JPPIPA 10(6) (2024)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

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

Project Based Learning (PjBL) in Chemistry Learning: Systematic Literature and Bibliometric Review 2015 - 2022

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Received: January 21, 2024
Revised: May 05, 2024
Accepted: June 20, 2024
Published: June 30, 2024

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DOI: 10.29303/jppipa.v10i6.7017

Abstract: Education is important to form an intelligent and competitive generation. Project Based Learning (PjBL) offers relevant and interactive learning, recognized by Grant (2002) as a student-centered model. PjBL creates a constructivist environment, developing content understanding and skills, such as communication, time management, research and critical thinking. This research focuses on the application of PjBL in chemistry learning, aiming to find out the results of previous research. This research uses Systematic Literature Review (SLR) and bibliometric review as methods. SLR is considered a systematic and transparent method of collecting, synthesizing and assessing study findings on a topic. The process includes planning (research identification), implementation (literature search and selection), and reporting (synthesis of findings). The research question (RQ) focuses on the application of Project Based Learning (PjBL) in chemistry learning. Twenty journals were selected, mostly from Scopus, with criteria ranging from 2015-2020. The analysis showed that 13 journals met the criteria, and a bibliometric review was then carried out on these journals. The research results show that PjBL focuses on skill development, learning innovation, and the impact on student understanding and participation. The research implications highlight the importance of the PjBL model to improve the learning process and better learning tools. The results revealed a wide variety of methods and samples. Six studies focused on the influence of PjBL, critical thinking abilities, psychomotor skills, problem solving, creativity, cognitive achievement, and teamwork. This framework generally involves students' innovative learning and laboratory experiments. Chemistry concepts include analytical, physical, environmental, basic, and organic chemistry. Data collection and analysis tools serve as benchmarks for future research and implications.

Keywords: Project Based Learning; Chemistry Learning; Sistematic Literature Review; Bibliometric review.

Introduction

Education is very important to achieve the vision and mission of a country because it is the main component in the formation of a smart and competitive future generation (Pawero, 2021; A. Yunita, Putra, & Anggreny, 2023). Based on Permendikbud number 65 year 2013, the learning process is carried out in an interactive, inspiring, interesting, and challenging manner, motivating active participation and providing sufficient space for initiative, creativity, and independence in accordance with the talents, interests, and physical and psychological development of students (Permendikbud, 2013). In an attempt to create such learning, Project Based Learning (PjBL) offers relevant and interactive learning. (Tamim & Grant, 2013; Almulla, 2020; Dewi, 2022)

How to Cite:
Pratiwi, E. A., & Ikhsan, J. (2024). Project Based Learning (PjBL) in Chemistry Learning: Systematic Literature and Bibliometric Review 2015 - 2022. *Jurnal Penelitian Pendidikan IPA*, *10*(6), 343–354. https://doi.org/10.29303/jppipa.v10i6.7017

PjBL can defined as a student-centered learning model to conduct an in-depth investigation of a topic. Students constructively deepen their learning with a research-based approach to problems and questions that are valuable, real and relevant (Grant, 2002; Philen, 2016; Y. Yunita, Juandi, Kusumah, & Suhendra, 2021; Prajoko et al., 2023). PjBL becomes a student-centered learning model and provides meaningful learning experiences for students. Students' learning experiences and concepts are built based on the products produced in the project-based learning process (Afriana, 2015; Ciptro Handrianto, 2018; Viana et al., 2019; Simbolon & Koeswanti, 2020; Suwarno et al., 2020; Syahril et al., 2021). PjBL is a learning model that provides opportunities for teachers to manage classroom learning by involving project work. Project work is a form of work that contains complex tasks based on questions and problems that are very challenging and lead students to design, solve problems, make decisions, carry out investigative activities, and provide opportunities for students to work independently. (Lestari, 2015; Almulla, 2020; Ningsih et al., 2020; Rahmania, 2021).

PjBL becomes a learning approach that creates a "constructivist" learning environment where students build their own knowledge and teachers become facilitators. (Goodman & Stivers, 2010; Brassler & Dettmers, 2017; Pujiriyanto et al., 2017; Žerovnik & Nančovska Šerbec, 2021). The characteristics of the Project-based Learning model include students being faced with concrete problems, finding solutions, and working on projects in teams to solve these problems (Juntunen & Aksela, 2014; Krajcik & Czerniak, 2018; Lion et al., 2022; Rofik et al., 2022). The PjBL model emphasizes that students not only understand the content, but also develop skills in students how to play a role in society (Jalinus & Nabawi, 2018; Ghosheh et al., 2021; Siboro et al., 2022).

In this way, PjBL includes both content understanding and skill development. Communication and presentation, time management and organization, research and inquiry, self-assessment and reflection, group participation and leadership, and critical thinking become the skills that are enhanced. Therefore, PjBL is not just a learning model; it is also an approach that teaches students the skills necessary to succeed in a changing era.

Based on the explanation above, researchers conducted research related to the application of PjBL in learning Chemistry by analyzing journals and previous research literature regarding the use of PjBL in learning Chemistry, using Systematic Literature Review, as well as bibliometric review, this study aims to see the implications of the application of PjBL and the gap of PjBL research against previous studies. By considering the research question of how PjBL is applied in learning Chemistry from previous studies, this study aims to provide a deeper understanding of the results of PjBL application.

Method

Systematic literature review (SLR) is the method used in this research. SLR provides a systematic and transparent way to collect, synthesize, and assess study findings on a particular topic or question (Mengist, et al., 2020; Azarian et al., 2023; Cabrera et al., 2023). The aim of SLR is to minimize bias associated with single studies and unsystematic reviews (Jesson, et al., 2011, p. 104; Kraus, et al., 2020; Sauer & Seuring, 2023).

Conducting a systematic review of research involves at least three main activities: identifying and describing relevant research (research planning); critically appraising research reports in a systematic way (conducting); and bringing findings together into a coherent statement, known as synthesis (reporting) (Gough et al., 2012; Siddaway et al., 2019; Linnenluecke et al., 2020).

Research Planning

The identification and description of SLR research refers to the research question (RQ) determined based on the research topic. The research question is as follows:
RQ1: how is the application of PjBL in Chemistry learning from previous research?

Conducting

The research conducted by SLR was adjusted to the RQ that had been determined at the planning stage. The stages in this section are as follows:

First: determining keywords in the literature search. The keywords used were "Problem Based Learning" and "chemistry learning".

Second: the keywords that have been determined are then used in the search using the available digital library. In this study, researchers looked for journals with international reputation and indexed by Scopus.

Third: the search results were then selected with predetermined criteria and quality.

Fourth: the criteria and quality of research used in this study use inclusion and exclusion standards in the form of: a) journals that have been published in the 2015-2020 time span, b) journals indexed by Scopus, and c) journals that match the research questions.

Fifth: quality assessment (QA) used to determine the accuracy of the literature that has been determined based on the criteria, namely: 1). QA1: was the journal published in the 2015-2020 timeframe? 2). QA2: is the

journal scopus indexed? 3). QA3: does the journal discuss PjBL in Chemistry learning?

Reporting

Reporting is the final stage in SLR research, at this stage QA is used as a reference to answer RQ.

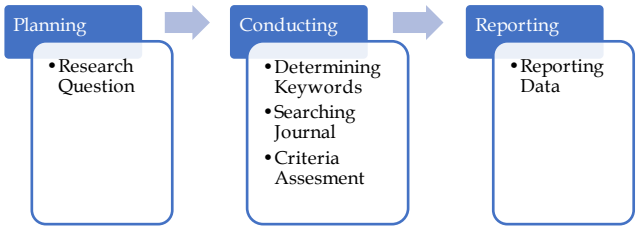

Figure 1 Research Flow

Then, this research also uses a bibliometric review. The bibliometric review aimed to identify patterns and trends that emerged in previous research on PjBL in Chemistry learning. Such identification provides a comprehensive picture of the dominant research focus, gaps in the literature, and potential further research directions (Rousseau, Egghe, & Guns, 2018).

The investigation stages in the bibliometric review in this research continue the previous SLR stages. The data that has been collected via SLR is then converted into RIS metadata format. By using VOS Viewer (van Eck & Waltman, 2007, 2014), researchers looked at the keyword patterns of the journals that form the data in this research.

Result and Discussion

Sytematic Literature Review

The journals used as sources in this SLR are as follows:

Tabel 1. Journal Sources

File Codes	References	Kind of Sources
1	Nainggolan, B., Hutabarat, W., Situmorang, M., & Situmorang, M. (2020). Developing Innovative Chemistry Laboratory Workbook Integrated with Project–based Learning and Character-based Chemistry. International Journal of Instruction, 13(3), 895-908. https://doi.org/10.29333/iji.2020.13359a	Journal
2	Lianda, Regina Lucia Pelachim & Brian Joyce. (2018). Applying Project-Based Learning (Pbl) In The Organic Chemistry Course While Studying Honey. Revista Ibero-Americana de Estudos em Educação,13(1),407-420. https://doi.org/10.21723/riaee.nesp1.v13.2018.11435	Journal
3	Wahyudiati, Dwi., et al. (2022). Improving pre-service chemistry teachers' critical thinking and problem-solving skills using project-based learning. World Journal on Educational Technology: Current Issues. 14(5), 1291-1304. https://doi.org/10.18844/wjet.v14i5.7268	Journal
4	Paristiowati, Maria., et al. (2022). Developing Preservice Chemistry Teachers' Engagement with Sustainability Education through an Online Project-Based Learning Summer Course Program. Sustainability SDG. 14(3), 1783 https://doi.org/10.3390/su14031783	Journal
5	Mahanan, M. S., Ibrahim, N. H., Surif, J., Osman, S., & Bunyamin, M. A. H. (2021). Dual Mode Module as New Innovation in Learning Chemistry: Project Based Learning Oriented. International Journal of Interactive Mobile Technologies, 15(18), 47-65. https://doi.org/10.3991/ijim.v15i18.24549	Journal
6	Matilainen, R., Nuora, P., & Valto, P. (2021). Student Experiences Of Project-Based Learning In An Analytical Chemistry Laboratory Course In Higher Education. Chemistry Teacher International. 3(3): 229–238 https://doi.org/10.1515/cti-2020-0032	Journal
7	Sumarni, W., Wardani, S., Sudarmin, S., & Gupitasari, D. N. (2016). Project based learning (PBL) to improve psychomotor skills: A classroom action research. Jurnal Pendidikan IPA Indonesia, 5(2), 157–163. https://doi.org/10.15294/jpii.v5i2.4402	Journal
8	Diawati, C., Liliasari, Setiabudi, A., & Buchari. (2017). Using Project-Based Learning To Design, Build, and Test StudentMade Photometer by	Journal

File Codes	References	Kind of Sources
	Measuring the Unknown Concentration of Colored Substances. Journal of Chemical Education. DOI:10.1021/acs.jchemed.7b00254	
9	Kızkapan, Oktay & Bektaş, Oktay. (2017). The Effect of Project Based Learning on Seventh Grade Students' Academic Achievement. International Journal of Instruction, 10 (1), 37-54.	Journal
10	Hugerat, Muhamad. (2016). How teaching science using project-based learning strategies affects the classroom learning environment. Learning Environ Res. DOI 10.1007/s10984-016-9212-y	Journal
11	Bilgin, I., Karakuyu, Y., Ay, Y. (2015). The Effects of Project Based Learning on Undergraduate Students' Achievement and SelfEfficacy Beliefs Towards Science Teaching. Eurasia Journal of Mathematics, Science & Technology Education, 11(3), 469-477	Journal
12	Domenici, Valentina. (2022). STEAM Project-Based Learning Activities at the Science Museum as an Effective Training for Future Chemistry Teachers. Education Science. 12, 30. https://doi.org/10.3390/educsci12010030	Journal
13	Barco, M. H., Martín, J. S., Cuello, I. C., & Cañada, F. C. (2021). Emotional Performance of a Low-Cost Eco-Friendly Project Based Learning Methodology for Science Education: An Approach in Prospective Teachers. Sustainability, 13, 3385. https://doi.org/10.3390/su13063385	Journal
14	Santyasa, I.W., Agustini, K., & Pratiwi, N. W. E. (2021). Project Based E-Learning and Academic Procrastination of Students in Learning Chemistry. International Journal of Instruction, 14(3), 909- 928.	Journal
15	Situmorang, M., Sitorus, M., & Sudrajat, A. (2022). Implementation of Project-based Learning Innovation to Develop Students' Critical Thinking Skills as a Strategy to Achieve Analytical Chemistry Competencies. Indian Journal of Pharmaceutical Education and Research, 56(2), 41-51.	Journal
16	Davis, E. J., Pauls, S., & Dick, J. (2016). Project-Based Learning in Undergraduate Environmental Chemistry Laboratory: Using EPA Methods To Guide Student Method Development for Pesticide Quantitation. Journal of Chemical Education, 94 (4), 451-457. doi:10.1021/acs.jchemed.6b00352	Journal
17	Tuan, N. N., Hanh, B. T., & Ninh, T. T. (2020). Project Based Learning in General Chemistry to Develop the Problem-Solving and Creativity. American Journal of Educational Research, 8(7), 475-479. DOI:10.12691/education-8-7-4	Journal
18	Hugerat, Muhamad. (2020). Incorporating Sustainability into Chemistry Education by Teaching through Project-Based Learning. ACS Symposium Series; American Chemical Society: Washington, DC. 79-96. DOI: 10.1021/bk-2020-1344.ch007	Journal
19	Yamin, Y, Permanasari, A., Redjeki, S., & Sopandi, W. (2017). Application of Model Project Based Learning on Integrated Science in Water Pollution. Journal of Physics: Conference Series, 89, 012153–. doi:10.1088/1742-6596/895/1/012153	Journal
20	Islami, D., Adlim, M., & Hasan, M. (2019). Project-based learning on water filtration experiment in high school chemistry subject. Journal of Physics: Conf. Series, 1460, 012082, doi:10.1088/1742-6596/1460/1/012082	Journal

From the above lookup result, the QA table can be displayed as follows:

QA1 Analysis Result: Year of publication of literature

Of the twenty literatures found by researchers through the search for internationally reputable journals on Google Scholar, Scopus, ERIC, ACS Publishing, and Science Direct, twenty journals met the criteria for publication years between 2015-2020.

QA2 Analysis Results: Scopus Indexed

Of the twenty literatures identified in the year of publication, eighteen journals were indexed by Scopus with details: four Q1 journals, depalan Q2 journals, five Q3 journals, and one Q4 journal.

QA3 Analysis Results: Discussing PjBL in Chemistry learning

From the eighteen identified journals indexed by Scopus, only 13 journals discuss PjBL in Chemistry learning. Journals with file codes 7, 9, 10, 11, 13, 19 and 20 will not be coded due to the aspect review.

Goals are one of the aspects that must be considered in learning. (Nur Nasution, 2017). Learning objectives from the literature discussing PjBL in chemistry learning are as follows:

Tabel 2. Quality Assesment

File Codes	QA1	QA2	QA3
1	✓	Q2	✓
2	✓	Q3	✓
3	✓	Q3	✓
4	✓	Q1	✓
5	✓	Q3	✓
6	✓	Q3	✓
7	✓	Q2	-
8	✓	Q2	✓
9	✓	Q2	-
10	✓	Q1	-
11	✓	Q2	-
12	✓	Q2	✓
13	✓	Q1	-
14	✓	Q2	✓
15	✓	Q3	✓
16	✓	Q2	✓
17	✓	Q1	✓
18	✓	Q4	✓
19	✓	-	-
20	✓	-	-

Based on the aim of the research from the aspect review consist 3 codes. In 6 studies aims to investigate the effect of implementing project based learning, describe critical thingking skills, psychomotor skills, problem solving skills, creative students, cognitive achievement and students' teamwork skills. Other aim is developing PjBL-based products such as laboratory workbook and chemistry module. Also raise awareness of sustainability and other environmental issues as the aim to develop the sustainability competence of chemistry teachers and increase students' awareness of sustainability and issues other environment.

Research methods related to PjBL in Chemistry learning as follows:

Tabel 3 Aims PjBL in Chiemistry Learning

File Code	Aim
1	To develop a Chemistry Laboratory Workbook (InochemLaW)
2	To implement project based learning in organic chemistry
3	To Improving pre-service chemistry teachers' critical thinking and problem solving skill in project based learning
4	To develop the sustainability competence of chemistry teachers
5	To develop a valid module of chemical representation
6	To develop dual mode module as new innovation in learning chemistry
8	To improve thinking skills high level, including problem solving skills
12	To improve motivation and interest towards museum science in chemistry laboratory experiment
14	To analyzing the effect of the project based e-learning compared to direct e-learning
15	To apply project-based learning to facilitate active and independent learning through project implementation to build students' critical thinking skills
16	To develop students' teamwork skills
17	To develop problem solving skills and creative for students
18	To increase students' awareness of sustainability and issues other environment

Tabel 4 Method Themes

File Code	Method
1	Research and development
2	Experiment
3	Quasy-experiment
4	Case study
5	Research and development
6	Research and development
8	Experiment
12	Survey
14	Quasy-experiment
15	Mixed Exploratory
16	Exsperiment
17	Experiment
18	Classroom action research

Based on the method from the aspect review, the dominant type of project based learning research is carried out by quantitative methods. In this analysis, there were 7 quantitative studies analyzed. They are 2 quasy experiment and 4 experiment. In addition, there are 2 qualitative studies, namely 1 case study and 1 classroom action research. There was 1 mixed exploratory and 3 were research and development.

Tabel 5. Method Themes

		Codes	Number of files
Method	Qualitative	Case study	1
		Classroom Action Research	1
	Quantitative	Quasy-experiment	2
		Experiment	4
		Survey	1
		Mixed exploratory	1
		Research and development	3
		Total	13

The sample of PjBL research in Chemistry learning is as follows:

Tabel 6. Research Sample

File Code	Sample
1	High school students
2	High school students
3	Chemistry pre-service teachers
4	Chemistry pre-service teachers
5	Chemistry teachers
6	High school students
8	University students
12	University students
14	High school student
15	University students
16	University students
17	University students
18	Middle school students

Tabel 7. Research Sample

		Codes	Number of files
Sample	Student	University	5
		High school	4
		Middle school	1
	Teacher	Pre-service chemistry teacher	2
		Chemistry teacher	1
Total			13

Based on the sample aspect review, the sample in project based learning studies is 10 journals for students consisting of university students, middle school students and high school students. In addition, there are chemistry teachers and pre-service teachers consisting of chemistry pre-service teachers and primary school pre-service teachers. The Chemistry learning topics researched from the identified journals are as tabel 8.

Tabel 8. Topics Research

File Code	Chemistry Topic
1	Colligative properties of solutions
2	Organic chemistry
3	Element, compound and mixture
4	Organic chemistry
5	Chemical reaction
6	Analytical laboratory experiment
8	Photometer
12	Chemistry experiment
14	Titration
15	Distillation method
16	Chemical environment
17	Chemical equilibrium
18	Chemical environment

Tabel 9. Topics Research

		Codes	Number of files
Chemistry Topic	Physical chemistry	Colligative properties of solutions	1
		Chemical reaction	1
		Chemical equilibrium	1
		Element, compound and mixture	1
	Analytical chemistry	Titration	1
		Distillation method	1
		Photometer	1
		Analytical laboratory experiment	1
	Chemical environment		2
	Chemistry experiment		1
	Organic Chemistry		2
Total			13

Based on the aspect review, the topic of chemistry has 5 different codes. They are 4 physical chemistry, 4 analytical chemistry, 2 chemical environment, 1 chemistry reaction, and 2 organic chemistry. All the different topics on chemistry means that project based learning can be used in any concept of chemistry learning. The framework of PjBL research in Chemistry learning is as follows:

Tabel 10. Research Framwork

File Code	Framework
1	Study chemistry by using the developed InoChemLaW aims to improve student learning independence by doing the chemistry projects guided by an innovative learning package
2	Cooperative learning; dialogic tasks; search for previous information on the topics before the classes; practical classes before the presented theory; use of technological tools
3	Students who were taught using PjBL experienced an increase in their critical thinking and problem-solving skills compared to students who were taught by the lecture method
4	Chemistry teachers could develop sustainable projects to develop students' skills. The participants were asked to review their project charter to include desirable, feasible, and viable aspects of sustainability
5	Innovative learning analysis, design template module, design activity, develop module, give to chemistry teacher, evaluation
6	Laboratory experiments, making the seminar presentation, drawing up the research plan and reporting the results
8	Performance assessment consists of the process of performance assessment for planning and designing the photometer, and the product performance assessment of a photometer that has been built by students
12	Visiting the museum science and make a student experiment project
14	Project based learning compared to direct e-learning and academic procrastination on students
15	Learning innovations and project themes that have been incorporated into the learning package for teaching distillation topics
16	Students were provided with industry-standard documentation in the form of EPA methods and allowed to develop both a research question using the procedures outlined and a detailed procedure that they and their colleagues would follow throughout the semester
17	Combining theory with real life, applying scientific and technical advances
18	Define and apply sustainability principles, recognize and assess how sustainability affects their lives and how their own actions influence sustainability.

Tabel 11. Research Framework

	Codes	Number of files
Research Framework	Student innovative learning independence	3
	Cooperative learning	1
	Compared class	2
	Sustainable projects	2
	Laboratory experiments	4
	Combining theory with real life	1
Total		13

Framework type of project based learning research consist 6 codes. Most of the research used student innovative learning and laboratory experiment as they framework research. Other research used cooperative learning, compared class, sustainable projects, and combining theory with real life for the framework. The data collection tools used in PjBL research in Chemistry learning are as follows.

Based on the table 13 the data collection tool consists of 9 different codes. They are 4 tests, 7 questionnaires, 4 observation sheets, 2 worksheets, 1 interviews, 1 reflective journals, 1 checklist rubrics, 1 written test and 1 experiment planner. The data analysis used for PjBL research in Chemistry learning is as follows:

Tabel 12. Data Collection Tools

File Codes	Data Collection Tools
1	Questionnaires, test and checklist rubrics
2	Questionnaire, observation sheets, and test
3	Test (Critical Thinking Skills Test (CTST) and the Problem-Solving Skills Test (PSST))
4	Observation, interviews, reflective journal
5	Questionnaire
6	Questionnaire
8	Worksheet
12	Questionnaire and experiment planner
14	Questionnaire and test
15	Questionnaire
16	Worksheet
17	Observation checklist and written test
18	Observation sheet

Tabel 13. Data Collection Tools

	Codes	Number of files
Data Collection	Questionnaire	7
	Worksheet	2
	Test	4
	Observation sheets	4
	Reflective journals	1
	Checklist rubrics	1
	Interviews	1
	Written test	1
	Experiment planner	1
Total		22

Tabel 14. Data Analysis

File Codes	Data Analysis
1	Descriptive statistics
2	Descriptive statistics
3	Independent samples t-tests and Cohen's d
4	Descriptive analysis
5	Descriptive statistics
6	Descriptive statistics
8	Descriptive statistics
12	Descriptive statistics
14	Descriptive statistics and Mancova
15	Descriptive statistics
16	Descriptive statistics and inferential statistics
17	Descriptive statistics
18	Descriptive analysis

Tabel 15. Data Analysis

	Codes	Number of files
Data Analysis	Descriptive statistics	10
	Descriptive analysis	2
	Mancova	1
	Cohen's d	1
	Inferential statistics	1
	Independent sample T test	1
Total		16

Based on data analysis, there are 6 codes for project based learning research. They are 10 Descriptive Statistics, 2 Descriptive Analysis, 1 Inferential Statistics, 1 Mancova, 1 Cohen's d, and 1 Independent sample T-Test. It can be implied that project based learning research mostly used descriptive statistics for data analyze. The implications of PjBL research from the literature found are as follows:

Based on the table 16, it can be concluded that project based learning research is recommended to conduct further research on the application of project based learning models in the chemistry learning process with any chemistry topics. In these journals it is stated that the project based learning model can create active learning and improve student experiment skills. In addition, 7 journals recommend the implications of learning media with project based learning models in the learning process. 1 journal recommends the implications of project based learning by incorporating the context of sustainability into the learning process and 1 other journal recommends improving school facilities and infrastructure with computers and websites.

Tabel 16. Implications

Recomendation Codes	File Codes	Number of files
Implications of project based learning in the learning process	2, 3, 4, 8, 12, 16, 17	7
The implications of learning media with project based learning models in the learning process	5, 6, 14,15	4
Improve school facilities and infrastructure with computers and websites	1	1
Implications of project based learning by incorporating the context of sustainability into the learning process	18	1
Total		13

Bibliometric Review

VOS Viewer provides three bibliometric analysis mappings, namely network visualization as in Figure 2. This visualization was obtained with the help of VOS software by extracting 13 articles selected based on title, keywords and abstract. There are 40 identifiable items spread across 7 clusters marked with different colors, namely red, green, dark blue, yellow, purple, light blue, orange. Each cluster represents the development of PjBL research in chemistry learning.

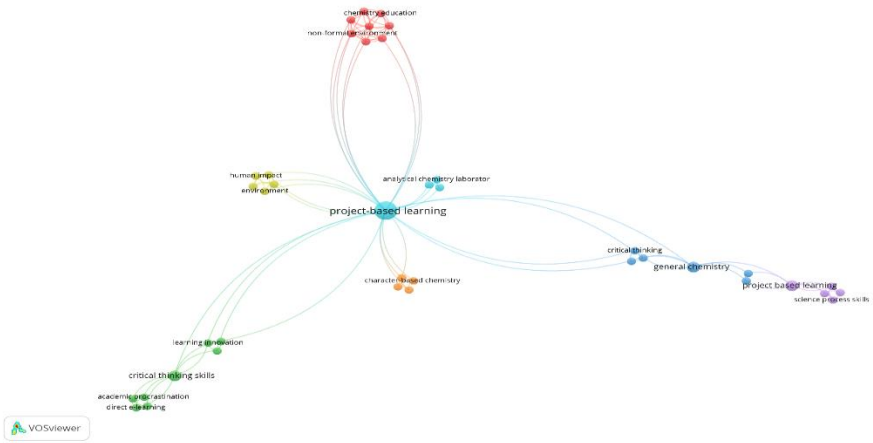

Figure 2 Network visualization keywords co-occurrence analysis

Tabel 17. Research Development of Each Cluster

Cluster	Number of Item	Keywords
Red	8	Chemistry education, interactive learning, non-formal environment, pjbl, science museum, steam, teacher training
Green	8	Academic procrastination, critical thingking skill, direct e-learning, learning inovation, learning outcomes, project based e-learning, student achievement, student competence
Dark Blue	6	Critical thingking, general chimestry, pre-service teacher, problem solving and creativity, problem solving skills, technical university students
Yellow	5	Environment, human impact, renewble energi, student advocacy, sustainability education
Purple	5	Chemical representation, chemistry, module, project based learning, science process skills
Light Blue	4	Analytical chimestry lab, project based learning, research project, student expierence
Orange	4	Character-based chimestry, chimestry inovation, colligative properties, laboratory workbokk

Conclusion

Most studies use students' innovative learning and laboratory experiments as the research framework. Based on the analysis of the PjBL journal, it was found that the chemical concepts applied were analytical chemistry, physical chemistry, environmental chemistry, basic chemistry and organic chemistry. Data collection and analysis tools can be used as benchmarks for carrying out implications and further research.

Acknowledgments
Thank you to all those who have supported the implementation of this research. Hopefully this research can be useful.

Author Contributions
Conceptualization, E.A.P. and J.I.; methodology, E.A.P.; validation, J.I.; formal analysis, E.A.P.; investigation, E.A.P.; resources, E.A.P.; data curation, E.A.P.; writing—original draft preparation, E.A.P.; writing—review and editing, E.A.P and J.I.; visualization, J.I. All authors have read and agreed to the published version of the manuscript.

Funding
This research received no external funding.

Conflicts of Interest
The authors declare no conflict of interest.

References

Afriana, J. (2015). *Project Based Learning (PjBL)*. Universitas Pendidikan Indonesia. Bandung.

Almulla, M. A. (2020). The Effectiveness of the Project-Based Learning (PBL) Approach as a Way to Engage Students in Learning. *SAGE Open, 10*(3). https://doi.org/10.1177/2158244020938702

Azarian, M., Yu, H., Shiferaw, A. T., & Stevik, T. K. (2023). Do We Perform Systematic Literature Review Right? A Scientific Mapping and Methodological Assessment. *Logistics, 7*(4). https://doi.org/10.3390/logistics7040089

Brassler, M., & Dettmers, J. (2017). How to Enhance Interdisciplinary Competence—Interdisciplinary Problem-Based Learning versus Interdisciplinary Project-Based Learning. *Interdisciplinary Journal of Problem-Based Learning, 11*(2). Retrieved from https://doi.org/10.7771/1541-5015.1686%0AThis

Cabrera, D., Cabrera, L., & Cabrera, E. (2023). Article title: The Steps to Doing a Systems Literature Review (SLR). *Journal of Systems Thinking, 6*, 1–28. https://doi.org/10.54120/jost.pr000019.v1

Ciptro Handrianto, M. A. R. (2018). Project Based Learning : A Review of Literature on its Outcomes and Implementation Issues. *LET : Linguistics, Literature and English Teaching Journal, 8*(2), 110–129. Retrieved from https://jurnal.uin-antasari.ac.id/index.php/let/article/view/2394

Davis, E. J., Pauls, S., & Dick, J. (2016). Project-Based Learning in Undergraduate Environmental Chemistry Laboratory: Using EPA Methods To Guide Student Method Development for Pesticide Quantitation. *Journal of Chemical Education, 94*(4), 451-457. https://doi.org/10.1021/acs.jchemed.6b00352

Davis, E. J., Pauls, S., & Dick, J. (2017). Project-Based Learning in Undergraduate Environmental Chemistry Laboratory: Using EPA Methods To Guide Student Method Development for Pesticide Quantitation. *Journal of Chemical Education, 94*(4), 451–457. https://doi.org/10.1021/acs.jchemed.6b00352

Dewi, M. R. (2022). Kelebihan dan Kekurangan Project-based Learning untuk Penguatan Profil Pelajar Pancasila Kurikulum Merdeka. *Inovasi Kurikulum,*

19(2), 213–226. Retrieved from https://ejournal.upi.edu/index.php/JIK/article/view/44226

Diawati, C., Liliasari, Setiabudi, A., & Buchari. (2017). Using Project-Based Learning To Design, Build, and Test StudentMade Photometer by Measuring the Unknown Concentration of Colored Substances. *Journal of Chemical Education, 95*(3), 468-475. https://doi.org/10.1021/acs.jchemed.7b00254

Diawati, C., Liliasari, Setiabudi, A., & Buchari. (2018). Using Project-Based Learning to Design, Build, and Test Student-Made Photometer by Measuring the Unknown Concentration of Colored Substances. *Journal of Chemical Education, 95*(3), 468–475. https://doi.org/10.1021/acs.jchemed.7b00254

Domenici, V. (2022). STEAM Project-Based Learning Activities at the Science Museum as an Effective Training for Future Chemistry Teachers. *Education Science, 12*, 30. https://doi.org/10.3390/educsci12010030

Ghosheh, W. D., Najjar, E. A., Sartawi, A. F., Abuzant, M., & Daher, W. (2021). The role of project-based language learning in developing students' life skills. *Sustainability, 13*(12), 1–14. https://doi.org/10.3390/su13126518

Goodman, B., & Stivers, J. (2010). *Project-based learning*. Educational Psychology.

Gough, D., Oliver, S., & Thomas, J. (2012). *An Introduction to Systemic Reviews.* Sage Publication Ltd.

Grant, M. M. (2002). *Getting A Grip of Project Based Learning : Theory, Cases and Recomandation*. North Carolina : Meredian A Middle School Computer Technologies.

Hugerat, M. (2020). *Incorporating Sustainability into Chemistry Education by Teaching through Project-Based Learning.* ACS Symposium Series; American Chemical Society: Washington, DC. https://doi.org/10.1021/bk-2020-1344.ch007

Jesson, J. K., Matheson, L., & Lacey, F. M. (2011). *Doing Your Literature Review: Traditional and Systematic Techniques. In Doing Practice-Based Research in Therapy: A Reflexive Approach.* London: Sage Publications Ltd. https://doi.org/10.4135/9781473921856.n6

Juntunen, M. K., & Aksela, M. K. (2014). Education for sustainable development in chemistry – Challenges, possibilities and pedagogical models in Finland and elsewhere. *Chemistry Education Research and Practice,* 1–15. https://doi.org/10.1039/x0xx00000x

Krajcik, J. S., & Czerniak, C. M. (2018). *Teaching Science in Elementary and Middle School: A Project-Based Learning Approach.* New York: Routledge. https://doi.org/10.4324/9781315205014

Kraus, S., Breier, M., & Dasí-Rodríguez, S. (2020). The art of crafting a systematic literature review in entrepreneurship research. *International Entrepreneurship and Management Journal, 16*(3), 1023–1042. https://doi.org/10.1007/s11365-020-00635-4

Lestari, T. (2015). *Peningkatan Hasil Belajar Kompetensi Dasar menyajikan Contoh-Contoh Ilustrasi Dengan Model Pembelajaran Project Based Learning dan Metode Pembelajaran Demonstrasi Bagi Siswa Kelas XI Multimedia SMK Muhammadiyah Wonosari*. Universitas Negeri Yogyakarta.

Lianda, R. L. P. & Joyce, B. (2018). Applying Project-Based Learning (Pbl) In The Organic Chemistry Course While Studying Honey. *Revista Ibero-Americana de Estudos em Educação, 13*(1), 407-420. https://doi.org/10.21723/riaee.nesp1.v13.2018.11435

Linnenluecke, M. K., Marrone, M., & Singh, A. K. (2020). Conducting systematic literature reviews and bibliometric analyses. *Australian Journal of Management, 45*(2), 175–194. https://doi.org/10.1177/0312896219877678

Lion, E., Ludang, Y., & Jaya, H. P. (2022). Edukasi Penerapan Pembelajaran Project Based Learning Untuk Meningkatkan Hasil Belajar Di Masa Pandemi Covid-19 Desa Telangkah. *J-ABDI: Jurnal Pengabdian Kepada Masyarakat, 2*(1), 3635–3642. https://doi.org/10.53625/jabdi.v2i1.2257

Mengist, W., Soromessa, T., & Legese, G. (2020). Method for conducting systematic literature review and meta-analysis for environmental science research. *MethodsX, 7*, 100777. https://doi.org/10.1016/j.mex.2019.100777

Matilainen, R., Nuora, P., & Valto, P. (2021). Student Experiences Of Project-Based Learning In An Analytical Chemistry Laboratory Course In Higher Education. *Chemistry Teacher International. 3*(3), 229–238 https://doi.org/10.1515/cti-2020-0032

Mahanan, M. S., Ibrahim, N. H., Surif, J., Osman, S., & Bunyamin, M. A. H. (2021). Dual Mode Module as New Innovation in Learning Chemistry: Project Based Learning Oriented. *International Journal of Interactive Mobile Technologies, 15*(18), 47-65. https://doi.org/10.3991/ijim.v15i18.24549

Nainggolan, B., Hutabarat, W., Situmorang, M., & Situmorang, M. (2020). Developing Innovative Chemistry Laboratory Workbook Integrated with Project–based Learning and Character-based Chemistry. *International Journal of Instruction, 13*(3), 895-908. https://doi.org/10.29333/iji.2020.13359a

Ningsih, S. R., Disman, Ahman, E., Suwatno, & Riswanto, A. (2020). Effectiveness of using the project-based learning model in improving creative-thinking ability. *Universal Journal of*

Educational Research, 8(4), 1628–1635. https://doi.org/10.13189/ujer.2020.080456

Nur Nasution, W. (2017). Perencanaan Pembelajaran Pengertian, Tujuan Dan Prosedur. *Ittihad: Jurnal Pendidikan, 1*(2), 185-195. Retrieved from http://repository.uinsu.ac.id/5341/1/PERENCANAAN%20PEMBELAJARAN%20PENGERTIAN,%20TUJUAN%20DAN%20PROSEDUR.pdf

Paristiowati, M., Rahmawati, Y., Fitriani, E., Satrio, J. A., & Putri Hasibuan, N. A. (2022). Developing preservice chemistry teachers' engagement with sustainability education through an online project-based learning summer course program. *Sustainability, 14*(3), 1783. https://doi.org/10.3390/su14031783

Pawero, A. M. D. (2021). Arah Baru Perencanaan Pendidikan dan Implikasinya Terhadap Kebijakan Pendidikan. *Dirasah: Jurnal Studi Ilmu dan Manajemen Pendidikan Islam*, 4(1), 16–32. Retrieved from https://www.ejournal.iaifa.ac.id/index.php/dirasah/article/view/177

Permendikbud. (2013). *Peraturan Menteri Pendidikan dan Kebudayaan Indonesia Nomor 65.* Kementerian Pendidikan Dan Kebudayaan.

Phillen, J. (2016). *Implementing Meaningful And Sustainable Project Based Learning Pedagogy.* Theses and Dissertation, University of New England. Retrieved from https://dune.une.edu/theses/103/

Prajoko, S., Sukmawati, I., Maris, A. F., & Wulanjani, A. N. (2023). Project Based Learning (Pjbl) Model With Stem Approach on Students' Conceptual Understanding and Creativity. *Jurnal Pendidikan IPA Indonesia, 12*(3), 401–409. https://doi.org/10.15294/jpii.v12i3.42973

Pujiriyanto, P., Haryanto, S., Mulyoto, M., & Rochsantiningsih, D. (2017). How Project Based Learning Boost Learning Environment. *Advances in Social Science, Education and Humanities Research (ASSEHR), 66,* 169–175. https://doi.org/10.2991/yicemap-17.2017.29

Rahmania, I. (2021). Project Based Learning (PjBL) Learning Model with STEM Approach in Natural Science Learning for the 21st Century. *Budapest International Research and Critics Institute (BIRCI-Journal): Humanities and Social Sciences, 4*(1), 1161–1167. https://doi.org/10.33258/birci.v4i1.1727

Rofik, A., Setyosari, P., Effendi, M., & Sulton. (2022). The Effect of Collaborative Problem Solving & Collaborative Project-Based Learning Models to Improve The Project Competences of Pre-Service Teachers. *Pegem Egitim ve Ogretim Dergisi, 12*(3), 130–143. https://doi.org/10.47750/pegegog.12.03.15

Rousseau, R., Egghe, L., & Guns, R. (2018). *Becoming Metric-Wise: A Bibliometric Guide for Researchers.* Cambridge: Elsevier.

Santyasa, I.W., Agustini, K., & Pratiwi, N. W. E. (2021). Project Based E-Learning and Academic Procrastination of Students in Learning Chemistry. *International Journal of Instruction, 14*(3), 909- 928. Retrieved from https://eric.ed.gov/?id=EJ1304700

Sauer, P. C., & Seuring, S. (2023). How to conduct systematic literature reviews in management research: a guide in 6 steps and 14 decisions. In *Review of Managerial Science, 17*(5), 1899-1933. https://doi.org/10.1007/s11846-023-00668-3

Siboro, A., Debataraja, E., & Tafonao, D. (2022). Pengaruh Model Project Based Learning (PjBL) Berbantuan Media Quizizz Terhadap Kemampuan Bepikir Kritis Peserta Didik. *Kewarganegaraan, 6*(3), 5182–5188.

Siddaway, A. P., Wood, A. M., & Hedges, L. V. (2019). How to Do a Systematic Review: A Best Practice Guide for Conducting and Reporting Narrative Reviews, Meta-Analyses, and Meta-Syntheses. *Annual Review of Psychology, 70,* 747–770. https://doi.org/10.1146/annurev-psych-010418-102803

Simbolon, R., & Koeswanti, H. D. (2020). Comparison Of Pbl (Project Based Learning) Models With Pbl (Problem Based Learning) Models To Determine Student Learning Outcomes And Motivation. International Journal of Elementary Education, 4(4), 519–529. Retrieved from https://ejournal.undiksha.ac.id/index.php/IJEE/article/view/30087

Situmorang, M., Sitorus, M., & Sudrajat, A. (2021). Implementation of Project-based Learning Innovation to Develop Students' Critical Thinking Skills as a Strategy to Achieve Analytical Chemistry Competencies. *Indian Journal of Pharmaceutical Education and Research, 56*(1), 41–51. https://doi.org/10.5530/ijper.56.1s.39

Situmorang, M., Sitorus, M., & Sudrajat, A. (2022). Implementation of Project-based Learning Innovation to Develop Students' Critical Thinking Skills as a Strategy to Achieve Analytical Chemistry Competencies. *Indian Journal of Pharmaceutical Education and Research, 56*(2), 41-51. https://doi.org/ 10.5530/ijper.56.1s.39

Suwarno, S., Wahidin, W., & Nur, S. H. (2020). Project-based learning model assisted by worksheet: It's effect on students' creativity and learning outcomes. *JPBI (Jurnal Pendidikan Biologi Indonesia), 6*(1), 113–122. https://doi.org/10.22219/jpbi.v6i1.10619

Syahril, S., Nabawi, R. A., & Safitri, D. (2021). Students' Perceptions of the Project Based on the Potential of their Region: A Project-based Learning Implementation. *Journal of Technology and Science Education, 11*(2), 295–314. https://doi.org/10.3926/JOTSE.1153

Tamim, S. R., & Grant, M. M. (2013). Definitions and Uses: Case Study of Teachers Implementing Project-based Learning. *Interdisciplinary Journal of Problem-Based Learning, 7*(2), 5–16. https://doi.org/10.7771/1541-5015.1323

Tuan, N. N., Hanh, B. T., & Ninh, T. T. (2020). Project Based Learning in General Chemistry to Develop the Problem-Solving and Creativity. *American Journal of Educational Research, 8*(7), 475-479. https://doi.org/10.12691/education-8-7-4

van Eck, N. J., & Waltman, L. (2007). VOS : A New Method for Visualizing. *Advances in Data Analysis. Studies in Classification, Data Analysis, and Knowledge Organization,* 299–306.

van Eck, N. J., & Waltman, L. (2014). Measuring Scholarly Impact. In *Measuring Scholarly Impact*, 285–320. https://doi.org/10.1007/978-3-319-10377-8

Viana, R. V., Jumadi, Wilujeng, I., & Kuswanto, H. (2019). The Influence of Project Based Learning based on Process Skills Approach to Student's Creative Thinking Skill. *Journal of Physics: Conference Series, 1233*(1). https://doi.org/10.1088/1742-6596/1233/1/012033

Wahyudiati, D., et al. (2022). Improving pre-service chemistry teachers' critical thinking and problem-solving skills using project-based learning. *World Journal on Educational Technology: Current Issues. 14*(5), 1291-1304. https://doi.org/10.18844/wjet.v14i5.7268

Yunita, A., Putra, W. S., & Anggreny, D. (2023). Konsep Dasar Kebijakan Pendidikan. *Journal Of International Multidisciplinary Research, 1*(2), 652–657. https://doi.org/10.62504/nc3ts542

Yunita, Y., Juandi, D., Kusumah, Y. S., & Suhendra, S. (2021). The effectiveness of the Project-Based Learning (PjBL) model in students' mathematical ability: A systematic literature review. *Journal of Physics: Conference Series, 1882*(1), 012080. https://doi.org/10.1088/1742-6596/1882/1/012080

Žerovnik, A., & Nančovska Šerbec, I. (2021). Project-based learning in higher education. In *Technology Supported Active Learning: Student-Centered Approaches,* 31–57. https://doi.org/10.1007/978-981-16-2082-9_3