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Bibliometric analysis of misconceptions regarding momentum and impulse based on the scopus database

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Abstract. This study aims to map the development of research on misconceptions regarding the concepts of momentum and impulse through bibliometric analysis of publications indexed in Scopus between 2007 and 2025. A total of 30 articles relevant to the keywords "misconceptions," "momentum," and "impulse" were analyzed based on publication trends, number of citations, affiliations, countries, prolific authors, document types, and fields of study. Data were extracted using Microsoft Excel and visualized using VOSviewer through network, overlay, and density views. The results show that publication trends are fluctuating but experienced a significant increase towards 2020. Indonesia is recorded as the country with the largest contribution, with the Indonesia University of Education (UPI) as the most productive affiliation. In addition, most studies were published in the form of articles and conference proceedings, especially in the field of Physics and Astronomy. VOSviewer visualization produced four main keyword clusters that describe the research focus on student misconceptions, the concept of momentum–impulse, diagnostic instruments, and learning approaches. Overall, this study provides a comprehensive overview of the research map of momentum and impulse misconceptions and can serve as a basis for further studies in the field of physics education.

Keywords: Bibliometric Analysis, Misconceptions, Momentum and Impulse, Physics Education, VOSviewer

INTRODUCTION

The concepts of momentum and impulse are fundamental concepts in classical mechanics that are often taught at the upper secondary and early university levels (Pricillya et al., 2022; Utoro, 2022). Although this concept is relatively simple mathematically, many physics education studies report that students often experience misconceptions (systematic conceptual misunderstandings) that hinder their ability to apply the ideas of momentum and impulse to new situations or contextual problems (Khoir et al., 2025; Maison et al., 2026; Wardani et al., 2025). This misconception not only hinders conceptual understanding, but also affects problem-solving abilities, interpretation of experimental results, and knowledge transfer to related topics such as collisions and momentum conservation (Cahya et al., 2024; Hamid, 2025; Pangestuti et al., 2026).

Previous studies have shown that misconceptions about momentum and impulse are still quite high at various levels of education (Maharani & Diyana, 2022; Rahmi & Lubis, 2025; Suwito & Firmansyah, 2026). Atmaja and Samsudin (2025) found that more than half of the students only had a partial understanding of momentum, impulse, and the law of conservation of momentum based on Rasch Model analysis (Atmaja & Samsudin, 2025). Hamdani (2025) showed that the ECIRR learning model effectively reduced misconceptions and improved student understanding without requiring additional remediation time (Hamdani, 2025). In addition, Nasyidiah, Siahaan, and Sasmita (2021) developed a four-tier diagnostic test and found that

the instrument was able to identify misconceptions, including the partial negative category experienced by most students (Nasyidiah et al., 2021). These three studies confirm that misconceptions about momentum and impulse remain an important issue that needs to be explored in greater depth through bibliometric analysis.

As the number of publications on misconceptions in physics education increases (Meiliyadi et al., 2026), bibliometric studies have become an important tool for mapping the research landscape: identifying publication trends, productive countries and institutions, researcher collaboration networks, dominant keywords, and gaps in topics that receive less attention (Damarsha et al., 2023; Jailani, 2024; Putra et al., 2023). Given that the Scopus database is one of the most extensive and cross-disciplinary sources of international publications, Scopus-based analysis can provide a more comprehensive quantitative and qualitative picture of research directions, frequently used methodologies, and areas that remain under-explored in the study of misconceptions of momentum and impulse (Ananda et al., 2025; Hakim & Hakim, 2024; Julianti et al., 2025; Nurzahra et al., 2025; Sophia et al., 2025). However, to date, there have been few bibliometric studies that specifically focus on misconceptions of momentum and impulse. Most previous studies have focused on misconceptions of physics in general or on other topics such as electricity and magnetism or linear motion.

Therefore, this study aims to conduct a bibliometric analysis of publications on misconceptions of momentum and impulse indexed in Scopus. The analysis focuses on publication trends per year, leading countries and institutions, prolific authors, and dominant keywords. This study also maps topic clusters to see the direction of research development. Data processing and visualization are carried out using VOSviewer through network mapping, overlay, and density. In addition, this study presents a classification of publications based on authors, year, keywords, number of citations, affiliation, and country. The results are expected to provide a comprehensive picture of the dynamics of research on misconceptions of momentum and impulse.

METHOD

This study uses bibliometric methods to examine the development of studies on misconceptions in momentum and impulse material, with data sources from the Scopus database (Donthu et al., 2021; L et al., 2023; Meiliyadi et al., 2025).

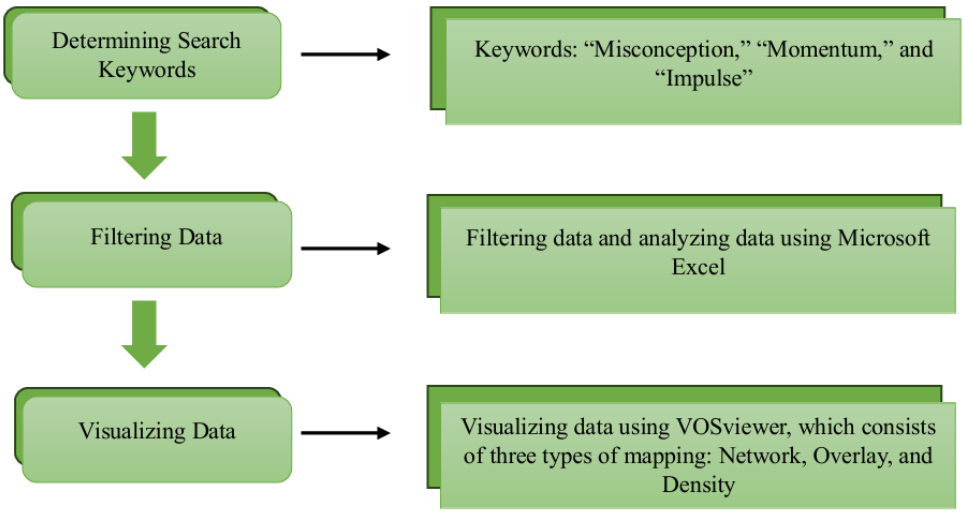

Figure 1. Steps in collecting bibliometric analysis data

a. The research procedure began with establishing three main keywords, namely "misconception," "momentum," and "impulse." These keywords were used to select articles based on title, year of publication, author, number of citations, and document type within the time frame of 2007–2025.

b. From this search process, 30 articles were obtained and then exported to Microsoft Excel for further analysis through examination of titles, distribution of publications per year, number of citations, author identities, and publication sources.
c. Next, bibliometric mapping was performed using VOSviewer software to describe the relationships between keywords and identify the authors who appeared most frequently in related studies. The visualization in this study included three types of displays, namely network visualization, overlay visualization, and density visualization. A number of previous studies have also provided comprehensive explanations regarding the use of VOSviewer in bibliometric analysis.

RESULT AND DISCUSSION

Figure 2 shows research trends using the keywords "misconception," "momentum," and "impulse." These trends are compiled based on publication data obtained from the Scopus database, covering the period from 2007 to 2025.

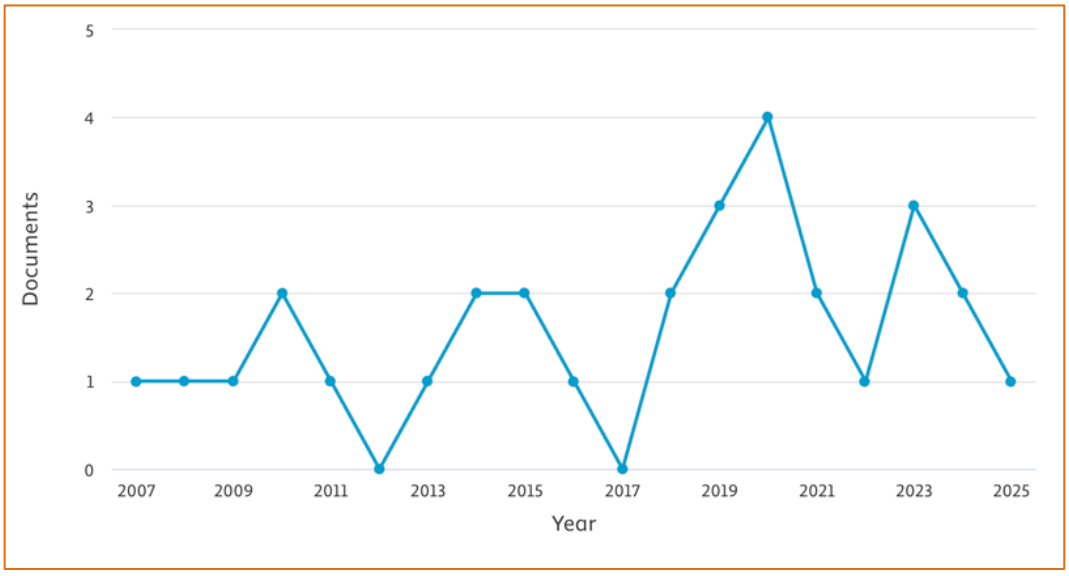

Figure 2. Research trends related to the keywords misconception, momentum, and impulse

Figure 2 shows the development of the number of publications using the keywords "misconception," "momentum," and "impulse" from 2007 to 2025. In general, the research trend fluctuated from year to year. In the early period (2007–2011), the number of publications was relatively stable at around 1 to 2 documents per year, namely 1 document in 2007–2009, increasing to 2 documents in 2010, and returning to 1 document in 2011. After that, there was a sharp decline in 2012 with the number of documents reaching 0. Entering the 2013–2017 period, the trend rose again but remained volatile, with 1 document in 2013, increasing to 2 documents in 2014 and 2015, then dropping to 1 document in 2016, and returning to 0 in 2017. The trend increased significantly in the 2018–2020 period, starting with 2 documents in 2018, increasing to 3 documents in 2019, and reaching a peak of 4 documents in 2020. After that peak, the number of publications fluctuated again, with 2 documents in 2021, 1 document in 2022, increasing to 3 documents in 2023, decreasing to 2 documents in 2024, and ending with 1 document in 2025. Overall, the data shows that research interest in the topics of "misconceptions," "momentum," and "impulse" is unstable, but has increased significantly, especially towards 2020.

Based on the observed fluctuation pattern, the graph in Figure 2 can be divided into three main stages. The first stage lasted from 2007 to 2012. During this stage, the number of publications showed a relatively stable pattern but at a low level, generally ranging from 1 to 2 documents per year. However, in 2012 there was a drastic decline to 0 documents, indicating a decline in interest or limitations in research on the topics of "misconceptions," "momentum," and "impulse" in that year.

The second phase covers the period from 2013 to 2017. During this period, the number of publications increased again, although it still showed a fluctuating pattern that was not too

high. Starting with 1 document in 2013, the number of publications increased to 2 documents in 2014 and 2015, then dropped back to 1 document in 2016. However, in 2017 there was a significant decline to 0 documents. These fluctuations indicate that research on this topic is beginning to revive, but has not yet reached stability or consistent growth.

The third phase took place from 2018 to 2025 and was marked by a more pronounced increase in the number of publications. In 2018, the number of documents reached 2, then continued to increase to 3 documents in 2019 and peaked at 4 documents in 2020. After that peak year, the number of publications fluctuated again, with 2 documents in 2021, 1 document in 2022, increasing to 3 documents in 2023, then 2 documents in 2024, and finally 1 document in 2025. This pattern illustrates that despite fluctuations in research trends, there has been a stronger increase in interest in studies related to "misconceptions," "momentum," and "impulse," especially after 2018.

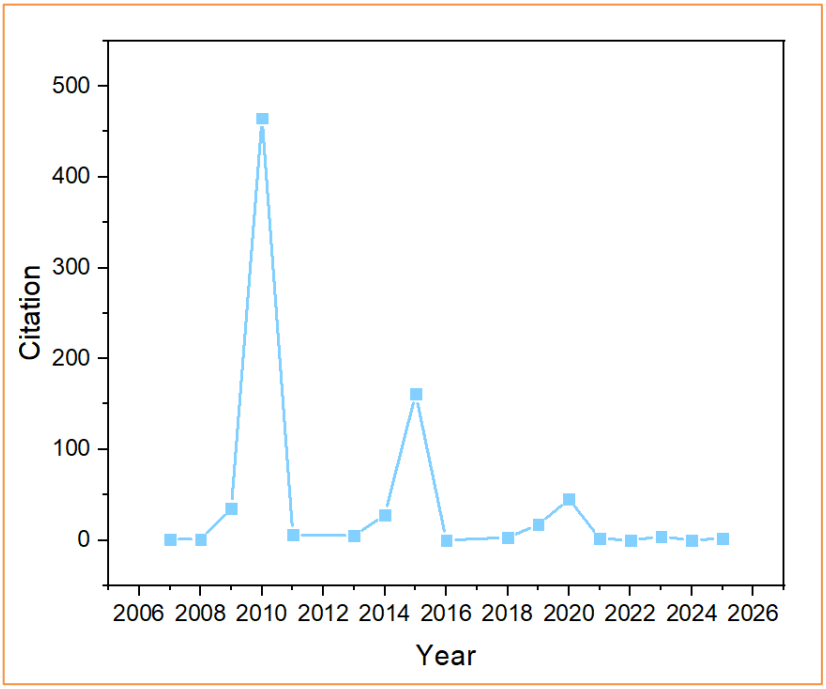

Figure 3. Research trends based on the number of citations each year

Figure 3 shows the number of citations per year from articles found in database searches. This data shows how research citation trends changed from 2007 to 2025. 2010 was the year with the highest number of citations, namely 465 citations, so it can be considered the peak of research contributions in that period. The year 2015 also showed a high number of citations, reaching 161 citations, followed by 2020 with 45 citations. This indicates that publications in those years had a significant influence and were widely referenced by other researchers. Several years showed low or even zero citation rates, such as 2016, 2014, 2013, 2018, and 2021, which were relatively small, as well as 2024 and 2022, which had 0 citations, possibly because the publications were still new or less relevant to subsequent research. In the early years, such as 2007 and 2008, citations were still very few, with only 1 citation each, indicating that research on this topic had not yet developed much at that time.

Articles included in the top 10 publications with the highest number of citations based on the keywords "misconception," "momentum," and "impulse."

Based on Table 1, there were 10 articles with the highest number of citations published in 2009, 2010, 2011, 2014, 2015, 2019, and 2020. Among these publications, the article released in 2010 was the most cited, reaching 465 citations. This finding shows that scientific works published in that year had a significant impact and were often used as references by researchers in related fields.

Table 1. Ten articles with the highest number of citations identified through the use of the keywords "misconception," "momentum," and "impulse."

No	Author	Title	Year	Number of Citation	References
1	Bogner, S.K., Furnstahl, R.J., Schwenkd, A.	From low-momentum interactions to nuclear structure	2010	465	(Bogner et al., 2024)
2	Luo, X.-W., Zhou, X., Li, C.-F.,….Guo, G.-C., Zhou, Z.-W.	Quantum simulation of 2D topological physics in a 1D array of optical cavities	2015	149	(Luo et al., 2015)
3	Bryce, T.G.K., MacMillan, K.,	Momentum and kinetic energy: Confusable concepts in secondary school physics	2009	35	(Bryce & Macmillan, 2009)
4	Xu. W., Liu, Q., Koenig, K., … Pan, S., Bao, L.,	Assessment of knowledge integration in student learning of momentum	2020	32	(Xu et al., 2020)
5	Kostic, M.M.	The elusive nature of entropy and its physical meaning	2014	26	(Kostic, 2014)
6	Ricardo, B., Lee, P.	Maximizing kinetic energy transfer in one-dimensional many-body collisions	2015	12	(Ricardo & Lee, 2015)
7	Bhattacharyya, D., Dawlaty, J.M.	Teaching Entropy from Phase Space Perspective: Connecting the Statistical and Thermodynamic Views Using a Simple One-Dimensional Model	2019	10	(Bhattacharyya & Dawlaty, 2019)
8	Adimayuda, R., Aminudin, A.H., Kaniawati, I., Suhendi, E., Samsudin, A.	A multitier open-ended momentum and impulse (MOMI) instrument: Developing and assessing quality of conception of 11^{th} grade Sundanese students with rasch analysis	2020	7	(Adimayuda et al., 2020)
9	Triyani, G., Danawan, A., Suyana, I., Kaniawati, I.	An investigation of students' misconceptions about momentum and impulse through interactive conceptual Instruction (ICI) with computer simulation	2019	6	(Triyani et al., 2018)
10	Costa, L. F., Natario, J., Zilhao, M.	Mathisson's helical motions demystified	2011	6	(Costa et al., 2012)

Articles reviewed based on affiliation, author, and country that most frequently use the keywords "misconception," "momentum," and "impulse."

According to data obtained from Scopus, Figure 3 shows the ten main affiliations that most frequently use the keywords misconception, momentum, and impulse.

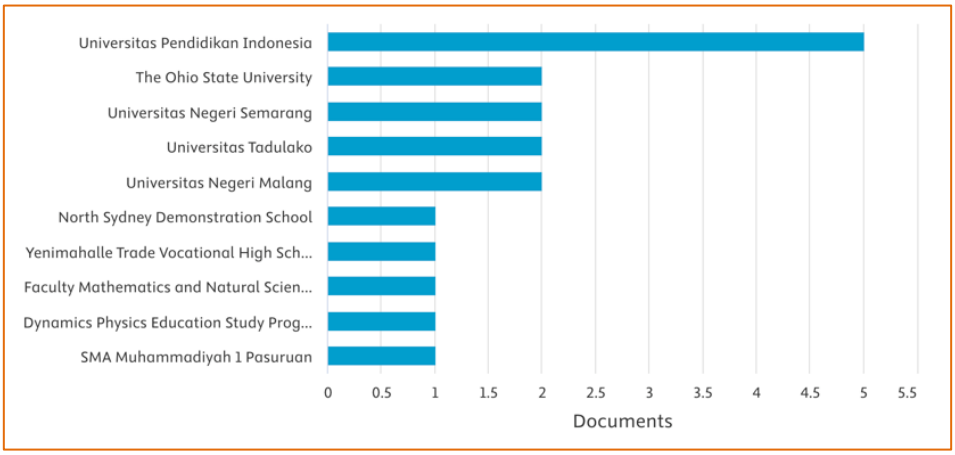

Figure 4. Affiliates showing the largest contribution to the use of the keywords "misconception," "momentum," and "impulse."

Based on Figure 4, the affiliation with the highest number of publications is the Indonesia University of Education (UPI) with a total of 5 documents. This shows that UPI is the most dominant and active institution in research related to the keywords "misconception," "momentum," and "impulse."

Note Figure 5, which shows the 10 most active countries in using the keywords "misconception," "momentum," and "impulse." Based on this figure, it can be seen that these ten countries dominate the number of publications related to these topics.

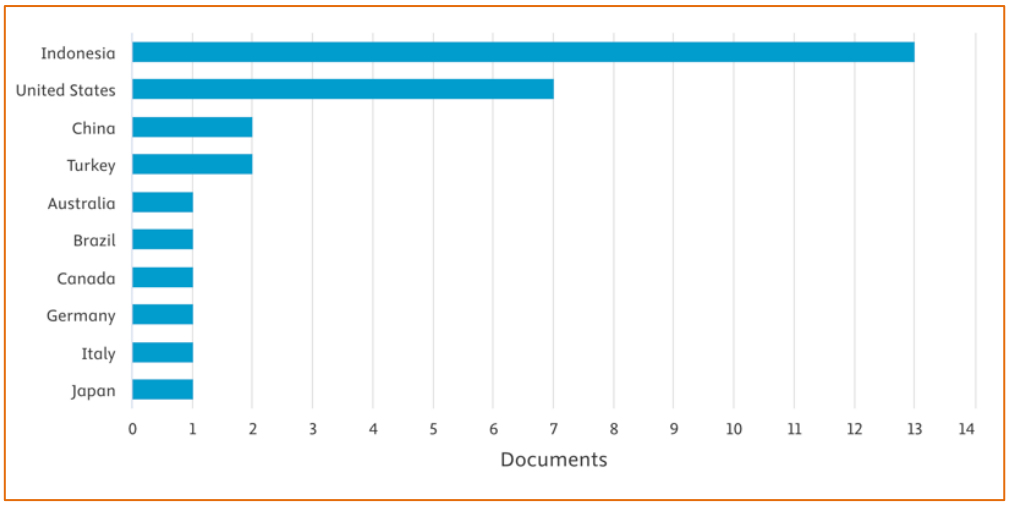

Figure 5. Ten countries with the largest contribution to publications mentioning the keywords "misconception," "momentum," and "impulse."

Based on Figure 5, the country that most frequently used the keywords "misconception," "momentum," and "impulse" in its publications was Indonesia, with a total of approximately 13 documents. This number is much higher than that of other countries. The United States ranked second with approximately 7 documents, followed by China and Turkey, each with approximately 2 documents. Countries such as Australia, Brazil, Canada, Germany, Italy, and Japan each contributed approximately 1 document. The findings in Figure 4 are in line with the results in Figure 3, which show that the affiliation with the most publications also comes from Indonesia, particularly the Indonesia University of Education (UPI) as the institution with the highest number of documents. This explains why Indonesia emerges as the country with the largest contribution to publications: because several universities in Indonesia, especially UPI and several other institutions such as Semarang State University, Tadulako University, and Malang State University, are very active in conducting research related to misconceptions, momentum, and impulse. Thus, the relationship between Figure 3 and Figure 4 shows consistency between affiliation and the country of origin of the researchers. The majority of affiliations are from Indonesia, and this directly influences the high number of Indonesian publications on these topics.

Take a look at Figure 6, which shows the 10 most active authors in using the keywords "misconception," "momentum," and "impulse." Based on this figure, it can be seen that these ten countries dominate the number of publications related to these topics.

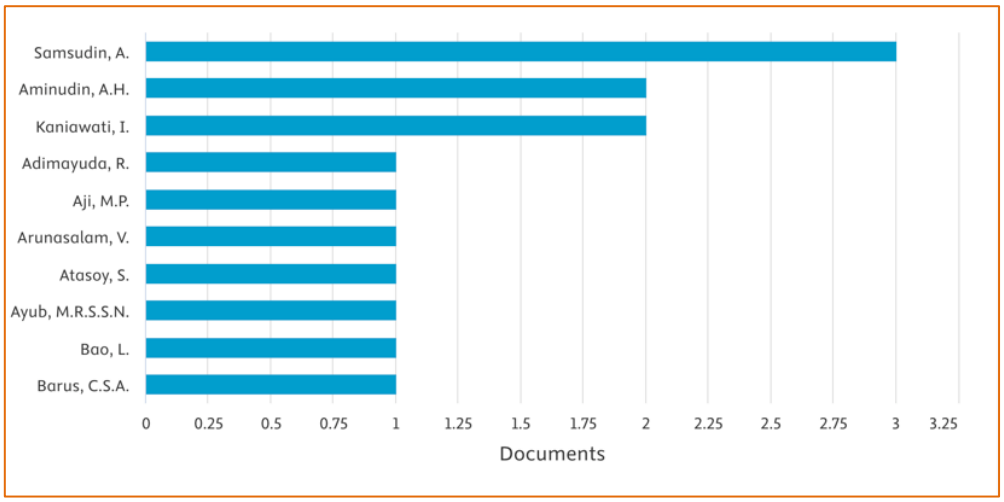

Figure 6. Ten authors who contributed most to publications mentioning the keywords "misconception," "momentum," and "impulse."

Based on Figure 6, which shows a list of the most active authors in publishing articles using the keywords "misconception," "momentum," and "impulse," the graph shows the ten authors with the highest number of documents based on data from Scopus. The graph shows that Samsudin, A. is the most productive author with a total of approximately 3 documents, followed by Aminudin, A.H. and Kaniawati, I., who each have 2 documents, indicating that these three authors have made significant contributions to research on this topic. Other authors such as Adimayuda, R., Aji, M.P., Arunasalam, V., Atasoy, S., Ayub, M.R.S.S.N., Bao, L., and Barus, C.S.A. each have one document, which shows that although their contributions are smaller, they are still part of a group of authors who are active in research on misconceptions about the concepts of momentum and impulse. Overall, Figure 5 provides information about the researchers who have contributed the most to this topic and shows that most of the authors with the most publications are from Indonesia, in line with the data in Figures 4 and 5.

Figure 7 illustrates the top ten funding agencies that most frequently support publications involving the use of the keywords "misconception," "momentum," and "impulse."

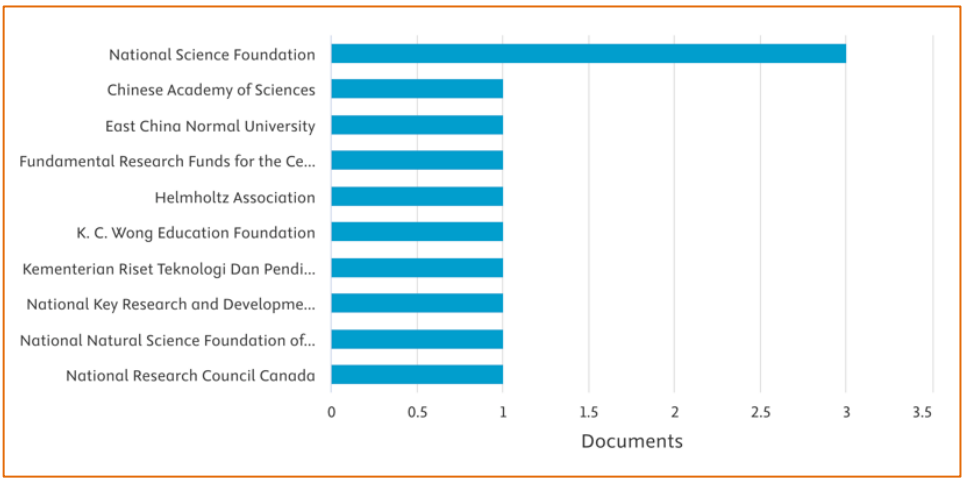

Figure 7. Ten funding agencies that contributed most to publications mentioning the keywords "misconception," "momentum," and "impulse."

Figure 7 shows the top ten funding agencies that contributed to the publication of research documents. The graph shows that the National Science Foundation is the agency with the largest funding contribution, with approximately 3 publications. Meanwhile, the other nine institutions,

including the Chinese Academy of Sciences, East China Normal University, Fundamental Research Funds for the Central Universities, Helmholtz Association, K. C. Wong Education Foundation, Ministry of Research, Technology and Higher Education, National Key Research and Development Program of China, National Natural Science Foundation of China, and National Research Council Canada, each funded approximately 1 research document. Overall, Figure 7 shows that the largest support came from the National Science Foundation, which had a significant lead over other funding agencies. This may indicate a greater focus on related research, both in terms of budget and the agency's commitment to encouraging scientific publications. While the other nine agencies still provided funding, the amounts were relatively lower and at almost the same level.

The publications that most frequently use the keywords "misconception," "momentum," and "impulse" cover various types, fields of study, and document sources.

Based on the results of a search in the Scopus database, Figure 8 shows that there are three main types of publications that most frequently use the keywords "misconception," "momentum," and "impulse."

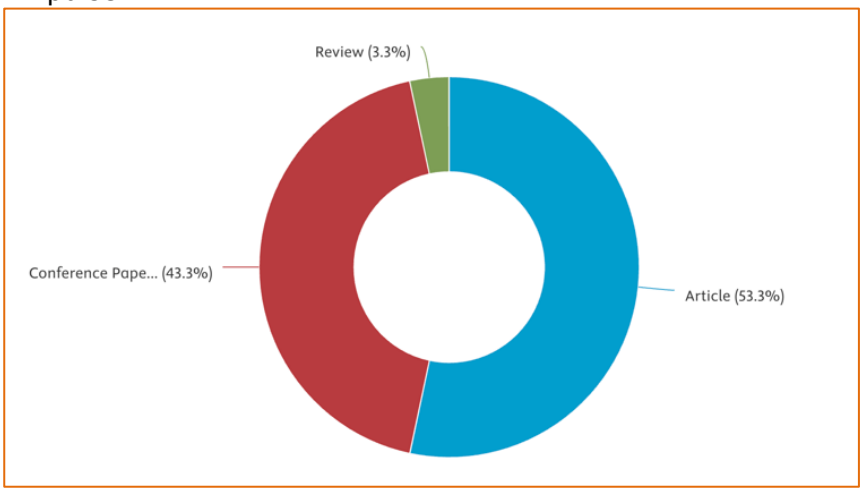

Figure 8. The top three types of documents that most frequently contain the keywords "misconception," "momentum," and "impulse."

Figure 8 shows the distribution of document types using the keywords "misconception," "momentum," and "impulse" based on data from Scopus. The diagram shows that most publications are articles, with a proportion of 53.3%. Next, conference papers are in second place with a contribution of 43.3%, indicating that this topic is also widely discussed in scientific conference forums. Reviews have the smallest percentage, at 3.3%, indicating that literature reviews on this topic are still very limited. Overall, Figure 8 illustrates that research on misconceptions in the concepts of momentum and impulse is predominantly published in the form of journal articles.

Figure 9 shows the top ten fields of study that most frequently use the keywords "misconception," "momentum," and "impulse" in scientific publications.

Figure 9 shows the distribution of research contributions by field of study. Physics and Astronomy accounts for the largest share with a percentage of 52.3%, meaning that more than half of all research comes from this field. The second largest contribution comes from the Social Sciences at 22.7%, indicating that the social sciences still play a significant role but remain far behind the dominance of research in physics and astronomy. Below that are several other fields such as Business and Management, Chemistry, and Computer Science, each contributing 4.5%. Meanwhile, other fields including Biochemistry, Engineering, Health Professions, Mathematics, and Psychology only contributed 2.3% of the total research publications.

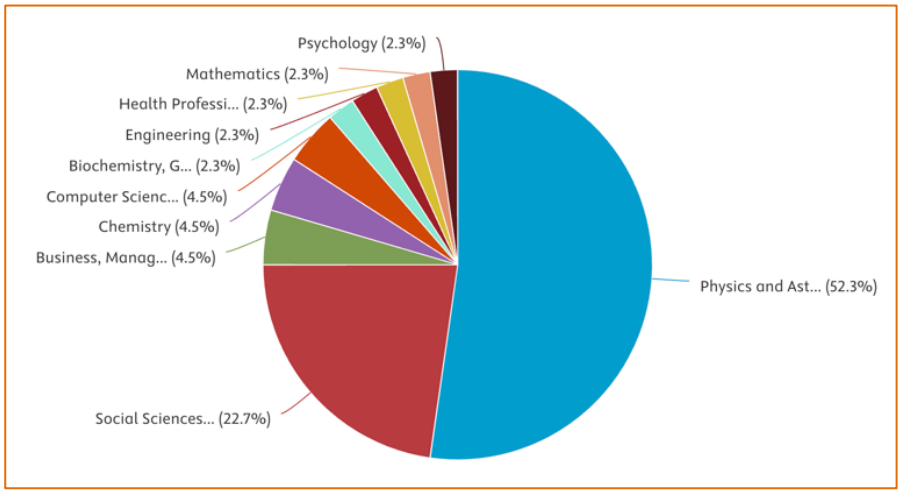

Figure 9. The top 10 fields of study that most frequently contain the keywords "misconception," "momentum," and "impulse."

Table 2 shows that the most frequent sources of publications utilize the keywords "misconception," "momentum," and "impulse."

No	Source	Number of Documents
1	Physics Journal Conference Series	7
2	Proceedings of the AIP Conference	6
3	Physics Teacher	2
4	Advances in Mathematical Physics	1
5	Educational Science	1
6	Entropy	1
7	European Journal of Educational Research	1
8	European Physics Journal	1

Table 2 presents a list of publication sources that most frequently use the keywords "misconception," "momentum," and "impulse" in scientific articles. Based on this data, the Physics Journal Conference Series is the source with the highest number of publications, namely 7 documents. The second position is occupied by the AIP Conference Proceedings with 6 documents, indicating that these two sources are the most dominant publications on this topic. Meanwhile, other sources such as Guru Fisika (Physics Teacher) has 2 documents, followed by several journals with smaller contributions, each with 1 document, namely Kemajuan dalam Fisika Matematika (Advances in Mathematical Physics), Ilmu Pendidikan (Education Science), Entropi (Entropy), Jurnal Penelitian Pendidikan Eropa (European Journal of Educational Research), and Jurnal Fisika Eropa (European Journal of Physics). Overall, this table illustrates that topics related to misconceptions, momentum, and impulse are published more in physics proceedings and conferences than in other multidisciplinary journals.

Mapping the visualization of the keywords misconceptions, momentum, and impulse using VOSviewer software.

To perform the analysis using VOSviewer, a minimum of 10 connections between terms is required. After mapping, four clusters appeared, represented by red, green, blue, and yellow, which indicate the interrelationships between themes in the research, as listed in Table 3. VOSviewer provides three types of bibliometric visualizations, namely network, overlay, and density. The keyword with the largest circle indicates that the term appears most frequently. Based on a search of the Scopus database for titles, keywords, and abstracts, 30 articles published between 2007 and 2025 were obtained.

Table 3. Clustering results generated by VOSviewer

No	Numbers of Item	Warna	Item
1	6	Red	Student, Momentum, Total, Coefficient of restitution, Collision and elasticity
2	4	Green	Landslides, conceptual understanding, natural disasters and disasters
3	3	Blue	Formative assessment, mathematical physics, center of gravity

Based on the clustering results using VOSviewer in Table 3, three clusters of keywords were obtained, each marked with a different color. The first cluster, colored red, consisted of six terms, namely students, momentum, total, coefficient of restitution, collision, and elastic. This group showed a topic correlation that focused on the concepts of momentum and collision in physics learning involving students. The second cluster, colored green, contains four keywords, namely landslide, conceptual understanding, natural disaster, and disaster, which describe studies related to students' understanding of natural disaster phenomena. Meanwhile, the third cluster, colored blue, contains three terms, namely formative assessment, mathematical physics, and center of gravity, which reflect research themes on learning evaluation and mathematical physics concepts. These three clusters show the interconnection between topics that appear in the literature based on bibliometric mapping.

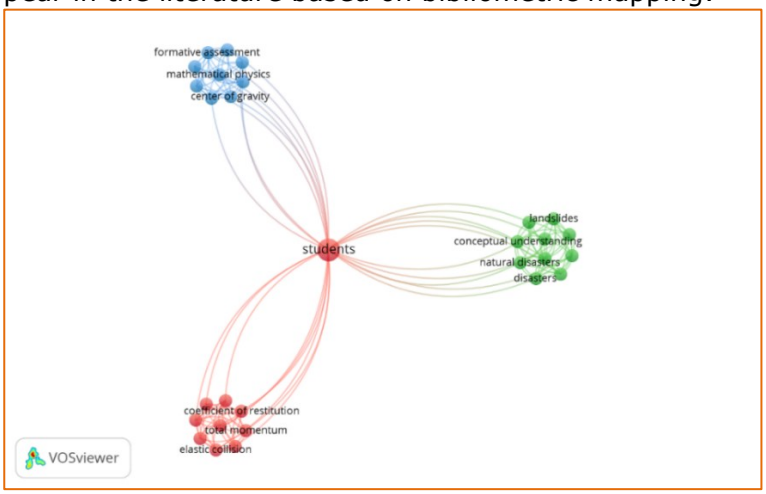

Figure 10. Visualization of the network generated based on keyword occurrence

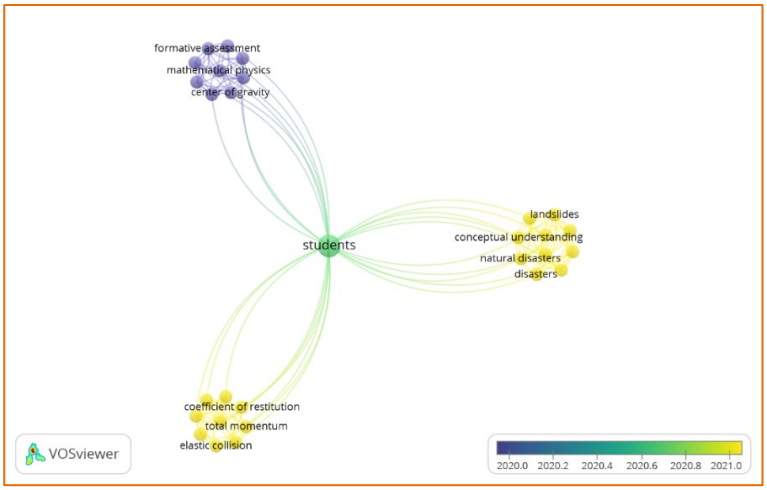

Figure 11. Visualization of overlays generated based on keyword occurrence

Based on Figure 10, the visualization is the result of bibliometric mapping using VOSviewer, which displays the relationships between keywords in three main clusters. Each cluster is depicted in a different color, namely red, green, and blue, each of which indicates a group of interrelated topics in the literature. The red cluster centers on the keyword students

and is connected to terms such as coefficient of restitution, total momentum, and elastic collision. This cluster illustrates research focusing on the concepts of momentum and collision in the context of teaching physics to students. The green cluster is also connected to the keyword students, but includes terms such as landslides, conceptual understanding, natural disasters, and disasters. This group shows research themes related to students' conceptual understanding of natural disaster phenomena, particularly landslides. Meanwhile, the blue cluster contains terms such as "formative assessment," "mathematical physics," and "center of gravity." This cluster shows a relationship between topics that focus on learning evaluation and mathematical physics concepts.

Based on Figure 11, the visualization displays an overlay mapping of keywords using VOSviewer. Unlike the network display, the overlay mapping provides additional information in the form of the time range of keyword appearances, which is represented by a color scale at the bottom of the image (Febriana et al., 2026; Rizki et al., 2026). The color of each keyword indicates the average year when the keyword appeared in publications. Colors closer to blue-purple indicate keywords that were more dominant in previous years, while green-yellow colors indicate keywords that are newer and more widely used in recent years. In this image, the keyword students is at the center of the network and appears green, indicating that the term was used consistently in the middle of the publication period. Groups of keywords such as coefficient of restitution, total momentum, and elastic collision tend to be yellow, indicating that these topics appeared more recently in the research period. Meanwhile, keywords such as formative assessment, mathematical physics, and center of gravity are more blue-green in color, indicating that these terms were used earlier.

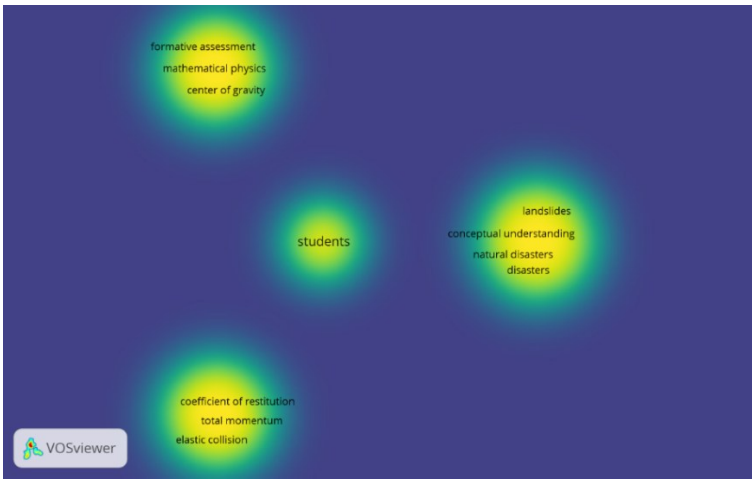

Figure 12. Density visualization based on keyword occurrence

Figure 12 shows a density visualization of the keyword mapping results using VOSviewer. In this view, colors are used to indicate the density or intensity of keyword occurrences in the network. Colors that are lighter towards yellow indicate that the keyword appears more frequently or has a stronger relationship in the analyzed data set. Conversely, dark blue areas indicate lower intensity. In this visualization, several bright areas indicate three main groups. First, the keyword groups formative assessment, mathematical physics, and center of gravity form a zone with a high density level. Second, the keyword groups coefficient of restitution, total momentum, and elastic collision also form a dense area, indicating topics that are widely discussed in the literature. Third, the keyword groups landslides, conceptual understanding, natural disasters, and disasters appear as areas with strong intensity, indicating that the themes of natural disasters and conceptual understanding are closely related. The keyword students is in the middle as a light green area, indicating that this term is a connecting point for the three topic groups even though it is not as bright as the other clusters.

CONCLUSION

This study was successful. Bibliometric analysis of 30 Scopus publications using the keywords "misconception," "momentum," and "impulse" in the period 2007–2025, it can be concluded that research on this topic has experienced fluctuating development but tends to

increase, especially after 2018, with peak productivity in 2020 and the highest citations in 2010, indicating the existence of highly influential articles. Indonesia was the largest contributor with 13 publications, supported by dominant affiliations such as the Indonesia University of Education, and prolific authors such as Samsudin, A., Aminudin, A.H., and Kaniawati, I., while the largest funding support came from the National Science Foundation. The types of documents were dominated by journal articles (53.3%), followed by conference papers (43.3%), and a small number of reviews, with Physics and Astronomy as the largest contributor to publications, followed by Social Sciences, which marked the connection between physics concepts and pedagogical approaches. The VOSviewer analysis results show three main clusters: the red cluster, which maps research on momentum, collisions, elasticity, and restitution coefficients; the green cluster, which focuses on learning processes and conceptual understanding; and the blue cluster, which relates to formative assessment and mathematical physics aspects. Overall, research on misconceptions of momentum and impulse has an important position in physics education and continues to develop, but there is still ample room for exploration, especially in review-based studies, international collaboration, the development of more comprehensive diagnostic instruments, and learning innovations to minimize misconceptions, so that these bibliometric results can be a reference for researchers in directing their research focus in the future.

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