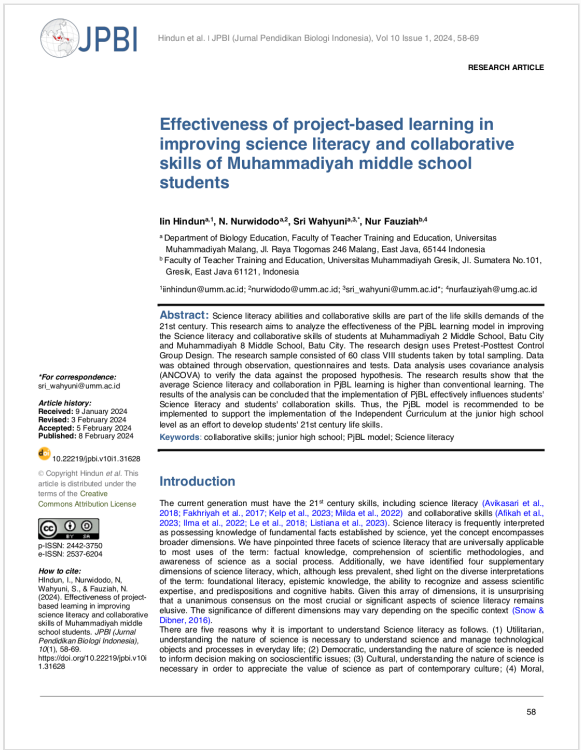
Digital Receipt

This receipt acknowledges that Turnitin received your paper. Below you will find the receipt information regarding your submission.

The first page of your submissions is displayed below.

Submission author:	Artikel 3
Assignment title:	Nurwidodo 1
Submission title:	Effectiveness of project-based learning in improving science...
File name:	do_Wahyuni_Fauziah_-_Effectiveness_of_project-based_learn...
File size:	365.73K
Page count:	12
Word count:	7,910
Character count:	45,240
Submission date:	24-Sep-2024 06:07AM (UTC+0700)
Submission ID:	2463460401



JPBI Hindun et al. / JPBI (Jurnal Pendidikan Biologi Indonesia), Vol 10 Issue 1, 2024, 58-69

RESEARCH ARTICLE

Effectiveness of project-based learning in improving science literacy and collaborative skills of Muhammadiyah middle school students

Iin Hindun[a,1], N. Nurwidodo[a,2], Sri Wahyuni[a,3,*], Nur Fauziah[b,4]

[a] Department of Biology Education, Faculty of Teacher Training and Education, Universitas Muhammadiyah Malang, Jl. Raya Tlogomas 246 Malang, East Java, 65144 Indonesia
[b] Faculty of Teacher Training and Education, Universitas Muhammadiyah Gresik, Jl. Sumatera No.101, Gresik, East Java 61121, Indonesia

[1]iinhindun@umm.ac.id; [2]nurwidodo@umm.ac.id; [3]sri_wahyuni@umm.ac.id*; [4]nurfauziyah@umg.ac.id

Abstract: Science literacy abilities and collaborative skills are part of the life skills demands of the 21st century. This research aims to analyze the effectiveness of the PjBL learning model in improving the Science literacy and collaborative skills of students at Muhammadiyah 2 Middle School, Batu City and Muhammadiyah 8 Middle School, Batu City. The research design uses Pretest-Posttest Control Group Design. The research sample consisted of 60 class VIII students taken by total sampling. Data was obtained through observation, questionnaires and tests. Data analysis uses covariance analysis (ANCOVA) to verify the data against the proposed hypothesis. The research results show that the average Science literacy and collaboration in PjBL learning is higher than conventional learning. The results of the analysis can be concluded that the implementation of PjBL effectively influences students' Science literacy and students' collaboration skills. Thus, the PjBL model is recommended to be implemented to support the implementation of the Independent Curriculum at the junior high school level as an effort to develop students' 21st century life skills.

Keywords: collaborative skills; junior high school; PjBL model; Science literacy

***For correspondence:** sri_wahyuni@umm.ac.id

Article history:
Received: 9 January 2024
Revised: 3 February 2024
Accepted: 5 February 2024
Published: 8 February 2024

10.22219/jpbi.v10i1.31628

p-ISSN: 2442-3750
e-ISSN: 2537-6204

How to cite:
Hindun, I., Nurwidodo, N., Wahyuni, S., & Fauziah, N. (2024). Effectiveness of project-based learning in improving science literacy and collaborative skills of Muhammadiyah middle school students. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *10*(1), 58-69. https://doi.org/10.22219/jpbi.v10i1.31628

Introduction

The current generation must have the 21st century skills, including science literacy (Avikasari et al., 2018; Fakhriyah et al., 2017; Kelp et al., 2023; Milda et al., 2022) and collaborative skills (Afikah et al., 2023; Ilma et al., 2022; Le et al., 2018; Listiana et al., 2023). Science literacy is frequently interpreted as possessing knowledge of fundamental facts established by science, yet the concept encompasses broader dimensions. We have pinpointed three facets of science literacy that are universally applicable to most uses of the term: factual knowledge, comprehension of scientific methodologies, and awareness of science as a social process. Additionally, we have identified four supplementary dimensions of science literacy, which, although less prevalent, shed light on the diverse interpretations of the term: foundational literacy, epistemic knowledge, the ability to recognize and assess scientific expertise, and predispositions and cognitive habits. Given this array of dimensions, it is unsurprising that a unanimous consensus on the most crucial or significant aspects of science literacy remains elusive. The significance of different dimensions may vary depending on the specific context (Snow & Dibner, 2016).

There are five reasons why it is important to understand Science literacy as follows. (1) Utilitarian, understanding the nature of science is necessary to understand science and manage technological objects and processes in everyday life; (2) Democratic, understanding the nature of science is needed to inform decision making on socioscientific issues; (3) Cultural, understanding the nature of science is necessary in order to appreciate the value of science as part of contemporary culture; (4) Moral,

Artikel 3

Eff ectiveness of project-based learning in improving science literacy and collaborative skills of Muhammadiyah middle sch...

Nurwidodo 1
Kepangkatan Dosen
University of Muhammadiyah Malang

Document Details

Submission ID
trn:oid:::1:3018328367

Submission Date
Sep 24, 2024, 6:07 AM GMT+7

Download Date
Sep 24, 2024, 6:18 AM GMT+7

File Name
do_Wahyuni_Fauziah_-_Effectiveness_of_project-based_learning.pdf

File Size
365.7 KB

12 Pages

7,910 Words

45,240 Characters

15% Overall Similarity

The combined total of all matches, including overlapping sources, for each database.

Filtered from the Report

- Bibliography
- Quoted Text

Exclusions

- 6 Excluded Sources

Match Groups

33 Not Cited or Quoted 11%
Matches with neither in-text citation nor quotation marks

6 Missing Quotations 2%
Matches that are still very similar to source material

0 Missing Citation 0%
Matches that have quotation marks, but no in-text citation

0 Cited and Quoted 0%
Matches with in-text citation present, but no quotation marks

Top Sources

12% Internet sources
9% Publications
8% Submitted works (Student Papers)

Integrity Flags

0 Integrity Flags for Review

No suspicious text manipulations found.

Our system's algorithms look deeply at a document for any inconsistencies that would set it apart from a normal submission. If we notice something strange, we flag it for you to review.

A Flag is not necessarily an indicator of a problem. However, we'd recommend you focus your attention there for further review.

Match Groups

- **33** Not Cited or Quoted 11%
  Matches with neither in-text citation nor quotation marks
- **6** Missing Quotations 2%
  Matches that are still very similar to source material
- **0** Missing Citation 0%
  Matches that have quotation marks, but no in-text citation
- **0** Cited and Quoted 0%
  Matches with in-text citation present, but no quotation marks

Top Sources

12% Internet sources
9% Publications
8% Submitted works (Student Papers)

Top Sources

The sources with the highest number of matches within the submission. Overlapping sources will not be displayed.

1	Student papers	
Universitas Borneo Tarakan		2%
2	Internet	
ijere.iaescore.com		2%
3	Internet	
eprints.umm.ac.id		2%
4	Student papers	
Universitas PGRI Semarang		2%
5	Internet	
pustaka-psm.unilak.ac.id		2%
6	Student papers	
Academic Library Consortium		1%
7	Student papers	
University of Chichester		1%
8	Publication	
Silfia Ilma, Mimien Henie Irawati Al Muhdhar, Fatchur Rohman, Murni Sapta Sari. ...		1%
9	Internet	
injotel.org		1%
10	Internet	
jppipa.unram.ac.id		1%

11 Internet

dergipark.org.tr 1%

12 Internet

nicsforschoolleaders.tpdatscalecoalition.org 1%

RESEARCH ARTICLE

Effectiveness of project-based learning in improving science literacy and collaborative skills of Muhammadiyah middle school students

Iin Hindun[a,1], N. Nurwidodo[a,2], Sri Wahyuni[a,3,*], Nur Fauziah[b,4]

[a] Department of Biology Education, Faculty of Teacher Training and Education, Universitas Muhammadiyah Malang, Jl. Raya Tlogomas 246 Malang, East Java, 65144 Indonesia

[b] Faculty of Teacher Training and Education, Universitas Muhammadiyah Gresik, Jl. Sumatera No.101, Gresik, East Java 61121, Indonesia

[1]iinhindun@umm.ac.id; [2]nurwidodo@umm.ac.id; [3]sri_wahyuni@umm.ac.id*; [4]nurfauziyah@umg.ac.id

Abstract: Science literacy abilities and collaborative skills are part of the life skills demands of the 21st century. This research aims to analyze the effectiveness of the PjBL learning model in improving the Science literacy and collaborative skills of students at Muhammadiyah 2 Middle School, Batu City and Muhammadiyah 8 Middle School, Batu City. The research design uses Pretest-Posttest Control Group Design. The research sample consisted of 60 class VIII students taken by total sampling. Data was obtained through observation, questionnaires and tests. Data analysis uses covariance analysis (ANCOVA) to verify the data against the proposed hypothesis. The research results show that the average Science literacy and collaboration in PjBL learning is higher than conventional learning. The results of the analysis can be concluded that the implementation of PjBL effectively influences students' Science literacy and students' collaboration skills. Thus, the PjBL model is recommended to be implemented to support the implementation of the Independent Curriculum at the junior high school level as an effort to develop students' 21st century life skills.

Keywords: collaborative skills; junior high school; PjBL model; Science literacy

For correspondence:
sri_wahyuni@umm.ac.id

Article history:
Received: 9 January 2024
Revised: 3 February 2024
Accepted: 5 February 2024
Published: 8 February 2024

10.22219/jpbi.v10i1.31628

p-ISSN: 2442-3750
e-ISSN: 2537-6204

How to cite:
HIndun, I., Nurwidodo, N, Wahyuni, S., & Fauziah, N. (2024). Effectiveness of project-based learning in improving science literacy and collaborative skills of Muhammadiyah middle school students. *JPBI (Jurnal Pendidikan Biologi Indonesia), 10*(1), 58-69.
https://doi.org/10.22219/jpbi.v10i1.31628

Introduction

The current generation must have the 21st century skills, including science literacy (Avikasari et al., 2018; Fakhriyah et al., 2017; Kelp et al., 2023; Milda et al., 2022) and collaborative skills (Afikah et al., 2023; Ilma et al., 2022; Le et al., 2018; Listiana et al., 2023). Science literacy is frequently interpreted as possessing knowledge of fundamental facts established by science, yet the concept encompasses broader dimensions. We have pinpointed three facets of science literacy that are universally applicable to most uses of the term: factual knowledge, comprehension of scientific methodologies, and awareness of science as a social process. Additionally, we have identified four supplementary dimensions of science literacy, which, although less prevalent, shed light on the diverse interpretations of the term: foundational literacy, epistemic knowledge, the ability to recognize and assess scientific expertise, and predispositions and cognitive habits. Given this array of dimensions, it is unsurprising that a unanimous consensus on the most crucial or significant aspects of science literacy remains elusive. The significance of different dimensions may vary depending on the specific context (Snow & Dibner, 2016).

There are five reasons why it is important to understand Science literacy as follows. (1) Utilitarian, understanding the nature of science is necessary to understand science and manage technological objects and processes in everyday life; (2) Democratic, understanding the nature of science is needed to inform decision making on socioscientific issues; (3) Cultural, understanding the nature of science is necessary in order to appreciate the value of science as part of contemporary culture; (4) Moral,

understanding the nature of science helps develop an understanding of the norms of the Science community which embodies moral commitments about general values in society; (5) Science learning: understanding the nature of science is used to facilitate understanding of material in science learning (Driver & Erickson, 1983).

Indonesian students' Science literacy is still relatively low. The Science literacy abilities of Indonesian students can be seen from survey achievements in the Program for International Student Assessment (PISA). In 2022, Indonesia's ranking will increase compared to the previous year, but the score obtained will decrease. The PISA 2022 score is among the lowest, especially in science literacy with a score of 383. Indonesia is ranked 67th out of 81 participating countries (OECD, 2023).

On the other hand, collaborative skills are the ability to participate in any activity to build relationships with other people, respect mutual relationships and teamwork to achieve the same goal. Ability to interact by appreciating differences, participating in discussions, providing suggestions, listening and supporting others (Scager et al., 2016). Indicators that show collaborative skills are contributing actively, working productively, showing flexibility and compromise, showing responsibility, and showing an attitude of respect (Greenstein, 2012).

It is known that the level of performance of collaborative skills at various levels of education in Indonesia is still low. In general, junior secondary education in Indonesia does not pay attention to the development of communication and collaborative skills. The results of the study show that the spread of gadgets and social media over the last decade has encouraged people to behave introverted, antisocial and have difficulty interacting with the real world (Priyambodo et al., 2023; Sufianti et al., 2024). This situation contributes to the low level of student collaboration. In one study of biology students at Riau Islamic University, it was stated that students' collaborative skills generally showed at a sufficient level, which means they were not able to collaborate well (Hidayati, 2019; Nurwidodo et al., 2023).

The results of a preliminary study on collaborative skills show that students' collaborative skills obtained low results. Meanwhile, in another study, collaborative skills were found to be a descriptor of productive work at 15%. Students sometimes work together, but not all members contribute to group work so it is difficult to complete the work. 25% indicate that group members work together well and focus on certain parts in completing his task (Anantyarta & Sari, 2017). The results of this study also show collaborative skills (65.4), lower than collaborative knowledge (70.33). Students have good collaborative knowledge, but collaborative skills or practices still need to be improved. In biology learning, students are not used to demonstrating optimal collaboration skills. As research has been conducted by Hayat et al (2019) that the student's lifelong learning profile is still quite low, especially for effective communication standards, namely only getting a score of 2.89 out of a total score of 4.00.

Students' collaborative skills are low because so far learning has tended to use lecture methods, teacher centered learning, conventional methods, and has not made much effort to explore students' collaborative skills. Collaborative skills as the ability to solve problems in new ways still receive less attention (Keiler, 2018; Kim et al., 2019; Vaughn, 2020). In fact, for a long time, the push to develop collaborative learning has been recommended by many researchers because it is seen as being able to develop higher order thinking, oral communication, self-management and leadership skills (Darling-Hammond et al., 2020; Lopes et al., 2018; van Laar et al., 2020).

Science literacy and collaborative skills are very necessary and are the key to overcoming increasingly complex Science problems and the demands of the 21st century life. It is necessary to implement an appropriate learning model, which is able to develop these two aspects. Project-based learning (PjBL) is a learning model that is thought to be capable, because it uses constructivist principles. In this learning, students actively participate in learning, where students are required to work collaboratively to solve problems, then discuss and reflect on what they have learned (Duke et al., 2020; Loyens et al., 2023; Marnewick, 2023; Şahin & Kiliç, 2023; Sukackė et al., 2022). Project-based learning is a systematic learning model where the main focus is learning through projects, which are monitored and guided by the teacher; and involving students in in-depth investigations to build knowledge, and supported by methods and technology that help students complete assignments independently (Duke et al., 2020; Rahmawati et al., 2020; Rehman et al., 2023; Zhang & Ma, 2023).

Various implementations of PjBL in junior high school learning have been carried out, both in the Indonesian and global contexts. There is research focused on how teachers implement projects (Markula & Aksela, 2022), teach speaking a spoken advertisement (Humairoh & Purwati, 2014), teachers' perception (Sartika et al., 2022), gadget play duration survey (Sitio et al., 2023), EFL classroom (Wijayanti & Budi, 2023), language learning (Ukah et al., 2023), teaching speaking to young learners (Widiyati & Pangesti, 2022), PjBL in in robotics meets (Zadok, 2020), music learning (Banua et al., 2023; Nugroho & Dewi, 2022), and management of project-based learning model at Sekolah Alam (Ahmad, 2021). In terms of abilities or competencies of junior high school students, PjBL research is focused on creative thinking skills (Biazus & Mahtari, 2022), critical thinking skills (Wibowo et al., 2018) and cooperative skills (Indriyana & Susilowati, 2020), students' engagement and speaking competence (Bunyamin, 2022), communication skills (Pratiwi et al., 2020), and collaboration, creativity, and computational thinking (Alkautsar et al., 2023). Several studies generally try to combine OIDDE-PjBL to

develop problem-solving skills and product creativity for environmental student teacher candidates (Husamah & Rahardjanto, 2018), Blended-PjBL for problem-solving skills and learning outcomes of prospective teacher students (Yayuk & Husamah, 2019), Hybrid-PjBL to look at learning outcomes, creative thinking skills, and learning motivation of preservice teachers (Rahardjanto et al., 2019), STAD-PjBL to develop motivation, thinking skills, and learning outcomes of biology department students (Husamah & Pantiwati, 2014), and STAD-PjBL to increase product creativity for prospective biology teacher students (Hindun & Husamah, 2019).

It can be said that there is still very little research focused on implementing PjBL to develop Science literacy, develop collaboration skills, let alone combine the two. Therefore, the aim of the research is to analyze the effectiveness of the PjBL learning model to improve the Science literacy and collaborative skills of Muhammadiyah Middle School students in Batu City. The research is expected to contribute theoretically and practically to the need to implement PjBL in Muhammadiyah schools, especially at the junior high school level in an effort to prepare students to be able to live and compete in the 21st century.

Method

This research is a quasi-experiment, with a Pretest-Posttest Non-equivalent Control Group Design. Sample determination was carried out by total sampling to determine research subjects. The learning model applied is project-based learning with the syntax as in Table 1 (adapted by Suradika et al., 2023).

Table 1. Syntax of the PjBL Model

No	Stages	Learning activity	
		Lecturer	Students
1.	*Start With the Essential Question*	Introduce the topic, examine relevant issues, and ask essential questions	Convey opinions, ideas and formulate essential problems
2.	*Design a Plan for the Project*	Directing students to work collaboratively to solve problems through project work	Students plan projects, choose activities, determine tools and materials to complete the project
3.	*Create a Schedule*	Guiding students in preparing activity schedules in completing projects	Create a schedule for completing the project, timeline, choose the method or way of completing the project
4.	*Monitor the Students and the Progress of the Project*	Monitor student project work, provide resources and guidance, prepare rubrics to record all important activities	Work collaboratively to complete project work, carry out exploration and investigation by utilizing various learning sources, and create products (artefacts) resulting from the project
5	*Assess the Outcome*	Assessing the achievement of student project work, evaluating learning progress, and providing feedback	Each group presents the results of project work, written reports, and products (artefacts) resulting from project work
6	*Evaluate the Experience*	Guiding students to reflect on the activities and results of projects that have been carried out	Reflect yourself by making a reflective journal on a series of project tasks carried out

The instruments used include: 1) observation sheets, to observe the implementation of semester learning plans in the learning process, 2) tests, used to obtain data on learning outcomes for critical thinking, communication and collaboration skills. The dependent variable instruments in this research are the Science Literacy understanding test instrument and the collaborative skills scoring rubric. Data on understanding Science Literacy is collected using questionnaires or test instruments. Science Literacy understanding questionnaire adapted from Lederman et al (2002). There are seven aspects of Science Literacy measured in this research, namely: science is tentative (can change), empirically based, subjective, is the result of inference, imagination and human creativity, is embedded socio-culturally, the difference between observation and inference, the relationship between theory and Science law. Specification tables, questionnaires and Science literacy assessment rubrics. Students' Science literacy is divided into five categories, namely: excellent, good, sufficient, less and poor.

The collaborative skills assessment instrument was developed from Greenstein (2012) with measurement variables including working productively, showing respect, compromise, and responsibility. This research instrument is in the form of a questionnaire which is structured as a closed questionnaire, namely a questionnaire that has provided alternative answers so that respondents just have to choose. This will make it easier for respondents to answer. The questionnaire is guided by the indicators of the research variables which are described in several questions. All the questions in the

questionnaire are objective questions so that the respondent just has to put a check mark (√) on one of the alternative answers which is considered most appropriate to the situation. This questionnaire provides four alternative answers. Each question item is given its own score, namely: score for the answer Very Good = 4, Good = 3, Fair = 2, Poor = 1.

Quantitative data were analyzed using inferential analysis to determine the significance of differences between the control and treatment classes. The proposed hypothesis was tested using ANACOVA with the independent variable PjBL learning model. Meanwhile, the dependent variable is Science literacy skills, collaborative skills.

Results and Discussion

Science Literacy

The pretest and posttest results of the effectiveness of the PjBL and conventional learning models on science literacy are seen in Table 2.

Table 2. Mean Pretest Posttest Science Literacy Scores

No	Variable	Pretest	Posttest
1	PjBL	58.41	77.78
2	Conventional	57.14	66.01

The results of the Anakova test on the Science Literacy variable show that the learning model has a significance value of 0.000, smaller than alpha 0.05 (p<α). The research hypothesis is accepted, meaning that there is an influence of the PjBL learning model on students' understanding of science literacy. A summary of ANACOVA results on the variable understanding of Science Literacy is presented in Table 3.

Table 3. Results of ANACOVA Variables Understanding Science Literacy

Source	Sum ofSquare	Df	Mean Square	F	Sign
Corrected Model	7150.868	6	1191.811	10.282	0.000
Intercept	15867.985	1	15867.985	136.903	0.000
Science Literacy	269.181	1	269.181	2.322	0.131
Learning model	6126.142	2	3063.071	26.427	0.000
Error	10547.545	91	115.907		
Total	581519.274	98			
Corrected Total	17698.413	97			

R squared= 0.404 (Adjusted R Squared= 0.365)

The ANACOVA results for the learning model show significant results, namely that there is an influence of the model on students' understanding of Science Literacy. The analysis was continued with the LSD test at a significance level of 0.05 to determine the corrected mean differences in each learning model. The results of this test can be seen in Table 4.

The LSD test results show that there are differences in the average corrected scores of students' Science literacy in each learning model. The corrected mean of the PjBL model compared to conventional (65.479). The difference in notation between the two learning models can be interpreted as meaning that the average corrected score is significantly different from conventional.

Table 4. LSD Model Test Results on Science Literacy

Model	Average		Corrected Average	Enhancement (%)	LSD notation
	Pretest	Posttest			
PJBL	58.412	77.777	77.492	33.15	a
Conventional	57.142	66.005	65.479	15.51	b

The research results show that the application of Project based Learning has a positive effect on students' science literacy. The PjBL stages contribute to increasing understanding of Science Literacy because indicators of understanding science literacy are trained from the beginning to the end of learning. In the first stage, starting with the essential question combined with mind mapping, students identify problems from environmental and social issues around them. Socioscientific issues are interesting contextual problem themes, and can be used to teach understanding of Science Literacy.

Students carry out several activities to formulate essential questions that will be answered through the project. Students observe phenomena and facts around them, make inferences, use Science theories and laws as a basis for thinking. At this stage, students prepare a mind map at the beginning of the project. Mind mapping directs students to develop creativity and imagination, and helps students create idea associations. Environmental themes and social issues studied in learning bring students closer to the context that science is influenced by social and cultural influences in society. Here several indicators of understanding Science Literacy have been studied and integrated in a real way.

Second stage, design a plan for the project. The activity of designing a project plan directs students to develop creativity in solving problems. Students use Science theories and laws as a basis for developing research frameworks and theoretical foundations. Students are encouraged to determine and choose various alternatives to solve problems, as well as determine appropriate research methods. Actual problems in project-based learning can provide broad learning experiences and are useful for improving student attitudes.

Project work directs students to think using metacognitive awareness, namely planning, organizing and monitoring project tasks to achieve the expected goals. As was done in stage three, students prepare a schedule, make a list of tools/materials needed, compile instruments and carry out investigations/investigations to solve project problems. Metacognitive awareness is needed to create effective learning and is a predictor of successful learning. Next, in stage four, monitor the students and the progress of the project. Students obtain empirical data through research and investigations carried out. At this stage, students are trained to prepare project progress reports based on empirical data obtained, using creativity and imagination during and after collecting data. In stages five and six, namely assess the outcome, followed by evaluation of the experience, evaluate the experience.

If we describe Science literacy based on its components, the average Science literacy score in the conventional learning model and PjBL is as presented in Figure 1.

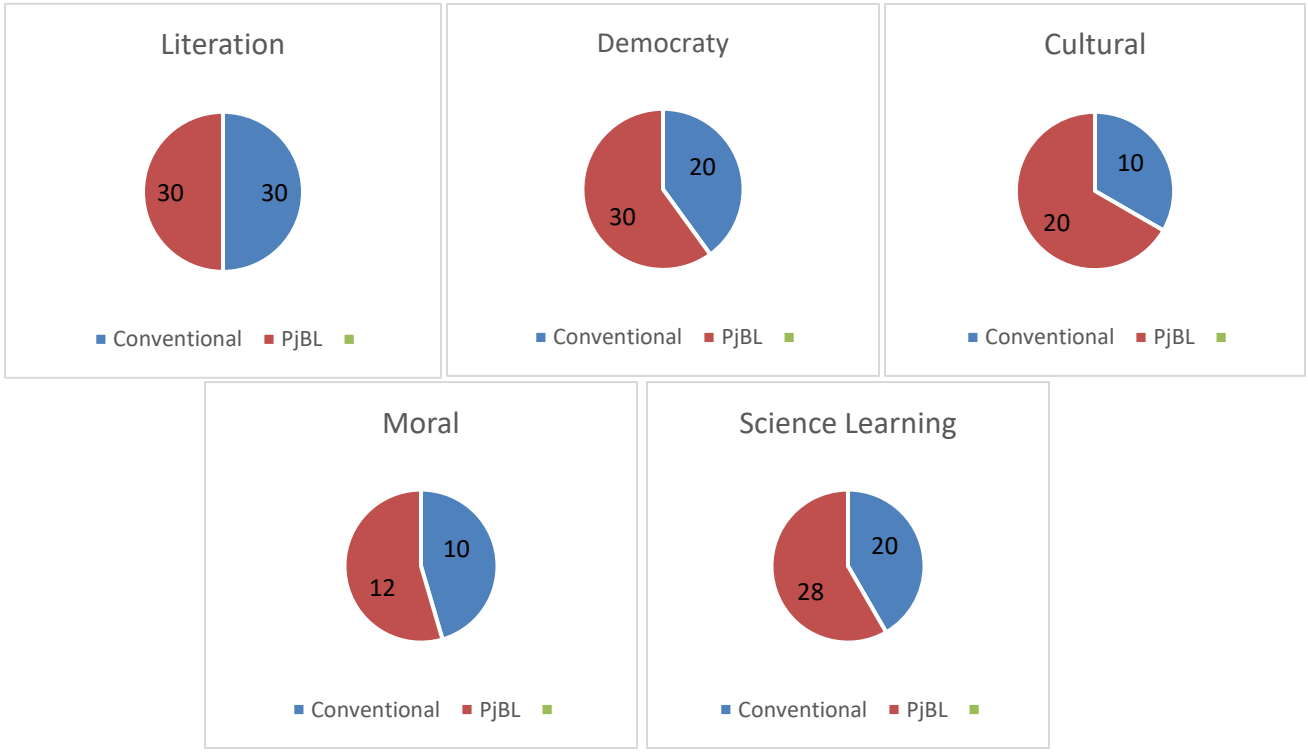


Figure 1. Average Science literacy score in the PjBL and Conventional Learning Model

Figure 1 shows the students' science literacy score with a maximum score of 100. Aspect 1) Utilitarians understand the nature of science in all classes achieving the maximum score. The conventional class got the lowest score in 2) the Democratic aspect, understanding the nature of science with a score of 50. Meanwhile the PJBL class got the maximum score. The highest score in 3) the Cultural aspect, understanding the nature of science, was achieved by the PjBL class, which got a score of 75. Meanwhile, the lowest score was obtained by the conventional class, which got a score of 31. The highest score in 4) the Moral aspect, understanding the nature of science, was achieved by the PJBL class, which got a score of 63. The lowest score was obtained by the conventional class which got a score of 25. The highest score in 5) the Science learning aspect: understanding the nature of science was achieved by the PJBL class which got a score of 92. The conventional class got the lowest score

of 42.

Collaboration Skills

The results of variations in the effectiveness of the PjBL and conventional learning models on collaboration skills are seen in Table 5.

Table 5. ANCOVA Results of Collaboration Skills

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	71232.590[a]	3	23744.197	127.249	.000	.786
Intercept	20741.292	1	20741.292	111.156	.000	.517
X collaboration	1.460	1	1.460	.008	.930	.000
Class	60205.225	2	30102.612	161.325	.000	.756
Error	19405.957	104	186.596			
Total	329869.000	108				
Corrected Total	90638.546	107				

a. R Squared = .786 (Adjusted R Squared = ,780)

Table 5 shows the differences in learning models [F count = 254.00 with p-value = 0.00. P-value < α (α = 0.05)]. Therefore, the hypothesis that the learning model influences students' collaboration skills is accepted, then the LSD test is carried out and the results can be seen in Table 6.

Table 6. LSD Collaboration Skills test results

Class	Pretest	Posttest	Corrected Average	BNT notation	Enhancement
PjBL	11.3056	78.9444	78.887	a	598.28 %
Conventional	15.5278	16.0556	16.119	c	3.40 %

Table 6 shows significant differences in learning models, and this can be seen from the highest posttest average scores in the PJBL (15.40) and conventional (6.72) classes. Based on these results, the PJBL class has the highest average value, and the average value is presented in Figure 2.

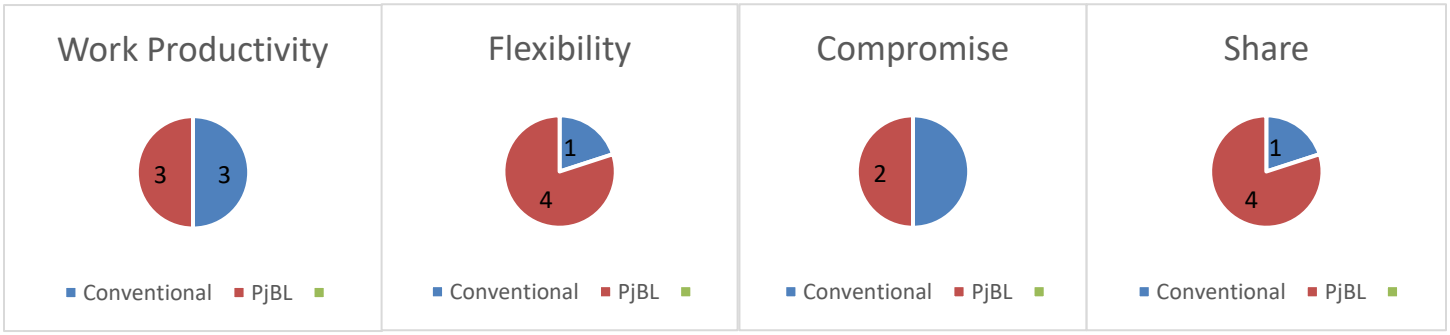


Figure 2. Average scores for collaboration skills in conventional learning models and PJBL

Figure 2 shows the student collaboration skills score with a maximum of 4. The productive work aspect has an average score of 2, 3, 2, and 4, where the highest in the very good category is in the PJBL class and the lowest is conventional in the sufficient category. The respect shown was 2, 3, 1, and 4, while the highest was in the PJBL class in the very good category and the lowest was in the poor category. Compromise has a value of 1, 2, 3, and 4, where the highest is in the PJBL class with a very good category and the lowest is conventional with a poor category. Shared responsibility has scores of 2, 4, 3, and 4, where the highest is in the PJBL class with the very good category, the lowest is in the conventional class with the sufficient category.
Based on these results, the PJBL class has the highest average value, and the average value for each aspect is presented in Figure 3.

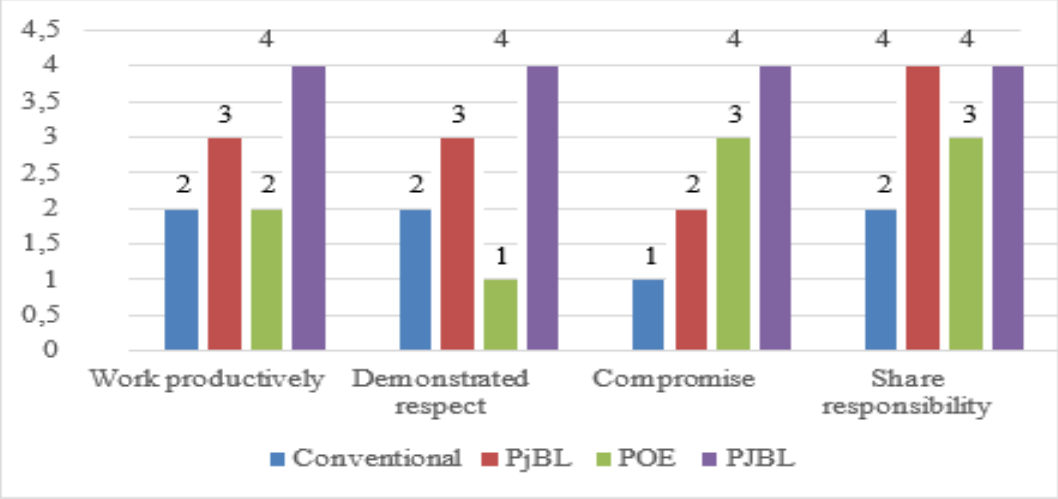


Figure 3. Average score of collaboration skills in the Conventional Learning Model and PjBL

Figure 3 shows the student collaboration skills score with a maximum of 4. The productive work aspect has an average score of 2, 3, 2, and 4, where the highest in the very good category is in the PJBL class and the lowest is conventional in the sufficient category. The respect shown was 2, 3, 1, and 4, while the highest was in the PJBL class in the very good category and the lowest was in the poor category. Compromise has 1, 2, 3, and 4, where the highest is in the PJBL class with the very good category and the lowest is conventional with the poor category. Shared responsibility is 2, 4, 3, and the lowest is in the conventional class with the adequate category. Where the highest is in the PjBL and PJBL classes with the very good category

The research results show that the learning model influences students' collaboration skills. The PJBL learning model provides the highest contribution to students' collaboration skills compared to conventional PJBL involves students in productive work, mutual respect, compromise, and responsibility in completing group assignments. Students must express their own opinions and discuss together to determine the right solution to overcome environmental problems. This is in accordance with the research results Sturner et al (2017) which conveys that students who are active in a group at least have knowledge about something.

Collaboration skills in aspects of productive work appear when students identify and analyze problems, plan action steps and carry out actions. Problem identification and analysis activities are carried out when students have succeeded in determining the factors that influence the emergence of the problem being studied. Productive work is recorded when students design action planning activities regarding solving problems encountered. Each group has a leader who helps the lecturer to divide tasks within the group. The activity of designing an action plan is carried out by preparing tools and materials, compiling work procedures, and making an activity schedule. Productive work can be achieved through dividing tasks in groups. Dividing tasks into groups will train students to be responsible. Responsibility is not only about punctuality in submitting assignments, but more about achieving the best work (Assbeihat, 2016; Green & Johnson, 2015; Rosen et al., 2018).

Collaboration skills in the aspect of mutual respect are seen when students have discussions with fellow group members and when presenting results outside the group. Students carefully listen to suggestions or ideas given by other groups. Mutual respect can be done through group learning activities. Mutual respect can provide positive energy to others. Similar things were recorded when students reported group progress, students conveyed the obstacles they faced and then other groups provided solutions (MacDonald et al., 2022; Tørring et al., 2019; van Jaarsveldt & Joubert, 2015).

There were significant differences found between PjBL and conventional learning in improving students' collaboration skills. It turns out that PjBL steps make a big contribution to developing students' collaboration skills through the process of observation, identification and analysis, action plans, implementation of monitoring and evaluation actions and follow-up plans. This is in accordance with previous research which explains that student collaboration can be improved through making identification, preparing action plans, carrying out actions, analyzing and carrying out monitoring and evaluation (Delgado et al., 2017; Hamilton et al., 2009; Schildkamp, 2019).

PjBL is significantly different from conventional learning. Conventional classroom learning is unable to facilitate the development of students' collaboration skills. Learning in conventional classes only carries out knowledge transfer activities, which are carried out individually without actively involving students in learning. Learning in conventional classes only provides assignments in the form of questions with a

lower level of cognition (Dhawan, 2020; Nguyen et al., 2022; Yeh et al., 2019). Students' collaboration skills are difficult to develop in learning that only emphasizes memory, understanding and analysis.

PjBL has several characteristics. PjBL provides students with opportunities to explore, make judgments, interpret, and synthesize information in a meaningful way. PjBL allows students to investigate phenomena, facts or problems in a more real and meaningful way. Students have different learning styles, so they need concrete experiences that are combined during PjBL. Completion of projects in the field, experiments, making models, posters, and making multimedia presentations are appropriate and typical activities in PjBL. PjBL also provides various ways for students to show their knowledge by providing many alternative answers, and not just one correct answer (Aránguiz et al., 2020; Darmuki et al., 2023; Descovich et al., 2013; Miller & Krajcik, 2019; Paschalis, 2017; Wakhid & Budiyanto, 2023).

Collaboration skills and science literacy have a close relationship in the context of project-based learning. In project-based learning, students are not only invited to develop a deep understanding of science concepts, but are also invited to collaborate actively with their friends. Collaboration skills are key in completing complex projects, where students need to share ideas, solve problems together, and utilize individual skills to achieve common goals. Science literacy supports collaboration by providing a critical foundation of knowledge regarding project topics, enabling students to contribute more effectively and make informed decisions. Thus, the combination of collaboration skills and Science literacy creates a holistic learning environment and prepares students to become critical thinkers and productive collaborators in the real world.

Conclusion

There is an influence of PjBL learning on students' Science literacy and collaboration skills. This is shown by the results of the ANCOVA hypothesis test with F count = 1.667 with a p value = 0.000 while the p value <α (α = 0.05). Then the LSD test showed a significant difference between the conventional learning model and PjBL. This was reflected in the average posttest score. The PjBL score is the highest (24.66), followed by conventional learning (21.18). There is an influence of the PjBL learning model on students' collaboration skills. This is shown by the results of the ANCOVA hypothesis test F count = 254.006 with p-value = 0.000. P-value < α (α = 0.05). Then the LSD test shows a significant difference between the PjBL and conventional learning models. It can be seen from the highest posttest average score in the PjBL (13.08) and conventional (6.72) classes. It is necessary to develop the impact of the PjBL model of learning on students' critical thinking, creative thinking and communication skills. This research needs to be expanded by comparing other innovative learning models, such as PBL, Discovery, Inquiry and cooperative models.

Acknowledgement

This research was carried out thanks to funding support from the Internal Research Fund Program of the Universitas Muhammadiyah Malang in 2023. Therefore, the author expresses his highest thanks and appreciation.

Author of Interest

I. Hindun: methodology, review and revision; **N. Nurwidodo:** conducting the research, collecting data, writing original article, and revision; **S. Wahyuni:** writing original article, collecting data and review**,** revision; and **N. Fauziah:** collecting data and review.

References

Afikah, A., Rohaeti, E., Jumadi, J., & Perdana, R. (2023). Student's higher-order thinking skills and collaboration skills in online learning during pandemic. *International Journal of Evaluation and Research in Education*, *12*(1), 23–33. https://doi.org/10.11591/ijere.v12i1.23797

Ahmad, M. (2021). Management of project-based learning model at Sekolah Alam Junior high school. *AL-ISHLAH: Jurnal Pendidikan*, *13*(2), 1152–1159. https://doi.org/10.35445/alishlah.v13i2.486

Alkautsar, S., Nuryady, M. M., Husamah, H., Wahyono, P., & Miharja, F. J. (2023). STEM-PjBL worksheet : Ways to improve students' collaboration, creativity, and computational thinking. *Jurnal Kependidikan: Jurnal Hasil Penelitian Dan Kajian Kepustakaan Di Bidang Pendidikan, Pengajaran Dan Pembelajaran*, *9*(2), 681–695. https://doi.org/10.33394/jk.v9i2.7587

Anantyarta, P., & Sari, R. L. I. (2017). Keterampilan kolaboratif dan metakognitif melalui multimedia

berbasis means ends. *Jurnal Biologi Dan Pembelajaran Biologi*, *2*(2), 33–43. http://jurnal.unmuhjember.ac.id/index.php/BIOMA/article/view/821

Aránguiz, P., Palau-Salvador, G., Belda, A., & Peris, J. (2020). Critical thinking using project-based learning: The case of the agroecological market at the “Universitat Politècnica de València.” In *Sustainability* (Vol. 12, Issue 9). https://doi.org/10.3390/su12093553

Assbeihat, J. M. (2016). The impact of collaboration among members on team’s performance. *Management and Administrative Sciences Review*, *5*(5), 248–259.

Avikasari, A., Rukayah, R., & Indriayu, M. (2018). The influence of science literacy-based teaching material towards science achievement. *International Journal of Evaluation and Research in Education (IJERE)*, *7*(3), 182–187. https://doi.org/10.11591/ijere.v7i3.14033

Banua, Y. J. S., Latuni, G., & Kaunang, M. (2023). Implementation of project-based learning on Kolintang music learning. *SoCul: International Journal of Research in Social Cultural Issues*, *2*(6), 725–733. https://doi.org/10.53682/soculijrccsscli.v2i6.7316

Biazus, M. de O., & Mahtari, S. (2022). The impact of project-based learning (PjBL) model on secondary students’ creative thinking skills. *International Journal of Essential Competencies in Education*, *1*(1), 38–48. https://doi.org/10.36312/ijece.v1i1.752

Bunyamin. (2022). Producing video project-based learning using online game to increase students’ engagement and speaking competence of students grade 9, State Junior High School 1 Slawi in the Covid-19 pandemic period. *The Proceedings of the English Language Teaching, Literature, and Translation*, *11*(1), 209.

Darling-Hammond, L., Flook, L., Cook-Harvey, C., Barron, B., & Osher, D. (2020). Implications for educational practice of the science of learning and development. *Applied Developmental Science*, *24*(2), 97–140. https://doi.org/10.1080/10888691.2018.1537791

Darmuki, A., Nugrahani, F., Fathurohman, I., Kanzunnudin, M., & Hidayati, N. A. (2023). The impact of inquiry collaboration project based learning model of Indonesian language course achievement. *International Journal of Instruction*, *16*(2), 247–266. https://doi.org/10.29333/iji.2023.16215a

Delgado, V. A., Collazos, C. A., Fardoun, H. M., & Safa, N. (2017). Collaboration increase through monitoring and evaluation mechanisms of the collaborative learning process. *International Conference on Social Computing and Social Media*, *10280 LNCS*, VII. https://doi.org/10.1007/978-3-319-58562-8

Descovich, M., Kannarunimit, D., & Yom, S. S. (2013). CyberKnife(r)-based SBRT for lung cancer. *Clinical Insights: Stereotactic Body Radiation Therapy: Lung Cancer*, *3*(7), 53–72. https://doi.org/10.2217/EBO.13.11

Dhawan, S. (2020). Online Learning: A Panacea in the Time of COVID-19 Crisis. *Journal of Educational Technology Systems*, *49*(1), 5–22. https://doi.org/10.1177/0047239520934018

Driver, R., & Erickson, G. (1983). Theories-in-action: Some theoretical and empirical issues in the study of students’ conceptual frameworks in science. *Studies in Science Education*, *10*(1), 37–60. https://doi.org/10.1080/03057268308559904

Duke, N. K., Halvorsen, A.-L., Strachan, S. L., Kim, J., & Konstantopoulos, S. (2020). Putting PjBL to the Test: The Impact of Project-Based Learning on Second Graders’ Social Studies and Literacy Learning and Motivation in Low-SES School Settings. *American Educational Research Journal*, *58*(1), 160–200. https://doi.org/10.3102/0002831220929638

Fakhriyah, F., Masfuah, S., Roysa, M., Rusilowati, A., & Rahayu, E. S. (2017). Student’s science literacy in the aspect of content science? *Jurnal Pendidikan IPA Indonesia*, *6*(1), 81–87. https://doi.org/10.15294/jpii.v6i1.7245

Green, B. N., & Johnson, C. D. (2015). Interprofessional collaboration in research, education, and clinical practice: working together for a better future. *The Journal of Chiropractic Education*, *29*(1), 1–10. https://doi.org/10.7899/JCE-14-36

Greenstein. (2012). Assessing 21st century skills: A guide to evaluating mastery and authentic learning. *Califoornia: Corwin A Sage Company*.

Hamilton, L., Halverson, R., Jackson, S., Mandinach, E., Supovitz, J., & Wayman, J. C. (2009). *Using student achievement data to support instructional decision making* (Vol. 13, Issue 20). National Center for Education Evaluation and Regional Assistance, Institute of Education Sciences, U.S. Department of Education. http://ies.ed.gov/ncee/wwc/publications/practiceguides/

Hayat, M. S., Rustaman, N. Y., Rahmat, A., & Redjeki, S. (2019). Profile of life-long learning of prospective teacher in learning biology. *Journal of Physics: Conference Series*, *1157*(2), 022083. https://doi.org/10.1088/1742-6596/1157/2/022083

Hidayati, N. (2019). Collaboration skill of biology students at Universitas Islam Riau, Indonesia. *International Journal of Scientific & Technology Research*, *8*(11), 208–211.

Hindun, I., & Husamah, H. (2019). Implementasi STAD-PjBL untuk meningkatkan kreativitas produk mahasiswa calon guru biologi. *JINoP (Jurnal Inovasi Pembelajaran)*, *5*(1), 139–154.

Humairoh, A. R., & Purwati, O. (2014). The implementation of project-based learning to teach speaking a spoken advertisement for the eight graders of SMPN 40 Surabaya. *Retain*, *2*(1), 1–10.

Husamah, H., & Pantiwati, Y. (2014). Cooperative learning STAD-PJBL: Motivation, thinking skills, and learning outcomes of biology department students. *International Journal of Education Learning and Development*, *2*(1), 77–94.

Husamah, H., & Rahardjanto, A. (2018). OIDDE-PjBL learning model: Problem-solving skills and product creativity for environmental study of biology Prospective Teacher. *Proceeding The 3rd Progressive and Fun Education International Seminar*, *August*, 41–50. http://eprints.umm.ac.id/44786/

Ilma, S., Al-Muhdhar, M. H. I., Rohman, F., & Saptasari, M. (2022). Promote collaboration skills during the COVID-19 pandemic through Predict-Observe-Explain-based Project (POEP) learning. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *8*(1), 32–39. https://doi.org/10.22219/jpbi.v8i1.17622

Indriyana, R. S., & Susilowati, S. (2020). The effects of model project-based learning approach on STEM (Science, Technology, Engineering, Mathematic) on natural science learning to junior high school student's critical thinking skills and cooperative skills at SMP N 1 Berbah. *Journal of Science Education Research*, *4*(2), 70–75. https://doi.org/10.21831/jser.v4i2.35717

Keiler, L. S. (2018). Teachers' roles and identities in student-centered classrooms. *International Journal of STEM Education*, *5*(1), 34. https://doi.org/10.1186/s40594-018-0131-6

Kelp, N. C., McCartney, M., Sarvary, M. A., Shaffer, J. F., & Wolyniak, M. J. (2023). Developing science literacy in students and society: Theory, research, and practice. In *Journal of microbiology & biology education* (Vol. 24, Issue 2). https://doi.org/10.1128/jmbe.00058-23

Kim, S., Raza, M., & Seidman, E. (2019). Improving 21st-century teaching skills: The key to effective 21st-century learners. *Research in Comparative and International Education*, *14*(1), 99–117. https://doi.org/10.1177/1745499919829214

Le, H., Janssen, J., & Wubbels, T. (2018). Collaborative learning practices: teacher and student perceived obstacles to effective student collaboration. *Cambridge Journal of Education*, *48*(1), 103–122. https://doi.org/10.1080/0305764X.2016.1259389

Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of nature of science questionnaire: Toward valid and meaningful assessment of learners' conceptions of nature of science. *Journal of Research in Science Teaching*, *39*(6), 497–521. https://doi.org/10.1002/tea.10034

Listiana, L., Loka, N. M., & Gayatri, Y. (2023). Does student's critical thinking and collaboration skills can empower through investigation and thinking learning strategy? *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *9*(3), 315–325. https://doi.org/10.22219/jpbi.v9i3.25118

Lopes, R. P., Mesquita, C., de la Cruz Del Río-Rama, M., & Álvarez-García, J. (2018). Collaborative learning experiences for the development of higher-order thinking. *Espacios*, *39*(17).

Loyens, S. M. M., van Meerten, J. E., Schaap, L., & Wijnia, L. (2023). Situating higher-order, critical, and critical-analytic thinking in problem- and project-based learning environments: A systematic review. *Educational Psychology Review*, *35*(2), 39. https://doi.org/10.1007/s10648-023-09757-x

MacDonald, L., Thomas, E., Javernick-Will, A., Austin-Breneman, J., Aranda, I., Salvinelli, C., Klees, R., Walters, J., Parmentier, M. J., Schaad, D., Shahi, A., Bedell, E., Platais, G., Brown, J., Gershenson, J., Watkins, D., Obonyo, E., Oyanedel-Craver, V., Olson, M., … Linden, K. (2022). Aligning learning objectives and approaches in global engineering graduate programs: Review and recommendations by an interdisciplinary working group. *Development Engineering*, *7*, 100095. https://doi.org/https://doi.org/10.1016/j.deveng.2022.100095

Markula, A., & Aksela, M. (2022). The key characteristics of project-based learning: how teachers implement projects in K-12 science education. *Disciplinary and Interdisciplinary Science Education Research*, *4*(2), 1–17. https://doi.org/10.1186/s43031-021-00042-x

Marnewick, C. (2023). Student experiences of project-based learning in agile project management education. *Project Leadership and Society*, *4*, 100096. https://doi.org/https://doi.org/10.1016/j.plas.2023.100096

Milda, Suyono, Sri Rahayu, Y., Hariyono, E., Prahani, B. K., & Annur, S. (2022). Profil of science literacy skill of junior high school student on energy materials in living systems in online learning. *AIP Conference Proceedings*, *2600*(1), 20009. https://doi.org/10.1063/5.0117637

Miller, E. C., & Krajcik, J. S. (2019). Promoting deep learning through project-based learning: a design problem. *Disciplinary and Interdisciplinary Science Education Research*, *1*(1), 7. https://doi.org/10.1186/s43031-019-0009-6

Nguyen, L. T., Kanjug, I., Lowatcharin, G., Manakul, T., Poonpon, K., Sarakorn, W., Somabut, A., Srisawasdi, N., Traiyarach, S., & Tuamsuk, K. (2022). How teachers manage their classroom in the digital learning environment – experiences from the University Smart Learning Project. *Heliyon*, *8*(10), e10817. https://doi.org/https://doi.org/10.1016/j.heliyon.2022.e10817

Nugroho, A. E., & Dewi, S. E. P. (2022). Implementation of project based learning (PjBL) method on music learning in junior high school Regina Pacis Surakarta. *Jurnal Seni Musik*, *11*(1), 102–111. https://doi.org/10.15294/jsm.v11i1.56645

Nurwidodo, N., Ibrohim, I., Sueb, S., Abrori, F. M., & Darojat, T. A. (2023). Improving the creative thinking and collaborative skills of prospective biology teachers using the EMKONTAN learning

model in environmental science courses. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, *9*(1), 15–25. https://doi.org/10.22219/jpbi.v9i1.24382

OECD. (2023). *PISA 2022 Results (Volume I)*. OECD. https://doi.org/https://doi.org/https://doi.org/10.1787/53f23881-en

Paschalis, G. (2017). A compound LAMS-moodle environment to support Collaborative Project-Based Learning: A case study with the Group Investigation method. *Turkish Online Journal of Distance Education*, *18*(2), 134–150. https://doi.org/10.17718/tojde.306565

Pratiwi, G., Sova, F., Putra, F. G., Yunian Putra, R. W., Kusuma, A. P., & Rahmawati, N. K. (2020). The influence of project-based learning (PjBL) and learning style on mathematics communication skills of junior high school students. *Journal of Physics: Conference Series*, *1467*(1), 012064. https://doi.org/10.1088/1742-6596/1467/1/012064

Priyambodo, P., Paidi, P., Wilujeng', I., & Djukri, D. (2023). Phenomenological studies: Strategies for improving Indonesian pre-service teacher collaboration skills. *Pegem Journal of Education and Instruction*, *13*(3), 350–361. https://doi.org/10.47750/pegegog.13.03.35

Rahardjanto, A., Husamah, & Fauzi, A. (2019). Hybrid-PjBL: Learning outcomes, creative thinking skills, and learning motivation of preservice teacher. *International Journal of Instruction*, *12*(2). https://doi.org/10.29333/iji.2019.12212a

Rahmawati, A., Suryani, N., Akhyar, M., & Sukarmin. (2020). *Technology-Integrated Project-Based Learning for Pre-Service Teacher Education: A Systematic Literature Review*. *10*(1), 620–629. https://doi.org/doi:10.1515/eng-2020-0069

Rehman, N., Zhang, W., Mahmood, A., Fareed, M. Z., & Batool, S. (2023). Fostering twenty-first century skills among primary school students through math project-based learning. *Humanities and Social Sciences Communications*, *10*(1), 424. https://doi.org/10.1057/s41599-023-01914-5

Rosen, M. A., DiazGranados, D., Dietz, A. S., Benishek, L. E., Thompson, D., Pronovost, P. J., & Weaver, S. J. (2018). Teamwork in healthcare: Key discoveries enabling safer, high-quality care. *The American Psychologist*, *73*(4), 433–450. https://doi.org/10.1037/amp0000298

Şahin, Ş., & Kiliç, A. (2023). Effectiveness of the project-based 6E learning model. *European Journal of Open, Distance and E-Learning*, *25*(1), 31–48. https://doi.org/10.2478/eurodl-2023-0003

Sartika, U. D., Syafryadin, S., & Azwandi, A. (2022). English teachers' perception of implementing project-based learning in secondary schools. *ENGLISH FRANCA : Academic Journal of English Language and Education*, *6*(2), 468–486. https://doi.org/10.29240/ef.v6i2.5452

Scager, K., Boonstra, J., Peeters, T., Vulperhorst, J., & Wiegant, F. (2016). Collaborative learning in higher education: Evoking positive interdependence. *CBE Life Sciences Education*, *15*(4), 1–9. https://doi.org/10.1187/cbe.16-07-0219

Schildkamp, K. (2019). Data-based decision-making for school improvement: Research insights and gaps. *Educational Research*, *61*(3), 257–273. https://doi.org/10.1080/00131881.2019.1625716

Sitio, S. D. U., Putri, R. I. I., & Aisyah, N. (2023). Project based learning design "gadget play duration survey" for junior high school students. *Proceedings of the Fifth Sriwijaya University Learning and Education International Conference (SULE-IC 2022)*, *1*, 90–101. https://doi.org/10.2991/978-2-38476-010-7_12

Snow, C. E., & Dibner, K. A. (2016). Science literacy: Concepts, contexts, and consequences. In *Science Literacy: Concepts, Contexts, and Consequences*. The National Academies Press. https://doi.org/10.17226/23595

Sturner, K. K., Bishop, P., & Lenhart, S. M. (2017). Developing collaboration skills in team undergraduate research experiences. *PRIMUS*, *27*(3), 370–388. https://doi.org/10.1080/10511970.2016.1188432

Sufianti, E., Kirana, C. A. D., Rahman, A., Cahyadi, C., Rahmi, Y., & Sundari, W. (2024). Cimanggung open junior high school as collaboration-based education in Cilembu Village Sumedang. *Proceedings of the Fourth International Conference on Administrative Science (ICAS 2022)*, *1*, 13–22. https://doi.org/10.2991/978-2-38476-104-3

Sukackė, V., Guerra, A. O., Ellinger, D., Carlos, V., Petronienė, S., Gaižiūnienė, L., Blanch, S., Marbà-Tallada, A., & Brose, A. (2022). Towards active evidence-based learning in engineering education: A systematic literature review of PBL, PjBL, and CBL. In *Sustainability* (Vol. 14, Issue 21). https://doi.org/10.3390/su142113955

Suradika, A., Dewi, H. I., & Nasution, M. I. (2023). Project-based learning and problem-based learning models in critical and creative students. *Jurnal Pendidikan IPA Indonesia*, *12*(1), 153–167. https://doi.org/10.15294/jpii.v12i1.39713

Tørring, B., Gittell, J. H., Laursen, M., Rasmussen, B. S., & Sørensen, E. E. (2019). Communication and relationship dynamics in surgical teams in the operating room: an ethnographic study. *BMC Health Services Research*, *19*(1), 528. https://doi.org/10.1186/s12913-019-4362-0

Ukah, Y., Ayewu, C., & Oworu, P. (2023). Improving students' language learning through project-based learning activities. *Jelita*, *4*(1), 9–23. https://jurnal.stkipmb.ac.id/index.php/jelita/article/view/142

van Jaarsveldt, D. E., & Joubert, A. (2015). Navigating diversity with nursing students through difficult

dialogues: A qualitative study. *International Journal of Africa Nursing Sciences*, *2*, 34–41. https://doi.org/https://doi.org/10.1016/j.ijans.2015.02.002

van Laar, E., van Deursen, A. J. A. M., van Dijk, J. A. G. M., & de Haan, J. (2020). Determinants of 21st-century skills and 21st-century digital skills for workers: A systematic literature review. *SAGE Open*, *10*(1). https://doi.org/10.1177/2158244019900176

Vaughn, G. A. (2020). *Lecture versus collaborative learning methods in community college classrooms*. Walden University.

Wakhid, N., & Budiyanto, C. W. (2023). Analysis of project-based learning model on the learning styles of PPLG SMK Negeri students in Surakarta. *Indonesian Journal of Informatics Education*, *7*(2), 1–6.

Wibowo, W. S., Roektiningroem, E., Bastian, N., & Hudda, K. S. (2018). Development of project-based learning science module to improve critical thinking skills of junior high school students. *Journal of Science Education Research*, *2*(2), 71–76. https://doi.org/10.21831/jser.v2i2.22471

Widiyati, E., & Pangesti, W. (2022). Project-based learning in teaching speaking to young learners: Is it effective? *EduLite: Journal of English Education, Literature and Culture*, *7*(1), 71. https://doi.org/10.30659/e.7.1.71-81

Wijayanti, F., & Budi, A. B. (2023). Project-based learning in EFL classroom: Strategies for success. *Journal of English in Academic and Professional Communication*, *9*(2), 108–117. https://doi.org/10.25047/jeapco.v9i2.4086

Yayuk, E., & Husamah, H. (2019). Peningkatan problem-solving skills dan hasil belajar mahasiswa pada mata kuliah ekologi melalui Blended-PjBL. *JIPVA (Jurnal Pendidikan IPA Veteran)*, *3*(2), 100. https://doi.org/10.31331/jipva.v3i2.914

Yeh, C. Y. C., Cheng, H. N. H., Chen, Z.-H., Liao, C. C. Y., & Chan, T.-W. (2019). Enhancing achievement and interest in mathematics learning through Math-Island. *Research and Practice in Technology Enhanced Learning*, *14*(1), 5. https://doi.org/10.1186/s41039-019-0100-9

Zadok, Y. (2020). Project-based learning in robotics meets junior high school. *Journal of Engineering, Design and Technology*, *18*(5), 941–958. https://doi.org/10.1108/JEDT-01-2019-0023

Zhang, L., & Ma, Y. (2023). A study of the impact of project-based learning on student learning effects: a meta-analysis study. In *Frontiers in psychology* (Vol. 14, p. 1202728). https://doi.org/10.3389/fpsyg.2023.1202728