Science Journal of Education
2025, Vol. 13, No. 1, pp. 11-21
https://doi.org/10.11648/j.sjedu.20251301.12

Research Article

Effectiveness of Project-Based-Learning on Laboratory Report Writing Skills Among Undergraduate Science Students

Saeed Almuntasheri*

Science Education, Al-Baha University, Al-Baha, Saudi Arabia

Abstract

The aim of this research is to evaluate the impact of project-based learning (PJBL) on writing skills of laboratory report for undergraduate female students at school of education in Al-Baha university. The study used a quasi-experimental design for the experimental and control groups, with a pre- and post-tests. The study sample included 40 female students distributed equally between the two groups. Learners in the experimental group were taught using the PJBL strategy while their peers in the control group were taught conventionally. The content analysis tool was employed to assess the writing skills of laboratory report components which include the introduction, methods and procedures, results and discussions. The Independent Samples T-test was used to compare the mean scores between the groups and Eta squared (η^2) formula was employed to evaluate the effectiveness level. Post-test results showed that the experimental group significantly outperformed the control group. This improvement of the experimental group reached the highest level in writing the method and procedures, while remaining at the intermediate level in writing the introduction, results, and discussion. This suggests that the PJBL strategy was effective in improving laboratory report writing skills in all three components: the introduction, methods and procedures, and results and discussion, as well as in the overall score. The effect size (η^2= 0.47) indicated the substantial impact of the PJBL strategy in developing the laboratory writing skills for science students. The study recommended the needs for training programs on teaching practices and group projects activities that enhance student skills in writing laboratory reports through engaging learners with the writing process and emphases on sharing newly learned scientific concepts.

Keywords

Project Based Learning, Laboratory Report, Scientific Writing

1. Introduction

In chemistry education it is essential to ensure that scientific results are justified and well-presented through scientific writing strategies [1]. Searching reliable sources such as journal articles, reading and citing references, discussing and justifying results, helps in deepening science students' knowledge and understanding. Laboratory report writing requires science students to explain data and interpret experimental results by using them as evidence to support their reasoning. Writing tasks emphasize communication among learners while designing assignments that support critical

*Corresponding author: salmuntasheri@bu.edu.sa (Saeed Almuntasheri)

Received: 28 December 2024; **Accepted:** 9 January 2025; **Published:** 24 January 2025

thinking skills and encourage scientific discourse and language when writing parts of laboratory reports.

Strong writing skills play a crucial role in academic success, whether in writing assignments, reports, or research proposals. Outcomes of writing skills provides information about student's ability to express ideas, content knowledge, and experiences. According to [2], possessing writing skills has multiple benefits including: (1) helps students in their learning and application of knowledge, (2) takes notes and recording information, (3) makes students' thinking explicit, and (4) strengthens students' problem-solving skills. Writing skills are also important due to its diverse applications such as, writing laboratory reports, exams and in descriptive and quantitative research. Discipline in writing enhances one's abilities as a reader and listener. Writing skills enhances students' critical thinking and promotes validating and preserving of their ideas through documentation [3].

PJBL is one of the modern teaching strategies that is appropriate for the skills of the twenty-first century and that activates the centrality of the learner to achieve learning outcomes through effective communication and sharing of scientific knowledge [4, 5]. Improving science teacher practices associated with PJBL among teachers could help reduce reliance on traditional teaching that aims to retrieve information and prepare learners for tests, which is widespread in many schools, especially in poor areas [6]. Many researchers have discussed the importance of meaningful learning, such as the use of PBL strategy, through which the role of the teacher in providing scientific knowledge is reduced and learners are encouraged to work collectively and collaboratively with the teacher to interpret scientific concepts instead of waiting for the teacher to present them [7, 8].

When applying PJBL to develop scientific writing, problems are used as a first step to gather and connect new knowledge with previous experiences while carrying out real-world activities. This strategy helps in developing students’ skills as it encourages the use of basic skills such as cooperative learning skills, planning, research, reading, and social skills that stimulate group decision-making, in addition to motor skills. This requires a comprehensive educational approach where student learning environments are designed to allow students to explore real problems and collaborate to grasp the scientific concepts related to the experiment, and implementation of multiple tasks to achieve meaningful learning [9]. Students are given a challenging yet realistic task or project, and they are provided with sufficient support to complete it. In addition, teaching using PJBL encourages competencies that help the learner become independent, take responsibility, and develop confidence and enhances analytical and critical thinking skills. Therefore, this strategy provides opportunities to engage science students in the process of comprehensive laboratory report writing [10].

Although scientific writing is supposed to increase the depth of understanding among students as they practice writing about scientific experiments, studies indicate that looking at many laboratory reports appears superficial in which students rely on step-by-step procedures that direct them to predetermined results. These traditional laboratories do not provide an opportunity to practice some technical and writing skills, with little focus on communication and cooperation skills among students [11-13] pointed out that assessing extensive laboratory reports can be a time-consuming task, causing professors and teachers to decrease or remove the writing requirements in laboratory assignments as they struggle to manage the grading workload. Additionally, the conventional approach to laboratory report writing does not adequately equip students with the skills needed to write a scientific paper, which typically involves collaboration among learners and a peer-review process. Studies also indicated that traditional laboratory reports lack opportunities for students to fully understand the material, reason their experiences, and become proficient in scientific methods [14, 11].

To overcome students challenges in writing laboratory report, research indicated that students could improve their writing skills when they participate in project-based experiments with a reasonable timeframe. This helps them to carry out, analyse, and present findings which enhances their writing abilities, experimental proficiency, and social skills [3, 11].

Studies have indicated the effectiveness of PJBL in developing writing skills in English language classes [15, 16]. Using PJBL strategy has had a significant effect on the outcomes of learners and has enhanced their writing skills in a collaborative environment.

Other studies, such as [17], have confirmed that PJBL can be used to build scientific culture among students in science courses, improving their conceptual understanding and attitudes toward learning science. This is due to the use of real-world problem scenarios to encourage students and engage them in a collaborative work. This study also emphasized the positive impact of PJBL on building students' informational knowledge.

Researchers also studied the effectiveness of PJBL in enhancing different types of writing skills among foundation year students at the Universiti Malaysia Sarawak Foundation in Science program [11]. Data were collected through pre-post reports, practical sessions, and student observations. Students improved their writing skills, with average scores of 84.9% for practical and 84.4%, for scientific writing. The results also indicated that applying a chemistry PJBL learning contributes to the development of learners’ social skills. Therefore, this study recommended implementing group chemistry projects as one of the learning activities and practical methods for higher education students.

From this standpoint, this study seeks to answer the following main question: What is the effectiveness of the project-based learning strategy in developing laboratory report writing skills? The following sub-questions emerge from the main question:

What is the effectiveness of project-based learning in developing the skills of writing the introduction of laboratory reports?

What is the effectiveness of project-based learning in developing the skills of writing methods and procedures of laboratory reports?

What is the effectiveness of project-based learning in developing the skills of writing results and discussion?

2. Literature Review

2.1. Project-Based Learning (PJBL)

PBL can be defined as an educational model that prioritizes learner-centeredness through discovering scientific knowledge, asking authentic questions, and completing the required tasks to achieve the learning goals [18]. It is also known as learning cooperatively to solve the problems through applying constructivist learning theory [19]. PBL is a form of collaborative, research-based learning that characterized by engaging learners as they plan, implement, and evaluate a project, solve problems collaboratively, and compare learning outcomes to develop a product for a specific audience [20, 5].

Many studies have agreed on some distinctive characteristics of PJBL strategy, although there is no specific definition for this strategy. [21] emphasized that these characteristics include creating a classroom environment that supports collaborative learning to solve a challenging problem, using scientific inquiry to solve the questions posed, supporting project selection, critically evaluating each step, and reflecting on the final project before presenting it to the public. [22] summarized the most important features of project-based learning as follows:

1) The centrality of PJBL in the curricula rather than it being for enrichment only.
2) It focuses on questions that strengthen the basic scientific concepts.
3) Encourages construction of knowledge among learners.
4) Projects are based largely on the efforts and management of learners.
5) The projects are realistic and different from school projects.

In science learning [23] indicated that PJBL projects are grounded on key ideas including "active construction", "situated learning", "social interactions", and "cognitive tools" [24] discussed three stages to be followed during PJBL including implementation, planning and report writing. In the planning stage, the project topic is determined, questions are asked activities are pre-examined before scheduling of PJBL. [25] confirmed that PJBL is based on student-centered learning approach by engaging learners in group work to solve open-ended problems using five steps that include: analyzing the problem, defining goals, collecting resources, and summarizing ideas before reflecting on problem- solving experiences.

Studies such as [26] summarized three main phases each has sub-steps explaining the implementation of PBL. In the identification phase, the aim is to help students to recognize the problem. In the exploration phase a deeper understanding is developed by searching for information and generating possible solutions through collaborative discussions to choose the most suitable response and discuss it between groups and instructor. In the final phase, the agreed upon solution is determined, incorporating the knowledge gained during the process. Throughout the entire procedure, interaction between individuals, peers, and instructors is required.

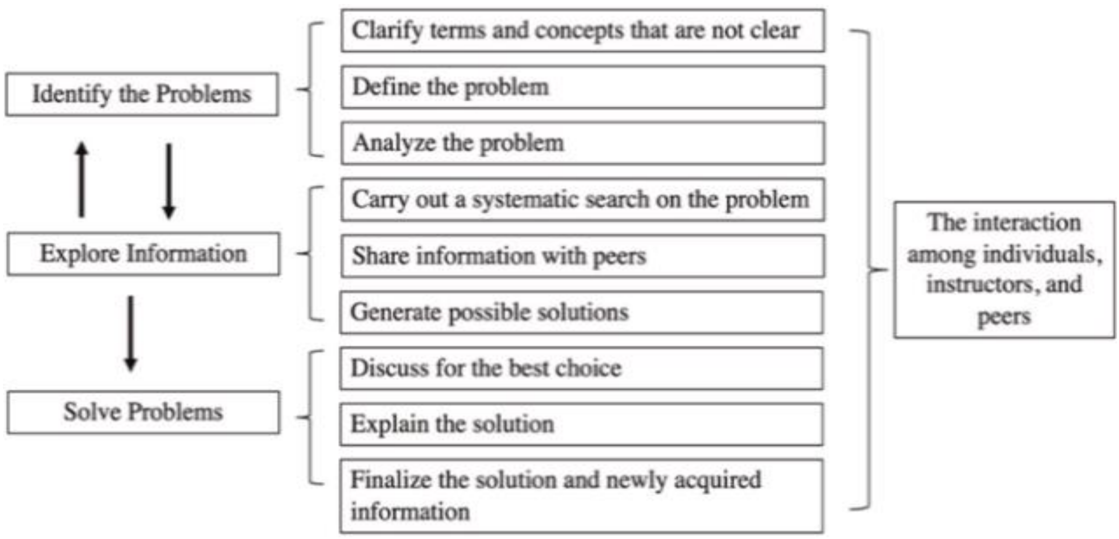

Figure 1. *Phases of PBL (Liu& Pásztor, 2022).*

Other researchers discussed the principles of PJBL, which include: 1) the active construction of real projects, 2) engaging learners through deep questions within real contexts, 3) actively engage learners in collaborative work, and 4) using cognitive tools [27].

Active construction involves the use of representations that derived from the process of knowledge construction (e.g., computational models), support students through stimulating their thinking during hands-on activities. The concept of active construction is rooted in the constructivist theory, which emphasizes that the effectiveness of students' learning is closely linked to their previous experiences and that previous knowledge plays an important role in assimilating new concepts. The learner links these concepts with their prior knowledge and reaches a stage of equilibration through cognitive conflict and problem solving. During the learning process, ideas and experiences must be shared. Scientific research is also important in the process of building knowledge of scientific phenomena.

The importance of cognitive tools lies in the fact that they help to gather ideas and information, encourage learners to design models that define the different roles, and expand the classroom discussion about scientific phenomena, their causes, and the factors influencing them. Throughout this process, the importance of cooperation and the exchange of ideas is emphasized within scientific practices, which involve discussions through the sharing of questions, offering scientific explanations with supporting evidence, and collecting data through scientific research.

2.2. Scientific Writing

Previous studies have confirmed that scientific writing plays a vital role in science education, particularly in developing metacognitive skills such as critical and analytical thinking, which contribute to achieving the goals of constructivist theory and meaningful learning [28].

Some studies have also highlighted the importance of certain types of scientific writing, especially those that enhance communication and scientific discourse in developing conceptual understanding of fundamental science concepts in school laboratories. This type of writing provides learners with opportunities to collect and document data while conducting experiments, allowing them to construct evidence-based interpretations while recording the scientific concepts related to the experiment's results [29].

The implementation of the Scientific Writing Heuristic (SWH) in writing a laboratory report is regarded as one of the most effective methods for involving students in inquiry-based scientific activities [30]. This approach encourages students to ask testable questions, design and conduct experiments, identify key findings in the collected data, provide evidence-based scientific explanations, and reflect on the inquiry learning process [31].

Based on educational contexts and the active participation in collaborative work among learners, three types of scientific writing have been developed [32, 33]. The first type, "writing to learn," focuses on using educational contexts to effectively apply scientific writing rather than concentrating on theoretical knowledge in specialized scientific fields. In "writing for learning," students discuss their knowledge of the subject using various activities, including deep debates and explaining supporting ideas of specific scientific writing, claims, and theories. In the third type, "writing to learn through learning to write," the two types are combined by applying scientific writing while studying related concepts.

Research also discussed the importance of writing laboratory reports that include peer review, where each pair or group is required to evaluate only one report [13]. Students gain value not only from receiving feedback on their own work but also from the process of critically reviewing the work of their peers. The use of peer review demonstrates how it can improve students' writing without taking up much time for the teacher. Additionally, peer review can increase task completion, enhance content discussion, encourage the use of appropriate scientific terminology, and provide students with a better understanding of how science operates in the real world.

3. Research Methodology

3.1. Study Approach

The study adopted a quasi-experimental method with a design involving control and experimental groups, along with pre- and post-tests. The content of laboratory reports submitted by students in both groups was analyzed. The experimental group was taught using PJBL strategy, while the students in the control group were taught traditionally. Subsequently, the laboratory reports submitted by both groups were analyzed.

3.2. Sample

The study population consisted of female students in the School Laboratory program at Al-Baha University, totaling 105 students. Given that the population is divided into teaching groups, two groups (experimental and control) were randomly selected, each consisting of 20 students.

3.3. Study Tool

A content analysis rubric was developed for evaluating the laboratory reports based on the criteria outlined in the School Laboratory program description. The rubric included 14 evaluative indicators that should be present in a clear, specific, and distinguished experimental report. These indicators were distributed as follows: 4 indicators for the introduction, 5 indicators for describing the method and procedures of the experiment, and 5 indicators for describing and discussing the results.

The scoring based on a three-tier criterion for the presence of the indicators (high, medium, low). An indicator received a "high" rating (3 points) if it was formulated comprehensively and fully met the requirements. A "medium" rating (2 points) was given if the formulation was good but had some shortcomings or did not fully meet the specified requirements. A "low" rating (1 point) was assigned if the indicator was poorly written and did not present the required data clearly. Thus, the total score on the card ranged from 14 to 42 points, and the mean scores ranged from 1 to 3. The level of proficiency in writing laboratory reports was assessed based on the following criteria:

High: mean score (2.34 - 3).

Moderate: mean score (1.67 - 2.33).

Low: mean score (1 - 1.66).

3.4. Validity

The content analysis rubric was presented to a panel of 8 experts in science education from Saudi universities. They provided feedback on the specified indicators, assessing their adequacy, comprehensiveness, and ability to ensure report quality. Any suggested modifications regarding wording, additions, or deletions were considered. A 75% agreement rate among the experts was required for modifications, as per Lawshe's criteria. After reviewing the experts' amendments, it was found that they agreed on the comprehensiveness and adequacy of the indicators, with some wording adjustments considered as evidence of content validity for the rubric.

3.5. Reliability

The reliability of the content analysis rubric was verified through agreement between analysts using Cooper's formula. The researcher and a colleague analyzed laboratory reports from a sample of four students (not included in the main study sample) and calculated the percentage of agreement between their analyses. The results are detailed below:

Table 1. *Reliability Analysis Using Cooper's Formula.*

Section	Indicators	Agree	Disagree	%	Reliability
Introduction	From general to specific	4	0	100%	1.00
	Contains the objectives of the experiment	4	0	100%	1.00
	Contains the importance of the experiment	3	1	75%	0.75
	Contains the questions of the experiment	3	1	75%	0.75
Reliability		14	2	87.5%	0.88
Method and Procedures	Provides a brief description of the methods and procedures	3	1	75%	0.75
	Includes all materials used in the experiment	4	0	100%	1.00
	Writes the steps of the experiment in sufficient details	3	1	75%	0.75
	Avoids details that prevent the reader from following the procedure	3	1	75%	0.75
	Avoids writing results prematurely	4	0	100%	1.00
Reliability		17	3	85%	0.85
Results and discussion	Presents all results in logical order according to the experiment steps	3	1	75%	0.75
	Includes necessary clarifications (tables, graphs, figures)	3	1	75%	0.75
	Links results to the objectives of the experiment	3	1	75%	0.75
	Conclusions are clear and based on the results of the experiment	3	1	75%	0.75
	Hypotheses are discussed, analyzed, addressed	4	0	100%	1.00
Reliability		16	4	80%	0.80
Overall		47	9	83.9%	0.84

Table 1 shows that the reliability coefficients of the indicators ranged between (0.75-1.00), while the reliability coefficients for the three dimensions ranged between (0.80-0.88). The overall reliability for the analysts' agreement was (0.84), which are acceptable coefficients and confirm the stability of the rubric.

3.6. Equivalence of the Groups

The content analysis rubric was utilized beforehand to correct the reports of both the control and experimental groups to ensure their equivalence in writing laboratory reports. The results were compared, and differences were calculated using the independent samples "t" test. The following table illustrates the results:

Table 2. T-test for groups' equivalence in the pre-test of laboratory report writing.

Variable	Group	M	SD	F	T-test	P
Introduction	Control	1.25	0.444	38	0.370	0.714
	Experimental	1.20	0.410			
Method and Procedures	Control	1.35	0.489	38	-1.265	0.214
	Experimental	1.55	0.510			
Results and discussion	Control	1.15	0.366	38	-0.406	0.687
	Experimental	1.20	0.410			
Overall	Control	1.25	0.388	38	-0.548	0.587
	Experimental	1.32	0.382			

Table 2 shows that T-values for the differences between the means of the control and experimental groups in the pre-test were not statistically significant in the three domains (introduction, methods and procedures, results and discussion) and in the overall score, as the significance levels were greater than (0.05). This shows that the two groups were equivalent in their pre-test laboratory report writing skills.

3.7. The Training Programs

A teaching program has been developed for the Lab Logs and Reports course for students in the School Laboratory Diploma. The program focuses on implementing the Project-Based Learning (PBL) strategy in writing lab reports. Students are divided into five collaborative groups, each consisting of four members. The main goal is to develop skills in writing lab reports, specifically in the areas of Introduction, Method and Procedures, and Results and Discussion.

The program spans 16 teaching hours over eight weeks, with two hours per week. It is structured in five phases. First, students are introduced to the project and plan the experiments for their reports. Three key chemistry topics are selected: acid-base reactions (measuring pH and determining acid/base concentration), testing strong and weak acids, and analyzing solution concentration through precipitation reactions. Second, students are trained on how to write scientifically, covering each section of the lab report—Introduction, method and procedures, and results and discussion. The fourth phase involves evaluating and discussing the lab reports submitted by each group, followed by feedback. Finally, students receive guidance on improving their reports before final submission. This program aims to provide students with the skills to write scientifically accurate lab reports while enhancing their understanding of experimental methods through the PBL approach.

4. Results

4.1. Effectiveness of PJBL in Writing Introduction of Laboratory Report

To examine the effectiveness of the PJBL strategy in developing laboratory report introduction writing skills, post-test scores for the control and experimental groups on writing laboratory report introductions were calculated. The mean scores were then compared using an Independent Samples T-test. The following Table 3 shows the results:

Table 3. *Post-test results in laboratory report introduction writing skills.*

Variable	Group	M	SD	F	T-Test	P-value
Methods	Control	1.55	0.510	38	-3.15	0.000
	Experimental	2.20	0.768			

**Statistically significant at the (0.01) level.

Table 3 shows a significant statistical difference between the average scores of the control and experimental groups in the introduction writing of laboratory reports (T=.-3.15, P= 0.003). The difference favors the experimental group, which had the higher mean score (M=2.20) in comparison to the control group (M=1.55). This suggests that the experimental group showed a moderate improvement in their ability to write introductions, with the mean score ranging from 1.67 to just below 2.34, which is close to a high level of performance. In contrast, the control group experienced only a slight improvement, increasing from a mean score of 1.25 in the pre-test to 1.55 in the post-test, remaining within the low level and just below the medium level.

Therefore, a statistically significant difference at the (0.01) level confirms the improvement of experimental group that was taught using the PJBL strategy. To assess the effect size of the teaching strategy on this difference as an indicator of effectiveness, the Eta Square (η^2) formula was used, as shown in the following Table 4.

Table 4. *Eta squared (η^2) of PJBL on laboratory report writing introduction skills.*

Independent	Tool	Dependent	T-value	F	η^2	Effect-Size
PJBL	Content rubric	Lab Introduction	-3.15	38	0.21	Large

Table 4 shows an effect size of (0.21), indicating a large effect since it exceeds the (0.14) which defined for significant effect size [34]. This implies that 21% of the overall variance in the skills required for writing laboratory report introductions can be attributed to the use of project-based learning strategies.

4.2. Effectiveness of PJBL in Writing Methods and Procedures of Laboratory Report

Table 5. *Post-test results in laboratory report methods and procedures writing skills.*

Variable	Group	M	SD	F	T-Test	P-value
Methods	Control	2.15	0.366	38	-4.13	0.000
	Experimental	2.70	0.470			

**Statistically significant at the (0.01) level.

To address this question, the means and standard deviations of the post-test scores for the methods and procedures of laboratory reports were calculated for both the control and experimental groups. The mean scores were then compared using an independent samples T-test. The results are presented in Table 5.

Table 5 indicates a statistically significant difference between the mean scores of the control and experimental groups in the writing laboratory report method and procedures (T= -4.13, P= 0.000). An analysis of the mean scores revealed a notable difference in favor of the experimental group, which achieved a higher mean score (M=2.70) at a high level, compared to the control group, which had a mean score of M=2.15, placing it at a medium level. This statistically significant difference at the (0.01) level confirms the positive impact of the project-based learning strategy on the experimental group's performance. To evaluate the effect size of the teaching strategy and its effectiveness, the Eta Square (η^2) formula was applied, with the results presented in the following Table 6.

Table 6. *Eta squared (η²) of PJBL on laboratory report writing method and procedure skills.*

Independent	Tool	Dependent	T-value	F	η^2	Effect size
PJBL	Content rubric	Method and Procedures	-4.13	38	0.31	Large

Table 6 shows that the effect size value is (0.31), which indicates a large effect size. This value suggests that approximately 31% of the total variance in laboratory report writing skills related to the method and procedures can be explained by the use of the PJBL strategy.

4.3. Effectiveness of PJBL in Writing Results and Discussions of Laboratory Report

To answer this question, the mean and standard deviation of the post-test scores for the results and discussion of the laboratory reports were calculated for both the control and experimental groups. An independent samples t-test was then used to compare the mean scores. The results are shown below in Table 7.

Table 7. *Post-test results in laboratory report results and discussions writing skills.*

Variable	Group	M	SD	F	T	P-value
Results discussion	Control	1.50	0.513	38	-4.40	0.000 **
	Experimental	2.05	0.224			

**Statistically significant at the (0.01) level.

The results in Table 7 show a statistically significant difference between the mean scores of the control and experimental groups in the writing and discussion results (T= -4.40, P= 0.000). The difference favors the experimental group with a higher mean score (M= 2.05) at a moderate level of improvement, compared to the control group, which scored a mean of only (M = 1.50) at a low level. This difference, found to be statistically significant at the 0.01 level, validates the positive effect of the project-based learning approach on the performance of the experimental group. To evaluate the effect size of the PJBL strategy on this difference, the Eta Squared (η²) formula was applied. The results are displayed in Table 8 below.

As shown in Table 8, the effect size value is (0.34), indicating a large effect. This indicates that 34% of the overall variation in results and discussion laboratory report writing skills can be explained by the use of the project-based learning strategy.

Table 8. *Eta squared (η²) of PJBL learning strategy on laboratory report writing result and discussion skills.*

Ind-pendent	Tool	Dep-ndent	T-value	F	η^2	Effect size
PJBL	Content rubric	Results discussion	-4.40	38	0.34	Large

4.4. Effectiveness of the PJBL in the Overall Writing Skills of Laboratory Report

The mean scores and standard deviations of the post-test scores for both the control and experimental groups were calculated using the laboratory report writing skills assessment. The means were compared using an Independent Samples T-Test. The results are presented in Table 9:

Table 9. *Post-test results in overall laboratory report writing skills.*

Variable	Group	M	SD	F	T	P-value
Overall Skills	Control	1.73	0.335	38	-5.84	0.000
	Experimental	2.32	0.296			

**Statistically significant at the 0.01 level.

Table 9 shows a statistically significant difference between the mean scores of the experimental and control groups on the overall laboratory report writing skills assessment, with a T-value of -5.84 and a significance level of 0.000, which is statistically significant at the 0.01 level. Overall, it is evident that the experimental group performed better, as their mean score was higher (M=2.32) while the control group obtained a mean score of only (M=1.73). This indicates that both groups showed improvement in their laboratory writing skills to a moderate level, with mean scores ranging from 1.67 to just below 2.34. However, the experimental group notably outperformed the control group, achieving mean scores at the higher end of the moderate proficiency level. To assess the magnitude of the effect of the strategy used, the Eta squared (η^2) formula was applied. The results are shown in the Table 10.

Table 10. *Eta squared (η^2) of PJBL on overall laboratory report writing skills.*

Independent	Tool	Dependent	T-value	F	η^2	Effect size
PJBL	Content rubric	Results discussion	-5.84	38	0.47	Large

Table 10 shows that the effect size (η^2) for overall laboratory report writing skills was 0.47, which indicates a large effect. This suggests that 47% of the total variance in laboratory report writing skills can be explained by the use of the PJBL strategy. This substantial effect size highlights the significant improvement in laboratory report writing skills, confirming the effectiveness of this educational strategy.

5. Discussion and Conclusion

The findings indicated that the experimental group, which was taught using the PJBL strategy, outperformed the control group in terms of overall laboratory report writing skills, as well as in each subskill (introduction, methods and procedures, and results and discussion). These outcomes can be attributed to several factors, with the most significant being the nature of the PJBL approach, which promotes active learning, encourages students to actively engage in the learning process, and facilitates a deeper understanding and integration of experiments. This hands-on approach helps students apply theoretical knowledge in practical settings, resulting in more focused, clearer, and more precise report writing. Moreover, working on group projects fosters collaboration, allowing students to exchange ideas and experiences, which in turn enhances their various skills, including writing. This is achieved through collaborative notes and feedback related to the experiments conducted within the group.

These findings align with the study by [35], which suggested that PJBL is an effective strategy for improving students' writing skills. PJBL allows students to refine their ideas, compose well-structured texts, and construct grammatically correct sentences. It also encourages critical thinking and the exchange and development of ideas with peers.

Additionally, the informational aspects of the PJBL strategy contribute to its effectiveness in improving laboratory report writing skills. By encouraging students to research and organize information efficiently, PJBL enhances their ability to produce accurate and detailed scientific reports. Furthermore, PJBL is inherently motivational, increasing students' enthusiasm for deeper learning and sparking their interest in scientific subjects. This aligns with the work of [36], who noted that PBL is an effective method for enhancing writing skills, as it equips students with a range of skills that directly influence the quality of their scientific writing. These include information gathering, conceptual knowledge acquisition, problem-solving, peer collaboration, and the practical application of knowledge—all of which significantly improve students' writing abilities and form the foundation for developing specialized writing skills for laboratory reports.

Moreover, the PJBL strategy is specifically tailored to address students' needs and the challenges they face when writing laboratory reports. This focus on student needs is one of the key strengths of this strategy, as the PJBL projects are designed to be closely aligned with students' learning needs, deepening their understanding of the targeted skills and providing opportunities for practice. Students are given the autonomy to take the lead in the learning process, within a supportive environment that encourages creative and critical thinking, the application of practical skills, learning from others, and exchanging ideas. This has contributed to improvements in students' vocabulary, writing skills, and overall performance in laboratory report writing.

These results are consistent with findings from other studies [3, 11] which also emphasize the importance of PJBL in enhancing laboratory report writing skills. These studies supported the effectiveness of PJBL in improving students' ability not only deepens students' scientific knowledge but also fosters better opportunities for interaction and scientific thinking during the collaborative writing process. Further research should focus on investigating the practices of open-inquiry laboratory tasks such as PJBL projects to write science laboratory reports. In these projects, science students take on the responsibility of exploring the processes involved in designing and conducting experiments, and subsequently write laboratory reports based on the data they collect and write their own explanations. This enables them to conduct, analyze, and present results, which improves their writing skills, experimental expertise, and social abilities.

Abbreviations

PJBL	Project Based Learning

Author Contributions

Saeed Almuntasheri is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares no conflicts of interest.

References

[1] Watts, F. M., Spencer, J. L., & Shultz, G. V. (2020). Writing assignments to support the learning goals of a CURE. Journal of Chemical Education, 98(2), 510-514. https://doi.org/10.1021/acs.jchemed.0c00915

[2] McWhorter, K. T. (2012). Successful college writing: skills-strategies-learning styles. Macmillan.

[3] Gustiani, S., Simanjuntak, T., & Agustinasari, E. (2021, January). The Effectiveness of Project Based Learning to Improve Students' Report Writing. In 4th Forum in Research, Science, and Technology (FIRST-T3-20) (pp. 21-25). Atlantis Press. https://doi.org/10.2991/ahsseh.k.210122.005

[4] Bell, S. (2010). Project-Based Learning for the 21st Century: Skills for the Future. The Clearing House: A Journal of Ed ucational Strategies, Issues and Ideas, 83(2), 39–43. https://doi.org/10.1080/00098650903505415

[5] Kokotsaki, D., Menzies, V., & Wiggins, A. (2016). Project-based learning: A review of the literatu re. Improving schools, 19(3), 267-277. https://doi.org/abs/10.1177/1365480216659733

[6] Almulla, M. A. (2020). The effectiveness of the pro ject-based learning (PBL) approach as a way to engage students in learning. Sage Open, 10(3), 2158244020938702. https://doi.org/10.1177/2158244020938702

[7] Kavanagh S. S., Rainey E. (2017). Learning to support adolescent literacy: Teacher educator pedagogy and novice teacher take up in secondary English language arts teacher preparation. American Educational Research Journal, 54(5), 904–937. https://doi.org/10.3102/0002831217710423

[8] Reisman, A., Kavanagh, S. S., Monte-Sano, C., Fogo, B., McGrew, S. C., Cipparone, P., & Simmons, E. (2018). Facilitating whole-class discussions in history: A framework for preparing teacher candidates. Journal of Teacher Edu cation, 69(3), 278-293. https://doi.org/10.1177/0022487117707463

[9] Habulembe, S. H. (2007). A Classroom Response to HIV/AIDS--Project Proposal Writing. In English Teaching Forum (Vol. 45, No. 1, pp. 36-42). US Department of State. Bureau of Educational and Cultural Affairs, Office of English Language Programs, SA-5. https://doi.org/10.1111/joes.12345

[10] Baş, G. (2011). Investigating the effects of project-based learning on students' academic achievement and attitudes towards English lesson. The online journal of New Horizons in Education, 1(4).

[11] Yusof, WR Wan, Melody Kimi, W. S. H. W. Zullkiplee, Mohd Alhafiizh Zailani, Mardhiah Shahabudin, Abdul Al-Hafiz Ismail, S. M. A. A. Abdullah, Iswan Nur Ariff Ismail, and Dhana Jay Raja Gopal. "Assessment of Practical and Scientific Writing Skills for Pre-University Students through Project-Based Learning. Journal of Chemical Education 99, no. 2 (2022): 715-722. https://doi.org/10.1021/acs.jchemed.1c00843

[12] Hancock, L. M., & Hollamby, M. J. (2020). Assessing the practical skills of undergraduates: the evolution of a station-based practical exam. Journal of Chemical Education, 97(4), 972-979. https://doi.org/10.1021/acs.jchemed.9b00733

[13] Brigati, J. R., & Swann, J. M. (2015). Facilitating improvements in laboratory report writing skills with less grading: a laboratory report peer-review process. Journal of Microbiology & Biology Education, 16(1), 61-68. https://doi.org/10.1128/jmbe.v16i1.884

[14] Hosbein, K. N., Alvarez-Bell, R., Callis-Duehl, K. L., Sampson, V., Wolf, S. F., & Walker, J. P. (2020). Development of the investigation design, explanation, and argument assessment for general chemistry laboratory. Journal of Chemical Education, 98(2), 293-306. https://doi.org/10.1021/acs.jchemed.0c01075

[15] Aghayani, B., & Hajmohammadi, E. (2019). Project-based learning: Promoting EFL learners' writing skills. LLT Journal: A Journal on Language and Language Teaching, 22(1), 78- 85 https://doi.org/10.24071/llt.2019.220108

[16] Susana, T., & Efendi, A. (2020, August). The Improvement of Short Story Reading and Writing Skill through Project-Based Learning. In 1st International Conference on Language, Literature, and Arts Education (ICLLAE 2019) (pp. 148-152). Atlantis Press.

[17] Juleha, S., Nugraha, I., & Feranie, S. (2019). The Effect of Project in Problem-Based Learning on Students' Scientific and Information Literacy in Learning Human Excretory System. Journal of Science Learning, 2(2), 33-41. https://doi.org/10.17509/jsl.v2i2.12840

[18] Parwati, N. W., Suarni, N. K., Suastra, I. W., & Adnyana, P. B. (2019, October). The effect of project based learning and authentic assessment on students' natural science learning outcome by con trolling critical thinking skill. In Journal of Physics: Conference Series (Vol. 1318, No. 1, p. 012096). IOP Publishing. https://doi.org/10.1088/1742-6596/1318/1/012096

[19] Grant, M. M. (2011). Learning, beliefs, and products: Students' perspectives with project-based learn ing. Interdisciplinary Journal of Problem-Based Learning, 5(2), 6. https://doi.org/10.7771/1541-5015.1254

[20] Loyens S. M., Jones S. H., Mikkers J., van Gog T. (2015). Problem-based learning as a facilitator of conceptual change. Learning and Instruction, 38, 34– 42. http://dx.doi.org/10.1016/j.learninstruc.2015.03.002.

[21] Grossman, P., Dean, C. G. P., Kavanagh, S. S., & Herrmann, Z. (2019). Preparing teachers for project- based teaching. Phi Delta Kappan, 100(7), 43-48. https://doi.org/10.1177/0031721719841338.

[22] Thomas, J. W. (2000). A review of research on project-based learning. San Rafael, CA: Autodesk Foundation Available http://www.bie.org/object/document/a_ review of research on project based-learning

[23] Krajcik, J. S., & Shin, N. (2014). Project-based learn ing. In R. K. Sawyer (Ed.), The Cambridge Hand book of the Learning Sciences (2nd ed., pp. 275– 297). Cambridge University Press. https://doi.org/10.1017/CBO9781139519526.018

[24] Stoller, F. (2006). Establishing a theoretical foundation for project-based learning in second and foreign language contexts. Project-based second and foreign language education: Past, present, and future, 19-40.

[25] Lin, C. F., Lu, M. S., Chung, C. C., & Yang, C. M. (2010). A comparison of problem-based learning and conventional teaching in nursing ethics education. Nursing Ethics, 17(3), 373–382. https://doi.org/10.1177/0969733009355380

[26] Liu, Y., & Pásztor, A. (2022). Effects of problem-based learning instructional intervention on critical thinking in higher education: A meta-analysis. Thinking Skills and Creativity, 45, 101069. https://doi.org/10.1016/j.tsc.2022.101069

[27] Shin, N., Bowers, J., Krajcik, J., & Damelin, D. (2021). Promoting computational thinking through project-based learning. Disciplinary and Interdisciplinary Science Education Research, 3, 1-15. https://doi.org/10.1186/s43031-021-00033-y

[28] Leinonen, T., Keune, A., Veermans, K., & Toikkanen, T. (2016). Mobile apps for reflection in learning: A design research in K-12 education. British Journal of Educational Technology, 47(1), 184–202. https://doi.org/10.1111/bjet.12224

[29] Jang, J. Y., & Hand, B. (2017). Examining the value of a scaffolded critique framework to promote argumentative and explanatory writings within an argument-based inquiry approach. Research in Science Education, 47(6), 1213–1231. https://doi.org/10.1007/s11165-016-9542-x

[30] Stephenson, N. S., & Sadler-McKnight, N. P. (2016). Developing critical thinking skills using the science writing heuristic in the chemistry laboratory. Chemistry Education Research and Practice, 17(1), 72–79. https://doi.org/10.1039/C5RP00102A

[31] Choi, A., Hand, B., & Greenbowe, T. (2013). Students' written arguments in general chemistry laboratory investigations. Research in Science Education, 43(5), 1763–1783. https://doi.org/10.1007/s11165-012-9330-1

[32] Chen, Y. C. (2019). Writing as an Epistemological Tool: Perspectives from Personal, Disciplinary, and Soci ocultural Landscapes. In Contemporary Trends and Issues in Science Education (pp. 115- 132). (Con temporary Trends and Issues in Science Education; Vol. 49). Springer Science and Business Media B. V. https://doi.org/10.1007/978-3-030-24013-4_8

[33] Sampson, V., Enderle, P., Grooms, J., & Witte, S. (2013). Writing to learn by learning to write during the school science laboratory: Helping middle and high school students develop argumentative writing skills as they learn core ideas. Science Education, 97(5), 643-670. https://doi.org/10.1002/sce.21069

[34] Cohen, J. 1988. Statistical Power Analysis for the Behavioral Sciences. 2nd edition. New York: Academic Press.

[35] Nurhajati, D. (2016). Project-based learning used to develop supplementary materials for writing skill. The Asian EFL Journal Professional Teaching Articles, 2, 51-56.

[36] Lu, Q. (2021). A New Project-Based Learning in English Writing. International journal of emerging technologies in learning, 15(5). 214-227. https://doi.org/10.3991/ijet.v16i05.21271

Biography

Saeed Almuntasheri is a sociate professor at Al-baha University, Science education Department. He completed his PhD in science education from University of Queensland- Australia in 2015, and his Master of science education teaching methods from Um-AlQura university - Saudi Arabia in 2008. Currently he is working as a lecturer at Al-baha university and supervision of master students.

Research Field

Saeed Almuntasheri: Professional development in teaching and learning science, formative assessment in science teaching, teaching strategies of science.