

JPPIPA 10(9) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education



http://jppipa.unram.ac.id/index.php/jppipa/index

# Trends Research Problem Based Learning (PBL) Model to Improve Generic Science Skills in Students' Science Learning (2015-2024): A Systematic Review

Aris Doyan<sup>1,2\*</sup>, Satutik Rahayu<sup>1,2</sup>, Fitirana Lugi<sup>2</sup>, Syarful Annam<sup>2</sup>

<sup>1</sup>Department of Physics Education, Universitas Mataram, Lombok, Indonesia.

<sup>2</sup> Masters of Science Education, Postgraduate Program, Universitas Mataram, Lombok, Indonesia.

Received: May 21, 2024 Revised: July 03, 2024 Accepted: September 25, 2024 Published: September 30, 2024

Corresponding Author: Aris Doyan aris\_doyan@unram.ac.id

# DOI: 10.29303/jppipa.v10i9.8370

© 2024 The Authors. This open access article is distributed under a (CC-BY License)

Introduction

Learning in the current curriculum is learning that emphasizes the scientific process (Meltzer, 2002). It is expected that students will be able to improve scientific activities, scientific attitudes and also scientific process skills in the learning process. Scientific process skills are needed in scientific activities (Rahayu et al., 2021). In the

Abstract: Generic science abilities are abilities that students must have so that the knowledge and skills obtained in the learning process can be applied in everyday life and answer the challenges of an increasingly developing era. Generic science skills can be facilitated through learning with a Problem Based Learning (PBL) model. This research aims to identify and analyze research trends of PBL model to improve generic science skill in science learning. This research method is descriptive and analytical. The data used in this research was obtained from documents indexed by Google Scholar from 2015-2024 using Publish or Perish and Dimension.ai. Research procedures use PRISMA guidelines. The data identified and analyzed are the type of publication, publication source, and the title of research on PBL model to improve generic science skill in science learning that is widely cited. The data analysis method uses bibliometric analysis assisted by VOS viewer software. The results of the analysis show that research trend on PBL model to improve generic science skill in science learning indexed by Google Scholar from 2015 to 2024 has experienced a fluctuating increase. Research trend with an increase in the number of publications from 2015 to 2018. However, in 2019 and 2022 the research trend on the generic science ability in learning has decreased from the previous year and the research trend increase again in 2023. There are many documents in the form of articles, proceedings, book chapters and edited books that discuss research about Problem Based Learning model to improve generic science skills in science learning. Key words that are often used in research of generic science are critical thinking, e module, science learning, PBL, etc.

**Keywords:** Generic science; Problem based learning; Review; Science learning

2013 curriculum and merdeka curriculum, learning takes place with four learning models, namely discovery learning, exploration, problem learning and project learning (Parker et al., 2022). The purpose of implementing this learning model is for students to learn independently so that the learning process is not centered on the teacher.

How to Cite:

Doyan, A., Rahayu, S., Lugi, F., & Annam, S. (2024). Trends Research Problem Based Learning (PBL) Model to Improve Generic Science Skills in Students' Science Learning (2015-2024): A Systematic Review. *Jurnal Penelitian Pendidikan IPA*, 10(9), 621–630. https://doi.org/10.29303/jppipa.v10i9.8370

Preparing active learning is also a government strategy to face the era of globalization and respond to the demands of the 21st century (Stehle & Peters-Burton, 2019; Van Laar et al., 2020; Larson & Miller, 2011; González-Pérez & Ramírez-Montoya, 2022). This strategy is expected to produce individuals who are competent in technology and science so that they can advance the nation (Muliani & Citra Wibawa, 2019; Mynbayeva et al., 2015). It is known that the demands of the 21st century are the main things that must be considered, especially in the field of education to face future challenges (Geisinger, 2016; Larson & Miller, 2011; Kaufman, 2013). So, in other words the skills required in the 21st century must be mastered (DiCerbo, 2014; Fry & Seely, 2011; Griffin, 2017; Jang, 2016; Lambert & Gong, 2010; Sibille et al., 2010).

One aspect that is part of 21st century skills are generic science skills (Yuberti et al., 2021). Generic science skills becomes very essential because able to improve students' understanding towards scientific concepts (Hadzigeorgiou & Schulz, 2019). This is because generic science skills not just a skill, but also is an intellectual ability arise from the interaction between scientific knowledge and skills. The role of generic science skills is essential in supporting the process learning, especially in context science learning that focuses on aspects of the learning process (Tuononen et al., 2022). Generic science abilities are one of the higher order thinking abilities (Devi et al., 2021). Generic science abilities can improve high-level thinking abilities well (Anjalina et al., 2019). Generic science abilities can be developed through science learning because they are really needed in science learning (Agustin, 2014). If students' generic science abilities are good then their understanding of science will also be good.

Generic science abilities are students' ability to think and act based on the knowledge they have. Generic science abilities can be used in carrying out scientific activities and are oriented towards higher knowledge (Syugiyanto, 2021). The quality of generic science abilities includes high-level thinking abilities, communication abilities, reasoning abilities, and lifelong learning (Sanjava, 2019). Generic science abilities can be applied in the world of work because they are produced from intellectual abilities combined with psychomotor abilities to produce attitudes that will last a lifetime (Karpinski et al., 2018). Generic science abilities are abilities that students must have so that the knowledge and skills obtained in the learning process can be applied in everyday life and answer the challenges of an increasingly developing era (Sakliressy et al., 2021).

Generic science abilities produce lifelong attitudes because of the combination of intellectual abilities and psychomotor skills. This skill is used to learn various concepts and solve science problems. The generic science skills has nine indicators, namely direct observation, indirect observation, awareness of scale, logical inference, mathematical modeling, symbolic language, law of cause and effect, logical framework, and discovery of new concepts. Students' generic science abilities must be improved in all subjects, including science.

In science learning, students are not only equipped with mastery of a number of sciences, but are also given sufficient space to apply the knowledge they learn in everyday life (Astalini et al., 2022; Kurniawan et al., 2019; Nurlia, 2023; Darmaji et al., 2021; Kurniawan et al., 2023; Ayu Sri Wahyuni, 2022). This is because in science learning, students do not only memorize concepts and answer questions, but students are also expected to be able to understand, observe, analyze and solve problems that will later be useful in everyday life (Maison et al., 2020).

One of the efforts to improve students' science process abilities is by implementing active learning models in the classroom, for example Problem Based Learning (PBL) assisted by Information and Communication media. Technologies (ICT) (Wulandari & Sari, 2023). Therefore, this research wants to know the research trend of the Problem Based Learning model to improve generic science skills. It is hoped that this research can become a reference in developing further research related to generic science in students' science learning.

# Method

This research method is descriptive and analytical, which aims to understand and describe research trends in the Problem Based Learning model to generic science skills in science learning. The data used in this study was obtained from information sources indexed by Google Scholar using analytical tools such as Publish or Perish and Dimension.ai. To carry out a search on Google Scholar, keywords related to research trends on the Problem Based Learning model to improve generic science skills in science Learning.

In this research, an analysis was carried out on 1,000 documents that had been indexed by Google Scholar between 2015 and 2024. The Google Scholar database was chosen as a place to search for documents because Google Scholar applies consistent standards in selecting documents to be included in its index, and Google Scholar displays more documents than the top databases. Others, especially research in the field of education (Hallinger & Chatpinyakoop, 2019; Hallinger & Nguyen, 2020; Zawacki-Richter et al., 2019). To filter data that has been collected via Publish or Perish, researchers used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

## **Result and Discussion**

This research aims to describe research trends on Problem Based Learning model to improve generic science skills conducted from 2014 to 2023. Research documents on research trends Problem Based Learning model to improve generic science skills in science learning are taken from documents from 2015 to 2024. Figure 1 is presented below regarding research trends on the Problem Based Learning model to improve generic science skills in science learning.

Figure 1 shows that the trend in research on the Problem Based Learning model to improve generic science skills in science learning experiencing increases and decreases. Where the research trend with an increase in the number of publications from 2015 to 2018. However, in 2019 and 2022 the research trend on Problem Based Learning model to improve generic science skills has decreased from the previous year and the research trend increase again in 2023. The increasing trend in research on the Problem Based Learning model to improve generic science skills caused by 21st century education has focused on improving generic science competence.

In 2015 there were 13 publications related to the Problem Based Learning model to improve generic science skills, then this will continue to increase to 69 publications in 2018. But publication decrease to 65 in 2019 and going increase again until 2023 with 96 publications. This increasing research trend provides a deeper understanding the problem which is low of generic science skills in science learning and ways to solve that problem. Research is able to improve generic science skills through various methods, one of them is Problem Based Learning model. Below are also table 1 presented research of Problem Based Learning model to improve generic science skills based on the type of publication.



Figure 1. Research trends in problem based learning model to improve generic science skills

**Table 1.** Trends in Problem Based Learning Model to Improve Generic Science Skills Research Based on Publication Types

Publication Type	Publications	
Article	533	
Proceeding	20	
Edited Book	10	
Chapter	5	
Monograph	1	

Based on Table 1, it is known that research Problem Based Learning model to improve generic science skills in science learning from 2015 to 2024 contained in 5 types of publications. In the form of articles there were 533 documents, chapters as many as 5 documents,

proceedings as many as 20 documents, edited books as many as 10 documents, and monographs only 1 document. Research trends Problem Based Learning model to improve generic science skills in science learning in article form is the type of publication that contains the most research about generic science skills in science learning compared to other types of publications. Meanwhile, the type of publication contains the least amount of research results Problem Based Learning model to improve generic science skills in science learning is a monograph. Research conducted by (2019) states that an article is a complete factual essay of a certain length created for publication in online or print media (via newspapers, magazines or bulletins) and aims to convey ideas and facts that can convince and 623

educate. These articles are usually published in scientific journals both in print and online (Suseno & Fauziah, 2020).

Below are also table 2 presented top ten (10) sources title trends in research on Problem Based Learning model to improve generic science skills in science learning which are often cited by other researchers related to this matter.

Table 2 shows that the most widely published source of research trends on the Problem Based Learning model to improve generic science skills in science learning is the Jurnal Penelitian Pendidikan IPA, namely 28 publications with 43 citations and an average citation of 1.54. Jurnal Penelitian Pendidikan IPA contains scientific articles form of research results that include science, technology, and teaching in the field of science. The first edition were published in 2015. All edition in this journal are open access, i.e. the articles published in them are immediately and permanently free to read, download, copy & distribute. Below are also table 3 presented top ten (10) article title trends in research on Problem Based Learning model to improve generic science skills in science learning which are often cited by other researchers related to this matter.

**Table 2.** Top 10 Sources Title Trend of Problem Based Learning Model to Improve Generic Science Skills in ScienceLearning Research in 2015-2024

Name	Publications	Citations	Citations Mean
Jurnal Penelitian Pendidikan IPA	28	43	1.54
Journal of Physics Conference Series	24	91	3.79
Advances in Social Science, Education and Humanities Research	15	23	1.53
Jurnal Pendidikan Sains Indonesia	14	69	4.93
Jurnal Ilmiah Pendidikan Fisika	14	19	1.36
Jurnal Ilmiah Profesi Pendidikan	13	3	0.23
Jurnal Pendidikan Fisika	9	21	2.33
Jurnal Penelitian Pembelajaran Fisika	9	10	1.11
Jurnal Penelitian & Pengembangan Pendidikan Fisika	7	27	3.86
Berkala Ilmiah Pendidikan Fisika	7	38	5.43

Table 3 shows that research on the problem based learning model to improve generic science skills in science learning that is widely cited by other researchers is about "The Effectiveness of Module Based on Discovery Learning to Increase Generic Science Skills" which is 12.00 (Khabibah et al., 2017). Then the research entitled "Effectiveness of Quantum Physics Learning Tools Using Blended Learning Models to Improve Critical Thinking and Generic Science Skills of Students" was cited 11.00 times per year (Doyan et al., 2022). Research by Razali et al. (2020), entitled "Effect of inquiry learning methods on generic science skills based on creativity level" is also widely cited by other researchers, namely 6.00 per year. Nastiti et al. (2019) in their research entitled "The Need Analysis of Module Development Based on Search, Solve, Create, and Share to Increase Generic Science Skills in Chemistry" was cited 5.83 per year.

This research data is comparable to data on the increasing trend of research on the Problem Based Learning model to improve generic science skills in science learning from 2015 to 2024. This means that in that year, research related to it was continuously cited by other researchers. In the articles researched and written by these researchers, there are many terms related to Problem Based Learning model and generic science skills in science learning. Below are presented ten (10) popular keywords related to Problem Based Learning model to improve generic science skills in science learning.

**Table 3.** Top 10 Citations on Trend of Problem Based Learning Model to Improve Generic Science Skills in Science Learning Research in 2015-2024

Cites/year	Year	Author	Title
12.00	2017	Elok Norma Khabibah, Mohammad	The Effectiveness of Module Based on Discovery Learning to Increase
		Masykuri, Maridi	Generic Science Skills
11.00	2022	Aris Doyan, Susilawati, S	Effectiveness of Quantum Physics Learning Tools Using Blended
		Hadisaputra, L Mulyadi	Learning Models to Improve Critical Thinking and Generic Science
			Skills of Students
6.00	2020	Razali, A Halim, A G Haji, E	Effect of inquiry learning methods on generic science skills based on
		Nurfadila	creativity level
5.83	2018	D. Nastiti, S. B. Rahardjo, Elfi	The Need Analysis of Module Development Based on Search, Solve,
		Susanti VH, R. Perdana	Create, and Share to Increase Generic Science Skills in Chemistry

Cites/year	Year	Author	Title
5.67	2015	Johar Maknun	The Implementation of Generative Learning Model on Physics Lesson
			to Increase Mastery Concepts and Generic Science Skills of Vocational
			Students
5.00	2022	Aris Doyan, Susilawati, S	Analysis Validation of Quantum Physics Learning Devices using
		Hadisaputra, L Mulyadi	Blended Learning Models to Improve Critical Thinking and Generic
			Science Skills of Students
4.50	2018	M Faradilla, M Hasan, Sulastri	The effectiveness of guided inquiry-based student worksheets on
			students' generic science skills
3.25	2020	Herianto, I Wilujeng	The correlation between students' curiosity and generic science skills
			in science learning
3.00	2023	Aris Doyan , Susilawati, Ahmad	The effectiveness of modern optical learning devices during the
		Harjono, L Mulyadi, Hamidi, H	Covid-19 pandemic to improve creativity and generic science skills of
		Fuadi, I G N Y Handayana	students
2.50	2022	N. M. Pujani, K. G. Y. Arsana, K.	The Effectiveness of Introduction to Astronomy Teaching Materials to
		Suma, K. Selamet, N. Erlina	Improve Problem-Solving and Generic Science Skills

**Table 4.** Keywords on Trend Problem Based Learning Model to Improve Generic science Skills in Science Learning Research in 2015-2024

Terms	Occurrences	Relevance
Critical Thinking	11	2.85
E module	9	2.78
Science Learning	8	2.59
Ethnoscience	7	2.33
Virtual Laboratory	5	1.67
Generative Learning	5	1.60
Interactive Multimedium	7	1.60
Technology	9	1.13
PBL	9	1.07
Project	7	1.04

Table 4 shows that the keywords that often appear related to research on the the Problem Based Learning model to improve generic science skills in science learning are critical thinking 11 times with a level of 2.85. This indicates that generic science abilities are often researched together with critical thinking abilities, for example, research conducted by Syuzita et al. (2023). Table 4 also shows that e module is also a keyword that appears frequently in research trends on the generic science skills in science learning, namely 9 times with a relevance of 2.78. E module has been proven to be able to improve students' generic science abilities (Sukarso et al., 2023).

Below are the visualization is accomplished by generating a landscape map, which offers a visual representation of subjects related to scientific studies. The outcomes of bibliometric mapping for the co-word network in articles related to the topic Problem Based Learning model to improve generic science skills in science learning are illustrated in Figure 2.



Figure 2. Network visualization on trend problem based learning model to improve generic science skills in science learning research

Figure 2 shows the results of bibliometric keyword mapping on research trends on the Problem Based Learning model to improve generic science skills in science learning. In Figure 2 there are 63 keyword items that are often used in research on the generic science skills in science learning from 2015 to 2024. Figure 2 also contains 5 clusters, where the first cluster is colored red and consists of 16 keyword items, namely inquiry, learning process, critical thinking, ethnoscience, etc. The second cluster in green consists of 15 keyword items, namely e module, PBL, teaching material, validation, etc. The third cluster in blue consists of 11 keyword items, namely development, interactive multimedium, discovery, etc. The fourth yellow cluster consists of 11 keyword items, namely teacher, application, technology, physics learning, etc. The fifth purple cluster consists of 10 keyword items, namely generative learning model, virtual laboratory, etc.

Figure 2 also shows that network visualization shows the network between the terms being visualized. Keywords classified into five clusters are arranged in a color chart showing the divisions that are connected to each other. The results of this analysis can be used to determine keyword research trends in the last year. This analysis shows several keywords that are often used in research on the Problem Based Learning model to improve generic science skills in science learning. The more keywords that appear, the wider the visualization displayed. Below are also presented keywords regarding the Problem Based Learning model to improve generic science skills in science learning based on overlay visualization.

Figure 3 shows the trend of keywords related to research on Problem Based Learning model to improve generic science skills in science learning in Google Scholar indexed journals from 2015 to 2024. Trends in the themes of writing articles related to the Problem Based learning model to improve generic science skills in science learning from the oldest to the newest year are marked with purple, blue themes, turquoise, dark green, light green and yellow. In the picture above you can see that the virtual laboratory, generative learning model, etc. This shows that these keywords were widely used by researchers in 2020. In 2021, the keywords that frequently appeared were critical thinking, physics, module, generic science, effectiveness etc.



Figure 3. Overlay visualization on trend problem based learning model to improve generic science skills in science learning research

Research on Problem Based Learning model to improve generic science skills in science learning is one area of research that has developed rapidly in recent years. The following also presents keywords for Problem Based Learning model to improve generic science skills in science learning research based on density visualization. Figure 4 shows density visualization. The density of research themes is shown in bright yellow. The brighter the colors of a theme, the more research is done. The fainter the color means the theme is rarely researched (Kaur et al., 2022; Liao et al., 2018). Faintly colored themes such as need, effort, term, evaluation are dimly colored keywords. This shows that these keywords can be used as a reference for further research. Bahtiar et al. (2023) stated that yellow indicates keywords that are currently and frequently used in research.



Figure 4. Density visualization on trend problem based learning model to improve generic science skills in science learning research

Overall, research on Problem Based Learning model to improve generic science skills in science learning is important because it makes significant contributions to the 21<sup>st</sup> century education and PBL model is a learning model that is able to facilitate generic science skills. Generic science skills are very important so that students are able to process information to solve problems both in learning and in real life. The research trend in Problem Based Learning model to improve generic science skills in science learning is expected to continue to develop in the next few years. This can be done by developing new combination of PBL model with technology or other things to facilitate students' generic science skills, especially in science subjects.

## Conclusion

Research on trends in the Problem Based Learning model to improve generic science skills in science learning has urgency high because of its potential to provide various benefits to 21st century education. The research trend on the Problem Based Learning model to improve generic science skills in science learning indexed by Google Scholar from 2015 to 2024 has experienced a fluctuating increase. Research trend with an increase in the number of publications from 2015 to 2018. However, in 2019 and 2022 the research trend on the generic science ability in learning has decreased from the previous year and the research trend increase again in 2023. There are many documents in the form of articles, proceedings, book chapters and edited books that discuss research about Problem Based Learning model to improve generic science skills in science learning. Key words that are often used in research of generic science are critical thinking, e module, science learning, PBL, etc.

#### Acknowledgments

Acknowledgments are expressed by the researchers to the team so that researchers can complete research in the form of journal publications.

#### **Author Contributions**

Conceptualization, A. D.; methodology, S. R.; validation, F. L.; formal analysis, S. A.; investigation, A. D.; resources, S. R.; data curation, F. L.: writing—original draft preparation, S. A.; writing—review and editing, A. D; visualization, S. R. All authors have read and agreed to the published version of the manuscript.

## Funding

No external funding.

#### **Conflicts of Interest**

No conflict interest.

## References

- Agustin, R. R. (2014). Pengembangan Keterampilan Generik Sains Melalui Penggunaan Multimedia Interaktif. Jurnal Pengajaran Matematika Dan Ilmu Pengetahuan Alam, 18(2), 253. https://doi.org/10.18269/jpmipa.v18i2.58
- Anjalina, E., Khaeruman, K., & Mashami, R. A. (2019). Pengembangan Multimedia Interaktif Hidrolisis Garam Berbasis Problem Based Learning Untuk Penumbuhan Keterampilan Generik Sains Siswa.

*JPIn: Jurnal Pendidik Indonesia*, 2(2), 1–10. https://doi.org/10.47165/jpin.v2i2.71

- Astalini, Darmaji, Kurniawan, D. A., Jaya, H., & Husna, S. M. (2022). Analysis of Teacher Responses to the Use of Web-based Assessment to Assess Students' Attitudes towards Science Subjects. *Integrated Science Education Journal*, 3(3), 66–71. https://doi.org/10.37251/isej.v3i3.282
- Bahtiar, B., Yusuf, Y., Doyan, A., & Ibrahim, I. (2023). Trend of Technology Pedagogical Content Knowledge (TPACK) Research in 2012-2022: Contribution to Science Learning of 21st Century. *Jurnal Penelitian Pendidikan IPA*, 9(5), 39–47. https://doi.org/10.29303/jppipa.v9i5.3685
- Darmaji, D., Astalini, A., Kurniawan, D. A., & Putri, W. A. (2021). Rural Student Analysis: Correlation Science Process Skills and Critical Thinking at a State Senior High School in Jambi Province. *Ta'dib*, 24(2), 229. https://doi.org/10.31958/jt.v24i2.3645
- Devi, V. M., Susilawati, S., & Gunada, I. W. (2021). Pengembangan Perangkat Pembelajaran Fisika Model Berbasis Masalah Pada Materi Elastisitas Untuk Meningkatkan Kemampuan Generik Sains Peserta Didik. ORBITA: Jurnal Kajian, Inovasi Dan Aplikasi Pendidikan Fisika, 7(1), 109. https://doi.org/10.31764/orbita.v7i1.3822
- DiCerbo, K. (2014). Assessment and teaching of 21st century skills. Assessment in Education: Principles, Policy & Practice, 21(4), 502–505. https://doi.org/10.1080/0969594X.2014.931836
- Doyan, A., Susilawati, Mahardika, I. K., Rizaldi, D. R., & Fatimah, Z. (2022). Structure and optical properties of Titanium Dioxide thin film with mixed Fluorine and Indium doping for solar cell components. *Journal of Physics: Conference Series*, 2165(1), 012009. https://doi.org/10.1088/1742-6596/2165/1/012009
- Fry, S., & Seely, S. (2011). Enhancing Preservice Elementary Teachers' 21st-Century Information and Media Literacy Skills. *Action in Teacher Education*, 33(2), 206–218. https://doi.org/10.1080/01626620.2011.569468
- Geisinger, K. F. (2016). 21st Century Skills: What Are They and How Do We Assess Them? *Applied Measurement in Education*, 29(4), 245–249. https://doi.org/10.1080/08957347.2016.1209207
- González-Pérez, L. I., & Ramírez-Montoya, M. S. (2022). Components of Education 4.0 in 21st Century Skills Frameworks: Systematic Review. *Sustainability*, 14(3), 1493. https://doi.org/10.3390/su14031493
- Griffin, P. (2017). Assessing and Teaching 21st Century Skills: Collaborative Problem Solving as a Case Study. In *Innovative Assessment of Collaboration* (pp. 113-134). Springer International Publishing. https://doi.org/10.1007/978-3-319-33261-1\_8

- Hadzigeorgiou, Y., & Schulz, R. M. (2019). Engaging Students in Science: The Potential Role of "Narrative Thinking" and "Romantic Understanding." *Frontiers in Education*, *4*, 38. https://doi.org/10.3389/feduc.2019.00038
- Hallinger, P., & Chatpinyakoop, C. (2019). A
  Bibliometric Review of Research on Higher
  Education for Sustainable Development, 1998–2018. Sustainability, 11(8), 2401.
  https://doi.org/10.3390/su11082401
- Hallinger, P., & Nguyen, V.-T. (2020). Mapping the Landscape and Structure of Research on Education for Sustainable Development: A Bibliometric Review. *Sustainability*, 12(5), 1947. https://doi.org/10.3390/su12051947
- Jang, H. (2016). Identifying 21st Century STEM Competencies Using Workplace Data. *Journal of Science Education and Technology*, 25(2), 284–301. https://doi.org/10.1007/s10956-015-9593-1
- Karpinski, R. I., Kinase Kolb, A. M., Tetreault, N. A., & Borowski, T. B. (2018). High intelligence: A risk factor for psychological and physiological overexcitabilities. *Intelligence*, 66, 8–23. https://doi.org/10.1016/j.intell.2017.09.001
- Kaufman, K. J. (2013). 21 Ways to 21st Century Skills: Why Students Need Them and Ideas for Practical Implementation. *Kappa Delta Pi Record*, 49(2), 78–83. https://doi.org/10.1080/00228958.2013.786594
- Kaur, S., Kumar, R., Kaur, R., Singh, S., Rani, S., & Kaur, A. (2022). Piezoelectric materials in sensors: Bibliometric and visualization analysis. *Materials Today: Proceedings*, 65, 3780–3786. https://doi.org/10.1016/j.matpr.2022.06.484
- Khabibah, E. N., Masykuri, M., & Maridi, M. (2017). The Effectiveness of Module Based on Discovery Learning to Increase Generic Science Skills. *Journal* of Education and Learning (EduLearn), 11(2), 146–153. https://doi.org/10.11591/edulearn.v11i2.6076
- Kurniawan, D. A., Astalini, A., & Kurniawan, N. (2019). Analisis Sikap Siswa SMP Terhadap Mata Pelajaran IPA. Lentera Pendidikan: Jurnal Ilmu Tarbiyah Dan Keguruan, 22(2), 323. https://doi.org/10.24252/lp.2019v22n2i14
- Kurniawan, D. A., Darmaji, D., Astalini, A., & Muslimatul Husna, S. (2023). Study of Critical Thinking Skills, Science Process Skills and Digital Literacy: Reviewed Based on the Gender. Jurnal Penelitian Pendidikan IPA, 9(4), 1741–1752. https://doi.org/10.29303/jppipa.v9i4.1644
- Lambert, J., & Gong, Y. (2010). 21st Century Paradigms for Pre-Service Teacher Technology Preparation. *Computers in the Schools*, 27(1), 54–70. https://doi.org/10.1080/07380560903536272
- Larson, L. C., & Miller, T. N. (2011). 21st Century Skills: Prepare Students for the Future. *Kappa Delta Pi* 628

*Record*, 47(3), 121–123. https://doi.org/10.1080/00228958.2011.10516575

- Liao, H., Tang, M., Luo, L., Li, C., Chiclana, F., & Zeng, X.-J. (2018). A Bibliometric Analysis and Visualization of Medical Big Data Research. *Sustainability*, 10(2), 166. https://doi.org/10.3390/su10010166
- Maison, M., Kurniawan, D. A., & Pratiwi, N. I. S. (2020). Pendidikan sains di sekolah menengah pertama perkotaan: Bagaimana sikap dan keaktifan belajar siswa terhadap sains? *Jurnal Inovasi Pendidikan IPA*, 6(2). https://doi.org/10.21831/jipi.v6i2.32425
- Meltzer, D. E. (2002). The relationship between mathematics preparation and conceptual learning gains in physics: A possible "hidden variable" in diagnostic pretest scores. *American Journal of Physics*, 70(12), 1259–1268. https://doi.org/10.1119/1.1514215
- Muliani, N. K. D., & Citra Wibawa, I. Md. (2019). Pengaruh Model Pembelajaran Inkuiri Terbimbing Berbantuan Video Terhadap Hasil Belajar IPA. *Jurnal Ilmiah Sekolah Dasar*, 3(1), 107. https://doi.org/10.23887/jisd.v3i1.17664
- Mynbayeva, A., Vishnevskaya, A., & Sadvakassova, Z. (2015). Diagnosis of Students Intellectual Potential on Pedagogical Specialties. *Procedia - Social and Behavioral Sciences*, 171, 776-781. https://doi.org/10.1016/j.sbspro.2015.01.191
- Nastiti, D., Rahardjo, S. B., & Van Hayus, E. S. (2019). Using module based on search, solve, create, and share effective to increase students' science generic skills. *Journal of Physics: Conference Series*, 1175, 012145. https://doi.org/10.1088/1742-6596/1175/1/012145
- Nurlia, N. (2023). Analisis Sikap Peserta Didik Terhadap Pembelajaran IPA Secara Online dan Tatap Muka Terbatas. *Jurnal Pendidikan*, 11(1), 100–109. https://doi.org/10.36232/pendidikan.v11i1.2216
- Oltarzhevskyi, D. O. (2019). Typology of contemporary corporate communication channels. *Corporate Communications: An International Journal*, 24(4), 608– 622. https://doi.org/10.1108/CCIJ-04-2019-0046
- Parker, R., Thomsen, B. S., & Berry, A. (2022). Learning Through Play at School – A Framework for Policy and Practice. *Frontiers in Education*, *7*, 751801. https://doi.org/10.3389/feduc.2022.751801
- Rahayu, S., Ahied, M., Hadi, W. P., & Wulandari, A. Y.
  R. (2021). Analisis Keterampilan Proses Sains Siswa
  SMP pada materi getaran gelombang dan bunyi.
  Natural Science Education Research, 4(1), 28–34.
  https://doi.org/10.21107/nser.v4i1.8389
- Razali, Halim, A., Haji, A. G., & Nurfadilla, E. (2020). Effect of inquiry learning methods on generic science skills based on creativity level. *Journal of Physics: Conference Series*, 1460(1), 012118.

https://doi.org/10.1088/1742-6596/1460/1/012118

- Sakliressy, M. T., Sunarno, W., & Nurosyid, F. (2021). The Generic Science Skill Profile of High School on Theory Momentum And Impulse. *Journal of Physics: Conference Series*, 1842(1), 012058. https://doi.org/10.1088/1742-6596/1842/1/012058
- Sanjaya, F. (2019). Keefektifan Model Pembelajaran Murder (Mood, Understand, Recall, Detect, Elaborate, Review) Melalui Teknik Kie Untuk Meningkatkan Aspek Sebab Akibat Kemampuan Generik Sains Siswa. Indonesian Journal of Natural Science Education (IJNSE), 2(1), 134–140. https://doi.org/10.31002/nse.v2i1.451
- Sibille, K., Greene, A., & Bush, J. P. (2010). Preparing Physicians for the 21st Century: Targeting Communication Skills and the Promotion of Health Behavior Change. *Annals of Behavioral Science and Medical Education*, 16(1), 7–13. https://doi.org/10.1007/BF03355111
- Stehle, S. M., & Peters-Burton, E. E. (2019). Developing student 21st Century skills in selected exemplary inclusive STEM high schools. *International Journal of STEM Education*, 6(1), 39. https://doi.org/10.1186/s40594-019-0192-1
- Sukarso, A. A., Syuzita, A., & Susilawati. (2023).
  Effectiveness of Science E-Module Using Argument-Driven Inquiry Models to Improve Students' Generic Science, Critical Thinking and Scientific Argumentation Abilities. Jurnal Penelitian Pendidikan IPA, 9(12), 11576–11581. https://doi.org/10.29303/jppipa.v9i12.6279
- Suseno, B. A., & Fauziah, E. (2020). Improving Penginyongan Literacy in Digital Era Through E-Paper Magazine of Ancas Banyumasan. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.3807680
- Syugiyanto, A. (2021). Analisis Kemampuan Keterampilan Generik Sains Pada Mahasiswa Calon Guru Pendidikan Biologi Fkip Uhamka. *ACADEMIA: Jurnal Inovasi Riset Akademik*, 1(2), 247–252.

https://doi.org/10.51878/academia.v1i2.742

- Syuzita, A., Susilawati, S., & Sukarso, A. (2023). Validation of E-Module Based on Argument-Driven Inquiry using 3D Page Flip Professional to Improve Students' Generic Science, Critical Thinking and Scientific Argumentation Abilities. Jurnal Penelitian Pendidikan IPA, 9(8), 6272–6277. https://doi.org/10.29303/jppipa.v9i8.4947
- Tuononen, T., Hyytinen, H., Kleemola, K., Hailikari, T., Männikkö, I., & Toom, A. (2022). Systematic Review of Learning Generic Skills in Higher Education–Enhancing and Impeding Factors.

- Van Laar, E., Van Deursen, A. J. A. M., Van Dijk, J. A. G. M., & De Haan, J. (2020). Determinants of 21st-Century Skills and 21st-Century Digital Skills for Workers: A Systematic Literature Review. SAGE Open, 10(1), 215824401990017. https://doi.org/10.1177/2158244019900176
- Wahyuni, A. S. (2022). Literature Review: Pendekatan Berdiferensiasi Dalam Pembelajaran IPA. *Jurnal Pendidikan MIPA*, 12(2), 118–126. https://doi.org/10.37630/jpm.v12i2.562
- Wulandari, F., & Sari, P. P. (2023). The effect of projectbased learning integrated STEM toward science process skill of elementary school student. *Jurnal Pijar Mipa*, 18(3), 362–368. https://doi.org/10.29303/jpm.v18i3.4943
- Yuberti, Kartika, I., Pratiwi, I., Riyadi, B., Latifah, S., & Pilia, Q. M. (2021). An analysis of generic science skills as 21 st -century skills for preservice physics teacher at UIN Raden Intan Lampung. *Journal of Physics: Conference Series*, 1796(1), 012043. https://doi.org/10.1088/1742-6596/1796/1/012043
- Zawacki-Richter, O., Marín, V. I., Bond, M., & Gouverneur, F. (2019). Systematic review of research on artificial intelligence applications in higher education – where are the educators? *International Journal of Educational Technology in Higher* Education, 16(1), 39. https://doi.org/10.1186/s41239-019-0171-0