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# Improving Students' Understanding of Chemistry Concepts Through Project-Based Learning (PJBL): A Systematic Literature Review

**[1]*Setia Rahmawan, [2]Septy Nur Fadhilah, [3]Edi Fackhurrohman**

[1,2,3] Chemistry Education, Faculty of Education and Teacher Training. Sunan Kalijaga State Islamic University. Jl. Laksda Adisucipto, Papringan, Caturtunggal, Depok Sub-district, Sleman Regency, Yogyakarta Special Region, Indonesia. Postal code: 55281

*Corresponding Author e-mail: setia.rahmawan@uin-suka.ac.id

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**Abstract**

One of the obstacles in chemistry learning is the large number of complex concepts, especially material that cannot be observed directly by students. Abstract and unobservable chemistry concepts often pose a major challenge in learning, resulting in low student comprehension and difficulty in relating theory to practice. PJBL is a learning model that allows students to gain direct experience with the chemistry concepts they encounter. This systematic literature review aims to synthesize existing research on the effectiveness of the PJBL model in improving the understanding of chemistry concepts. This type of research is a literature study using the Systematic Literature Review (SLR) method on 10 articles from 2015 to 2024 to evaluate the effectiveness of the Project Based Learning (PJBL) model in improving the understanding of chemistry concepts. Based on several articles, the results show that PJBL consistently produces a significant increase in conceptual understanding, as demonstrated by an increase in student N-gain scores in the moderate to high categories, as well as encouraging learning achievement in repetitive learning. The main contribution of SLR in this study is to provide an integrated and structured summary that can be used as a practical reference for educators in designing contextual and applicable project-based learning models. This study supports the integration of PJBL in learning to strengthen student engagement and deep conceptual understanding.

**Keywords**: Chemical Concepts; Learning Model; Project Based Learning (PJBL); Student Understanding.

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## INTRODUCTION

Chemistry is one of the subjects that has abstract concepts. These include the structure, composition, properties, and changes of matter and the energy that accompanies it (Andriani et al., 2019). The conceptual understanding that needs to be achieved in studying chemistry includes the ability to translate chemical problems into forms or representations that can be observed directly (macroscopic), in the form of chemical particles (microscopic), and symbolic forms such as reaction equations (Faizah et al., 2013). However, the abstract nature of chemistry often becomes an

obstacle to students' understanding, even though in reality chemistry is very close to everyday life (Rosid et al., 2019).

One of the obstacles in chemistry learning is the large number of complex concepts, especially materials that students cannot observe directly (Andriani et al., 2019). This is especially true when students are faced with materials that require a higher level of understanding and are related to problem-solving skills (Faizah et al., 2013). Poor conceptual understanding is also influenced by the close interrelationship between materials, which causes students to experience difficulties if they do not fully understand the previous concepts (Pramitadan et al., 2016). In addition, many teachers experience difficulties in delivering chemistry material effectively, making it difficult for students to understand these concepts (Miswadi & Haryani, 2013).

To overcome these challenges, a learning model that encourages active student participation and trains critical thinking skills is needed. One relevant model is Project-Based Learning (PBL), which provides hands-on experience through projects and experiments, helping students conceptualize previously abstract theories in a more concrete and applicable way. A learning model that can encourage active engagement and train critical thinking skills in problem solving is needed to improve understanding of chemistry concepts. The right method or approach in delivering chemistry concepts will become the foundation of useful competencies to support effective chemistry learning (Sasmono, 2018)

Project-Based Learning (PBL) is designed as a means for students to practice problem-solving skills. Project-based learning will provide students with direct experience, thereby strengthening their understanding of chemistry concepts (Anggriani et al., 2019). Students will be actively involved in learning activities, such as conducting experiments, observing phenomena, and remembering information they obtain directly from these activities (Muderawan et al., 2013). Thus, project-based learning can help students conceptualize abstract theories in a more concrete and applicable way.

According to several studies, the PJBL model can help students understand chemistry concepts. Research conducted by Handayani (2015) shows that the PJBL learning model is more effective than the Discovery Learning model in improving students' conceptual understanding and critical thinking skills. This is because students are more active in observing, analyzing, and applying chemistry concepts in their projects. In addition, other studies show that project-based learning methods can help students connect theory with practice, which improves their understanding of concepts that were previously considered abstract.

Various studies have shown that PJBL is effective in improving students' understanding of chemistry concepts and critical thinking skills. Although many individual studies have reported the success of the PJBL model, existing studies often have a limited scope that focuses on a single chemistry topic. There is a lack of systematic studies comparing the effectiveness of PJBL on various chemistry subtopics, such as atomic structure, chemical bonding, redox reactions, etc. In addition, there has been minimal exploration of how PJBL facilitates the shift from symbolic to microscopic understanding, which is a major challenge in understanding chemistry concepts. There is also a reliance on older literature or limited journal

sources, necessitating a systematic review that incorporates the latest findings from a wider range of sources.

Based on this background, a systematic literature review is needed to synthesize findings related to the effectiveness of PJBL on a broader scale. This literature study will review various studies that have been conducted previously to determine the effectiveness and impact of the PJBL model on the understanding of chemistry concepts. Therefore, this literature review aims to combine the results of various studies conducted between 2015 and 2024 by conducting a systematic analysis to see the extent to which PJBL improves students' understanding of chemistry concepts compared to other models.

The results of this study are expected to serve as a reference and alternative for educators in choosing more effective learning methods to improve the quality of chemistry learning, especially in terms of understanding chemistry concepts. This review is important because it can serve as a reference for educators in choosing more effective and contextual learning approaches. By understanding how PJBL works in various chemistry learning contexts, educators can design more appropriate strategies to improve the quality of learning, especially in improving students' understanding of chemistry concepts.

## METHOD

This type of research is a literature study using the Systematic Literature Review (SLR) method, SLR is a scientific approach which is used as a review of relevant research literature which is structured (Lame, 2019). The steps taken in the SLR method are formulating research questions (developing research questions), searching for literature that is in accordance with the topic of discussion (developing search strategies), sorting literature according to the established inclusion criteria (selection criteria), analyzing data and evaluating (evaluate and analyze data), and the last step reports the results or findings (interpreting) (Ananda & Aini, 2022). The following is the framework of the SLR method used.

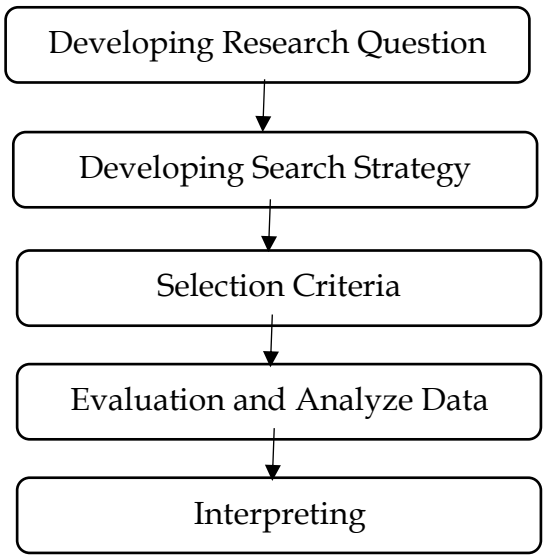



***Figure 1.*** SLR method framework

Literature search was conducted by accessing databases such as Google Scholar, Research Gate, Connected Paper, Directory of Open Access Journals (DOAJ), and others. The scope of the literature studied was related to chemistry learning using the Project-Based Learning (PBL) model and its relationship to improving students' understanding of chemistry concepts. The literature used consisted of research articles from the last 10 years, limited to the period from 2015 to 2025, in Indonesian and English.

The inclusion criteria used in this review include: 1) Journal articles discussing the use of PJBL models in chemistry learning, 2) Studies that measure or discuss students' understanding of chemistry concepts as one of the main variables, 3) Studies conducted at the senior high school level, 4) Articles available in full-text and accessible for free. The exclusion criteria used were articles that only discussed PBL in general without linking it to chemistry learning. Furthermore, the data screening process was carried out in three stages, starting from initial identification, further screening, and final selection. Each article that met the criteria was written in a table containing information such as the author, year of publication, method, and chemistry material that was the object, as well as the results related to the effectiveness of using the PJBL model on students' understanding of concepts.

Data from selected articles were extracted using a table format to facilitate the identification or comparison process and to determine whether there was an increase in students' understanding of concepts in learning chemistry using the PJBL model. The results of this SLR method research were then used to examine the data using descriptive qualitative analysis. This study used qualitative methodology to produce descriptive data.

## RESULTS AND DISCUSSION

Literature study data from several research journals related to the implementation of the Project Based Learning model to improve students' concept understanding can be seen in Table 1.

***Table 1***. Journal Analysis

| No | Author | Research Method | Chemistry Topic | Comparison model | Result |
|---|---|---|---|---|---|
| 1 | (Anggriani et al., 2019) | Experiment modified prettest-postest group comparison design | Solubility Product Constant (Ksp) | - | The PJBL model had an effect on learning outcomes of 10.89% and an effect on science process skills of 16%. |
| 2 | (Sholahuddin et al., 2023) | Quasy eksperimental | Acid-Base Solution | Conventional model | Mann Whitney U test with Asymp sig. (2-tailed) 0.000<0.05. Effect size value 2.78 with a percentage of 49.73%. |
| 3 | (Oktavia et al., 2022) | Quasy eksperimental | Sel Volta | - | $F_{count}$ = 17.196 with a significance value of 0.046 < 0.05. There is an interaction effect between the PjBL-STEAM model and conceptual understanding on student creativity. |

| No | Author | Research Method | Chemistry Topic | Comparison model | Result |
|---|---|---|---|---|---|
| 4 | (Handayani. et al., 2015) | Quasy eksperimental | Understanding of chemical concepts and scientific attitudes in general. | Problem based learning model (PBL) | The Normalized Gain Score value shows 0.752. The Test of Between-Subject Effects results in the learning model at F=5.602 with sig. 0.020. |
| 5 | (Sonia et al., 2021) | Weak-experiment design. One group pretest-posstest design | Temperature and Heat | - | N-gain value of 0.7 with a high category. |
| 6 | (Kadtabalubun et al., 2023) | Quantitative descriptive | Reaction Rate | - | Of the 36 students, 30 students experienced improvement (83.3%) in the high category and 6 students (16.7%) in the moderate category. The average N-gain score was 0.78. |
| 7 | (Tri Wahyuni, 2020) | Classroom action research | Compound formulas and chemical compound nomenclature | Discovery learning | Achievements in the pre-cycle were 13.89%, in cycle-1 19.44%, and in cycle-2 80.56%. |
| 8 | (Siburian et al., 2021) | Classroom action research | Acid-Base | - | Achievement increased by 22.23%. In cycle 1, it was 66.67% and in cycle 2, it was 88.90%. |
| 9 | (Tinari, 2019) | Action Research | Koloid | - | Increases from cycle 1 and cycle 2 of 61% and 89.7%, respectively. |
| 10 | (Triastuti, 2020) | Pre-Experimen Design dengan metode One-Group Pretest Posttest Design. | Freezing point depression of solutions | - | The average pretest score was 63.21 and the posttest score was 90.71 with a N gain score of 0.75 in the high category. |

Project-based learning (PBL) has been widely established in science education, particularly chemistry, to increase student engagement and learning outcomes. Project-based learning (PBL) is known as learning that directly involves students in assigned projects. Students are directly involved in transferring their knowledge through a process that involves questions structured in the form of projects or tasks to solve a problem (Wena & Made, 2009). Project-based learning can be viewed as open contextual activity-based learning, whose learning process emphasizes collaborative problem-solving aspects. The use of problem-based concepts as a first step can attract students to gather and integrate the knowledge they already have, as well as new knowledge gained from direct experience.

Table 1. shows various project-based approaches used in classroom action research and pre-experiments. Each approach is designed to encourage students to be active in the exploration process, which is the core of PJBL. The George Lucas

Educational Foundation (Nurohman, n.d. 2007) developed the following steps for the Project Based Learning (PJBL) model:

1. Start with the Essential Question, where learning begins by asking important questions that can attract students to do something in solving the given problem.
2. Design a Plan for the Project, where project planning begins with choosing the type of project and materials used, until the stage of completing the project.
3. Create a Schedule, learners and teachers return collaboratively in the process of preparing a schedule of activities that will be carried out in the project. Starting from creating a timeline, project deadline, to the stage of work to formulate an explanation of the activities carried out.
4. Monitor the Students and the Progress of the Project, in this case the teacher has the task of monitoring students. Monitoring activities are carried out by giving students the opportunity to ask questions and convey the progress that has been done in their project.
5. Assess the Outcome, assessment is carried out to help teachers measure the achievements that have been achieved by students through the projects they have worked on.
6. Evaluate the Experience, learners and teachers reflect together on the project that has been completed. This reflection process gives learners the opportunity to express their feelings and experiences while working on the project. Thus, teachers and learners can find answers or solutions to the problems that became their first step in completing the project.

There are several factors that can influence student learning outcomes, one of which is conceptual understanding. Students who truly understand concepts well and accurately and are able to master them will achieve positive learning outcomes. Conceptual understanding will greatly help students in organizing the information they obtain, because the process of conceptual understanding involves the processes of recognition, comprehension, and formulation of existing facts. However, in improving their understanding of concepts, the experiences faced by students also play an important role as a means for students to deal with various concepts in different situations (Danial et al., 2017). This is because concepts develop simultaneously with experiences in situations or events, either directly or indirectly (Trianto, 2009).

A concept is something that represents an object, activity, or relationship between events. A person can be said to understand something well if they are able to organize what they have learned and apply it in their daily lives. Understanding a concept is not limited to the ability to remember, but also involves the ability to explain, describe, and interpret the meaning of the concept (Dahar, 2011). In this case, students are not limited to remembering and memorizing all the information obtained in learning, but each student must be able to organize all the information and knowledge that has been obtained.

Based on the literature obtained, it can be concluded that the ability to understand chemistry concepts can be improved by using a project-based learning (PBL) model. The PBL model shows a positive impact on improving conceptual understanding through student learning outcomes on various chemistry topics. Several studies show that PBL can increase N-gain scores in the moderate to high

categories. Meanwhile, studies using a classroom action approach show an increase in learning outcomes from cycle 1 to cycle 2. This identifies that PJBL is also effective in the context of repetitive and reflective learning.

The achievement of conceptual understanding can be seen, among other things, from student learning outcomes. The overall effectiveness of using the PJBL model is due to the different learning atmosphere applied in the PJBL model. In practice, students who learn on a project basis by presenting initial problems will make students more active in discussing and asking questions that lead to the problem-solving process provided (Sholahuddin et al., 2023). Cooperation between students in solving the problems given is very evident when using the PJBL model. Students appear enthusiastic in learning when they are able to discuss with other students and teachers as mentors (Tri Wahyuni, 2020). In general, PJBL provides space for students to be actively involved in the learning process through exploration, design, and completion of projects that are relevant to real life.

PJBL appears to be most effective when applied to contextual and applied chemistry materials. Applied chemistry topics that are often encountered in everyday life allow students to directly explore, observe, and test chemical phenomena, thereby strengthening a deeper and more integrative conceptual understanding than the previous abstract one.

The PJBL learning model is quite effective in improving students' understanding of chemistry concepts. However, students' understanding of concepts cannot be fully accurate immediately and at that moment. This is because differences in conceptual understanding among students can be influenced by several factors. The way students think in certain situations, their intellectual abilities, habits, and the time spent in a certain period can create differences in the conceptual understanding of each student (Boy Kristi Siburian et al., 2021). In addition, the empirical evidence shown in the results table also has limitations, so it needs to be further studied to strengthen the evidence of the effectiveness of PJBL, such as varying research designs, which limit internal validity. Differences in comparison models (conventional, discovery learning, and no comparison) will make it difficult to synthesize the effects of PJBL comparatively.

## CONCLUSION

Based on ten studies reviewed, the Project-Based Learning (PJBL) approach has been proven to contribute positively to chemistry learning in various chemistry topics. The use of the Project-Based Learning (PBL) model can improve students' understanding of chemistry concepts, as students can be actively and enthusiastically involved in discussions to solve the problems they are working on. The effectiveness of PBL is reflected in the increase in N-gain scores, comparisons of scores between classes, and improvements in learning outcomes between cycles in classroom action research. Several studies show quantitative data results in the form of N-gain scores in the moderate to high category of 0.49 and 0.62. There was an increase in learning outcomes of up to 10.80%, and the Mann-Whitney test results showed an asymp sig. of 0.006 < 0.05, indicating that there was a significant difference between the PJBL class and the comparison class.

## RECOMMENDATION

Based on the literature review conducted, every educational institution should integrate the Project-Based Learning (PBL) model more broadly, especially in chemistry subjects that are abstract and cannot be observed directly. The integration of PBL also needs to be supported by a flexible, competency-based curriculum, such as the independent curriculum, which provides space for educators and students to explore project-based learning in a contextual and meaningful way. Every chemistry teacher should design learning projects that are relevant to students' daily lives, so that each student's involvement increases and their conceptual understanding becomes more profound. Examples include projects such as making environmentally friendly soap or detergent, which are related to the concepts of saponification reactions and surfactant properties.

In addition, further research is needed to explore internal factors originating from students, such as thinking styles, intellectual abilities, and learning habits, which can affect the effectiveness of PJBL in understanding chemistry concepts. Subsequent research is also recommended to use the Systematic Literature Review (SLR) method in a broader context, covering various educational cultures in developing and developed countries, in order to identify differences in approaches, challenges, and successes in implementing PBL globally.

**Author Contributions**

Setia Rahmawan was responsible for conceptualizing the study, developing the methodology, conducting the formal analysis, and preparing the initial draft of the manuscript. Septy Nur Fadhilah contributed to the validation process, data curation, and the review and editing of the manuscript. Edi Fackhurrohman supported the investigation, provided resources and references, assisted with visualization, and supervised the overall research process. All authors have read and approved the final version of the manuscript.

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**Conflict of interests**

The authors declare no conflict of interest that could influence the results, interpretation, or presentation of this research. This study was conducted independently, and no funder had any role in the study design, data collection, analysis, manuscript preparation, or the decision to publish the findings.

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