was in 1983, entitled "*Career guidance needs assessment of black secondary school students in the transvaal province of the republic of South Africa*" written by a researcher from the University of Bophuthatswana, South Africa, whose name was Chuenyane (1983). Meanwhile, the last publication in 2023 experienced increased documents (6 documents). One of the articles was published by writers from Indonesia, namely Blegur, Rajagukguk, et al. (2023) with an article entitled "*Innovation of analytical thinking skills instrument for throwing and catching game activities for elementary school students.*"

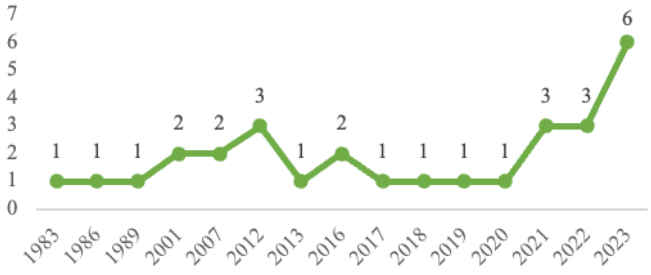

Figure 1. Publication trends by year

The 29 published documents represent at least four types: each article type is 16 documents (55%), the conference paper type is 10 documents (35%), the book chapter type is two documents (7%), and the review type is 1 document. (3%). The two lowest types (book chapter and review) are explained as follows. The first book chapter document was written by Jones (2019) with the title *"Connectivity, socialization and identity formation. Exploring mental well-being in online distance learning law students,"* which was published as a chapter in the book Educating for Well-being in Law: Positive Professional Identities and Practice published by Routledge. The second chapter was published in 2021 by Tsalapatas et al. (2021) with the chapter title "*The design of a problem-based learning platform for engineering education"* in the book Technology Supported Active Learning: Lecture Notes in Educational Technology published by Springer.

Meanwhile, Cooper & Tauber (2007) from the University of Pennsylvania wrote the only review-type document with the title "*Values and Ethics: A collection of curricular reforms for a new generation of physicians."* Which was published in the journal Academic Medicine, volume 82, number 4, April 2007.

Figure 2. Publication trends by doctype

Eighty-six authors contributed to 29 ATS articles in PE. A particular author did not dominate this contribution because only 1 out of 29 documents were the largest publication. It means that 86 authors (100%) only managed to contribute 1 document. Apart from that, of the 86 authors, only six (7%) contributed as independent authors. Three of them are first; Kremer (2001) published an article entitled *"Teaching a rigorous problem-solving framework in entry-level mechanical engineering courses - Theory and practice."* Second, Bramstedt (2016) published an article entitled *"The use of visual arts as a window to diagnosing medical pathologies."* Third, Jones (2019) published an article in a book chapter entitled *"Connectivity, socialization and identity formation: Exploring mental well-being in online distance learning law students."*

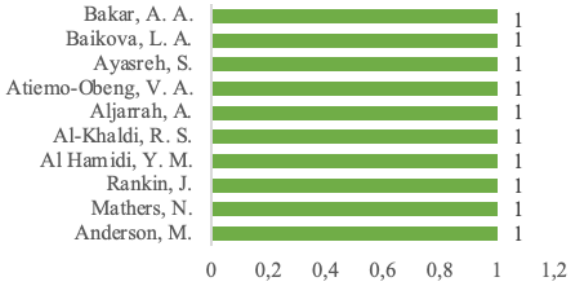

Figure 3. Publication trends by author

Overall, 86 authors are spread across 54 affiliates, and each only contributes 1 article. Some of them are the Victorian Space Science Education Center, Ural Federal University, University of Thessaly, University of South Florida, University of Pennsylvania, University of Michigan-Flint, University of Kentucky Sports Medicine Center, University of Canterbury, University of Belgrade, Universiti Malaya, and others. The Indonesian affiliates recorded are Universitas Kristen Artha Wacana, Kupang, East Nusa Tenggara, and Universitas Pattimura, Ambon, Maluku (Figure 4 only shows ten affiliates as examples).

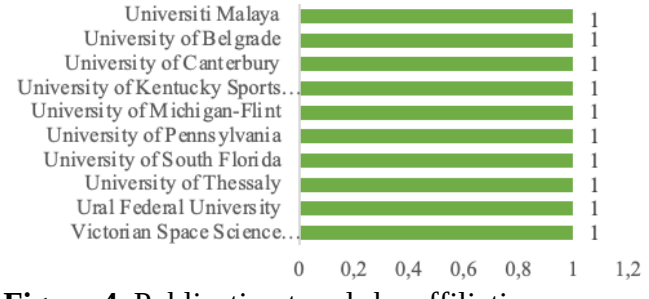

Figure 4. Publication trends by affiliation

Based on author affiliation, it was tracked that 86 authors came from 18 countries, such as the United States, Australia, Colombia, Greece, Russia, Hong Kong, China, Indonesia, Jordan, Malaysia, New Zealand, Portugal, Qatar, Serbia, South Africa, Spain, Thailand, and the United Kingdom. If measured by country, the United States contributed 36.4% of articles, then Australia, Colombia, Greece, and Russia each contributed 6.1%, while other countries only contributed 3% of articles.

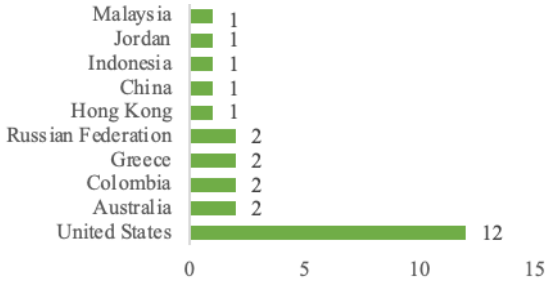

Figure 5. Publication trends by country/territory

Citation Trends

Twenty-nine published articles generated 176 citations. This metric's results still need to be added to the positive trend of publications with ATS title words. The article with the highest number of citations was in 2012, with a total of 90 citations (51.1%), and the lowest was in 2018, 2019, and 2021, with 1 citation (0.6%) (see Figure 6). Meanwhile, articles published in 1986 and 2013 do not have a citation metric (0). Each article that has not received citations is entitled *"Environmental chemistry baccalaureate degree program: A philosophical overview,"* written by Cope & O'Keeffe (1986) in the National Meeting-American Chemical Society, Division of Environmental Chemistry. Next is the article entitled *"Challenges and opportunities in developing STEM curricula for tertiary institutions in Africa: Materials science and engineering at AUST-Abuja"* written by Osseo-Asare & Atiemo-Obeng (2013) published in the ASEE International Forum, American Society for Engineering Education.

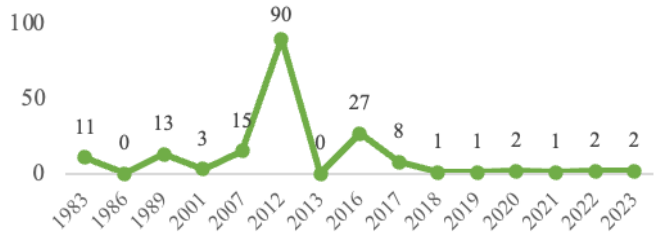

Figure 6. Citation trends based on publication year

The highest 90 citations in 2012 as a contribution from two articles, 48 citations each from the article entitled *"Robotic mission to Mars: Hands-on, minds-on, web-based learning,"* written by Mathers et al. (2012). Another 42 citations are from the article *"Developing students' futures thinking in science education,"* written by Jones et al. (2012). Meanwhile, the article with the lowest citations, 13 citations (in the top 5 citations), was written by Slaughter et al. (1989) with the *title "Improving physical therapy students' clinical problem-solving skills: An analytical questioning model*."

Articles that only received 1 citation were in 2018, 2019, and 2021. The article cited in 2018 was entitled *"Formation of students' scientific thinking based on the learning of methods of the substance analysis,"* written by Kosareva et al. (2018). The article cited in 2019 was entitled *"Connectivity, socialization and identity formation: Exploring mental well-being in online distance learning law students,"* written by Jones (2019). The last article cited in 2021 was entitled *"Implementing a blended design studio model in archi tectural engineering education,"* written by Milošević (2021).

Table 2. 5 top cited articles

No	Citation	Title	Journal identity	Author	Affiliation	Year
1	48	Robotic Mission to Mars: Hands-on, minds-on, web-based learning	Acta Astronautica, vol. 80, pp. 124-131, Dec., 2012	Naomi Mathers, Ali Haydar Göktoğan, John Rankin, Marion Anderson	Victorian Space Science Education Centre, The University of Sydney, La Trobe University, Monash University	2012
2	42	Developing students' futures thinking in science education	Research in Science Education, vol. 42, pp. 687-708, Apr., 2012	Alister Jones, Cathy Buntting, Rose Hipkins, Anne McKim, Lindsey Conner, Kathy Saunders	University of Waikato, New Zealand Council of Educational Research, University of Canterbury	2012
3	17	The use of visual arts as a window to diagnosing medical pathologies	AMA Journal of Ethics, vol. 18, no. 8, pp. 843-854, Aug., 2016	Katrina A. Bramstedt	Bond University	2016
4	15	Values and ethics: A collection of curricular reforms for a new generation of physicians	Academic Medicine, vol. 82, no. 4, pp. 321-323, Apr., 2007	Richard A. Cooper, Alfred I. Tauber	University of Pennsylvania, Boston University	2007
5	13	Improving physical therapy students' clinical problem-solving skills: An analytical questioning model	Physical Therapy, vol. 69, no. 6, pp. 441-448, June, 1989	Diane S. Slaughter, Debra S. Brown, Davis L. Gardner, Lea J. Perritt	University of Kentucky	1989

Co-authorship

Researchers used the complete counting method in co-authorship analysis, with a minimum number of documents of an author of 1, so that 29 met the threshold of 29 authors. The analysis results (select no on unconnected items) verify that there are 29 authors spread into 29 clusters and do not form links, and the total link strength is (0). Furthermore, Figure 7 visualizes that all authors have labels (circles) of the same size. It means no circle of an item (author) predominantly publishes articles (all authors only contribute to 1 ATS document).

There are six recent documents (in 2023) published by the authors regarding ATS. First, Chen et al. (2023) published an article entitled "*Metaverse in education: Contributors, cooperations, and research themes.*" Second, Blegur, Rajagukguk, et al. (2023) published an article entitled *"Innovation of analytical thinking skills instrument for throwing and catching game activities for elementary school students."* Third, Cruz et al. (2023) published an article entitled *"Accelerating engineering education and workforce development in automation & control for the semiconductor industry based on cognitive neuroscience."* Fourth, Ibrahim et al. (2023) published an article entitled *"Creating creative educational opportunities among engineering and arts students."* Fifth, Hua et al. (2023) published an article entitled *"Cultivating comprehensive and critical thinking in architecture education through promoting theoretical cognition."* Sixth, Dimitriu et al. (2023) published an article entitled *"The mind fitness program© provides training for STEM careers."*

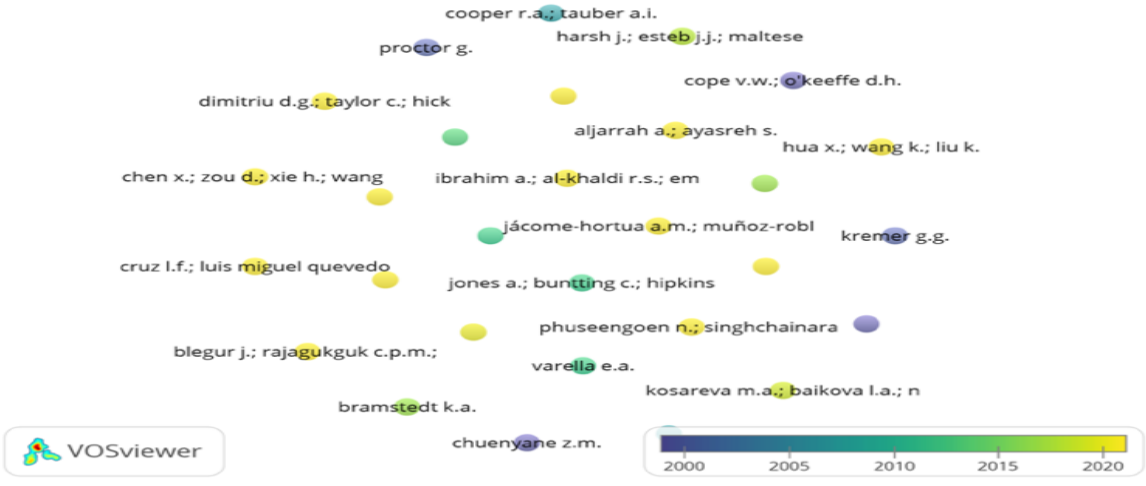

Figure 7. Co-authorship (overlay visualization)

Co-occurrence

This analysis (co-occurrence) uses a complete counting method with a minimum number of co-occurrence keywords set at three so that it succeeded in forming 10, meeting the threshold out of 267 keywords in the VOSviewer networking map. The analysis results verify that ten keywords only form 3 clusters, 27 links, and 46 total link strength. Cluster 1 includes education, human, medical education, and teaching. Cluster 2 includes curriculum, education computing, and students. Cluster 3 includes engineering education, problem-based learning, and professional aspects. The ATS keyword does not appear in the VOSviewer visualization (for example, the visualization overlay in Figure 8) because the number of co-occurrence keywords is <3, so it can be concluded that the development of ATS research has great potential for future researchers in the future.

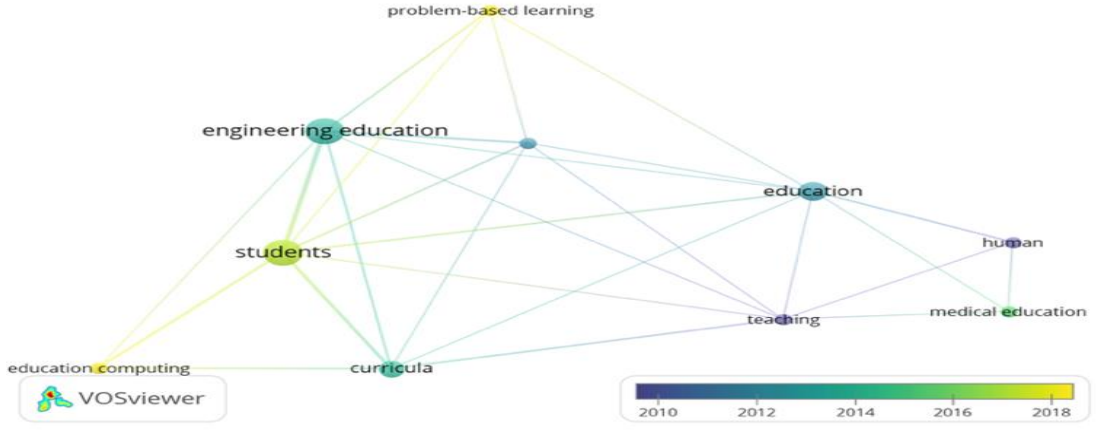

Figure 8. Co-occurrence (overlay visualization)

Title and Abstract

In the choose threshold display, five minimum numbers of occurrences of a term are used, from 1608 terms, thus successfully forming 81 meet the threshold. The results of the analysis found that 49 number items were selected, forming 5 clusters (see Table 3), 639 links, and 4530 total link strengths.

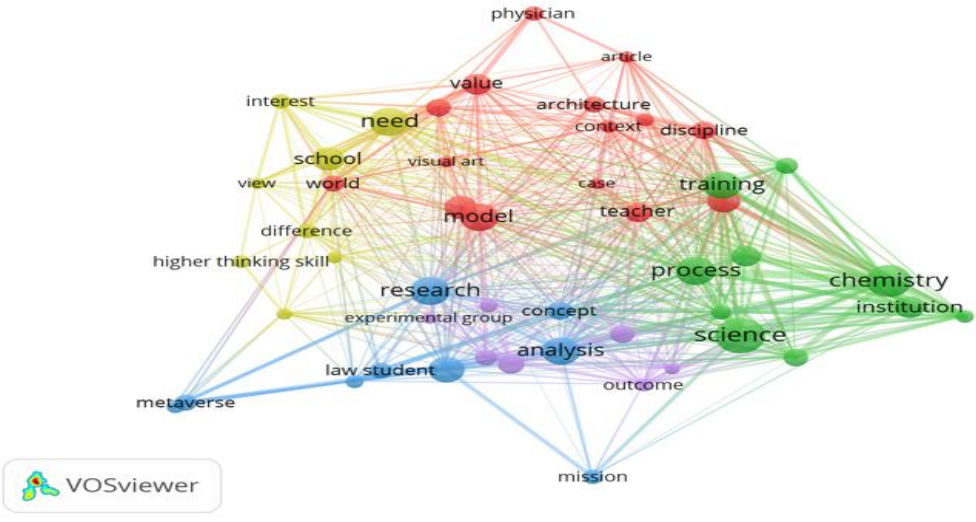

Figure 9. Title and abstract (network visualization)

The term analytical thinking is included in cluster 4 (yellow), and the term analytical thinking skills is included in cluster 5 (magenta). From the network of terms *"analytical thinking"* that was formed (18 terms), the term *"physical education"* is included in the closest and newest terms. Meanwhile, *"analytical thinking skills"* form a network of 12 terms. Apart from that, if looking closely at the density visualization, the term ATS is invisible. Thus, VOSviewer visualization confirms that the investigation of ATS in PE still needs to be improved. Therefore, investigating ATS in future research has the potential to support the creation of quality PE learning that supports students to survive in the future through empowering their ATS.

Table 3. Cluster of 49 items

Cluster	Colour	Item	Total
1	Red	Architecture, article, capacity, case, contecxt, discipline, framework, model, physician, project, teacher, theory, value, visual art, wolrd	15 items
2	Green	Area, chemistry, competence, ects credit, graduate, institution, process, quality, science, training	10 items
3	Blue	Analysis, concept, edu metaverse, environment, law student, learner, metaverse, mission, research	9 items
4	Yellow	Analytical thinking, difference, higher thinking skill, interest, need, physical education, school, view	8 items
5	Magenta	Analytical thinking skill, effect, experimental group, innovation, instrument, outcome, question	7 items

DISCUSSION

Overall, from 29 articles (1983-2023), publication trend metrics in the last three years prove that research on ATS is starting to increase. In 2021 and 2022, each published three articles, and in 2023, this will increase to 6 documents. Even though there was an increase, after researchers carried out a more profound investigation (content examination) of the published articles (29 articles), there were only three articles (10.3%) that discussed ATS in PE. The articles in question are consecutive; first, "*The extent of applying higher thinking skills in practical subjects among the students of the faculty of physical education at Yarmouk University,*" written by Aljarrah & Ayasreh (2021). Second, *"Effects of STEM-integrated movement activities*

on movement and analytical thinking skills of lower secondary students" written by Phuseengoen & Singhchainara (2022). Third, *"Innovation of analytical thinking skills instrument for throwing and catching game activities for elementary school students"* written by Blegur, Rajagukguk, et al. (2023).

The ATS article that Aljarrah & Ayasreh (2021) did not specifically discuss ATS but rather the use of HOTS in general among PE students at Yarmouk University, Jordan. Their study proves that the HOTS rankings are metacognitive thinking (4.11), critical thinking (4.03), reflective thinking (4.03), analytical thinking (3.92), and creative thinking (3.90), which means there is no statistically significant difference in usage. HOTS in practical courses. The two researchers further recommended investing in sports activities and practical courses to develop HOTS among university students. Continuing with Phuseengoen & Singhchainara (2022), they criticized conventional PE, which only focuses on developing students' physical competence and health fitness but also needs to provide an integrated learning and teaching environment to realize the "STEM" concept (Science, Technology, Engineering, and Mathematics) through various physical activities and sports for grade 8 students in Thailand. As a result, STEM learning is better at improving students' physical movement activities and analytical thinking skills. Finally, a study by Blegur, Rajagukguk, et al. (2023) succeeded in developing an analytical thinking instrument using concepts from Anderson et al. (2001) in throwing and catching PE learning for elementary school students (grade 6) in Indonesia. This study uses descriptive analysis, Aiken-v analysis, factor analysis, Pearson correlation, item difficulty, discriminant index, and Cronbach's alpha. The result is an instrument (9 open questions) recommended for teachers to identify student ATS.

Apart from the three studies from the Scopus database, one recent study in 2023 from the Google Scholar database promotes ATS in PE. This study was carried out by Blegur, Yustiana, et al. (2023) by integrating ATS into the scientific learning model to improve students' PE learning outcomes. Of the four studies, three, each from the Scopus database and one from the Google Scholar database, confirmed that the investigation of ATS in PE was very limited. ATS is one of the HOTS groups that have been mandated in the Indonesian Education Curriculum (Astuti et al., 2021; Blegur, Mahendra, et al., 2023; Blegur, Rajagukguk, et al., 2023; Mayarni & Nopiyanti, 2021; Sartika, 2018; Sundari et al., 2020; Suyatman et al., 2021b). As students develop ATS through their movement experiences, they are trained in identifying problems (Kesorn et al., 2020) by breaking down complex ideas into small parts to develop hypotheses and ultimately reach solutions (Hollett & Cassalia, 2022). For example, it is exemplified by Rink (2014) about how students transfer experience from implementing zone defense in six-on-six football matches. Students can transfer experience well because they have succeeded in developing ATS through problem-solving experience, so this success can be transferred to different contexts. Once again, ATS significantly contributes to students' life experiences in the 21st century, so based on the results of this study (limited investigation of ATS in PE), future researchers have the potential to develop ATS in various aspects not limited to model development, instrument development, integration ATS to support transfer learning and others.

Conclusion

This research aims to conduct a bibliometric analysis of ATS articles in PE published in the Scopus database in the last 40 years (1983-2023). The inspection results found only 29 articles, but only three articles specifically reviewed ATS (1 article used a sample of university students, 1 article used a sample of junior high school students, and one other article used a sample of elementary school students). There are no dominant authors or affiliates who contribute to ATS publications. However, if tracked by country, the United States dominates by contributing 36.4% of articles, followed by Australia, Colombia, Greece, and Russia (6.1%), while other countries only contribute 3% of articles. The highest citation trend was in 2012, with 90 citations from two articles. Meanwhile, if it is reported by article, the article entitled *"Robotic mission to Mars: Hands-on, minds-on, web-based learning,"* gets the highest number of citations, 48.

Research on ATS in PE is, in fact, still very limited; the VOSviewer visualization results prove this. ATS does not have a large label load because the number of co-occurrence keywords is <3. Apart from that, visualization using the ATS term from the title and abstract also confirms that the AT and ATS terms are, in fact, included in the last

2 clusters (4 and 5) while also explaining that these two terms do not have a high item load so that the visualization of the network, overlay, and density is not visible clear. The results of this study provide potential opportunities for future researchers to develop ATS research themes in various aspects that are not limited to testing learning models that support ATS development, strategies for improving ATS, developing ATS learning models, developing ATS instruments, integrating ATS for supports transfer learning and others.

Declaration of Conflicting Interests

Author declare no conflicts of interest.

Funding

Author received no financial support for the research, authorship and/or publication of this article.

Ethics Statement

This research does not require an ethical statement because it uses a research platform from the Scopus database.

Author Contributions

Study Design, MRPW; Data Collection, MRPW; Statistical Analysis, MRPW; Data Interpretation, MRPW; Manuscript Preparation, MRPW; Literature Search, MRPW. Author have read and agreed to the published version of the manuscript.

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