Bibliometric analysis of physics problem solving

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Abstract. Problem-solving in physics learning began to be researched in 2001. The bibliometric approach used in this study aimed to map the research literature on problem-solving in physics learning using Scopus as the metadata source. The downloaded database had been input into the VOSviewer software to be mapped. There were 52 analyzed articles taken from 24 leading journals from January 1st, 2001 to August 31st, 2020 (20 years period). The articles were written by 132 authors affiliated to 85 institutions in 16 countries. Indonesia was the most productive country. 91.7% of authors own 2 publications. From 4 reviewed clusters, the most frequently appeared keywords and topics are students, problem-solving, problem-solving skills, problem-solving abilities, and physics learning. The uncommon variables and have not been widely researched related to problem-solving in physics learning are presented along with future study opportunities.

Keywords: Problem-solving, physics learning, bibliometric analysis, VOSviewer

1. Introduction

Several recent studies have experienced exponential growth, one of which is research on physics problem-solving skills [1]. The first problem-solving research in physics was published in 2001 [2]. Nowadays, many researchers associate physics problem-solving with other fields, such as in the field of problem-solving abilities [3–5], learning system [6–8], learning method [4], sampling techniques [9], students [3,10–12], problem-solving skills [13–16], physics learning [13,17–19], and physics media [19–22]. In the 21st-century, humans are required to be able to adapt to face every challenge due to the rapid changing of times [23]. Competition of this century involves all fields of life [24] including in the field of physics which has a relatively high level of competition [25]. There are several skills that humans must master in this century, such as problem-solving-skills, metacognitive, computational thinking, and critical thinking [17,26,27].

The complex concept of physics is one of the reasons that makes solving problems in learning physics important [17,28]. Also, solving physics learning problems requires a correlation with other knowledge [29]. Physics is a science that works as a basis for the development of various technologies. Thus, it is not surprising that physics problem-solving skills are needed today [30].

There have been many researchers who discuss problem-solving skills in physics learning [11,13,14,22,31–34]. This study has developed from year to year, but until now, research on solving physics learning problems is not yet known with certainty. Also, a bibliometric analysis of "solving physics learning problems" does not exist until now. Responding to the volume of research to solve
problems in physics learning, bibliometric analysis is deemed necessary to map the development of research.

2. Research Method
The bibliometric approach had been employed in this study to map the research literature on physics problem solving using Scopus as the source of metadata. Scopus is a collection of scientific publications often used in research studies [1,35]. This study was quantitative research. The analysis was assisted by the VOSviewer software to map journals with the required context by applying a 5-step analysis method adopted from other studies [36,37].

The database used was the Scopus metadata to be analyzed and mapped using VOSviewer software.

The search had been carried out using a minimum of 2 occurrences which resulted in 44 items, 4 clusters, and 315 links. The first cluster was a node in red which contained 12 items categories, namely collaborative (2), collaborative learning (2), control groups (3), e-learning (2), experimental
groups (3), industrial revolutions (2), physics (8), problem-based learning (5), problem-solving abilities (13), problem-solving skills (2), students (22), and t-test (3). The second cluster with dark green nodes contained 12 items categories, namely cooperative learning (2), education computing (10), learning systems (6), multiple choice (2), physics education (2), problem-solving (15), quantitative research (2), research designs (3), research instruments (2), teaching (3), and test instruments (2). The third cluster consisted of 10 items categories, namely Android (2), Android operating system (2), computer-assisted instructor (2), data collection (4), experiment study (2), high school (2), learning media (2), problem-solving ability (2), problem-solving skills (11), and problem-solving abilities (2). The fourth cluster contained 10 items categories, namely high school students (4), learning models (2), learning physics (2), physics learning (11), physics teaching (3), quantitative data (2), random sampling (3), research methods (2), sampling technique (2), and senior high school students (3).

Figure 3. Publication Growth

Figure 4. Publication Distribution in Each Country

Figure 3 shows that publication growth from 2001 to August 2020 has increased quite rapidly. The highest publication rate was in 2020. Figure 4 shows that of the 6 major countries, Indonesia was the country with the highest level of publication. Several new topics emerged in mid-2019 until now. Based on the mapping displayed by the VOSviewer software, the bright yellow nodes are emerging keywords and the light green nodes refer to keywords in mid-2019. The following are topics that have not been researched too often:
Table 1. Keywords

| Learning Media       | High School | Android (Operating System) |
|----------------------|-------------|----------------------------|
| Industrial Revolutions| Sampling Technique | Multiple Choice |
| Experiment Study     | Physics Teaching | Research Methods |
| Learning Physics     |             |                            |

Table 2. Subject Area and Number of Publications

| Subject Area                              | Number of Publications | Subject Area                              | Number of Publications |
|------------------------------------------|------------------------|------------------------------------------|------------------------|
| Physics and Astronomy                   | 30                     | Mathematics                              | 3                      |
| Social Sciences                          | 21                     | Agricultural and Biological Sciences     | 1                      |
| Computer Science                         | 4                      | Arts and Humanities                      | 1                      |
| Business, Management, and Accounting     | 3                      | Chemical                                 | 1                      |
| Engineering                              | 3                      | Earth and Planetary Sciences             | 1                      |
| Environmental Science                    | 3                      | Economics, Econometrics, and Finance     | 1                      |
| Energy                                   | 1                      | Materials Science                        | 1                      |

Figure 5. The Authors and the Number of Publications
Based on Figure 5, one out of eleven authors who had published two or more documents. Figure 6 shows the keywords that have not been researched too often in mid-2019 to the present. It can be seen that the students, problem-solving, and problem-solving skills are the keywords with the highest occurrence rate.

Several studies on physics problem-solving show that in its application, physics problem-solving can be improved by applying several treatments, including:

**Table 3. Previous Research Results**

| Reference             | Title                                                                 | Results                                                                                                                                                                                                 | Publisher                                      |
|-----------------------|-----------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|
| Sherin, B., 2016      | Common sense clarified: The role of intuitive knowledge in solving physics problems | It is found that intuitive physics knowledge can play a role in various fields of problem-solving. In this study, the researcher observed the students while working in pairs to solve physics problems. | Journal of Research in Science Teaching        |
| Pol, HJ, Harskamp, EG, Suhre, CJM, Goedhart, MJ., 2019 | How indirect supportive digital assistance during and after solving physics problems can improve problem-solving abilities | It was found that a computerized instruction scheme has proven effective in increasing students' knowledge of problem-solving strategies.                                                                 | Computers and Education                        |
| Maries, A., Singh, C., 2018 | Do students benefit from drawing productive diagrams on their while solving introductory physics problems? case of two electrostatics problems | The researchers investigated two problems involving electric fields and electric forces and found that students who drew productive diagrams were more successful problem solvers. | European Journal of Physics                   |
| Zaza, K., Garmendia, M., Barragués, J.-I., Guisasola, | Exercise is a problem too: Implications for teaching problem-solving in an introductory physics course | The researchers provided a priori simple exercises in physics. Even though the theory involved may seem fundamental at first glance, it was able to increase stimulation towards | European Journal of Physics                   |
| Reference | Title | Results | Publisher |
|-----------|-------|---------|-----------|
| J., 2016  |       | problem-solving by following proper procedures. It is hoped that teachers will be able to apply it during teaching and learning activities. |                                      |
| Hidaayatullaa, HN, Dwikoranto, Suprapto, N., Muba ok, H., Wulandari, D., 2020 | Application of Problem Based Learning to Train Problem-Solving Skills for Physics Students | After conducting the research, it was found that the PBL learning model affected students’ problem-solving skills, both in the experimental group and in the test group. | Journal of Physics: Conference Series |
| Sari, ASD, Prahani, BK, Munasir, M., Jatmiko, B., 2018 | Improved students' physics problem-solving abilities through the application of the PhET media-assisted by the PO2E2W learning model | After conducting the research, the results showed that the assisted PO2E2W learning model through PhET media can improve students' problem-solving skills in physics. | Journal of Physics: Conference Series |
| Simbolon, M., Sari, DK, Reski, A., 2019 | Development of physics learning materials with multimodal representations to improve problem-solving skills of high school students based on Rosengrant stages | The sample used in the study was divided into 2 classes, namely the control class and the experimental class. The experimental class used multimodal representation learning materials with Rosengrant stages. The results show that the experimental class experienced an improvement in problem-solving skills. | IOP Conference Series: Earth and Environmenta l Sciences |
| Retno, NHD, Sunarno, W., Marzuki, A., 2019 | The effect of physics problem-solving ability through project-based learning on vocational high school students’ learning outcomes | This study used 20 multiple choice questions and 5 essay questions regarding physics problem-solving skills. Based on the normality test, homogeneity test, and hypothesis test using the ANOVA technique, it can be concluded that the interaction between learning methods and problem-solving abilities affected students’ cognitive learning outcomes. | Physics Journal: Conference Series |

Based on the research data that has been presented, there are many ways to improve or practice problem-solving skills in physics learning, such as by applying the PBL learning model which turns out able to practice physics problem-solving skills. Besides PBL, the PO2E2W learning model can also be used to improve physics problem-solving skills [3,38]. Some learning media can be used to practice problem-solving skills, such as PhET and diagrams [19,38]. Students' critical-thinking skills needed to be improved [39,40] through learning approaches [19,39] and instrument and media development [16,33,41].

Based on data mapped by VOSviewer software, several yellow nodes (learning media, learning physics, high school, and Android operating system) indicated that the topics are relatively new and have not been researched much. Thus, they provide opportunities for further research.
In this study, the physics problem-solving keywords consisted of 4 clusters by providing 2 limitations. The keywords with a high occurrence rate were students, problem-solving, and problem-solving skills. Indonesia is a country with the highest level of publication. Also, no authors who have more than 2 publications.

3. Conclusion
Physics problem-solving skills can be improved by applying several treatments using learning models and developing instruments and media. The research opportunities on physics problem-solving are the topics of learning media, physics learning, high school, and Android operating system. In practice, this study has several limitations; first, keywords search used consisted of only one type of metadata so that it did not maximize database processing. Second, the software used requires human intervention so it did not rule out data inaccuracies. In further research, the use of metadata sources should be paid attention by using more than one source.

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