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The Trend of Physics Education Research During COVID-19 Pandemic

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Abstract: Currently, physics education is a science that is still considered abstract by many students and the public. Thus, there is a need for information on the current trends in physics education to adapt to the current situation. Based on the Scopus, the research objective is to explore the ongoing trends in the last ten years and during the COVID-19 pandemic. This research is a bibliometric and bibliometric analysis. The findings show that research related to physics education is dominated by the most developed during the COVID-19 pandemic (2020 – 2021) countries Indonesia. Meanwhile, the Journal of Physics Conference Series is the journal that publishes the most publications (Scopus) related to physics education, followed by the AIP Conference Proceeding. Research implication to research, librarian, and policy maker (1) Research and development need to be carried out in-depth related to the growing trend of physics education so that it can be published in Scopus. (2) Cooperation and collaboration between other universities to increase publications at the international level. (3) The need for continuous research to follow current trends.

Keywords: *COVID-19, physics education, research, trend.*

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Introduction

Technology has become a human need in the 21st century. Technological and scientific developments continue to increase (Lai & Bower, 2019; Nguyen & Kieuthi, 2020). However, the COVID-19 pandemic has significantly impacted several sectors, including education. According to research results by Onyema et al. (2020), COVID-19 harms learning, access to education, and research. That way, innovations with global trends and realities in education emerge in the COVID-19 pandemic era (Fauza et al., 2020; Jatmiko et al., 2021). Various ways and innovations have been carried out to ensure access to education continues to run smoothly, even in the COVID-19 situation. One of the educations that needs more attention is physics learning. It is because physics education is an abstract science; studying it online will make it more abstract (Kersting et al., 2018). In this case, bibliometric studies are constructive to identify trends in physics education that have an impact during the pandemic (Siwach & Kumar, 2015; Suprapto et al., 2021).

The COVID-19 pandemic that has hit the world has had a different impact on each sector, one of which is the education sector. Various physics education research has been carried out in the last few decades (Çepni et al., 2017; Yanuarti & Suprapto, 2021). Based on Scopus data taken as of January 10, 2022 (www.scopus.com), in 2012 – 2021, international indexed journals (all countries) contain as many as 667 documents, and international indexed journals (Indonesia) contain 83 documents. Then it was narrowed again in 2020-2021, which for International indexed journals (all countries) contained 188 documents and International indexed journals (Indonesia) contained 42 documents. In the education sector, publications are one of the sources of reference in learning and writing. Moreover, reference sources are indexed internationally. Scopus is so important because it is a leading international index used as a reference for world researchers in publishing their research results (Aksnes & Sivertsen, 2019; Baas et al., 2020;).

However, the work (article) that wants to be published on Scopus is not easy because it requires a different trend of research topics than before. By research results (Campos et al., 2020; Chen et al., 2020; MacIntyre et al., 2019),

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following the developing trend can increase the publication in recent years. In addition, the COVID-19 pandemic forces researchers to be more creative in conducting research (Aliyyah et al., 2020). The course has an impact on the research topic being studied. That way, it is necessary to know a trend that is currently well known, especially in physics education.

Based on the problems and urgency above, needed study of research topics in international physics education and in Indonesia to identify research trends in the COVID-19 pandemic era. It is hoped that the results of this study can help future researchers. In addition, this research has a specific purpose, namely exploring research trends and, at the same time, providing information about the direction of physics education research in the future. There are several research questions were asked to help achieve the specific research problem:

1) How is the number of publications of Scopus International (all countries) in the field of physics education from the year (2012 – 2021)?
2) How is the number of publications by Scopus International (Indonesia) in the field of physics education from the year (2012 – 2021)?
3) How is the development of international physics education research (all countries) during the COVID-19 pandemic (2020 – 2021)?
4) How is the research trend in physics education International (Indonesia) during the COVID-19 pandemic (2020 – 2021)?
5) How is the trend of visualization maps in physics education with keywords?
6) What is the finding and recommendation from the top-cited article during the COVID-19 pandemic?

Research questions such as the above are essential to guide researchers in the research process to investigate and solve research problems.

Literature Review

Several previous studies discussed educational research trends. However, no one has discussed the trend of special physics education during the COVID-19 pandemic. A study conducted by Chang et al. (2010) focused on research trends in science education from 1990 to 2007 in the journals; Indonesian Journal on Software Engineering (IJSE), Science Education (SE), Journal of Research in Science Teaching (JRST), and Review of Irish Studies in Europe (RISE). This study found that conceptual change and concept mapping were the most studied topics in that time interval. Another research conducted by Zawacki-Richter and Naidu (2016) is related to educational trends for 35 (1980-2014) years from the Journal of Distance Education. The results of his research indicate that in each period, there is a change in research trends that occur. From this, it can be seen that education and research trends can change over time. However, this research is still a continuation of future studies. Based on the literature review, there has been no specific research related to the trend of physics education. It is a critical study to do, and it can be a reference source for further research.

Methodology

The type of research used is a bibliometric type using the Scopus database. The research uses bibliometric analysis, which is proven to have been able to find novelties and research trends (Kulakli & Osmanaj, 2020; Lu et al., 2021; Suprapto et al., 2021; Xie et al., 2020). Data collection was obtained by searching for the based on TITLE physics education on Scopus. Data retrieval was carried out four times by comparing indexed journals International (all countries) and International (Indonesia). The data obtained as of January 10, 2022, namely:

1) The year 2012 – 2021 for International (All countries) contains 667 documents with the following: TITLE (physics AND education) AND (LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2014) OR LIMIT-TO (PUBYEAR, 2013) OR LIMIT-TO (PUBYEAR, 2012))
2) Year 2012 – 2021 for International (Indonesia) contains 83 documents with the following string: TITLE (physics AND education) AND (LIMIT- TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016) OR LIMIT-TO (PUBYEAR, 2015) OR LIMIT-TO (PUBYEAR, 2014) OR LIMIT-TO (PUBYEAR, 2013) OR LIMIT-TO (PUBYEAR, 2012)) AND (LIMIT-TO (AFFILCOUNTRY , "Indonesia"))
3) The year 2020 – 2021 for International (all countries) contains 188 documents with the following string: TITLE (physics AND education) AND (LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020))
4) Years 2020 – 2021 for International (Indonesia) contains 42 documents with the following string: TITLE (physics AND education) AND (LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020)) AND (LIMIT-TO (AFFILCOUNTRY, "Indonesia")

Then the metadata is stored in CSV and RIS forms for further analysis. Furthermore, the data were analyzed using MS-Excel and VOSviewer to visualize it in a more attractive display form such as Tables, graphs, diagrams, and maps (Colavizza et al., 2021; Suprapto et al., 2021; van Eck & Waltman, 2020). In the last few years, there have been many recent studies that prove the effectiveness of VOSViewer in research indexed by Scopus, including Putri et al. (2021), Han and Gong (2021), and Suprapto et al. (2021).

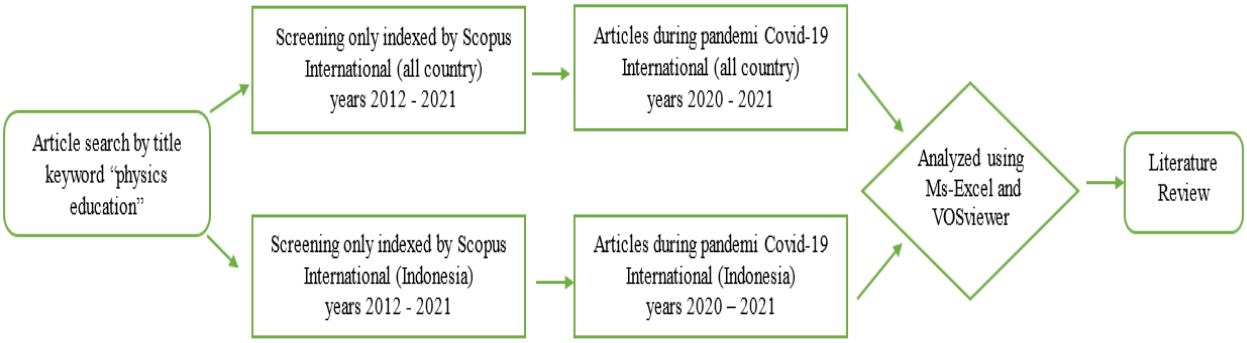

Figure 1. Flowchart Research

Findings / Results

Publication By Year

There are 667 documents in the Scopus Journal that are relevant to physics education (2012 – 2021) International (all countries) and 83 documents for the international level (Indonesia). Then for documents in the Scopus Journal for the year (2020 – 2021), international (all countries) contain 188 documents and International (Indonesia) contains 42 documents. The following are presented data by year in Table 1.

Table 1. The document by year Research on Physics Education

International				Indonesia			
Year 2012-2021	**Total**	**Year 2020-2021**	**Total**	**Year 2012-2021**	**Total**	**Year 2020-2021**	**Total**
2012	44	-	-	2012	-	-	-
2013	45	-	-	2013	-	-	-
2014	57	-	-	2014	1	-	-
2015	43	-	-	2015	1	-	-
2016	57	-	-	2016	1	-	-
2017	68		-	2017	3	-	-
2018	67	-	-	2018	11	-	-
2019	98	-	-	2019	24	-	-
2020	96	2020	96	2020	18	2020	18
2021	92	2021	92	2021	24	2021	24

Table 1 shows that for the publication of physics education documents in (2012 – 2021) International (All countries), there is an increase in each publication, while for International (Indonesia), there is an increase as well, but in 2012 – 2013 no publication took place. Furthermore, in the year (2020-2021) for International (all countries), there was a decrease in the publication of four articles from 96 to 92 documents, while for International (Indonesia), there was an increase in the publication of articles from 18 to 24 documents.

The Document Type, Source Type, and Source Title

The topic of physics education research for the years (2012 – 2021) & (2020 – 2021) at the International (all countries) and International (Indonesia) levels based on Scopus data shown in Document Type (Table 2), Source Type (Table 3), and Source Title (Table 4).

Table 2. Document Type Research on Physics Education

International				Indonesia			
Document Type 2012-2021	**Total**	**Document Type 2020-2021**	**Total**	**Document Type 2012-2021**	**Total**	**Document Type 2020-2021**	**Total**
Article	308	Article	93	Conference Paper	69	Conference Paper	36
Conference Paper	251	Conference Paper	67	Article	11	Article	5
Erratum	27	Review	8	Erratum	2	Review	1
Review	24	Editorial	6	Review	1	-	
Book Chapter	15	Book Chapter	4	-	-	-	-
Conference Review	9	Conference Review	4	-	-	-	-
Note Show	7	Erratum	4	-	-	-	-
Letter Show	7	Letter Show	1	-	-	-	-
Book Show	4	-	-	-	-	-	-
Short Survey	1	-	-	-	-	-	-

Table 2 describes the document types for the year (2012 – 2021) & (2020 – 2021) u for International (All countries) and International (Indonesia) levels. Based on documents at the international level (all countries) are dominated by the type of paper articles. Meanwhile, International (Indonesia) is the dominant paper conference Paper (Proceedings). For detailed information, it is expanded based on the Source Type seen in Table 3

Table 3. Document Source Type on Physics Education

International				Indonesia			
Source Type 2012-2021	**Total**	**Source Type 2020-2021**	**Total**	**Source Type 2012-2021**	**Total**	**Source Type 2020-2021**	**Total**
Journal	396	Journal	111	Conference Proceeding	71	Conference Proceeding	36
Conference Proceeding	238	Conference Proceeding	73	Journal	12	Journal	6
Book	6	Book	3	-	-	-	-
Book Series	12	Book Series	1	-	-	-	-
Trade Journal	15	-	-	-	-	-	-

Table 3 explains the topic of physics education research (2012 – 2021) & (2020 – 2021) for International (All countries) and International (Indonesia) levels. At the international level (all countries), the Types of Sources used are dominated by papers in the form of journals. However, in International (Indonesia) where the dominant one is Conference Proceeding. Furthermore, it continues to develop based on Title Source-based data, which can be seen in Table 4.

Table 4. Document Source Title Research on Physics Education (Top 15)

International				Indonesia			
Source Title 2012-2021	**Total**	**Source Title 2020-2021**	**Total**	**Source Title 2012-2021**	**Total**	**Source Title 2020-2021**	**Total**
Journal of Physics Conference Series	92	Journal of Physics Conference Series	45	Journal of Physics Conference	62	Journal of Physics Conference Series	30
AIP Conference Proceeding	37	Physical Review Physics Education Research	11	AIP Conference Proceeding	5	AIP Conference Proceeding	4
Physical Review Physics Education	36	New Physics Sae Mulli	7	IOP Conference Series Earth and Environmental Science	2	IOP Conference Series Earth and Environmental Science	2

Table 4. Continued

International				Indonesia			
Source Title 2012-2021	**Total**	**Source Title 2020-2021**	**Total**	**Source Title 2012-2021**	**Total**	**Source Title 2020-2021**	**Total**
Physics Education	31	Revista Brasileira Ensino De Fisica	7	Indonesian Science Education Journal	2	Universal Journal of Education Research	2
New Physics Sae Mulli	17	Physics Education	6	Universal Journal of Education Research	2	Eurasia Journal of Mathematics Science and Technology Education	1
Physical Review Special Topics Physics Education Research	15	Physics Teacher	6	2014 International Conference on Physics ICP 2014	1	Journal of Science Education	1
Physics Teacher	15	AIP Conference Proceeding	5	Eurasia Journal of Mathematics Science and Technology Education	1	Library Philosophy and Practice	1
Revista Brasileira Ensino De Physica	15	Physics Education Research Conference Proceeding	5	International Journal of Engineering and Technology UAE	1	Physics Education	1
Science And Education	12	Science and Education	4	International Journal of Evaluation and Research in Education	1	-	-
Physics Education Research Conference Proceeding	11	Universal Journal of Education Research	4	International Journal of Interactive Mobile Technologies	1	-	-
Medical Physics	10	European Journal of Physics	3	IOP Conference Series Materials Science and Engineering	1	-	-
ASEE Annual Conference and Exposition Conference Proceedings	9	Journal of Baltic Science Education	3	Journal of Baltic Science Education	1	-	-
Springer Proceedings in Physics	9	20th Conference of Czech and Slovak Physicist Proceeding	2	Journal of Information Technology Education Research	1	-	-
International Journal of Science Education	8	ASEE Annual Conference and Exposition	2	Library Philosophy and Practice	1	-	-
European Journal of Physics	7	Eurasia Journal of Mathematics Science and Technology Education	2	Physics Education	1	-	-

Table 4 shows the research topics of physics education (Top 15) in (2012 – 2021) & (2020 – 2021) for International (all countries) and International (Indonesia) levels. Based on the Source Title at the International (All countries) and International (Indonesia) levels, the dominant one is the (JPCS) Journal of Physics Conference Series.

Affiliation and Keywords

Based on documents obtained from Scopus that the Topics Research in Physics Education in (2012 – 2021) & (2020 – 2021) for International (all countries) and International (Indonesia) levels of affiliate are shown in Table 5. Topics Research in Physics Education in (2012 – 2021) & (2020 – 2021) for International (all countries) and International (Indonesia) levels of the keywords shown in Table 6.

Table 5. Affiliation in Research on Physics Education

International				Indonesia			
Affiliation 2012-2021	**Total**	**Affiliation Title 2020-2021**	**Total**	**Affiliation 2012-2021**	**Total**	**Affiliation 2020-2021**	**Total**
Universitas Negeri Surabaya	12	Universitas Negeri Jakarta	8	Universitas Negeri Surabaya	12	Universitas Negeri Jakarta	8
University of Colorado Boulder	11	Universitas Negeri Surabaya	7	Universitas Pendidikan Indonesia	10	Universitas Negeri Surabaya	7
Universitas Pendidikan Indonesia	10	Universida de Federal do Rio Grande do Soul	6	Universitas Negeri Jakarta	8	Universitas Negeri Yogyakarta	6
Michigan State University	8	Universitas Negeri Yogyakarta	6	Universitas Negeri Padang	8	Universitas Negeri Malang	5
Universitas Negeri Jakarta	8	Universitas Negeri Malang	6	Universitas Negeri Yogyakarta	7	Universitas Pendidikan Indonesia	3
Universitas Negeri Padang	8	Czech Technical University	4	Universitas Negeri Malang	7	Universitas Negeri Padang	3
Western Michigan University	7	Universiti Teknologi Malaysia	4	Universitas Negeri Semarang	5	Institut Teknologi Bandung	2
Helsingin yliopisto	7	Chosun University	3	UIN Sunan Gunung Djati	4	Universitas Syiah Kuala	2
Czech Technical University	7	Universitas Pendidikan Indonesia	3	Institut Teknologi Bandung	3	Halu Ole University	1

Table 5 shows research affiliations in Physics Education which are still very lacking. If viewed from the international level (all countries), it seems it has not reached the hundreds. Even for Scopus documents starting from 10, there are only a few from Universitas Negeri Surabaya (12), University of Colorado Boulder (11), and Universitas Pendidikan Indonesia (10). It is based on Scopus data from Year (2012 – 2021) & (2020 – 2021) for the International (all countries) and International (Indonesia) levels. Keywords in physics education research topics are shown in Table 6.

Table 6. Keyword Research on Physics Education

International				Indonesia			
Affiliation 2012-2021	**Total**	**Affiliation 2020-2021**	**Total**	**Affiliation 2012-2021**	**Total**	**Affiliation 2020-2021**	**Total**
Physics Education	136	Physics Education	43	Students	46	Student	22
Student	125	Student	40	Physics Education	39	Physics Education	18
Education	90	Physics	21	Education Computing	20	Physics Learning	8
Physics	89	Curricula	13	Physics Learning	18	Surveys	7
Teaching	55	Education	12	Curricula	16	Curricula	6
Curricula	32	Education Computing	9	Surveys	12	Education Computing	6
Engineering Education	31	Physic Learning	9	Physics	10	Learning Process	6
Human	29	Physics Teaching	9	Critical Thinking Skill	7	Is Researches	5
E-Learning	25	Surveys	9	Descriptive Analysis	7	Learning Physics	5
Physics Learning	22	E-Learning	8	E-Learning	7	Physics	5

Table 6 shows the keywords in physics education research topics Year (2012 – 2021) & (2020 – 2021) for International (all countries) and International (Indonesia) levels. The top keywords for International (All countries) are physics education (136) years (2012 – 2021) and physics education (43) years (2020 – 2021). Next for International (Indonesia) are students (46) year (2012 – 2021) and students (22) now (2020 – 2021).

The most frequently used keywords in physics education can be seen in Figure 2. The font size shows that the words are often used in this topic. Based on Figure 2, the most frequently used words are physics education, student, physics, teaching, human, curriculum, and e-learning.

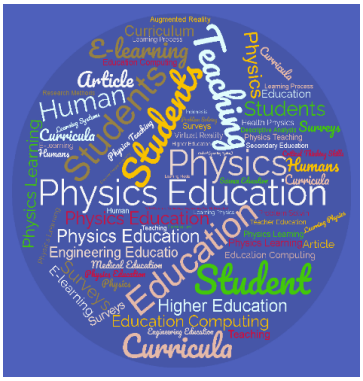

Figure 2. Most Relevant Keywords

Visualization of Physics Education Research Trends at the Level Year 2012 – 2021

International (all countries), in (2012 – 2021), there were 667 international level documents (all countries) related to the topic of physics education in Scopus data. Then the researcher visualizes the trend of the research topic with the help of VOSviewer. Research trends in physics education are shown in Figures 3a, Figure 3b, and Figure 3c. Figure 3a is a visualization of the entire Scopus data-based research on physics education for the year (2012 – 2021). The visualization results produce four-color clusters (red, blue, yellow, and green).

The first cluster (red color) are effect, motivation, test, sample, engineering, technique, simulation, high school, motion, grade, difference, ability, form, stem, plan, profile, percentage, physics education student, data collection, t-test, test, stem education, significant difference, control group, and critical thinking. The second cluster (blue color) is training, survey, quality, goal, trends, faculty, teaching physics, community, gender, benefit, collaboration, variety, scientist, physicist, individual, Europe, medical physicist, medical physics, graduate, institution, respondent, survey, module, and department. The third cluster (yellow color) is physics education research, direction, editorial, focus, per, collection, part, step, sight, web, proceeding, stage, and success. The fourth cluster (green color) is a difficulty, sequence, philosophy, chemistry, theory, erratum, structure, advantage, nature, video, text, high school, device, and case.

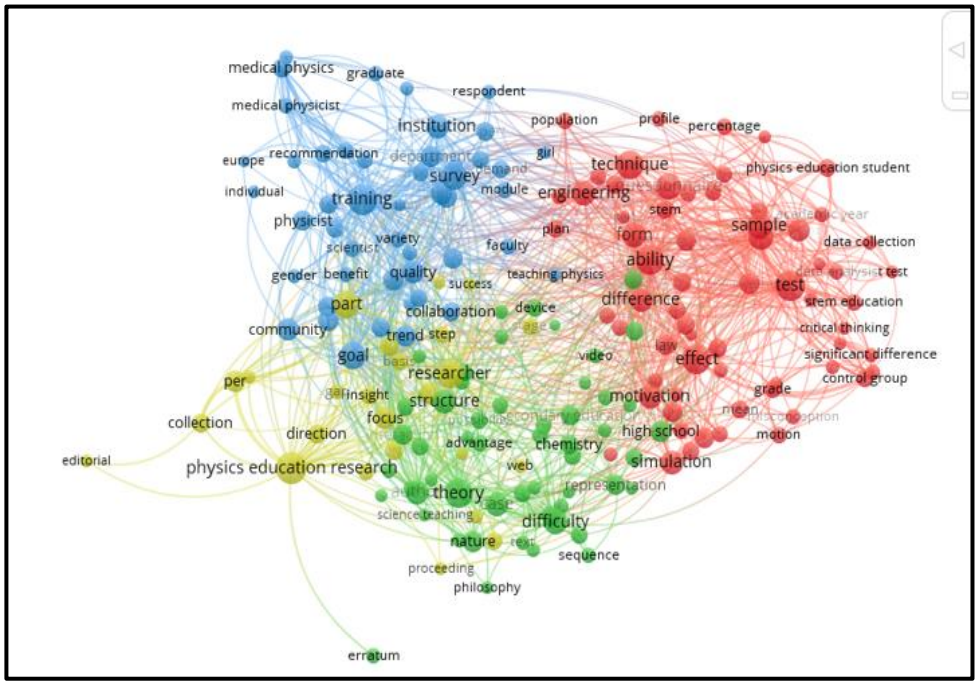

Figure 3a. Network Visualization research trend International (all countries) physics education (2012 – 2021)

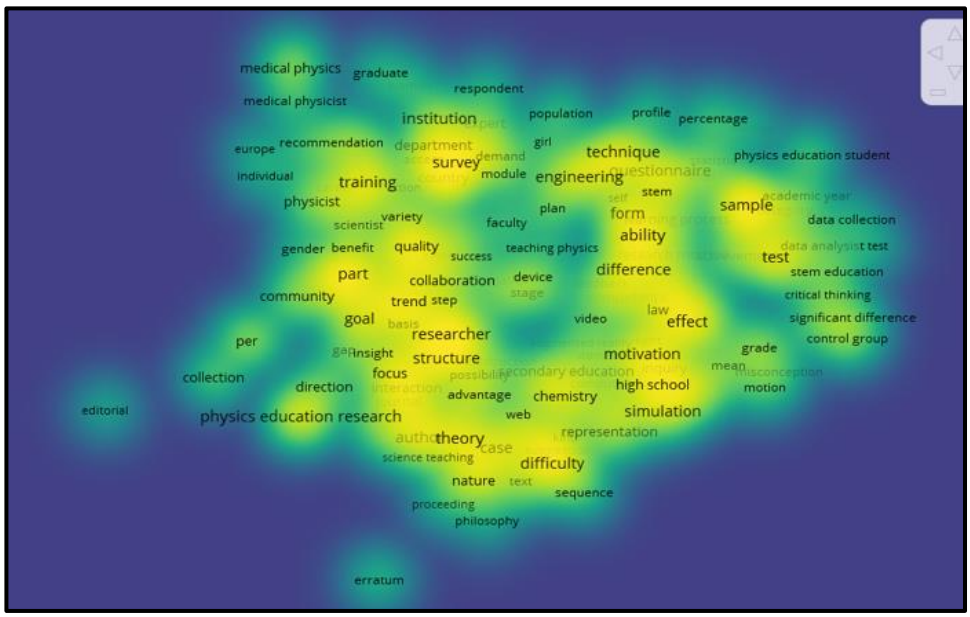

Figure 3b. Density Visualization Research Trend International (all countries) Physics Education (2012 – 2021)

Figure 3b shows Density Visualization with high-intensity yellow seen in several parts, namely, theory, physics education research, difficulty, simulation, effect, structure, quality, survey, part, goal, researcher, focus, difference, ability sample, test, technique, etc. There are several that have the potential to be developed in the future, namely, editorial, collection, proceeding, basis, text, and case.

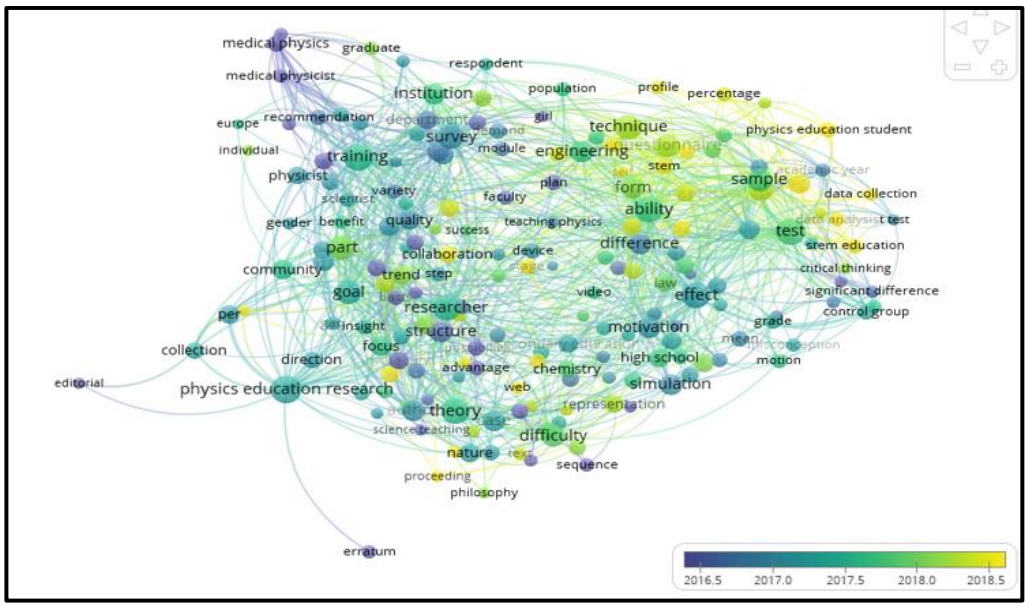

Figure 3c. Overlay Visualization Research Trend International (All Countries) Physics Education (2012 – 2021)

Figure 3c shows Overlay Visualization from physics education research trends. There are four colors: blue, purple, yellow, and green. You can see the dominant blue color with its roots in physics education research, and the yellow indicator is research that is currently being carried out. Cluster yellow there are web, proceeding, collaboration, profile, and stem education.

Visualization of Physics Education Research Trends at the International (All Countries) Level Year 2020 – 2021

Research trends in physics education are shown in Figure 4. In (2020 – 2021), there were 188 international level documents (all countries) on physics education topics in Scopus data. Then the researcher visualizes the trend of the research topic with the help of VOSviewer. Figure 4 is a visualization of the entire Scopus data-based research on physics education for the year (2020 – to 2021). The visualization results produce four-color clusters that show (blue, red, yellow, and green).

The first clusters (blue color) are physics education research, field, topic, paper, focus, trend, impact, journal, instruction, change, hand, and use. The second cluster (red color) is activity, skill, implementation, learning process, ability, discipline, form, stage, problem, experience, example, way, process, type, and collaboration. The third cluster (yellow) is a sample, implication, data, higher education, evaluation, mathematics, and assessment. Cluster four (green color) is a difficulty, sequence, philosophy, chemistry, theory, erratum, structure, advantage, nature, questionnaire, interview, physics teacher, perception, order, innovation, importance, factor, training, need, survey, area, practice, part, and relation.

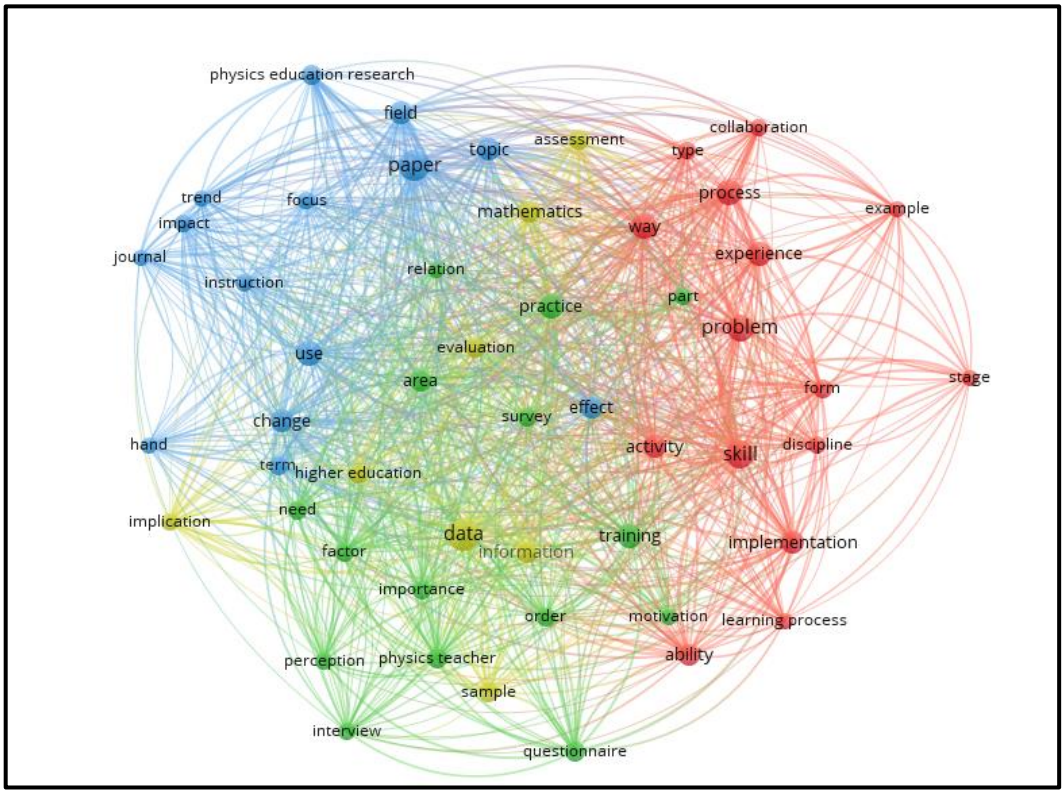

Figure 4. Network Visualization Research Trend International (All Countries) Physics Education (2020 – 2021)

The density visualization with almost the same intensity. What appears clearer is physics education, filed, focus, trend, impact, journal, instruction, use, change, hand, term, paper, topic, effect, use, relation, implication, higher education, data, sample, mathematics, assessment, area, need, factor, importance, perception, physics teacher, evaluation, ability, learning process, implementation, activity, skill, discipline, form, stage, problem, experience, way, example, process, type, and collaboration. In Density Visualization there are several words that are still unclear, one of which is the word information. It is hoped that in the future it will be clear that the relationship between research and continuous publication will be clear.

The overlay visualization of physics education research trends there are four colors, namely blue, purple, yellow, and green. The blue color cluster is dominant with the words, namely, stage, implementation, motivation, order, data, net, perception, implication, change, paper, way, and experience. The purple color clusters are physics education research, journal, assessment, type, collaboration, practice, part, problem, survey, activity, form, and physics teacher. The yellow clusters are relation, higher education, importance, instruction, impact, and trend. The green color clusters are, interview, factor, questionnaire, training, area, filed, and ability.

Visualization of Physics Education Research Trends at the International (All Countries) Level Year 2020 – 2021

In (2012 – 2021) there were 83 documents at the International (Indonesian) level which discussed topics related to physics education contained in the Scopus database. Then the researcher uses the help of VOSviewer to visualize the trend of the research topic being studied. Research trends in physics education are shown in Figure 6.

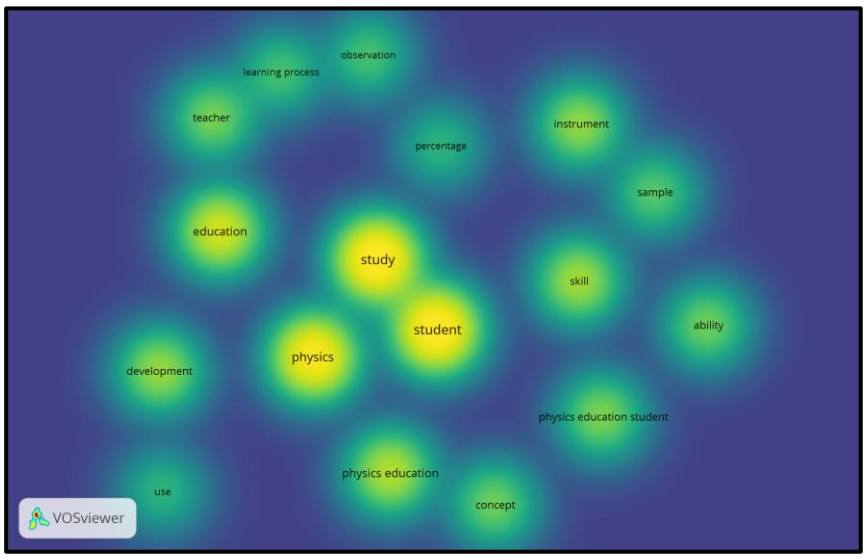

Figure 5. Density Visualization Research Trend International (Indonesia) Physics Education (2012 – 2021)

Figure 5 shows Density Visualization with an intensity almost the same as the bright colors. The color consists of use, development, physics, study, education, teacher, learning process, observation, student, instrument, sample, skill, ability, physics education, student, concept, physics education, and the percentage. The visualization of the entire Scopus data–based research on physics education for the year (2012 – 2021). The visualization results produce three-color clusters shown in (red, blue, and green). The first cluster (green color) are physics, study, observation, learning process, teacher, education, development, and use. The second cluster (blue color) is a percentage. The third cluster (red color) is students, physics education, instrument, sample, skill, physics education research, concept, and ability. The Overlay Visualization from physics education research shows four colors: blue, purple, yellow, and green. The blue color cluster consists of the student, study, learning process, and physics education. The purple clusters are skill, percentage, and observation. The yellow cluster is teacher, sample, and instruction. The green color cluster consists of physics, use, physics education students, and ability. It is clearer the relationship between one another.

Visualization of Physics Education Research Trends at the International (Indonesia) Level Year 2020 – 2021

In (2020 – 2021), there are 42 documents at the International (Indonesian) level on the topic of physics education in the Scopus data. Then the researcher visualizes the trend of the research topic with the help of VOSviewer. Research trends in physics education are illustrated in Figure 6, a visualization of the entire Scopus data–based research on physics education for the year (2020 – 2021). The visualization results produce one color cluster of physics education, student, physics, research, and study.

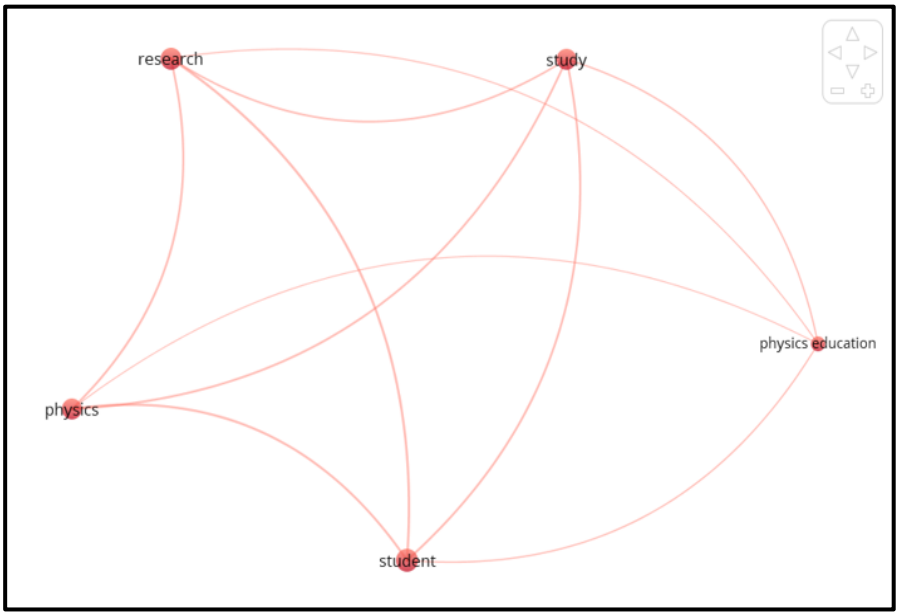

Figure 6. Network Visualization Research Trend International (Indonesia) Physics Education (2020 – 2021)

The density visualization with intensity the highest to the lowest yellowness are student, physics, research, study, and physics education. The overlay visualization of physics research trend Education has four colors, namely blue, purple, yellow, and green. The yellow cluster consists only of the word physics. The purple cluster only consists of the word research. The green cluster only consists of the word study. The blue cluster consists of the world's physics education and students.

Table 7a. Top Cited Physics Education International (All Country) Years (2012 – 2021)

No	Authors	Source	Cited by
1	Docktor and Mestre (2014)	Physical Review Special Topics - Physics Education Research	183
2	Dünser et al. (2012)	Proceedings of the 24th Australian Computer-Human	71
3	Fidan and Tuncel (2019)	Computers and Education	62
4	Uhden et al. (2012)	Science and Education	62
5	Traxler et al. (2016)	Physical Review Physics Education Research	60

Table 7b. Top Cited Physics Education International (All Country) Years (2012 – 2021)

No	Authors	Finding	Recommendations
1	Docktor and Mestre (2014)	There are six topic areas assigned by the National Academy: (1) Concept Understanding, (2) Problem solving, (3) curriculum, (4) Assessment, (5) Psychological knowledge, and (6) Learning with learning confidence.	For future research should use every part of the topical confirmed by the National Academy so that future research directions for physics education are more promising.
2	Dünser et al. (2012)	Learning using Augmented Reality books has a very good impact on students. This can be known through the treatment of learning the test results are given to students.	Researchers suggest developing further related to AR, which has the potential to teach complex 3D concepts.
3	Fidan and Tuncel (2019)	Integrating AR into PBL learning can improve student achievement and give a positive attitude towards physics subjects. Through interviews, students said that AR applications are more useful because they are more realistic and exciting to learn.	It is hoped that future researchers will conduct more profound studies related to AR so that it can be integrated into learning models.
4	Uhden et al. (2012)	The study results indicate that students still memorize formulas for learning physics. Mathematics is considered a tool for calculations that hinders the conceptual understanding of physical principles.	The study results indicate that students still memorize formulas for learning physics. Mathematics is considered a tool for calculations that hinders the conceptual understanding of physical principles.
5	Traxler et al. (2016)	This research is related to gender in physics for women and men. There are gender differences between men and women in participation, performance, and attitudes towards physics.	It is suggested to conduct research related to gender deviation, which is expanded to physics education research.

Table 8a. Top Cited Physics Education International (Indonesia) Years (2012 – 2021)

No	Authors	Source	Cited by
1	Darmaji, Kurniawan, Astalini et al. (2019)	International Journal of Interactive Mobile Technologies	32
2	Pandiangan et al. (2017)	Journal of Baltic Science Education	22
3	Darmaji, Kurniawan and Irdianti (2019)	International Journal of Evaluation and Research in Education	21
4	Suyatna (2019)	Journal of Physics: Conference Series	20
5	Suhendi et al. (2018)	International Journal of Engineering and Technology	20

Table 8b. Top Cited Physics Education International (Indonesia) Years (2012 – 2021)

No	Authors	Finding	Recommendations
1	Darmaji, Kurniawan, Astalini et al. (2019)	Using mobile learning in physics practicum can improve students' perceptual abilities by increasing the distribution of better values.	In the future, it is necessary to develop mobile learning-based learning media to improve and develop students' ICT skills.
2	Pandiangan et al. (2017)	The Physics Independent Learning (PIL) model can increase students' independence and physics problem-solving skills. This is known through the collected pretest and posttest data.	It is hoped that future research can be developed related to Physics Independent Learning (PIL) to improve problem-solving abilities.

Table 8b. Continued

No	Authors	Finding	Recommendations
3	Darmaji, Kurniawan and Irdianti (2019)	The measurement method with a sampling technique recruited 91 students that participated in this study. The results showed that students could do their practicum in the learning process with good categories. The category most mastered by students is science process skills in concave motion.	In the future, it is hoped that process-based practice skills can improve science process skills, especially in physics education study program.
4	Suyatna (2019)	The results of the research conducted involving 233 high school students and three physics teachers to support STEM learning required teaching materials for the National Curriculum, which were equipped with lesson plans, books, animations, stimulation, and videos.	In the future, it is hoped that all teaching materials that will be used are STEM-based and integrated with e-learning or mobile learning to support the National Curriculum.
5	Suhendi et al. (2018)	Assessment in physics learning can be done with several approaches, including analytical verification and operational verification.	This research provides suggestions in the future so that physics learning can be applied with verified assessment techniques so that domain measuring tools can be accounted for in an objective and dynamic manner.

Table 9a. Top Cited Physics Education International (All Countries) During Pandemic COVID-19 (2020 – 2021)

No	Authors	Source	Cited by
1	Kanim and Cid (2020)	Physical Review Physics Education Research	28
2	Ugwuanyi et al. (2020)	Journal of Rational - Emotive and Cognitive - Behavior Therapy	10
3	Parno et al. (2020)	Jurnal Pendidikan IPA Indonesia	10
4	Yun (2020)	Journal of Baltic Science Education	9
5	Barabino et al. (2020)	Science and Engineering Ethics	6

Table 9b. Top Cited Physics Education International (All Countries) During Pandemic COVID-19 (2020 – 2021)

No	Authors	Finding	Recommendations
1	Kanim and Cid (2020)	Physics education research as a whole is better prepared on the subject mathematically and comes from a narrow subset that cannot be represented and generalized to the entire student population.	In the future, it is hoped that the Physics education research community can make a more representative demo of the subjects studied.
2	Ugwuanyi et al. (2020)	Some of the findings from this study, namely, the procrastination behavior of students will increase if they are not adequately counseled. This is proven through cognitive behavioral therapy carried out on science students.	It is hoped that the government or the minister of education can provide sufficient guidance counselors in various higher education institutions because it will help students in the academic field when using CBT.
3	Parno et al. (2020)	One of the most needed in 21st century is literacy skills. The results showed that each class had different literacy abilities. Literacy ability with the treatment of the PBL-STEM method is in the highest category, PBL is in the middle category, and conventional learning is in the low category.	Future research is expected to focus more on students' literacy skills in the 21st century.
4	Yun (2020)	By using the topic modeling from Mallet, namely the Late Dirichlet Model, there are 13 topic trends in the last few years 'pedagogical contents of knowledge (PCK)," "assessment" of achievement and "gender" of students have been topics of increasing interest; "teacher education" and "students' reasoning process" introductory physics" and "problem solving".	For further researchers, it is hoped that they can develop learning models that can train students' abilities in physics.

Table 9b. Continued

No	Authors	Finding	Recommendations
5	Barabino et al. (2020)	The Association of Physics and Engineering Scientists is committed to advancing women by (1) identifying the role of women in achieving a successful life, (b) creating programs to develop female leaders, and (c) creating opportunities for women to increase international visibility in the scientific community, and (d) building archives and women in STEM.	Gender equality is fundamental in the future so that women and men can be treated fairly, especially in the balance in the STEM field.

Table 10a. Top Cited Physics Education International (Indonesia) During Pandemic COVID-19 (2020 – 2021)

No	Authors	Source	Cited by
1	Parno et al. (2020)	Jurnal Pendidikan IPA Indonesia	10
2	Fenditasari and Istiyono (2020)	Journal of Physics: Conference Series	3
3	Maison et al. (2020)	Universal Journal of Educational Research	3
4	Dwijananti et al. (2021)	Journal of Physics: Conference Series	1
5	Syuhendri (2021)	Journal of Physics: Conference Series	1

Table 10b. Top Cited Physics Education International (Indonesia) During Pandemic COVID-19 (2020 – 2021)

No	Authors	Finding	Recommendation
1	Parno et al. (2020)	One of the most needed skills in the 21st century is literacy skills. The results showed that each class had different literacy abilities. Literacy ability with the treatment of the PBL-STEM method is in the highest category, PBL is in the middle category, and conventional learning is in a low category.	Literacy skills are critical to be studied in the future because they are one of the most needed skills for being human.
2	Fenditasari and Istiyono (2020)	The four-level diagnostic results classify that there are still very high misconceptions and require special school attention for remediation.	Through this research, it is hoped that it can be a basis for consideration for teachers and lecturers in teaching heat and temperature material to be more effective.
3	Maison et al. (2020)	Through an assessment in the form of an E-assessment, gets a good response, seen from the attitude of students who are enthusiastic and have a high curiosity.	It is hoped that in the future, the evaluation in the form of E-assessment will continue to be studied and developed.
4	Dwijananti et al. (2021)	The study results show that students' critical thinking ability is still classified as low with a score of 10.1%from 15.84% using an instrument that has been validated with a value of 90%.	Need to check practically and effectiveness.
5	Syuhendri (2021)	By using the Conceptual Change Texts model in physics learning for students. There is a relatively high increase in understanding of concepts in the experimental class.	For the following research can use the Conceptual Change Texts model to train students' conceptual understanding skills.

Discussion

During the COVID-19 pandemic era, research trends, especially physics education at home and abroad, experienced an increase in practical learning innovations. It is a positive impact of the COVID-19 pandemic. Widodo et al. (2020) stated that during the COVID-19 pandemic, various platforms supported learning that was developed and used. However, all of them had different effects and functions for each level of education. In addition, the COVID-19 pandemic has also made students closer to technological developments, and teachers are more innovative in making online learning-based teaching materials (Abdullah et al., 2021) and (Suryaman et al., 2020).

The development of physics education does not only cover the understanding of students. However, many other aspects exist, such as assessment, media, learning models, etc. In addition, based on the top-cited papers discussed, there are always recommendations for each result. This can be an opportunity for further researchers to develop existing research and certainly will have the potential to be published internationally indexed. Therefore, an in-depth study of each paper will provide new information and open insight so that they can think more broadly, especially in the field of physics education.

Martín-Gutiérrez et al. (2017) conducting research related to virtual technology trends in education. Fundamental Research Implication: (1) There are contributions related to physics education research policy makers after the COVID-19 pandemic, (2) For researchers and librarians, these results can be a reference in the development of physics education research that has the basis of empirical studies during the COVID-19 pandemic. The research results indicate that the development and use of technology worldwide are very important. It is shown from the access to education that uses Augmented Reality and Virtual Reality as learning innovations carried out. The advantage of this research is that it provides information related to accessing technology being developed and provides good accessibility for virtual learning. From the results of the trend, it turns out that it is by the current learning conditions. Thus, it is necessary to adapt media, methods, and learning models in accordance with the current COVID-19 pandemic conditions.

Conclusion

The number of article publications (Scopus) at the international (all countries) and international (Indonesia) levels increased from 2012 to 2021. However, the increase occurred most drastically in (2020 – 2021) at the International (all countries) and International (Indonesia) levels. The trend of physics education has developed more rapidly in the last two years during the pandemic (2020 – 2021). In this case, the affiliation in research on Physics Education is dominated by universities from Indonesia. Meanwhile, the Journal of Physics Conference Series is the journal with the most publications related to physics education, followed by AIP Conference Proceeding.

Recommendations

Based on the results of the discussions that have been carried out, there are several recommendations for the future (1) Further, more in-depth research is needed regarding the trend of physics education that continues to innovate so that it can be submitted to international indexed journals. (2) Cooperation and collaboration between other universities to increase publications at the international level. (3) The need for continuous research so that current trends can be followed. Future research should focus more on physics education topics that are currently developing, can use one or more relevant keywords, and collaborate with researchers who are experts in physics education.

Limitations

This study has several limitations, including; (1) The research data used is only based on the Scopus database to find out trends in physics education research during the COVID-19 pandemic, (2) The document used based on TITLE (without string): TITLE (physics AND education) for 2012 - 2021 and 2020 - 2021 for International (all countries) and International (Indonesia), and (3) this research focuses on the field of physics education only.

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Authorship Contribution Statement

Prahani: Research design and concept, data acquisition, drafting research manuscript, revision, supervision. Bin Amiruddin: Drafting manuscript, research data analysis, technical and material support, research data acquisition. Suprapto: Technical and material support, data acquisition. Deta: Translating, proofreading, final approval. Cheng: Reviewing, technical and material support.

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