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THE LANDSCAPE OF PHYSICS SUBJECT EDUCATION IN ASEAN COUNTRIES: A BIBLIOMETRIC STUDY

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Abstract:

This study examines the research encompassing physics subject education conducted between 2000 and 2023, sourced from the Web of Science database using bibliometric analysis. The paper's objective is to analyse the evolving research landscape surrounding physics subject education in the ASEAN countries. While previous studies have explored the area of physics education on a global scale, this research offers a more focused analysis, exclusively focusing on the ASEAN nations. To accomplish this, an array of bibliometric analysis tools, including MS Excel, VOSviewer, and Harzing's Publish or Perish software, were used. Performance analysis was done and named based on the subsection. The study's findings unveil a trend that exhibited an upward total publication trajectory from 2014 to 2020, followed by a gradual decline from 2021 to 2023. Indonesia's substantial contributions account for an astounding 81.5% of total ASEAN publications, spanning both influential and prolific organization categories. Among the top authors were from Singapore, Indonesia, Malaysia and Thailand. From the authorship section, the collaborative nature of researchers within ASEAN countries can be seen,

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particularly those who share common affiliations. The funding shows that only 30.1% of overall physics subject education publications in ASEAN are funded. Finally, the keyword analysis shows the patterns highlighting its evolving interaction with technological advancements. This marks a compelling transformation within the sphere of physics subject education landscape, providing valuable insights for educators, researchers, and policymakers to assess their performance and indicators to assess the nation's educational initiatives and their impact on various aspects of physics subject education.

Keywords:

ASEAN, Bibliometric Analysis, Performance Analysis, Physics, Physics Education, Science Mapping

Introduction

Recent years have witnessed collaborative efforts among ASEAN nations to drive technological and educational advancement throughout the region (Khalid et al., 2019). The emergence of technologies such as 5G, artificial intelligence, and the digital economy exemplifies the interconnected and interdependent nature of ASEAN member states, working together to advance the prosperity and harmony of the Southeast Asian Nations community while at the same time refining the educational landscape within the region (Avirutha, 2021; Martinus, 2020). However, in the meantime, variations in science literacy particularly relating to physics, exist among secondary students in ASEAN nations. Some countries exhibit low levels of literacy, while others demonstrate higher levels (Firman, 2021). Blaming education policy and its aims alone for these disparities is not entirely accurate. This is because the learning of physics shares fundamental principles with the practices of physicists, involving scientific inquiry, the scientific method, and investigative approaches (Bitzenbauer, 2021). The role of physics education at the tertiary level extends beyond imparting fundamental principles, as it also plays a critical role in shaping the future workforce in the fourth industrial revolution, involving the preparation of students for careers in physics-related industries (Al-Maskari et al., 2022). This encompasses the transformation of proof-of-principle experiments into marketable products, highlighting the indispensable need for specialized skills alongside a deep understanding of fundamental principles (Fox et al., 2020). Besides, the scaling of artificial intelligence and digitalization in the post-COVID-19 era has facilitated the adoption of online teaching tools in higher education institutions, delivering personalized learning experiences for individuals, although it is acknowledged that artificial intelligence cannot fully displace human wisdom and intellect (Chaka, 2023). It became essential to providing the landscape of research output in the field of physics subject among ASEAN countries relating to education regarding such a major shift in the modern world.

Thus, the primary objective of this bibliometric study is to assess the research publication performance in physics subjects' education across ASEAN countries apart from a broad overview of existing research publications by utilizing the Web of Science (WoS) database. This provides insights into the trends and directions of physics-related activities. This effort corresponds to the essential goal of this article, which is to contribute to the enhancement of physics education through the application of bibliometric analysis Furthermore, the study aligns with the broader goals of ASEAN, promoting social progress and the advancement of Southeast Asian studies within the region, as well as contributing to the United Nations'

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Sustainable Development Goal (SDG-4), which advocates for lifelong learning opportunities (Khalid et al., 2019; Lye, 2021). In pursuit of this objective, the article intentionally abstains from conducting an extensive content analysis of the physics education research field but is limited to bibliometric analysis.

Research Questions

To begin, a comprehensive bibliometric analysis to address key inquiries relevant to physics subject education within the ASEAN region, covering the years 2000 to 2023 (24 years). The investigation seeks to illuminate the following aspects:

1. Which ASEAN member exhibits the highest volume of WoS publications in physics subject education?
2. Identifying the organization within ASEAN nations with the most influential and prolific physics subject education through publication output and highest total citations.
3. Which author with the most significant WoS total citations, total publication, and citation rates per year in the field?
4. Exploring the collaborative landscape among researchers in ASEAN countries concerning the field of physics subject education.
5. A brief assessment of research funding in physics subject education across ASEAN countries.
6. Uncovering the keywords and co-occurrence patterns prevalent in articles centered on physics subject education.

These inquiries provide the framework for the bibliometric analysis, offering insights into the scholarly landscape of physics education within the ASEAN.

Methodology

Bibliometric analysis has gained attention, particularly in the domain of physics education research. This Bibliometric study is utilized for quantitative analysis of vast academic literature, enabling individuals and institutions to assess research impact based on measurements like citations, number of documents authors produced and keywords used (Donthu et al., 2021). There are several examples of bibliometric study has been done on physics subject education topic such as online physics learning during the COVID-19 pandemic (Jatmiko et al., 2021), trend of physics education research during the COVID-19 pandemic (Prahani et al., 2022), publication trends in physics education (Jamali et al., 2017), quantum physics education (Bitzenbauer, 2021) and STEM-physics research evolution (Mardian et al., 2023) were among the article that analyses the related topic using bibliometric techniques.

The techniques applied in this study are categorised into two different types which are performance analysis and science mapping. The main function of Performance analysis is essentially to evaluate the contributions of research constituents, predominantly authors' citations, total publication, and affiliation. Other information such as country of origin, year of publication, source title and funding information can be obtained and examined. This stage of analysis is done using Harzing's Publish or Perish (8.9.4538 version for Windows) and Microsoft Excel (Microsoft Excel 97-2003 Worksheet). The data type required for these two software is a tab-delimited file (.txt) and MS Excel (.xls) respectively. While using MS Excel, new attributes such as % funded publication and citation per publication were created. The data is derived by counting the name of the "Funding Orgs" in the dataset. Appropriate formulas

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were used to calculate the percentages and ratios. The use of Harzing's Publish or Perish is to cross-reference and refine the data analysed through MS Excel. Meanwhile, science mapping explores the interconnections among co-authorship, citation, and co-occurrence relationships. To generate a visual representation of these connections, the VOSviewer (1.6.19 version) software is used. In this stage of analysis, the data type required by the software to be imported is similar to Harzing's Publish or Perish (.txt). All the stated data types can be obtained through the WoS Core Collection database by selecting export and choosing the type of data format to be exported. To make the analysis smooth, some functions of VOSviewer were used such as the type of analysis set to "citation" with the unit of analysis to "authors", "source" and "organization" respectively. The output of the analysis will show the list of authors, sources, and organizations based on the metric of documents and citations. From these, the top 10 of each influential and prolific category can be determined. The term 'prolific' refers to the number of publications produced, while 'influential' pertains to the number of citations received. These metrics are analyzed further at the levels of authorship, organizational affiliation, and source titles to assess research productivity and impact. Next, the data produced from the VOSviewer is transferred to MS Excel for further analysis, and added relevant information to make the data presentation more conceivable. Figure 1 is a brief simplification of the methodology represented through the flowchart.

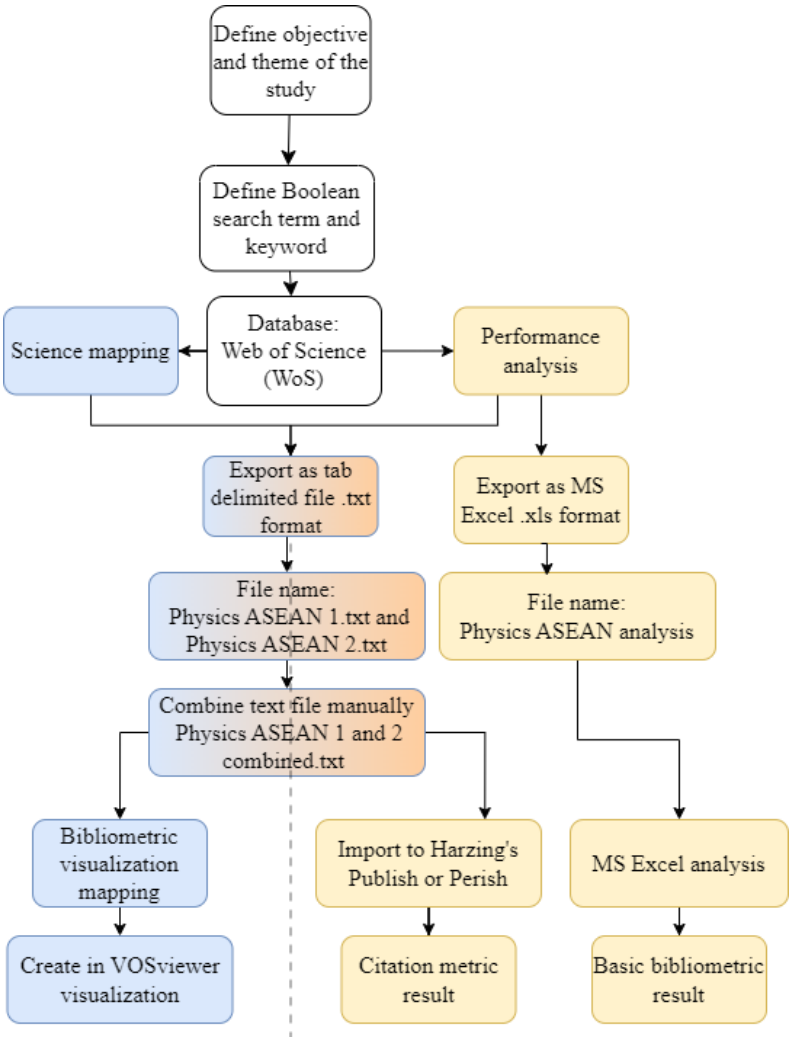

Figure 1: Flowchart of Methodology

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The Web of Science Core Collection database is used as the primary source of data due to its well-known academic database collection and can greatly help in bibliometric analysis (Ang et al., 2022). The focus of this study revolves around the topic of physics subject education in ASEAN countries, a dedicated search string as defined in Table 1 was employed within the WoS database. A total of 703 results were generated spanning the extensive timeframe from 2000 to 2023, covering 24 years. Next, the search was not constrained by language, source type, or document selection criteria. The chosen geographical scope covered all ASEAN member nations, including Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Vietnam. During the keyword and search string selection, three ASEAN countries were not found in the selection. It was assumed the data from the three countries were not obtainable from the database and would be stated as unavailable or the dash symbol '-'throughout the study. A quick-add keyword, as listed in Table 2, was included. The selected keywords are highly related to physics subject education topic and were suggested by the WoS database search engine. Upon selecting the search button, a substantial dataset was generated and presented on the database page. Following the compilation of data from the WoS database, a thorough examination of each title was conducted to ensure its relevancy to the study's objectives. Titles and associated content that met the study's criteria were identified and accordingly marked in the checkbox. Subsequently, this marked data was transferred to a dedicated "Marked List" within the WoS database for organized storage. Next, the extracted 703 data then undergo a screening process to determine its relevancy to the topic of the study. Any duplication among the dataset is removed. Studies that were unrelated to ASEAN countries and the topic of physics education were removed and validated with other co-authors and experts in the field of physics education. Consequently, a total of 32 data points were afterward excluded from the initial dataset with 691 data remaining. A structured screening protocol was followed to ensure consistency in identifying the relevance to the scope of physics education in ASEAN countries. The search approach for finding the database followed a guideline contained in the Preferred Reporting Items of Systematic Reviews and Meta-Analysis (PRISMA) as simplified in the flow diagram in Figure 2. Finally, the data was analyzed quantitatively trough performance analysis and science mapping.

Table 1: Physics Subject Education Full Search String

Search inquiries
("Physics" AND (subject* OR education* OR learn* OR teach* OR school*) AND student*) (Title) and Physics Problem-solving Skills (Should – Search within the topic) and Physics Learning (Should – Search within the topic) and Teaching Of Physics (Should – Search within topic) and Physics Course (Should – Search within topic) and Physics Education (Should – Search within topic) and Physics Teaching (Should – Search within topic) and Teaching Physics (Should – Search within topic) and 2023 or 2022 or 2021 or 2020 or 2019 or 2018 or 2017 or 2016 or 2015 or 2014 or 2013 or 2012 or 2011 or 2005 or 2004 or 2003 or 2002 or 2001 or 2000 (Publication Years) and INDONESIA or LAOS or MALAYSIA or PHILIPPINES or SINGAPORE or THAILAND or VIETNAM (Countries/Regions)

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Table 2: Seven Additional Keywords Added to The Search Inquiries

Additional keyword added	
Physis Course	Teaching of Physics
Physics Education	Physics Teaching
Physics Learning	Physics Problem-Solving Skills
Teaching Physics	

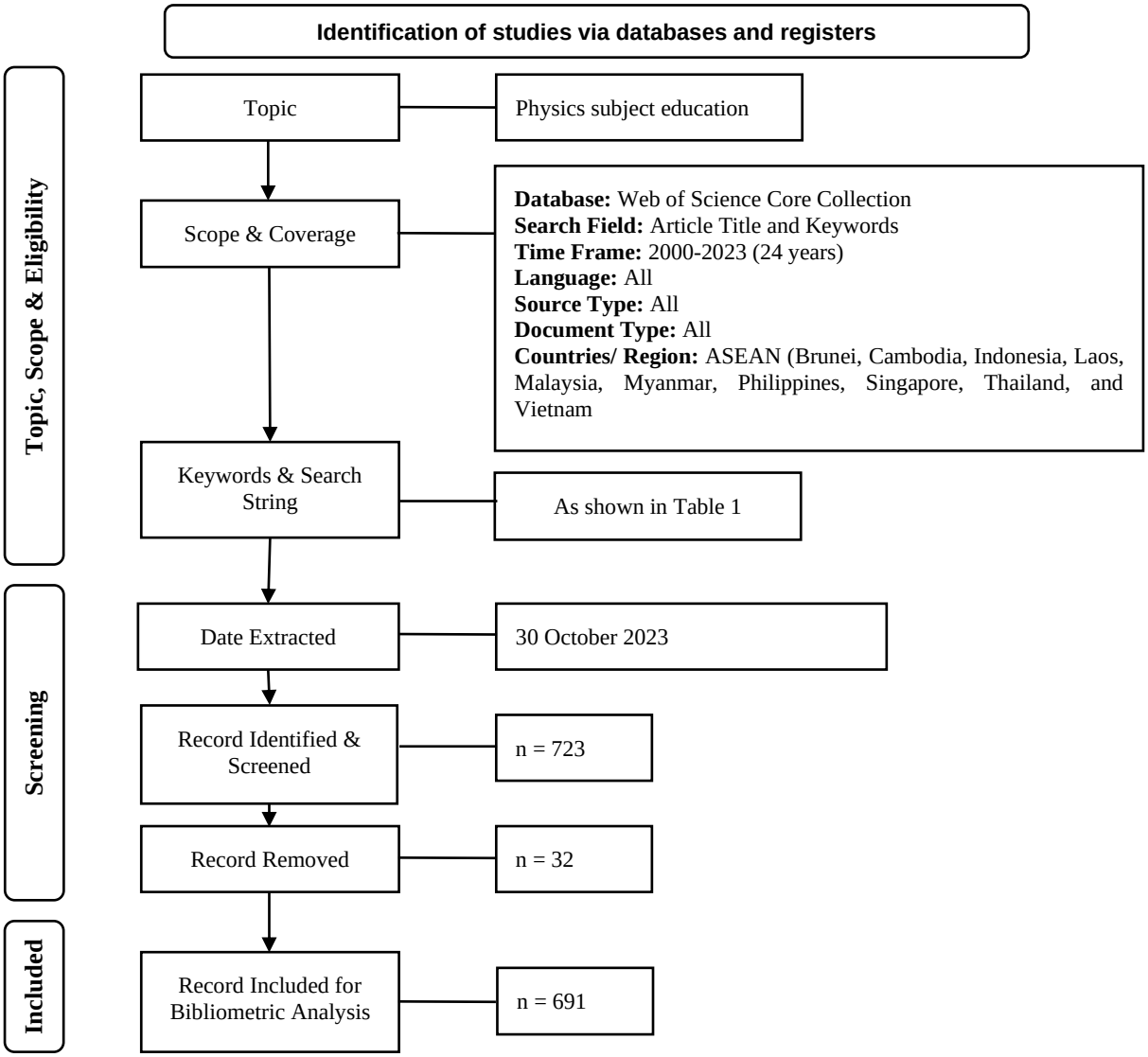

Figure 2: PRISMA Flow Diagram of the Search Approach

Source: Adapted Accordingly from (Ishak et al., 2023)

Results and Interpretation

The study provides an insightful overview of the current landscape concerning publications in the field of physics education across ASEAN countries. As illustrated in Table 3, the data retrieved from the WoS is summarized based on various parameters, including the total number of documents, document types, languages, research areas, prolific and influential authors, prolific and influential organizations, funding agencies, and total citation with all of these parameters will be assessed against countries whenever applicable. The ensuing sections will

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delve into a comprehensive discussion of each of these summary items, providing a more detailed analysis of the research landscape.

The total document gathered from the WoS database consists of 691 documents with five documents existing in two different languages other than English. Research areas that were related to the topic of physics subject education cover 16 different areas although technically some are rather broader terms for physics such as “Science & Technology” or rather specific example “Energy & Fuel”. The study identified a total of 1,528 individuals, including lead authors and co-authors, contributing to publications in the field of physics education.

Table 3: Main Information from the Search of Physics Subject Education in WoS

Item	Productivity
Total documents	691
Document types	5
Language	3
Research area	16
Countries	7
Authors	1528
Funding agencies	172
Total overall citations	1689

Publication by Countries and Type of Document

Over the period from 2000 to 2023, the dataset for "physics subject education" publications in ASEAN countries amounted to a total of 691, as visually represented in Figure 3 and Figure 4. Remarkably, Indonesia exhibited the most substantial contribution, constituting an impressive 79.9% of the total publications, encompassing a majority of document types such as articles (128) and proceedings papers (423). This completely surpasses the contributions of other ASEAN members, with Thailand and Malaysia occupying the second and third positions, respectively, in terms of publication count. Thailand accounts for 6.2%, while Malaysia follows closely with 4.2% of the total publications within the study. From the trend at the beginning of 2015, Indonesia started to ramp up its physics subject education even before the pandemic COVID-19 pandemic. Table 4 provides a comprehensive breakdown of the various document types and their respective publication counts that facilitate the publication percentage contribution of ASEAN country's illustration.

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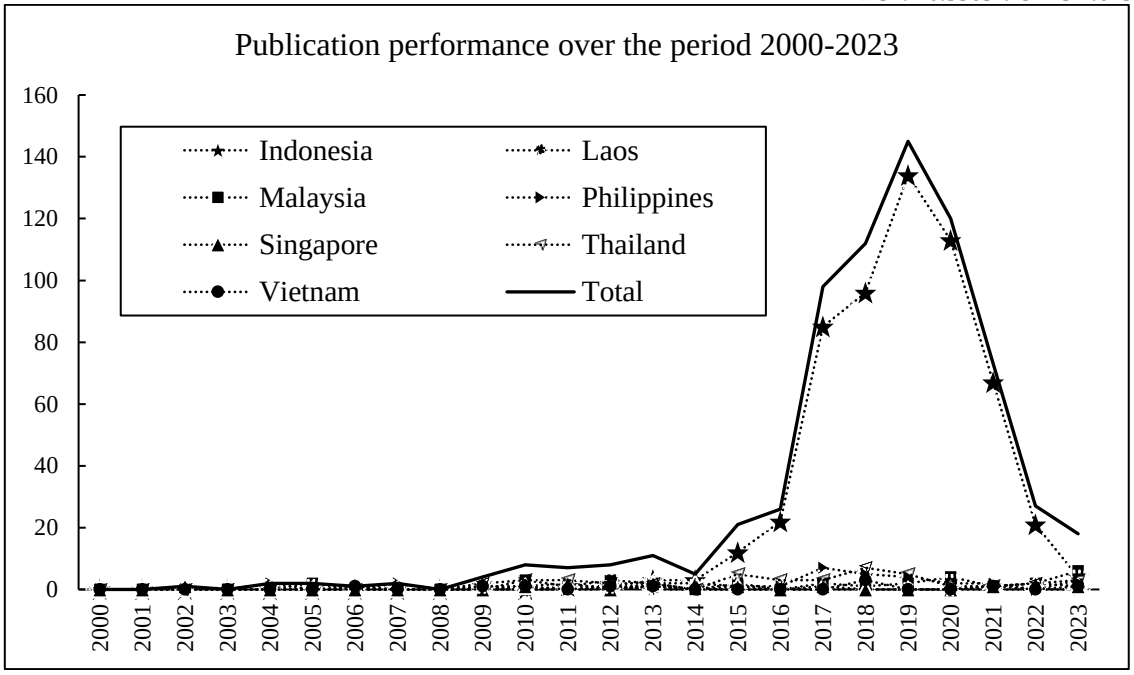

Figure 3: Publication Performance of ASEAN Countries over the Period 2000-2023

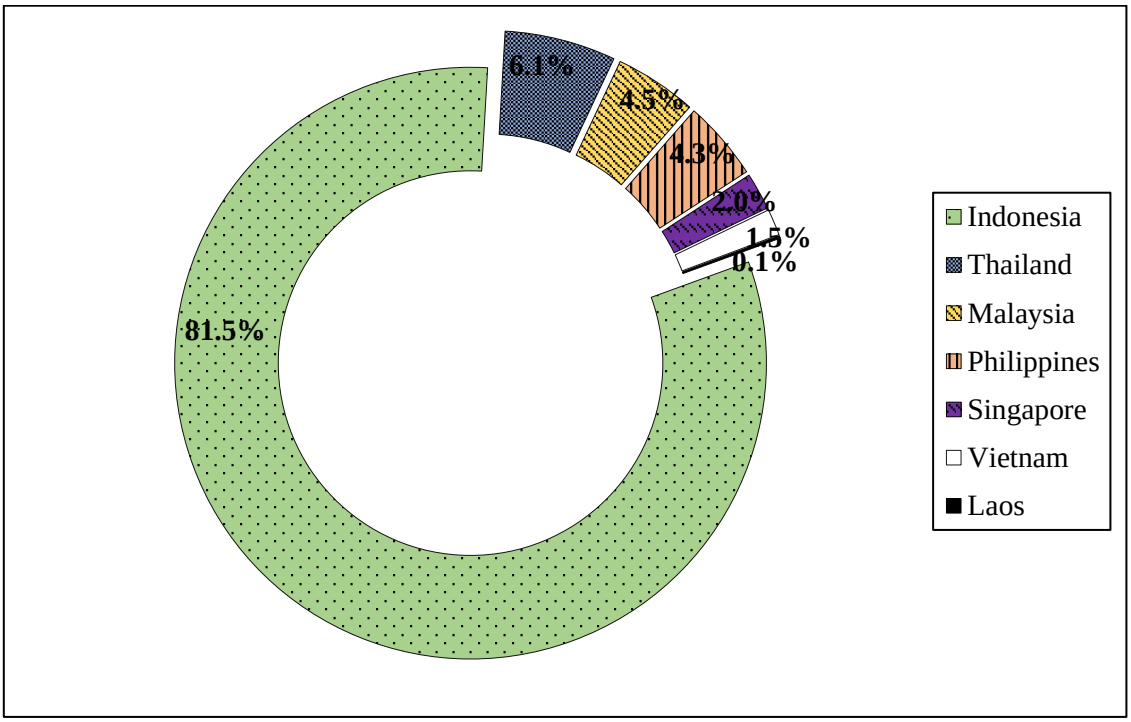

Figure 4: Publications Percentage by ASEAN Countries

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Table 4: Document Types of Each ASEAN Countries

Country/Doc type	Article	Book chapter	Editorial Material	Meeting Abstract	Proceedings Paper	Total per country	**% *(N=691)***
Brunei	-	-	-	-	-	-	-
Cambodia	-	-	-	-	-	-	-
Indonesia	125	-	1	-	437	563	**81.5**
Laos	1	-	-	-	-	1	**0.1**
Malaysia	22	1	-	1	7	31	**4.5**
Myanmar	-	-	-	-	-	-	-
Philippines	11	-	-	-	19	30	**4.3**
Singapore	11	-	-	-	3	14	**2.0**
Thailand	19	-	-	-	23	42	**6.1**
Vietnam	3	-	-	-	7	10	**1.4**
Total per document	**192**	**1**	**1**	**1**	**496**	**691**	**100.0**

The co-authorship analysis using VOSviewer examines the structured partnerships forged between countries, leading to a heightened comprehension of the intricate network of relationships within the research domain (Donthu et al., 2021). Based on Figure 5, the bibliometric analysis using VOSviewer provides a visual representation of the publication landscape within the field of physics subject education among ASEAN countries. Each node or bubble within the diagram represents a specific country, with the size of the bubble indicating the volume of research documents produced. Additionally, the colour of the nodes reflects the activity or recency of the documents, offering insights into the temporal progression of research activities (Ishak et al., 2023). Particularly, Indonesia stands out with the largest node, emphasizing its significant contribution to the topic in physics subject education. The size of this bubble signifies the sheer volume of documents originating from Indonesia, making it a central player in this research domain.

A closer examination of the colour-coded nodes reveals intriguing patterns. For instance, Singapore, depicted in a distinctive purple colour, is associated with the early stages of physics subject education research (2014-2015). This pioneering role is further evident in its connections with other countries, such as Australia and Vietnam, indicating collaborative efforts in shaping the initial landscape of this research field. In contrast, the green nodes, which correspond to the years 2016-2017, illustrate the continued momentum in research activities, particularly in Malaysia and Thailand. These countries have adeptly built upon the groundwork laid by previous studies, contributing to the evolution and expansion of physics subject education research. Finally, Indonesia represented by a sizable yellow node, emerges as a frontrunner in the latest research activities in physics subject education. Furthermore, the inclusion of Taiwan as a slowly emerging node suggests the evolving nature of this research domain and the growing collaboration interest in this field. Inherently, this visualization provides a glimpse of the broader landscape of involvement in physics subject education among ASEAN countries.

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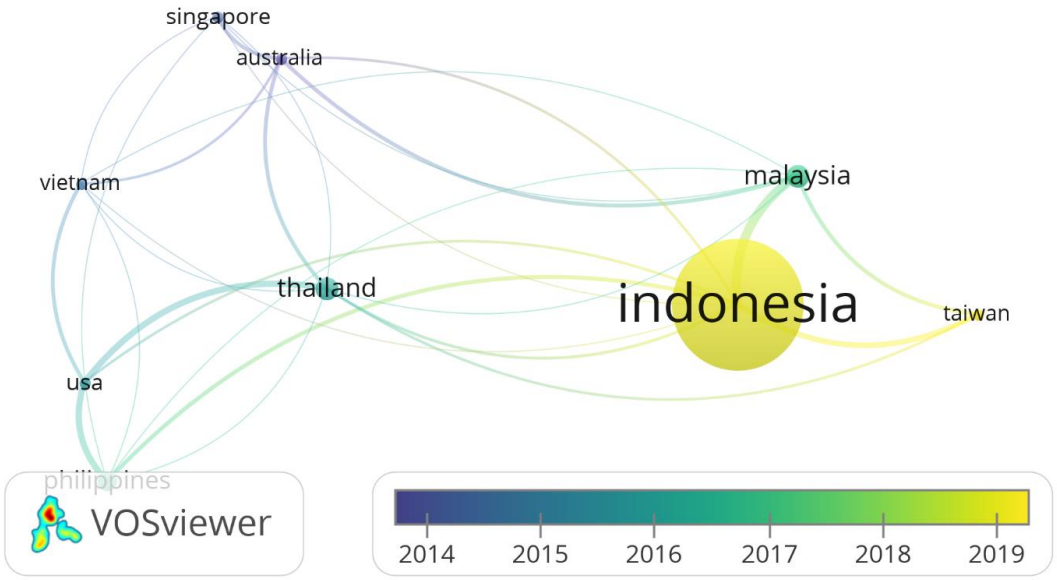

Figure 5: Overlay Visualization of the Co-Authorship by a Unit of Countries

Influential and Prolific Organization

In general, as a follow-up to the previous section, where Indonesia significantly contributed to a large number of publications, it becomes evident that Indonesia occupies a prominent position in both influential and prolific categories within ASEAN countries. The top-ranked influential and prolific organization is Universitas Pendidikan Indonesia, which has accumulated 239 citations and 102 total documents. Furthermore, in the prolific category, all of the leading organizations are based in Indonesia, demonstrating their dominance in terms of document production. Meanwhile, in the influential organization category, although Indonesia makes the most substantial contribution, Singapore through Nanyang Technological University closely follows with 165 citations, securing its position as the third most influential organization among ASEAN countries followed by another Indonesian organization Universitas Negeri Yogyakarta (146). These analyses offer compelling evidence of the Indonesian government's substantial strides toward realizing its goal of establishing a world-class education system by the year 2025 (Vidi Sukmayadi & Azizul Halim Yahya, 2020). Tables 5 and Table 6 present detailed information regarding citation counts and document counts for respective organizations within each country, further shedding light on the research landscape.

Continuing from the previous discussion, Figure 6 offers a comprehensive visualization of the distribution of total documents by representing each circle's size or node, with node colour indicating the publication years. Particularly, Universitas Pendidikan Indonesia emerges as the largest node, reflecting its substantial contribution to the documents included in the WoS Core Database. The cyan colour of this node indicates that the organization has maintained an active publication profile, particularly between 2018 and 2019. "Universitas Negeri Surabaya" and " Universitas Negeri Yogyakarta " also stand out as influential and prolific organizations in the mapping and shows many links with other organization as documented by the data in Tables 5 and Table 6.

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Table 5: Top 10 Influential Organizations Among the ASEAN Countries

Organization	Country	Citations
Universitas Pendidikan Indonesia	Indonesia	239
Universitas Negeri Surabaya	Indonesia	207
Nanyang Technological University	Singapore	165
Universitas Negeri Yogyakarta	Indonesia	146
Universiti Malaya	Malaysia	70
Khon Kaen University	Thailand	61
Mahidol University	Thailand	60
Taylor's University	Malaysia	59
Universitas Jember	Indonesia	53
Indonesia Open University	Indonesia	46

Table 6: Top 10 Prolific Organizations Among ASEAN Dominated by Indonesian Institution

Organization	Country	Documents
Universitas Pendidikan Indonesia	Indonesia	102
Universitas Negeri Jakarta	Indonesia	47
Universitas Negeri Yogyakarta	Indonesia	77
Universitas Negeri Surabaya	Indonesia	39
Universitas Negeri Malang	Indonesia	20
Universitas Negeri Semarang	Indonesia	17
Universitas Negeri Padang	Indonesia	14
Universitas Mataram	Indonesia	14
Universitas Sebelas Maret	Indonesia	25
Universitas Jember	Indonesia	12

Figure 6: Mapping of Co-Authorship by Unit of Organization

Influential and Prolific Publication by Source Title

The ranking of source titles based on Table 7 is separated into two categories: influential and prolific. To assess influence, the ranking is determined by the highest total citation an individual document has acquired within the source title. The individual document of similar nationality is grouped to count the total citation. Similarly, the prolific category considers the total number of individual documents of similar nationality from the source title but mainly ranks on its total document. Across both segments, Indonesia consistently exhibits its prominence by securing the top position in both influential and prolific source titles. In the

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influential category, Indonesia possesses the highest count of citations (141) in the "Journal of Baltic Science Education" and the greatest number of published documents (45) in the "Jurnal Pendidikan Fisika Indonesia." A thorough analysis of the source titles highlights Indonesia's substantial influence across various categories. However, it's important to note that the "International Journal of Science Education" and "Physica Medica-European Journal of Medical Physics" as exceptions, where Singapore and Malaysia take the lead with 136 and 67 citations respectively of the source titles, in the influential category. Meanwhile, within the prolific category, Indonesia overwhelmingly dominates, claiming the top position across six distinct source titles. The most prolific source title employed by Indonesia is Journal Pendidikan Fisika Indonesia (45 documents). Subsequently, the prolific source titles were International Conference on Mathematics and Science Education 2019 (31 documents), International Conference on Mathematics and Science Education 2018 (30 documents), and International Seminar on Science Education (28 documents). Therefore, these findings shed light on the major source titles that contribute to physics subject education topics.

Table 7: Top 6 Influential and Prolific Source Titles

	Influential (based on citation count)		Prolific (based on total document)	
	1. Journal of Baltic Science Education		1.Jurnal Pendidikan Fisika Indonesia	
Country	Total document	Total citation	Total document	Total citation
Indonesia	12	141	45	67
Malaysia	3	1	-	-
Philippines	2	2	-	-
Total	17	144	45	67
	2. International Journal of Science Education		2. International Conference on Mathematics and Science Education 2019 (ICMSCE 2019)	
	Total document	Total citation	Total document	Total citation
Indonesia	-	-	31	34
Singapore	3	136	-	-
Vietnam	1	8	-	-
Total	4	144	31	34
	3. International Journal of Instruction		3. International Conference on Mathematics and Science Education 2018 (ICMSCE 2018)	
	Total document	Total citation	Total document	Total citation
Indonesia	18	119	30	63
Philippines	1	-	-	-
Thailand	1	-	-	-
Total	20	119	30	62
	4. Physica Medica-European Journal of Medical Physics		4. International Seminar on Science Education	
	Total document	Total citation	Total document	Total citation
Indonesia	-	-	28	38
Malaysia	2	67	-	-
Thailand	1	2	-	-
Total	3	69	28	38

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	5. Jurnal Pendidikan Fisika Indonesia		5. International Journal of Instruction	
	Total document	Total citation	Total document	Total citation
Indonesia	45	67	18	119
Philippines	-	-	1	-
Thailand	-	-	1	-
Total	45	67	20	119
	6. International Conference on Mathematics and Science Education (ICMSCE 2018)		6. Journal of Baltic Science Education	
	Total document	Total citation	Total document	Total citation
Indonesia	30	63	12	141
Malaysia	-	-	3	1
Philippines	-	-	2	2
Total	30	63	17	144

Language of Documents

Based on the data presented in Table 8, English emerges as the dominant language in the study, accounting for a substantial 98.84% of the total documents analysed. In contrast, Indonesian and Malay, when combined, represent a mere 1.16% of the dataset. This overwhelming prevalence of English can be attributed to its widespread acceptance and comprehensibility, rendering it the primary medium for communication and the dissemination of academic content in the context of the study.

However, it is necessary to acknowledge that, other national languages beyond Indonesian and Malay were absent from the dataset. It is speculated that the publication of various ASEAN countries using native language does exist, but the usage of keywords is largely based on English. Thus, publications featuring synonyms for the term "physics" in other languages were likely omitted. The implementation of an intelligent system within the WoS Core Collection database that can decipher and comprehend the meaning of words in various languages, without the necessity for translation, would be a valuable innovation in narrowing the study inquiries (Yang et al., 2020). It is worth noting that such technology already exists within the realm of artificial intelligence but has yet to be used for such applications.

Table 8: Languages Used in Publication

Language	Total	% (*N=691*)
English	683	98.84
Indonesian	6	0.87
Malay	2	0.29
Total	691	100.00

Research Area and ASEAN Countries Contribution

As indicated in Table 9, the research area “Education & Educational Research” notably stands out as the most extensively studied area (70.19%) within the context of physics subject education. This observation supports the data’s reliability, affirming its alignment with the study’s core focus. Following closely are “Physics” and “Computer Science” contributing 12.01% and 5.21%, respectively. These findings underscore the growing influence of

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technology and the increasing integration of digitalization in the realm of education. These technological advancements, notably within the domain of computer science have catalysed an upward trend, bolstering the prominence of the "Education & Educational Research" field in the study (Bruneau et al., 2023). Figures 7, Figure 8, and Figure 9 detail the foremost contributions of the top three research areas by countries. Across these visual representations, Indonesia emerges as a dominant contributor in “Education & Educational Research”, “Physics” and “Computer Science” accounting for substantial percentages of 84%, 93%, and 61%, respectively, within each of these research domains. These figures collectively underscore the substantial role that Indonesia has assumed in driving knowledge and research in these vital domains. While recognizing the valuable contributions from other nations to the research arena, it is notable that Thailand emerges as the next major contributor after Indonesia in the fields of “Education & Educational Research” and “Physics” signifying its commendable efforts in maintaining a strong position. Similarly to the Philippines, in the field of “Computer Science” research.

Table 9: Research Area Focus Involving the Physics Subject Education

Research Area	Total	% (*N = 691*)
Education & Educational Research	485	70.19
Physics	83	12.01
Computer Science	36	5.21
Engineering	26	3.76
Science & Technology	25	3.62
Social Sciences	10	1.45
Mathematics	6	0.87
Chemistry	4	0.58
Radiology, Nuclear Medicine & Medical Imaging	4	0.58
Materials Science	3	0.43
Astronomy & Astrophysics	2	0.29
Business & Economics	2	0.29
Cultural Studies	2	0.29
Area Studies	1	0.14
Energy & Fuels	1	0.14
Psychology	1	0.14

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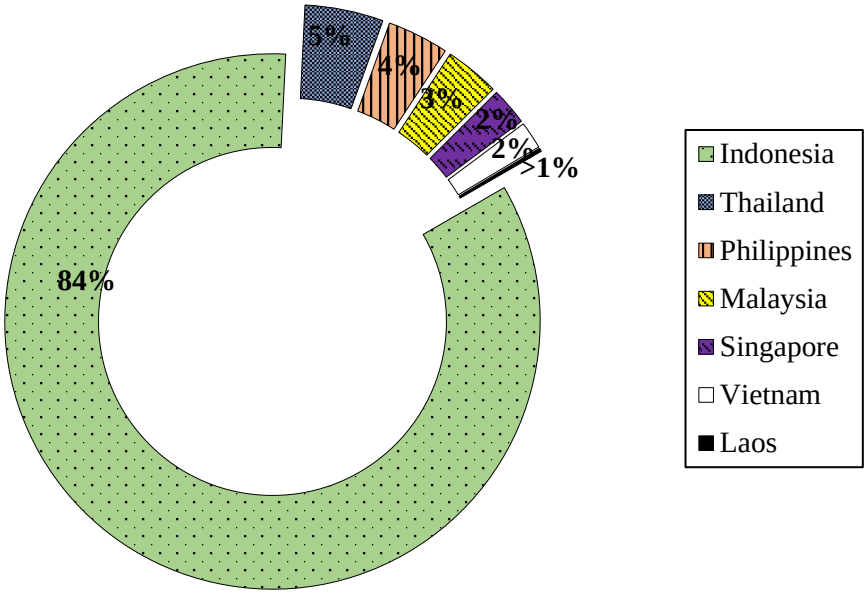

Figure 7: Percentage of Countries' Contribution to "Education & Educational Research" Research Area

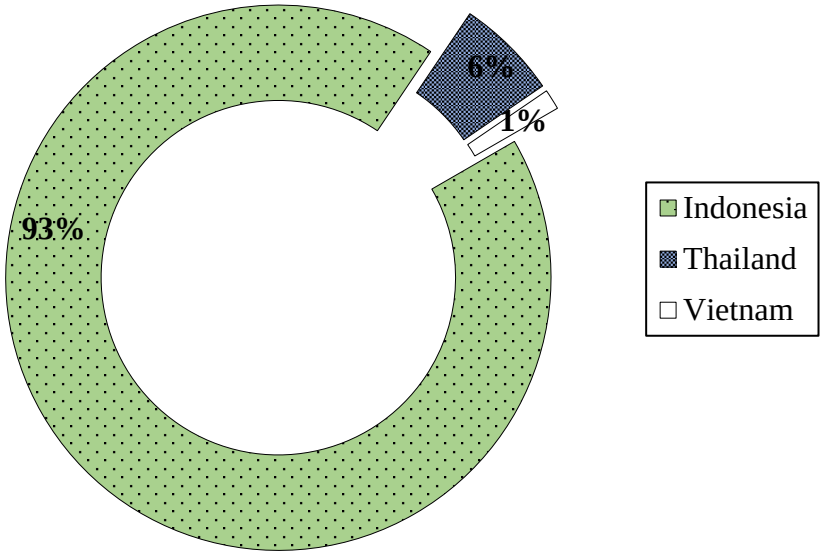

Figure 8: Percentage of Countries' Contribution to "Physics" Research Area

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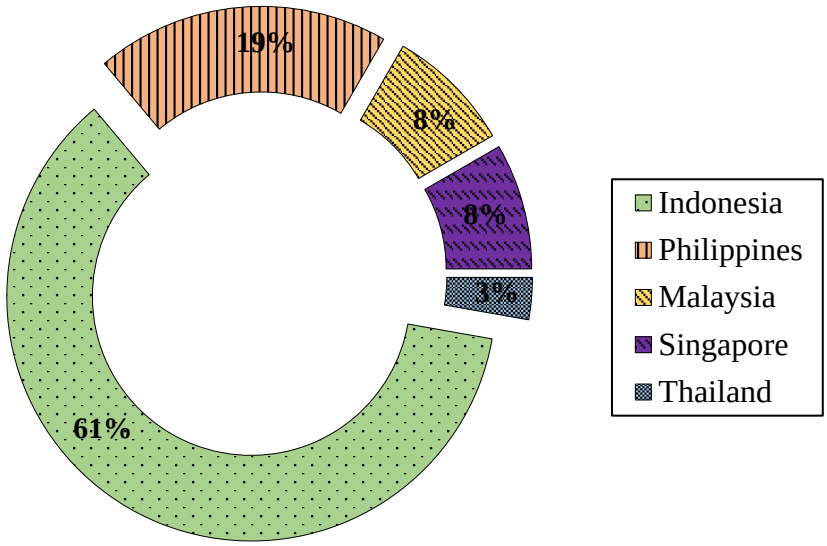

Figure 9: Percentage of Countries' Contribution in "Computer Science" Research Area

Authorship

This section emphasizes an intricate analysis of author citation metrics concerning their affiliations and countries of origin, separating influential and prolific attributes. In the category of influential authors, "Subramaniam, R." emerges as the highly cited individual, amassing a remarkable total of 130 citations, a number that substantially exceeds those of other authors across ASEAN countries. A more detailed examination of the dataset exposes that "Subramaniam, R." authored four articles, two of which were published as early as 2010 and 2011, adding 105 and 25 citations, respectively. These contributions collectively contribute to the 130 citations, thus securing "Subramaniam, R."'s position as the most influential author in the study of physics subject education among authors from various ASEAN nations. Following closely in prominence is "Caleon, Imelda" who interestingly serves as the first author in one of "Subramaniam, R." 's publications. An in-depth investigation reveals that these two authors share a common affiliation, "Nanyang Technological University". Further extrapolation exposes additional research by "Caleon, Imelda" in the field of physics subject education, although regrettably, these works are not recorded within the WoS Core Collection database. By extrapolation from the profiles accessible through Google Scholar, it is evident that both researchers collaborate on similar themes within the realm of physics subject education, even though this collaboration is not fully represented in the WoS database, with only one article associated together with "Subramaniam, R." present in the study. A third influential author, "Suhandi, A.," exhibits a close association with "Setiawan, A.," ranked sixth with several documents jointly credited to their names. A comprehensive compilation of influential authors can be found in Table 10 for a clearer representation of this citation category.

Table 10: Top 10 Influential Author and Their Affiliation

Author	Country	Affiliation	Citations
Subramaniam, R.	Singapore	Nanyang Technological University	130
Caleon, Imelda	Singapore	Nanyang Technological University	105
Suhandi, A.	Indonesia	Universitas Pendidikan Indonesia	70
Jatmiko, Budi	Indonesia	Universitas Negeri Surabaya	70

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Kuswanto, Heru	Indonesia	Universitas Negeri Yogyakarta	68
Setiawan, A.	Indonesia	Universitas Pendidikan Indonesia	67
Ng, Kwan Hoong	Malaysia	Universiti Malaya	67
Wong, Jeannie Hsiu Ding	Malaysia	Universiti Malaya	67
Srisawasdi, Niwat	Thailand	Khon Kaen University	60
Azlan, Che Ahmad	Malaysia	Universiti Malaya	59

Shifting the attention to the prolific author category, it becomes apparent that Indonesian affiliations have exerted a significant inducement, with "Kuswanto, Heru" affiliated with "Universitas Negeri Yogyakarta" emerging as the most prolific author across all affiliations, contributing 37 documents to the study. A more extensive examination reveals that this author has often collaborated with "Jumadi" and "Wilujeng, Insih," both of whom also have similar affiliations and rank among the top 10 prolific authors. This collaborative trend is evidenced by the multiple co-authored documents featuring these three authors. This phenomenon of prolific authors working in tandem is not unique, as "Setiawan, A.", "Suhandi, A.", "Rusdiana, D.", "Malik, A." and "Samsudin, A." likewise engaged in collaborative efforts, although the presence or absence of such collaborations can vary.

From the analysis authors who share similar affiliations are more likely to engage in collaborative efforts aimed at producing academic documents. As gleaned from the previous data presented in Table 6, "Universitas Pendidikan Indonesia" emerges as the institution with the most substantial document count. This observation implies that this institution maintains remarkable group research output as can be seen in the prevalence of extensive collaboration among its prolific authors within the same institutional framework. This phenomenon signifies a vibrant academic environment that fosters cohesive research efforts and synergistic knowledge creation. A thorough compilation of prolific authors can be found in Table 11 for a more apparent representation of this category.

Table 11: Top 10 Prolific Author and Their Affiliation

Author	Country	Affiliation	Documents
Kuswanto, Heru	Indonesia	Universitas Negeri Yogyakarta	37
Setiawan, A,	Indonesia	Universitas Pendidikan Indonesia	25
Suhandi, A.	Indonesia	Universitas Pendidikan Indonesia	22
Jumadi	Indonesia	Universitas Negeri Yogyakarta	21
Wilujeng, Insih	Indonesia	Universitas Negeri Yogyakarta	20
Rusdiana, D.	Indonesia	Universitas Pendidikan Indonesia	15
Kaniawati,	Indonesia	Universitas Pendidikan Indonesia	12
Malik, A.	Indonesia	Universitas Pendidikan Indonesia	11
Bakri, Fauzi	Indonesia	Universitas Negeri Jakarta	10
Samsudin, A.	Indonesia	Universitas Pendidikan Indonesia	10
Muliyati, Dewi	Indonesia	Universitas Negeri Jakarta	10

The final segment of the authorship analysis takes a deeper dive into the evaluation of authors with the most notable citation rates per year, a metric calculated from the publication year of the article through 2023. This specific metric stands apart from the total citation count as it

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serves to highlight the popularity of an article. While the total citation count represents the cumulative number of citations an article has garnered up to the present, this annual citation rate demonstrates the number of citations an article receives every year during its publication period.

As disclosed in the comprehensive data provided in Table 12, the article that shines with the most remarkable citation rate per year is the work of Azlan et al., originating from the year 2020. This article boasts an impressive annual average of 19.7 citations, far surpassing the second most cited article, which is Simeon et al.'s publication from 2022. An intriguing aspect of this observation is that both articles with the highest citation rates per year originated from Malaysia, despite their relatively recent release in 2020.

Furthermore, Singapore, represented by Caleon & Subramaniam, showcases the third-highest citation rate per year. Their 2010 article not only maintains its relevance but also holds the distinction of amassing the highest total citation count at 105. This case raises intriguing questions regarding the enduring impact of research, as even the oldest article in Table 12 continues to capture scholarly attention.

Table 12: Top 10 Highly Cited Articles

Authors	Article Title	Country	Total Citation	Citation per year
1. Azlan et al. (2020)	Teaching and learning of postgraduate medical physics using Internet-based e-learning during the COVID-19 pandemic - A case study from Malaysia	Malaysia	59	19.7
2. Simeon et al. (2022)	Effect of design thinking approach on students' achievement in some selected physics concepts in the context of STEM learning	Malaysia	10	10.0
3. Caleon & Subramaniam (2010)	Development and Application of a Three-Tier Diagnostic Test to Assess Secondary Students' Understanding of Waves	Singapore	105	8.1
4. Santyasa et al. (2020)	Project Based Learning and Academic Procrastination of Students in Learning Physics	Indonesia	18	6.0
5. Suyidno et al. (2018)	Effectiveness of Creative Responsibility Based Teaching (CRBT) Model on Basic Physics Learning to Increase Student's Scientific Creativity and Responsibility	Indonesia	21	4.2
6. Lai & Cheong (2022)	Educational Opportunities and Challenges in Augmented Reality: Featuring Implementations in Physics Education	Singapore	4	4.0

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7.	Van Vo & Csapó (2021)	Development of scientific reasoning test measuring control of variables strategy in physics for high school students: evidence of validity and latent predictors of item difficulty	Vietnam	8	4.0
8.	Shabrina & Kuswanto (2018)	Android-Assisted Mobile Physics Learning Through Indonesian Batik Culture: Improving Students' Creative Thinking and Problem Solving	Indonesia	19	3.8
9.	Yusuf & Widyaningsih (2020)	Implementing E-Learning-Based Virtual Laboratory Media to Students' Metacognitive Skills	Indonesia	11	3.7
10.	Salam et al. (2018)	Teaching Problem-solving Skills through Learner Autonomy based Learning and Local Wisdom Insight	Indonesia	21	3.5

Funding Publication

As per the findings presented in Table 13, Thailand emerges as the leader with the highest percentage of funded publications, with almost half of its publications (45.2%) being funded. Intriguingly, despite this substantial funding, the citation per publication slightly falls below the mean value of citation per publication, with an average of 3.7, compared to the mean value of 4.4. Similarly with Philippines, which has the second-highest proportion of funded publications (36.7%), achieves a citation per publication of 2.1. Indonesia, despite being the ASEAN country with the highest number of publications at 563, only sees 29.3% of its publications funded. Yet, it garners a total citation count of 1121, surpassing all other ASEAN nations. Notably, Singapore, with 35.7% of its publications funded, boasts the highest citation per publication. In the case of Malaysia, while it has the smallest proportion of funded publications at 16.1%, it manages to achieve an impressive 4.6 citations per publication, ranking second after Singapore among ASEAN nations. Upon review, it becomes apparent that the majority of ASEAN countries exhibit citation rates per publication below the mean, with Singapore and Malaysia being the sole exceptions, surpassing the mean. A preliminary inference from the analysis indicates that the quantity of funded publications does not necessarily correlate with the citation rate per publication. This is evident in the case of Singapore, which has higher levels of funding, and Malaysia, which has lower levels of funding, yet both surpass the mean citation rate per publication.

Table 13: ASEAN Countries Funded Publication Contribution

Country	Funded publication count	Total publication	Total citation	% funded publication	Citation per publication ($\bar{x}$=4.42)
Thailand	19	42	155	45.2	3.7
Philippines	11	30	62	36.7	2.1
Singapore	5	14	186	35.7	13.3
Vietnam	3	10	23	30	2.3
Indonesia	165	563	1121	29.3	2

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Malaysia	5	31	142	16.1	4.6
Laos	-	1	3	-	3
Total	**208**	**691**	**1692**	**30.1**	**2.4**

Keywords Analysis

This study's selected type of analysis is co-occurrence analysis, which exclusively utilizes Author Keywords. This choice was made primarily due to its ability to provide a more streamlined and focused examination of the bibliometric data, aligning with the study's emphasis on author selections, as opposed to Keyword Plus, which tends to be broader in scope (Zhang et al., 2016). While both types of analysis have their respective advantages, the former was selected for its convenience. The size of the node in the mapping represents the occurrence or the total frequency of the occurrence while the distance between the node relates to its degree of relatability. Meanwhile, the colour represents the category of the cluster shows keywords that are more similar to each other than those of other clusters.

In Figure 10, four major clusters are represented by colours red, green, blue, and yellow. The first clusters of red consist of 10 keywords which are computer simulation, conceptual understanding, misconception, motivation, online learning, physics education, physics education research, physics teaching, scaffolding approach, and science process skills. The first red cluster explores the connections among computer simulation, conceptual understanding, identifying misconceptions, student motivation, online learning, and physics education research. It considers effective physics teaching using innovative approaches like scaffolding to encourage science process skills and improve the learning experience. The green cluster contains six keywords which are android, e-learning, learning media, learning outcomes, physics, and problem-solving skills. The assessment that can be made on this cluster is it shows digital learning, exploring the integration of Android platforms, e-learning tools, and innovative learning media. Its intended aim is to optimize learning outcomes by emphasizing the development of problem-solving skills through technologies within the context of physics education. The third cluster is represented by blue and contains six keywords which are assessment, critical thinking, local wisdom, medical physics, physics learning and problem-based learning. The third cluster may convey information on the critical thinking required in medical physics by problem-based learning in physics learning assessment to impart local wisdom among the students. Finally, the fourth cluster represented colour yellow contains two keywords which are creativity and guided inquiry. This cluster might convey information on creativity needed to guide an inquiry. However, this cluster is far from the other cluster indicating the keyword is less related to other keywords in the physics subject education. Finally based on Table 14 the keywords physics education, physics and critical thinking had the highest frequency of occurrences keywords indicating the most discussed themes of physics subject education in ASEAN. To summarize, the topic of physics subject education in ASEAN revolves around implementing technological tools such as online platform, Androids and computer simulation to motivate students with creative method, scaffolding approach and problem-solving skills leading to enriched physics teaching.

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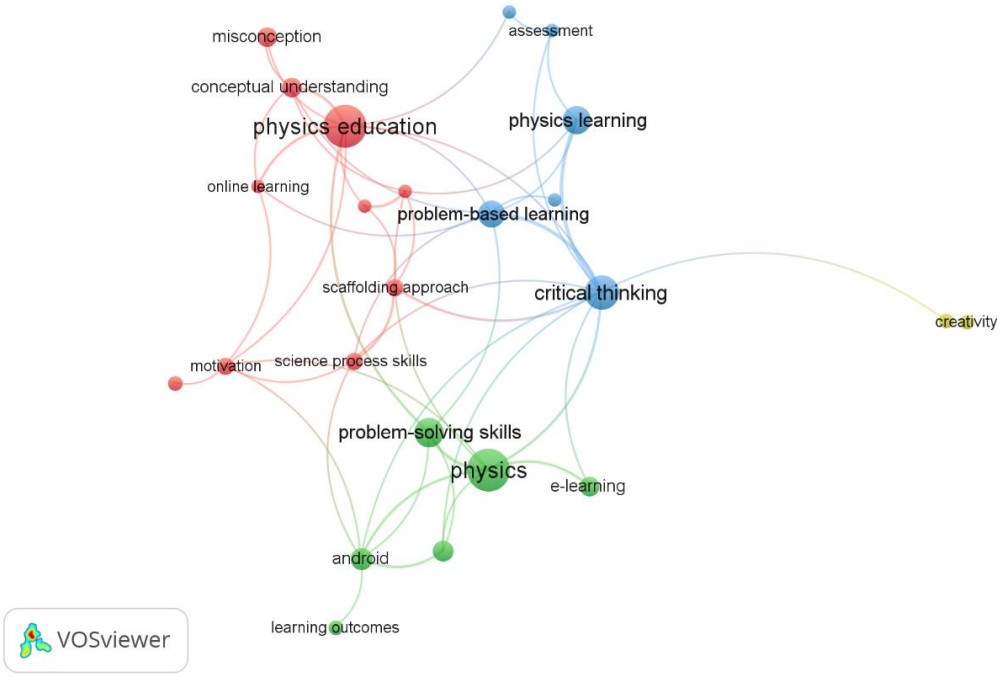

Figure 10: Overall Network Visualization Map of the Author Keyword Occurrence

Table 14: Top Keywords

Keywords	Occurrences	Total link strength
critical thinking	22	19
physics	32	16
physics education	32	13
problem-based learning	15	11
android	11	9
motivation	7	8
physics learning	16	8
problem-solving skills	17	8
computer simulation	5	7
conceptual understanding	9	6
online learning	5	6
scaffolding approach	7	6
science process skills	7	6
learning media	10	5
physics education research	5	4
assessment	5	3
e-learning	9	3
guided inquiry	6	2
local wisdom	5	2
medical physics	5	2
misconception	9	2
creativity	6	1
learning outcomes	6	1
physics teaching	6	1

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Limitation and Future Studies

All in all, this study is not without its limitations and constraints. Firstly, it exclusively draws data from one database, WoS, neglecting the wealth of scientific studies available in alternative databases such as Elsevier's Scopus. This limited data source might introduce bias and hinder the comprehensiveness of the findings. However, based on careful analysis this impact will be lesser due to the large amount of collection that has been gathered from a single database. Additionally, the acquired data from WoS only consisted of indexed publications. Whereby additional non-written discourses such as conference TED Talks, dialogue, forums, and action could provide more depth to the bibliometric analysis. Moreover, the limitation of this study is the potential inclusion of predatory journals within the indexed WoS dataset, as their presence in bibliometric databases may distort citation metrics and publication trends. However, this is unlikely because WoS ensures a high standard for publication verification. Future research should focus on developing a methodology to identify and exclude such journals for a more accurate analysis. For example, each source title should be cross-checked with the Beall's List Furthermore, this study primarily focuses on describing associations between variables. It is important to show that bibliometric analysis, by its nature, is not equipped to establish causal relationships. Therefore, while the study offers valuable insights into the field of physics subject education, it does not provide a basis for causal inferences. Hence, these metrics can serve as valuable indicators of performance within the educational area, allowing for the assessment of a nation's educational initiatives and their impact on various aspects of physics education. Regardless, an additional quantitative analysis could provide a better analysis to complement the research findings. Another future study could consider analyzing the ratio of tertiary education institutions to the number of personnel as a factor contributing to the performance of research publications and citations. This would provide the depths of the data for quantitative analysis in the field of physics education.

Conclusion

Over the past decade, research in physics education has grown significantly among ASEAN countries, with Indonesia emerging as a leading contributor in this field. Dominating the total publication with overwhelmingly 81.5% of overall ASEAN publication with a sum of 1121 citations. Additionally, when considering citation rates per publication, Singapore emerges as the leader, boasting the highest average citation count across the years. This prominence can be attributed to Singapore's status as one of the top three well-funded countries in the region, with 35.7% of its total publications being funded. Finally, keyword analysis on physics education in ASEAN revolves around using tech tools like online platforms, Androids, and computer simulation. The focus is on motivating students with creative methods and developing problem-solving skills, enriching physics teaching. This transformation also underscores the evolving landscape of education and its intersection with technological advancements.

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Volume 6 Issue 23 (December 2024) PP. 202-226
DOI: 10.35631/IJMOE.623015

References

Al-Maskari, A., Al Riyami, T., & Ghnimi, S. (2022). Factors affecting students' preparedness for the fourth industrial revolution in higher education institutions. *Journal of Applied Research in Higher Education*. https://doi.org/10.1108/JARHE-05-2022-0169

Ang, L. S., Yaakob, M. H., Nasir, N. A. H. A., Shuhaime, N., & Ghani, Z. A. (2022). More Than Five Decades of Research on Urease Inhibitors: a Bibliometric Study. *Journal of Sustainability Science and Management*, *17*(9), 75–95. https://doi.org/10.46754/jssm.2022.09.006

Avirutha, A. (2021). ASEAN in Digital Economy: Opportunities and Challenges. *Journal of ASEAN PLUS+ Studies*, *2*(1), 17–25.

Azlan, C. A., Wong, J. H. D., Tan, L. K., Muhammad Shahrun, M. S. N., Ung, N. M., Pallath, V., Tan, C. P. L., Yeong, C. H., & Ng, K. H. (2020). Teaching and learning of postgraduate medical physics using Internet-based e-learning during the COVID-19 pandemic – A case study from Malaysia. *Physica Medica*, *80*, 10–16. https://doi.org/10.1016/j.ejmp.2020.10.002

Bitzenbauer, P. (2021). Quantum physics education research over the last two decades: A bibliometric analysis. *Education Sciences*, *11*(11). https://doi.org/10.3390/educsci11110699

Bruneau, P., Wang, J., Cao Bee, L. A., & Hana Truong, V. (2023). The Potential of ChatGPT to Enhance Physics Education in Vietnamese High Schools. *Jounal Physics Education*, 1–8. https://doi.org/DOI: 10.35542/osf.io/36qw9

Caleon, I., & Subramaniam, R. (2010). Development and application of a three-tier diagnostic test to assess secondary students' understanding of waves. *International Journal of Science Education*, *32*(7), 939–961. https://doi.org/10.1080/09500690902890130

Chaka, C. (2023). Fourth industrial revolution—a review of applications, prospects, and challenges for artificial intelligence, robotics and blockchain in higher education. *Research and Practice in Technology Enhanced Learning*, *18*. https://doi.org/10.58459/rptel.2023.18002

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, *133*, 285–296. https://doi.org/10.1016/j.jbusres.2021.04.070

Firman, H. (2021). Science Curriculum and Education Policy in ASEAN Context. *Science Education*, 1–11.

Fox, M. F. J., Zwickl, B. M., & Lewandowski, H. J. (2020). Preparing for the quantum revolution: What is the role of higher education? *Physical Review Physics Education Research*, *16*(2), 20131. https://doi.org/10.1103/PhysRevPhysEducRes.16.020131

Ishak, M. S., Sarkowi, A., Ahmi, A., Abdulrauf-Salau, A., & Memon, S. (2023). Global Research Trends in School Bullying: A Bibliometric Analysis. *Journal of Educational and Social Research*, *13*(1), 91–105. https://doi.org/10.36941/jesr-2023-0009

Jamali, S. M., Zain, A. N. M., Samsudin, M. A., & Ebrahim, N. A. (2017). *Publication Trends in Physics Education: A Bibliometric study*. *35*, 1–14. https://doi.org/10.5281/zenodo.801889

Jatmiko, B., Prahani, B. K., Suprapto, N., Admoko, S., Deta, U. A., Lestari, N. A., Jauhariyah, M. N. R., Yantidewi, M., & Muliyati, D. (2021). Bibliometric analysis on online physics learning during COVID-19 Pandemic: Contribution to physics education undergraduate program. *Journal of Physics: Conference Series*, *2110*(1). https://doi.org/10.1088/1742-6596/2110/1/012018

International Journal of Modern Education
IJMOE
EISSN: 2637-0905
Volume 6 Issue 23 (December 2024) PP. 202-226
DOI: 10.35631/IJMOE.623015
Khalid, J., Ali, A. J., Nordin, N. M., & Shah, S. F. H. (2019). Regional cooperation in higher education: Can it lead ASEAN toward harmonization? *Southeast Asian Studies*, *8*(1), 81–98. https://doi.org/10.20495/seas.8.1_81

Lai, J. W., & Cheong, K. H. (2022). Educational Opportunities and Challenges in Augmented Reality: Featuring Implementations in Physics Education. *IEEE Access*, *10*, 43143–43158. https://doi.org/10.1109/ACCESS.2022.3166478

Lye, L. H. (2021). The Implementation of Sdg 4 - Achieving the Sustainable Development Goals Through Education on the Environment. In *Implementing the Sustainable Development Goals (SDGs) - Strategies for a Livable World* (pp. 1–17). https://doi.org/10.2139/ssrn.3812871

Mardian, V., Utama, J. A., & Suwarma, I. R. (2023). Bibliometric Map of STEM-Physics Research Evolution. *Berkala Ilmiah Pendidikan Fisika*, *11*(2), 262–276. https://doi.org/10.20527/bipf.v11i2.16284

Martinus, M. (2020). The Intricacies of 5G Development in Southeast Asia. *ISEAS Yusof Ishak Institute*, *130*, 1–9.

Prahani, B. K., Amiruddin, M. Z. Bin, Suprapto, N., Deta, U. A., & Cheng, T. H. (2022). The Trend of Physics Education Research during COVID-19 Pandemic. *International Journal of Educational Methodology*, *8*(3), 517–533. https://doi.org/10.12973/ijem.8.3.517

Salam, A., Miriam, S., & Misbah, M. (2018). *Teaching Problem-solving Skills Through Learner Autonomy Based Learning and Local Wisdom Insight*. *147*, 4–7. https://doi.org/10.2991/icsse-17.2018.1

Santyasa, I. W., Rapi, N. K., & Sara, I. W. W. (2020). Project based learning and academic procrastination of students in learning physics. *International Journal of Instruction*, *13*(1), 489–508. https://doi.org/10.29333/iji.2020.13132a

Shabrina, & Kuswanto, H. (2018). Android-assisted mobile physics learning through indonesian batik culture: Improving students' creative thinking and problem solving. *International Journal of Instruction*, *11*(4), 287–302. https://doi.org/10.12973/iji.2018.11419a

Simeon, M. I., Samsudin, M. A., & Yakob, N. A. (2022). Effect of design thinking approach on students' achievement in some selected physics concepts. *International Journal of Technology and Design Education*, *32*, 185–212. https://doi.org/https://doi.org/10.1007/s10798-020-09601-1

Suyidno, Nur, M., Yuanita, L., & Prahani, binar kurnia. (2018). Effectiveness of Creative Responsibility Based Teaching (CRBT) Model on Basic Physics Learning To Increase Student ' S Scientific Creativity and Responsibiity. *Journal of Baltic Science Education*, *17*(1), 136–151.

Van Vo, D., & Csapó, B. (2021). Development of scientific reasoning test measuring control of variables strategy in physics for high school students: evidence of validity and latent predictors of item difficulty. *International Journal of Science Education*, *43*(13), 2185–2205. https://doi.org/10.1080/09500693.2021.1957515

Vidi Sukmayadi, & Azizul Halim Yahya. (2020). Indonesian Education Landscape and the 21 st Century Challenges. *Journal of Social Studies Education Research*, *11*(4), 219–234.

Yang, W., Zhao, H., Wang, M., & Ji, J. (2020). Design of Intelligent Search Engine Service Performance Evaluation System. *2020 5th Asia-Pacific Conference on Intelligent Robot Systems, ACIRS 2020*, *18*, 86–91. https://doi.org/10.1109/ACIRS49895.2020.9162611

International Journal of Modern Education
IJMOE
EISSN: 2637-0905
Volume 6 Issue 23 (December 2024) PP. 202-226
DOI: 10.35631/IJMOE.623015

Yusuf, I., & Widyaningsih, S. W. (2020). Implementing e-learning-based virtual laboratory media to students' metacognitive skills. *International Journal of Emerging Technologies in Learning*, *15*(5), 63–74. https://doi.org/10.3991/ijet.v15i05.12029

Zhang, J., Yu, Q., Zheng, F., Long, C., Lu, Z., & Duan, Z. (2016). Comparing keywords plus of WOS and author keywords: A case study of patient adherence research. *Journal of the Association for Information Science and Technology*, *67*(4), 967–972. https://doi.org/10.1002/asi.23437