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Exploring Research Trends of Physics Concept Mapping in Physics Learning: Bibliometric Analysis

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ABSTRACT

Research related to the application of concept mapping in physics learning is increasing and has become a trending topic for decades. This research purpose is (1) Analyze the research network and visualization concept mapping research in physics learning and contributions to learning physics (2) Analyze contribution of Indonesian Researchers on Concept mapping research (3) Analyze research recommendations related to concept mapping in physics learning. This bibliometric analysis using Scopus database in 2012-2023 period documents and analyze by VOSviewer. Visualization results with physics concept mapping be found in 6 clusters with the dominant items are mapping, students, and physics. The implementation of concept mapping in physics learning has many impacts there are conceptual understanding, student performance, learning outcome, problem solving and physics misconception. Indonesia has contributed in physics concept mapping research with Universitas Negeri Manado being the most productive affiliations, Polukan c. being the most productive author and the most cited publication is "The effectiveness of Concept Mapping Content Representation Lesson Study (ComCoReLS) model to improve skills of Creating Physics Lesson Plan (CPLP) for pre-service physics teacher". Based on network visualization the research recommendation about physics concept mapping is about concept mapping's research in problem solving and misconceptions.

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INTRODUCTION

One of difficult subjects in school is physics (Samudra *et al.*, 2014). Physics is a branch of natural science which has a very important role in the development of science and technology (Izzati *et al.*, 2019). Physics is one of the Sciences subjects that can develop analytical thinking skills in problem solving related to phenomena in everyday life (Depdiknas, 2002). Concept in physics learning is ignored by students. Most students prefer to memorize and use formulas when solving physics problems rather than understanding the concepts (Harun, 2016). This happens because the formula is easier to remember without understood the concepts (Izzati *et al.*, 2019). Besides that, the way to learn is by memorizing and demands accuracy in counting as well have an impact on students' perceptions of Physics subjects. Lack of student interest in physics learning so that it affects the lack of student activity in the learning process (Abbas & Hidayat, 2018). Some students think that physics is difficult subject because only learn formulas and apply them in calculations (Sandari, 2021)

Concept mapping is a concrete line illustration that indicates how a single concept is related to other concepts in the same category (Trianto, 2009). A concept mapping learning used by drawing the main concept, while some other words are written in connecting lines. The lines

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on the concept map show the relationships between the concepts. The words written on the lines give the relationship between the concepts (Purnamasari & Salim, 2021). Concept mapping is a way to show the concepts and proportions of a material to be studied (Ummah *et al.*, 2019). Concept mapping is arranged hierarchically, meaning that the more inclusive concepts are placed at the top of the map, the further down the concepts are sorted into less inclusive concepts. In Concept Mapping, it makes abstract information concrete and is very useful in increasing the memory of a learning concept, and showing students that thoughts have a form (Widyastuti *et al.*, 2019).

Concept mapping method was popularized by Buzan, an expert and prolific writer in the fields of psychology, creativity and self-development in the 1970s. Buzan explained that a concept mapping or mind mapping is a creative, effective, and literally way of taking notes that will map the whole concepts. Concept maps is one of ways that teachers can use to find out what concept students already know based on Ausabel's learning theory. Ausabel learning theory emphasized that teachers must know the concepts that students already have. So that meaningful learning can take place. Concept maps are used to express relationships between concepts in the form of propositions. Propositions are two or more concepts connected by words in one semantic unit. In meaningful learning, new knowledge must be associated with relevant concepts that already exist in students' cognitive structures. If in the cognitive structure there are no relevant concepts, the new knowledge that has been learned is just rote (Uripah, 2022).

One of the action needed to make physics learning doesn't just theoretical but can be meaningful for students. The use of good physics learning strategy is needed that is appropriate, interesting, and directly related to the student's real world. Based on this, the learning strategy that is in accordance with the scientific approach is concept mapping. By making a concept map students see what will be learned. By making a concept map students see the subject matter more clearly and meaningfully (Ummah *et al.*, 2019). Concept maps are a dynamic learning method to motivate students to read and increase their creativity. The technique uses generalized format that allows information to be represented in a way that the brain functions. Concept mapping learning method emphasizes team/group evaluation. Concept mapping learning activity more effectively in developing learning materials (Uripah, 2022).

Research related to the application of concept mapping in physics learning is increasing and has become a trending topic for decades. Research related to literature studies related to concept mapping is not specific to physics learning and literature research related to bibliometric analysis has not been studied enough. Research using bibliometric analysis on physics concept mapping using the Scopus database has not been studied enough. Scopus is used to search for bibliographies as a database source. This is because Scopus is one of the largest databases that provides peer-reviewed literature and publications (Utami & Karlina, 2022).

Based on this, researchers need to conduct a bibliometric analysis with the Scopus database to analyze concept mapping trends that can be integrated into physics learning using the Scopus database. The research problems are

1. How is the research network and visualization concept mapping research in physics learning and contributions to learning physics?
2. How is contribution of Indonesian Researchers on Concept mapping research?
3. What are the research recommendations related to concept mapping in physics learning?

RESEARCH METHOD

This research uses bibliometric visualization method and bibliometric analysis. As a quantitative method, bibliometric analysis uses an evaluative and descriptive approach to represent research trends and publications characteristics (Muhammad *et al.*, 2022). The bibliometric visualization method is used to show a structural representation of a particular

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research area (Garfield *et al.*, 2009). Bibliometric analysis can provide a level of development of a research at a higher level by looking at the characteristic and improvement of the research concerned (Utami & Karlina, 2022).

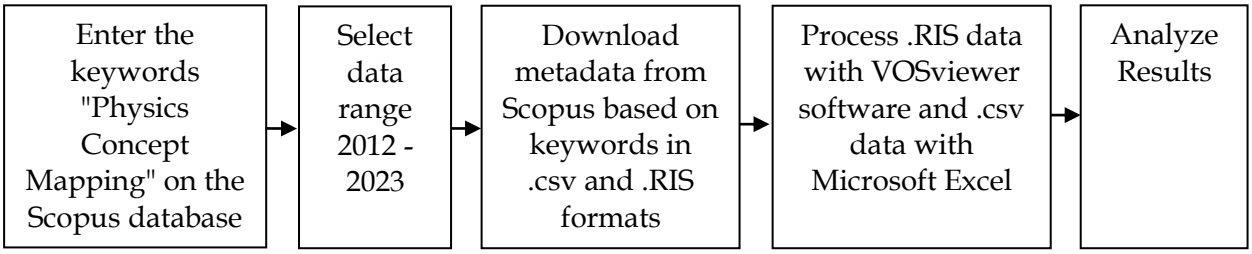

Figure 1. Bibliometric analysis stages

RESULTS AND DISCUSSION

Research network and visualization concept mapping research in physics learning and contributions to learning physics

Based on research result of metadata about concept mapping in physics learning from Scopus database in 2012 until 2023 period there are 332 documents. Figure 2 shows the network visualization of concept mapping in physics learning from Scopus database using VOSviewer with a minimum number of occurrences of 2 and selecting 469 keyword based on suitability into physics learning.

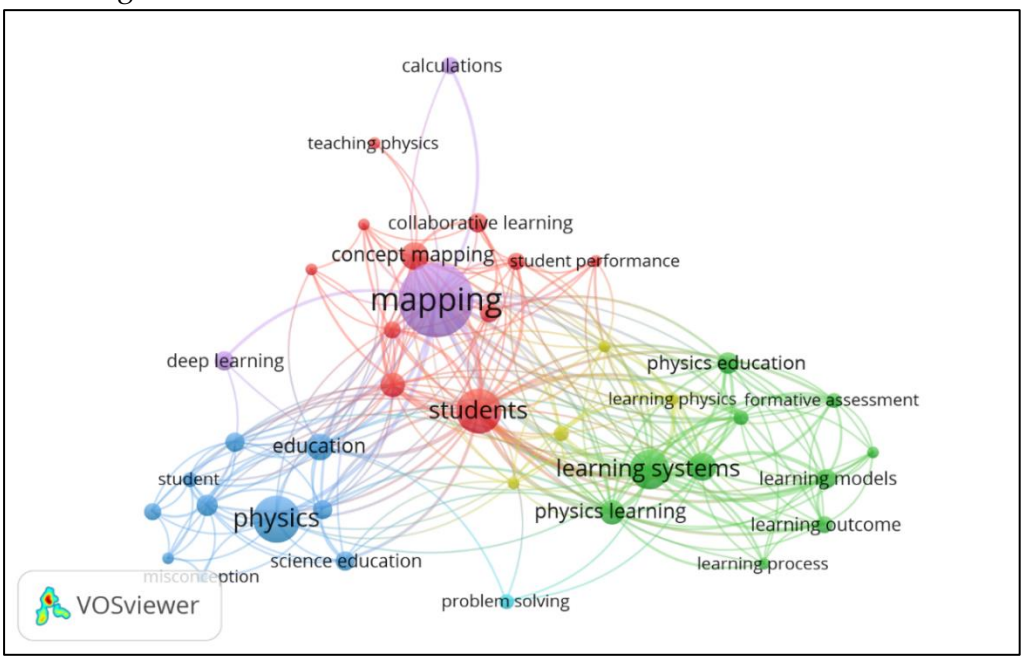

Figure 2. Network visualization concept mapping in physics learning in 2012 until 2023 on the Scopus database

Based on Figure 2 there are 6 clusters from 39 items and 243 links. Cluster 1 (red) related to collaborative learning, student performance, teaching physics etc. Cluster 2 (green) related to physics education, formative assessment, learning outcome, learning system etc. Cluster 3 (blue) related to physics, science education, student and misconception etc. Cluster 4 (yellow) related to pre service teacher, learning physics, teaching and learning etc. Cluster 5 (purple) related to calculations, deep learning and mapping. Cluster 6 (light blue) related to problem solving.

Based on the physics concept mapping network relationship so it can be said that concept mapping has closed relationship with learning with the dominant keyword visualization

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besides mapping itself are student terms with 35 link, 102 total link strength and 25 number of occurrences and physics terms with 16 link, 23 total link strength and 27 number of occurences.

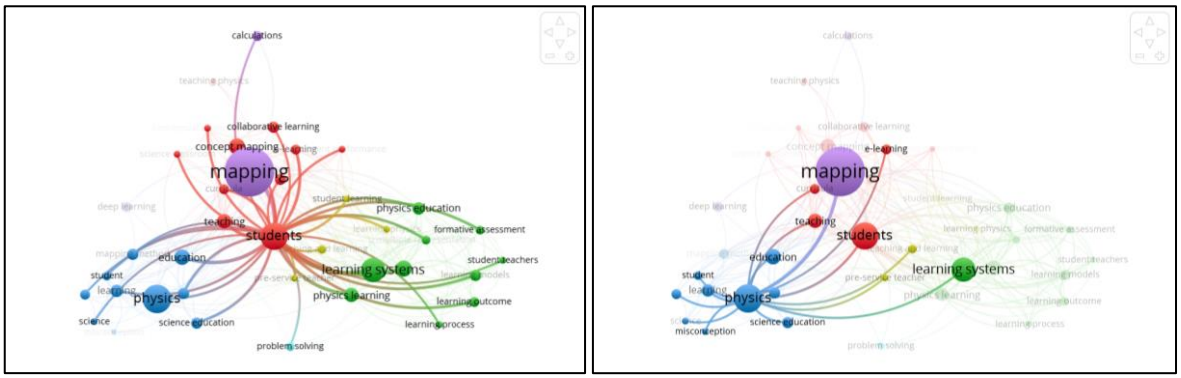

Figure 3. (a) Students terms in visualization of concept mapping in physics learning (b) Physics terms in visualization of concept mapping in physics learning

From Figure 3 (a) describe that the implementation of concept mapping in physics learning has many impact on student there are conceptual understanding, student performance, learning outcome and problem solving also based on figure 3 (b) concept mapping has a relationship with physics misconception

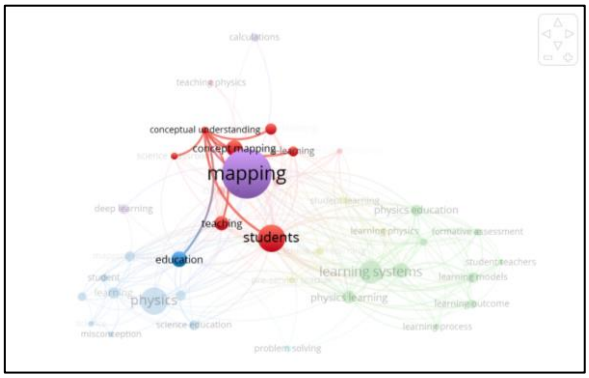

Figure 4. Terms of conceptual understanding in concept mapping in physics learning

Figure 4 describe that concept mapping related into conceptual understanding in science learning especially physics learning. Concept mapping learning model provides many benefits in the learning process because it makes a student trained organizing and grouping important information from the main concepts or ideas of the material has been studied. Mind mapping is very useful for brain function, if someone is used to making mind maps, it will automatically understand concepts faster (Rahmawati *et al.*, 2023).

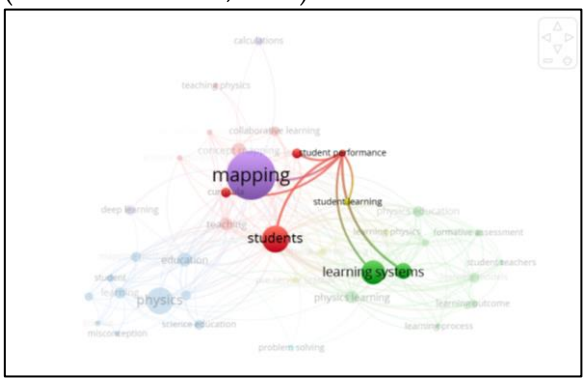

Figure 5. Terms of student performance in concept mapping in physics learning

Figure 5 describe that concept mapping related to student performance. The application of the mind mapping method in physics learning is able to encourage students to be actively

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involved in designing and building their own knowledge in a concept maps (Dewi *et al.*, 2020). Mind mapping method also increases student participation. The use of color also activates the right side of the brain. Student learning motivation increases. This is reflected in all students who are excited and enthusiastic in following the lesson (Arsana *et al.*, 2019).

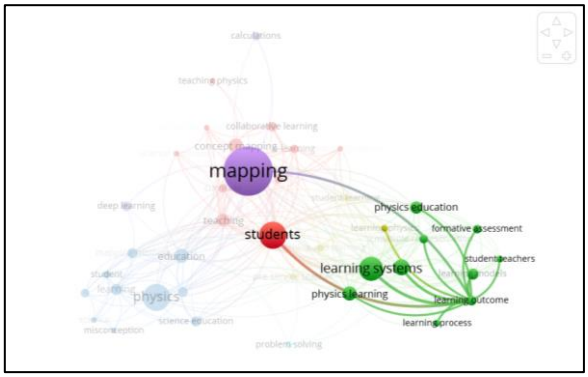

Figure 6. Terms of learning outcome in concept mapping in physics learning

Figure 6 describe that concept mapping related to learning outcome. In using the mind map learning method, students are more interested and more easily understand the concepts of the material being studied (Shihombing *et al.*, 2023). This is different from the conventional learning model where the teacher is the main regulator of student activities. Students are only recipients of information from teachers and teachers provide more explanations or lectures which make students passive, in other words the learning process only goes in one direction (Ma'ruf *et al.*, 2019). Optimal learning outcomes can be achieved if there is something that is remembered and understood and is needed for the next learning process (Andriani *et al.*, 2023).

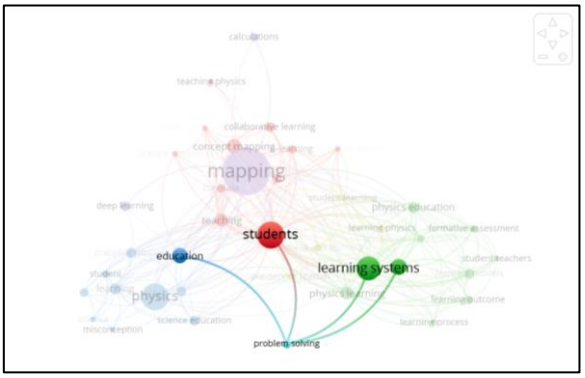

Figure 7. Terms of problem solving in concept mapping in physics learning

Figure 7 describe that concept mapping related to student's problem solving. In addition, in mind mapping or concept mapping based learning, students are taught material with the addition of a mind map in the form of a summary of the material and the formulas contained therein which can improve the quality of learning (Asuri *et al.*, 2021). Concept mapping is able to improve the quality of students' physics learning, because the concept maps already contain lesson concepts that can be easily understood (Bukit & Sirait, 2019). Concept mapping's research in problem solving can be the research opportunity for future researchers in concept mapping because problem solving terms has low link, link strength and occurrences there are 4 link and 3 occurrences with 4 total link strength.

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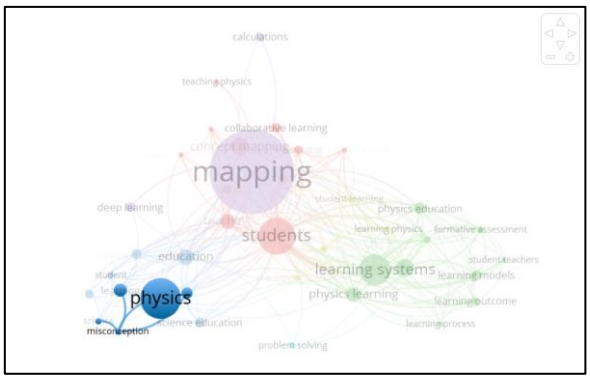

Figure 8. Terms of misconception in concept mapping in physics learning

Figure 8 describe that concept mapping related to student's concept mapping. Concept mapping is a method that can be used to detect misconceptions in physics learning (Respasari *et al.*, 2022). In addition to detecting misconceptions about the application of concept mapping to learning physics, it can also remedy misconceptions. This is because there are many misconceptions are not just because of the understanding of the wrong concept during the teaching and learning process, but the initial conception (preconception) that by students before class (Khoirunisa *et al.*, 2020). By using concept mapping teacher can remedy misconceptions by represent the true concept and draw the correlation between concepts. Concept mapping's research in misconception can be the research opportunity for future researchers in concept mapping because misconception terms has low link, link strength and occurrences there are 4 link and 2 occurrences with 4 total link strength.

Contribution of Indonesian Researchers on Concept mapping research

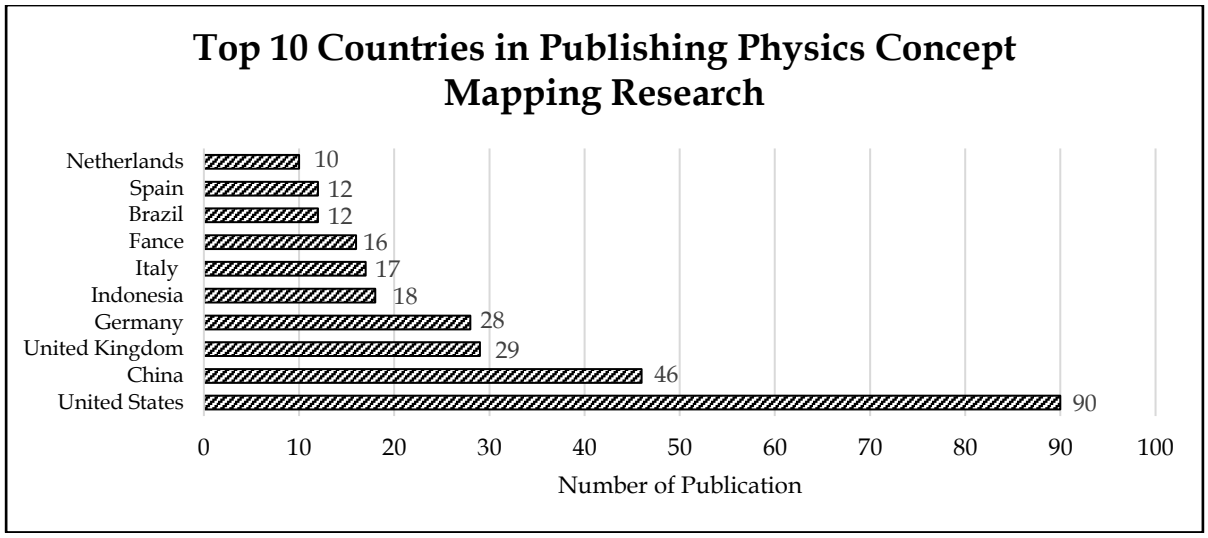

Figure 9. Top 10 countries in publishing physics concept mapping research during 2012-2023 on Scopus database

Indonesia being Top 10 countries in publishing physics concept mapping research. It means that Indonesia being one of productive countries in publishing physics concept mapping research. Based on Scopus metadata during 2012-2023 Indonesian researcher contributing 18 papers related physics concept mapping research. The whole document all published as conference paper. Figure 9 shows the network visualization of concept mapping in physics learning by Indonesian researcher from Scopus database using VOSviewer with a minimum number of occurrences of 2 and selecting 18 keyword based on suitability into physics learning.

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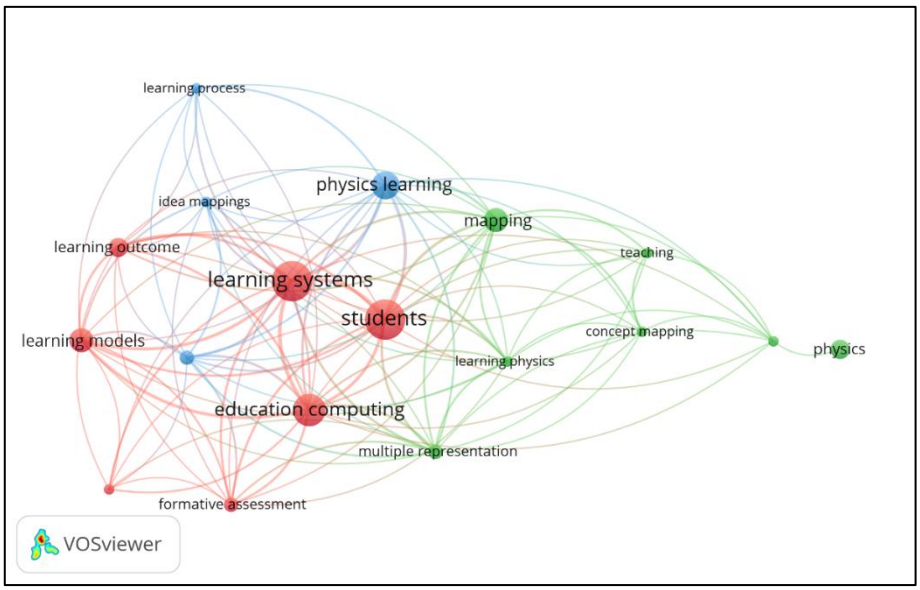

Figure 10. Network visualization concept mapping in physics learning performed by Indonesian researcher during 2012-2023 on the Scopus database

Based on Figure 9 there are 3 clusters from 18 items and 109 links. Cluster 1 (red) related to learning outcome, formative assessment, education computing etc. Cluster 2 (green) related to concept mapping, multiple representation, pre-service teacher etc. Cluster 3 (blue) related to idea mapping, physics learning, learning process etc.

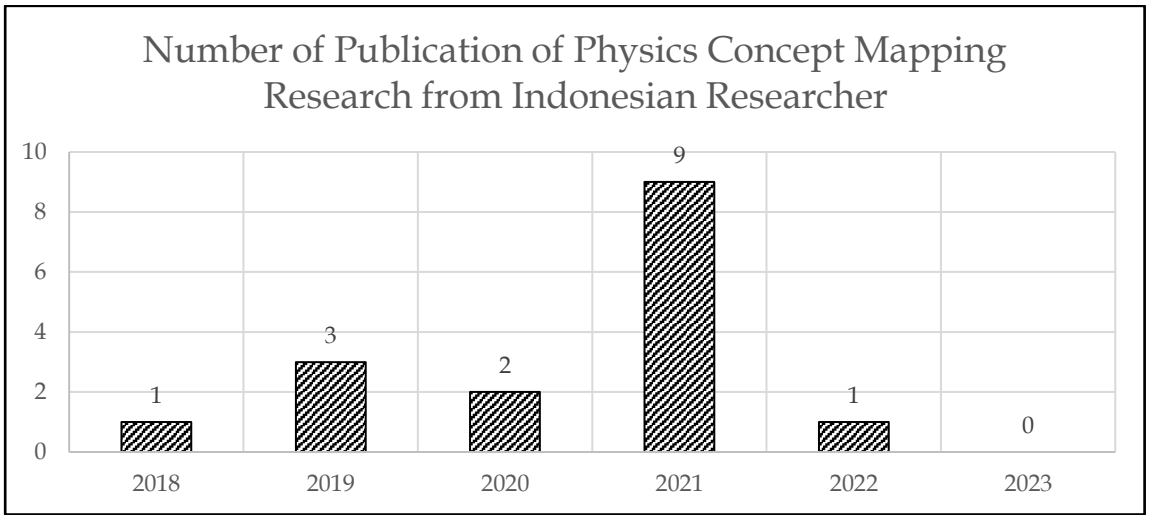

Figure 11. Number of Publication of Physics Concept Mapping from Indonesian Researcher during 2012-2023 on Scopus database

Based on Figure 10 number of publication of physics concept mapping research increase in 5 years and at 2021 increased significantly. Even though in 2022 and 2023 number of publication decrease. More Specific in 2023 there are 0 number of publication. This is an opportunity for Indonesian researcher to contribute on physics concept mapping research.

Table 1 describe about top 5 Indonesian affiliation in publishing physics concept mapping research. Universitas Negeri Manado being the most productive Indonesian affiliations with 7 publication and 7 citation.

Table 1. Top 5 Indonesian Affiliation based on Number of Publication and Citation

No	Affiliations	Number of Publication	Number of citation
1	Universitas Negeri Manado	7	7

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No	Affiliations	Number of Publication	Number of citation
2	Universitas Sebelas Maret	2	2
3	Universitas Negeri Surabaya	2	0
4	Universitas Negeri Malang	1	7
5	Universitas Pendidikan Indonesia	1	2

Table 2 describe about top 5 Indonesian author in publishing physics concept mapping research. Polukan c. being the most productive Indonesian author with 7 publication and 7 citation. Based on table 2 all of Indonesian author's paper has cited 1 times or has 1 number of citation per publication

Table 2. Top 5 Indonesian Author based on Number of Publication and Citation

No	Author	Number of Publication	Number of citation
1	polukan c.	7	7
2	mondolang a. h.	4	4
3	mongan s. w.	2	2
4	silangen p. m.	2	2
5	dido f.	1	1

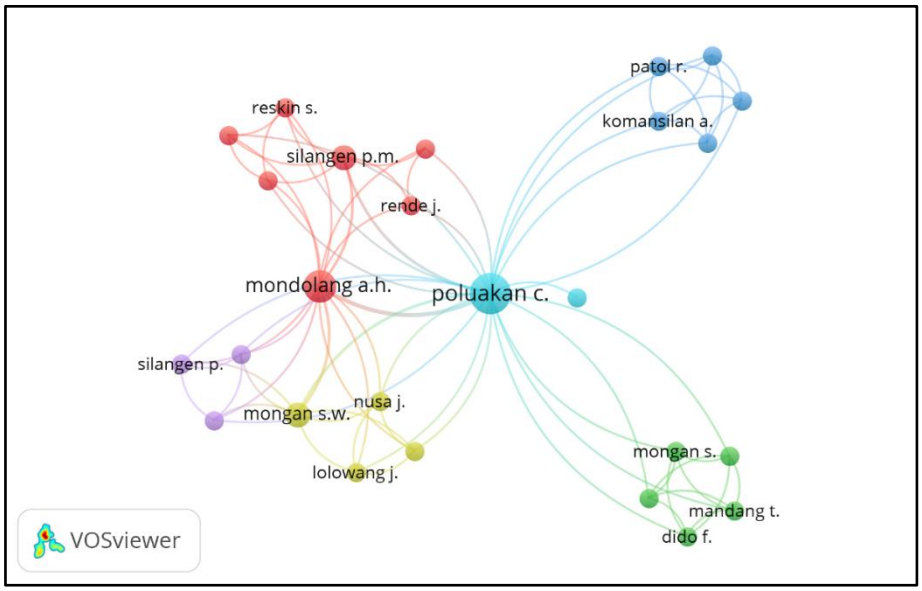

Figure 12. Network visualization of Indonesian researcher concept mapping in physics learning performed during 2012-2023 on the Scopus database

Based on figure 11 polukan c. has 25 link, next one is mondolang a. h. has 14 link, futermore mongan s. w. and silangen p. m. has 7 link. It show that polukan s., mondolang a. h., mongan s. w. and silangen p. m. has many collaborated with other researcher to publish physics concept mapping research. Because of that polukan c. has the most number of publication. That is what caused them put into top 5 Indonesian author based on number of publication and polukan c. become the most productive Indonesian Author in published physics concept mapping paper.

All of Indonesian researchers publish their paper as conference paper than article. This shows that researchers are more interested in publishing their papers in conferences than in journal articles and books. Some conference has been chosen to publish physics concept mapping based on number of publication and citation show in Table 3.

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Table 3. Top 5 Conference based on Number of Publication and Citation

No	Conference	Number of Publication	Number of citation
1	International Conference on Mathematics and Natural Sciences Education, Research and Assessment (ICMANSERA)	6	6
2	International Conference on Mathematics and Science Education (ICMScE)	2	4
3	Seminar Nasional Fisika (SNF)	1	7
4	International Conference on Mathematics and Science Education: Strengthening Mathematics and Science Education Research for the Challenge of Global Society, (ICoMSE)	1	2
5	International Conference Science Physics and Education (ICSPE)	1	1

Table 4 describe about top 5 most cited publication about physics concept mapping from Indonesian author. The title of most cited publication is "The effectiveness of Concept Mapping Content Representation Lesson Study (ComCoReLS) model to improve skills of Creating Physics Lesson Plan (CPLP) for pre-service physics teacher" about the use of Concept mapping model namely ComCoReLS (Concept Mapping Content Representation Lesson Study) to increase Creating Physics Lesson Plan (CPLP) for pre-service physics teacher in State University of Malang (Purwaningsih & Prahani, 2018). This paper published at 2018 and has cited 7 times.

Table 4. Top 5 Most Cited Publication from Indonesian Author

No	Author (s)	Year	Title	Citation
1	Purwaningsih E., Suyatno, Wasis, Prahani B.K.	2018	The effectiveness of Concept Mapping Content Representation Lesson Study (ComCoReLS) model to improve skills of Creating Physics Lesson Plan (CPLP) for pre-service physics teacher	7
2	Rusyati L., Rustaman N.Y., Widodo A., Ha M.	2021	A review of research trends on meta-cognitive in science education within the past decade	2
3	Puspitasari M.D.M., Wahyuniar L.S., Wardani A.S.	2020	The analysis of student epistemic games reviewed from physics understanding	2
4	Viyanti V., Cari C., Sunarno W., Prasetyo Z.K.	2017	Level of Skill Argued Students on Physics Material	2
5	Poluakan C., Katuuk D.	2022	PIMCA: A New Alternatives to Physics Learning Model	1

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Research recommendations related to concept mapping in physics learning

The research opportunity has not has been research enough can be see based on the items and link in network visualization at VOSviewer. The items that presented with small circle has big opportunity for researcher to published document with that topic (Hidaayatullaah *et al.*, 2021). The less link that item has the more opportunity to researcher contribute with publish papers with that topic. Based on network visualization the research recommendation about concept mapping in physics learning are about concept mapping's research in problem solving and concept mapping's research in misconceptions. In concept mapping's research in problem solving has less of link and not has connected into physics or physics learning. So it can be a novelty for the future research to contribute published paper about concept mapping to increase student's problem solving in physics learning

CONCLUSION

Based on result and discussion result of visualization with physics concept mapping metadata from Scopus database in 2012 until 2023 period be found in 6 clusters with the dominant items are mapping, students, and physics. The implementation of concept mapping in physics learning has many impact on student there are conceptual understanding, student performance, learning outcome and problem solving and physics misconception. Indonesia has contribute in physics concept mapping research with network visualization from Indonesian research be found in 3 clusters. For more specific contributions are Universitas Negeri Manado being the most productive affiliations, Polukan c. being the most productive author and the most cited publication is "The effectiveness of Concept Mapping Content Representation Lesson Study (ComCoReLS) model to improve skills of Creating Physics Lesson Plan (CPLP) for pre-service physics teacher". Based on network visualization the research recommendation about concept mapping in physics learning are about concept mapping's research in problem solving and concept mapping's research in misconceptions.

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