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The Effect of Scaffolding Provision an Acid and Base Learning Project on Students' Science Process Skills

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Abstract: The purpose of this study was to investigate the effect of the scaffolding guidance provision on students' science process skills (SPS) in a project-based learning (PjBL) about acid and base concepts. A quasi-experimental research design was applied to collect data using a pre-validated SPS-observation. An experiment group of students of SMAN 3 in Jambi City had learnt the concepts using a scaffolding-assisted PjBL while a control group from the same school had learnt it using PjBL without scaffolding. Data was analyzed using t-test assisted by SPSS software. The results of analyses showed that the SPS of the experiment group was higher than their counterparts' SPS. Statistical analyses showed an effect of the use of the scaffolding guidance on the students' SPS with the p-value of .000 < .05. The experiment students had been observed achieved the indicators of the SPS during the learning process while their counterparts had not; and those may be due to the benefits of the provision of the scaffolding guidance that eased them to do their tasks. It can be concluded that the use of scaffolding guidance is able to overcome the problems faced by students in a project-based learning that thus improve their SPS.

Keywords: Acid; Project-based Learning; Scaffolding; Science Process Skills

Introduction

Science learning is projected to nurture knowledge and skills on students. One of those is the science process skills (SPS). According to Özgelen (2012), SPS is the scientific thinking skills that is useful for students in solving problems and making formulation of science results. Hasanah and Utami (2017) explained that SPS must be aligned with the development of science and technology. Educators need to not only teach science concepts but also provide more complex and concrete examples. Toplis and Allen also argue that SPS are the substantive part of the curriculum needed for the development of a country (Hardiyanti et al., 2017). However, facts from the field inform that students' SPS are low. This means that educators need to evaluate their learning process in order to improve the quality. It can be achieved by modifying and inventing more effective learning models, methods, and strategies.

The aspects of SPS are interrelated. These include the skills of asking questions, predicting results, formulating hypotheses, designing experiments, applying concepts, and communicating results. Skills of asking questions and predicting results can have an impact on improving the skills of formulating hypotheses and designing experiments. It in turns will improve the skills in applying concepts and communicating conclusions.

Students' SPS as well as science attitude can be improved by using a project-based learning (PjBL) (Suhanda & Suryanto, 2018). The focus of PjBL is to actively involved students in a project-based activities in class. This way, students are given opportunities to work independently and to construct knowledge that hence are able to present their findings (Siwa et al., 2013) .

PjBL is recommended by curriculum to be implemented in the learning process in the classroom. PjBL encourages students to be focus on products they need to make. For example, they need to make videos,

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power point presentations or reports. In compiling the curriculum, the learning designer prepares academic standards, determines the treatment that can be carried out by students and arranges projects as evidence of increased skills (Cuddihy, & Guan in Belland & Evidence, 2017) .

The George Lucas Educational Foundation divides six stages of PjBL those are; posing basic questions, designing projects, compiling schedules, monitoring students, testing results, and evaluating the experiences (Widayanti, Yuberti, Irwandani, & Hamid, 2018). PjBL should begin with a problem or question that will make students be exposed to the main concepts. This is continued by the remaining steps that lead to the discovery process of the project that involves transformation of information from teacher to students and amongst students (Demir, 2020) .

Other advantages of the PjBL can make students to be motivated in learning that hence being able to increase their creativity to produce products from a project they carried out. Besides that, it can also improve students' critical thinking skills and information seeking skill from many sources and materials. PjBL invites students to be actively involved in learning by applying the material to a project. PjBL is thus believed as an innovative student-centered method (Parmani, Sumiati, & Meliasari, 2019 ; Bahriah & Suryaningsih, 2017) .

Although it has many advantages, in fact PjBL has weaknesses in the learning process. The weaknesses of this model include; The number of tools required, acquire students with experiments and gathering information skills to avoid difficulties, Students' involvement and participation, adequate time, and adequate funds (Parmani et al., 2019). This supposition is in accordance with the results of research conducted by Effendi-Hasibuan, Harizon, Ngatijo, & Mukminin (2019) who found that various obstacles such as lack of time, lack of knowledge, and lack of skills and experience of educators and students had been the barriers to the implementation of learning models recommended by the 2013 curriculum. Quintana et al., (2004) also describe some obstacles faced by students when managing the science discovery process. According to Bransford, the inability to compile appropriate steps in carrying out activities and coordinating investigations by students are also other obstacles for PjBL.

Taken those obstacles into account, it appears that PjBL will not also be optimally applied. Consequently, this may cause the low SPS of students. The obstacles lie on the learning facilities and what is more important is on the low science ability of students. This is supported by Jack (2013) who argues that the causes of low SPS of students may not only come from the lack of learning facilities such as the low laboratory infrastructure but also from the low initial science ability of students.

Daily observations carried out in the MIPA class at SMA Negeri 3 Jambi City found that science process skills were still low and needed help. For example, the ability to hypothesize, predict, communicate, collaborate and relate results to the material is still low. This discovery causes ineffectiveness in implementing the project based learning model in the classroom. For this reason, an effort is needed to improve science process skills and make project-based learning a success.

Chemistry is one of the science subjects that can be taught by applying the PjBL. One of its concepts is the acid and base. Students need to understand how to analyze the pH change trajectories of several natural indicators through experiments. When students have prior knowledge, students will not experience difficulties. This acid-base concept is the prerequisite material for studying buffer concept, hydrolysis, acid-base titrations, chemical reactions, equilibrium, the nature of matter and solutions as well as stoichiometry (Artdej et al., 2010; Sesen & Tarhan, 2011; Amry et al., 2017) .

However, anecdotal data inform that students still have difficulties in solving problems in acid-base concept. This is caused by the lack of knowledge and understanding of the concept delivered by the teacher in class. Yuriev et al., (2017) explained that the difficulties in solving chemical problems may be caused by the lack of knowledge related to basic concepts of chemistry and the poor problem-solving strategy. The impact that arises from students' lack of understanding is the misconceptions about symbols and formulas, difficulties in understanding the context, in generalizing the concepts, and in using incorrect problem solving strategies (Yuriev, Naidu, Schembri, & Short, 2017 ; Parastuti, Suharti, & Ibnu , 2016). This misunderstanding arises because of the characteristics of the chemical itself. Johnstone (2006) explained that there are three characteristics of chemistry, namely symbolic, submicroscopic and macroscopic. Symbols or icons used in chemical equations enter the symbolic aspect. The description of particulates, molecules and matter is included in the microscopic aspect, and events that can be directly observed and can be described are included in the macroscopic aspect.

The results of Nugraha's research (2019) found the location of misconceptions that occur in acid-base material, namely; the concept of electrolyte and non-electrolyte properties in acid-base solutions, the concept of acid-base solutions, the concept of strong and weak acids, the strength of acids, and the concept of the development of acid-base theory. Recent research conducted by Mubarak and Yahdi (2020) found that some students had not acquired good initial knowledge regarding acid-base concepts such as acid-base theory, strong and weak acid-base concepts and dissociation of strong and weak acids. To help students understand acid-base material better, multiple representatives need to be involved to help students understand symbols, chemical material and chemical molecules.

Based on the two difficulties faced by students, namely the low SPS of students in carrying out project based leaning and the low ability of students to understand the concept of acids and bases, teachers need to provide alternative assistance such as scaffolding so that students can succeed in project-based learning.

Scaffolding is an interactive support from teachers by utilizing the prior knowledge students have aims at easing them in solving problems which is beyond their ability. Scaffolding is a step-by-step assistance provided by a teacher to students which according to Fisher and Frey (2010) includes questioning aims to check students' understanding, prompting aims to speed up students' cognitive processes, cueing aims to give more specific instructions and explaining aims to explain the problems directly to students. Therefore, Belland and Evidence (2017) affirm that an implementation of a student-centered learning needs to be strengthened by scaffolding. This is becoming more important in PjBL. In PjBL, the improved abilities students can perform is becoming able to solve the project-related problems, to design the project itself, and to complete the project.

In details, Belland and Evidence (2017) explains that this scaffolding aid has a purpose. First, scaffolding aims to help students solve current problems. Second, it can further lead to enable students to solve either unstructured or structured problems independently in the future. Third, it can be used to improve the existing abilities of students. Fourth, it can simplify some elements of tasks so that students understand it easily. The goal is for students to focus on the problems given and experience meaningful learning from the assignments presented. In shorts, interaction supported by scaffolding can have a positive impact on students. Students can demonstrate high-level skills such as the ability to solve unstructured problems, to make argumentation and to possess in-depth meaning of subjects.

However, according to Quintana et al., (2004), there are two important points about scaffolding. First, assistance is given to students to help them with difficulties in completing the assignments given. Second, improving process skills and content understanding comes from the experience gained during the learning process. Model representations should be specifically designed and more focus as a tool to assist students in completing tasks. The scaffolding is given on a way with the increasing of learning independence while the requirement for guidance is reduced. Belland and Evidence (2017) affirm that the purpose of scaffolding learners not only acquire the skills necessary to perform tasks independently, but also take responsibility for the tasks themselves.

In addition, according to Anghileri (2006) , scaffolding refers to encouragement and stimulation in the environment, direct interactions between educators and students, as well as making connections between students' previous knowledge and experiences with new things to learn. Scaffolding is divided into three level categories which are explained as follows: At level 1, educators can provide assistance in the form of preparing a learning environment for students (classroom organization). At level 2, there is direct interaction between educators and students. At level 3, there is a development of conceptual thinking by creating opportunities to express understanding as a result of interactions between educators and students. This means that, the provision of scaffolding will be very effective in the Zone of Proximal Development (ZPD) of students. This zone is a zone of students' capability that can be assisted by adults to develop. Adults are needed to do so as they are much better able to solve problems, projects or questions presented than students without reducing the difficulty level of the task. ZPD is also a zone where interactions occur between students and educators (Rusdi, 2018).

This scaffolding assistance can also be provided conceptually and instructionally. Conceptually, Belland and Evidence (2017) explains that conceptually scaffolding assistance is able to help narrow down the information that students find, making it easier to choose and understand material concepts. Pol et al., 2010) added that conceptual techniques in scaffolding focus on helping students solve problems, manage, and integrate the information obtained. Meanwhile, Wu explained that the use of procedural scaffolding helps students to complete assignments, achieve goals and solve problems. Procedural scaffolding is useful for helping students' performance in the process of scientific inquiry. Before achieving higher abilities, students must first feel comfortable with the syntax of scientific inquiry by being given assistance in the form of instructions during the investigation. Posters, worksheets, concept maps and others are supporting tools for instructional scaffolding techniques (Puspitaningsih, Wartono, & Handayanto, 2018).

Based on the description above, scaffolding is considered a suitable effort and solution needed to overcome problems faced by students in the learning process as well as in increasing their SPS. To find out the effectiveness thus this guidance needs to be applied in the learning process. This includes the use of questioning, cueing, prompting, and explaining. This article therefore reports the results of a study investigating the effectiveness of using scaffolding in helping senior high school students in Jambi city Indonesia completing a project-based learning in the acid and base concepts. The effect on students' SPS is also reported. Two research questions are posed: How is the SPS of students who learnt acid-base project under the provision of scaffolding and that of without the scaffolding? And Is there any effect of the provision of the scaffolding guidance on students' SPS.

Method

Research Design

This study used a quasy experimental research design. This study involved two groups of students who are allocated as an experiment group and control group. Both groups were invited in a project-based learning in acid-base concept. However, the experiment group was given the scaffolding guidance while the control group was not. The scaffolding consists of questioning, prompting, cueing and explaining (Fisher & Frey, 2010).

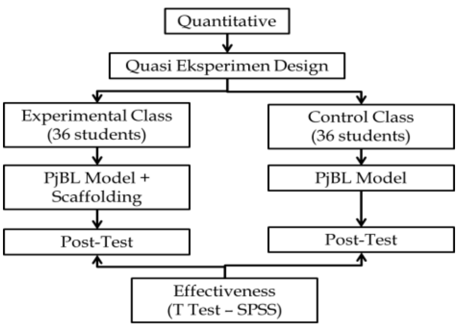

Figure 1. Research Design Scheme

Participants

This study involved 72 of XI grade senior high school students in Jambi city Indonesia. They were in the first semester between July-December 2022 in the educational calendar of Indonesia. They were aged 16-year-old comprised of 45 female and 27 male students. They were recruited randomly and their parents agreed to sign a consent form.

Learning and Projects

This study involved students to learn the acid and base concepts using the PjBL model according to the syntaxes constructed by George Lucas Educational Foundation (Demir, 2020). The students were involved in a project to make natural pH indicators consisting of tasks of making procedures, plant extracts, standard solutions, and color bands of pH indicators. During the lessons, the teacher was walking around the class to identify the constraints students faced. For the control group, the teacher fully helped the students with the tasks, while for the experiment group, the teacher decided to use one amongst questioning, prompting, cueing and explaining strategy which meet the students' ability in order to help them solve the problems.

Instruments

The instruments used in this study were observation sheet about students' SPS. This was constructed by the researchers under the guidance of a relevant SPS theory and thus contently validated by an expert. The observation sheet was then tried to collect data about students' SPS in a real practicum prior to the utilization.

Data Collecting Technique

Data about the students' SPS were collected by the researchers during the learning process using the SPS-observation sheet, rated between 1 to 5. This aimed to observe the ability of the science process skills the students performed in each syntax of the PjBL in the project work process. In the first syntax, a fundamental question was given to collect data about the students' ability in observing, interpreting, and asking questions. In the second syntax, a task to design a project plan was given to collect data about the students' ability in making an experiment plan. In the third syntax, a task to make a production schedule was given to collect data about the students' ability in planning research. In the fourth syntax, students' ability in using tools and materials, and in predicting and interpreting observations results were collected. In the fifth syntax, students' ability to classify, apply concepts and communicate was collected. In the final syntax, students' ability to communicate and ask questions were collected.

Data Analysis Techniques

Data regarding the students' SPS were analyzed using statistics. These includes the descriptive tests including mean and standard deviation of the data. Inferential test that includes T-test was also carried out to investigate the effect of the scaffolding use on the students' SPS. Normality and homogeneity of the data were also tested prior to the use of the T-test and all these tests were conducted by the help of statistical software, SPSS verse 23.

Result and Discussion

The science process skills (SPS) of the students in both groups

The results of analysis on the data collected from the SPS-observation are presented in Table 1. Table 1 shows that the initial SPS scores of both groups were low. The score of the experiment group was 47.66 and the control group was 46.81. Those was not surprising as according to the researchers' daily observations that science teaching in Jambi rarely utilizes projects in science teaching. Both students were rarely involved in a learning process that nurture their science process skills. Rather, science teaching is mostly carried out in the traditional styles which dominantly activate students to learn theories and concepts, to discuss them, and to do drills.

Not only were low but those scores were relatively similar. That was supported by the results of an independent t-test which show that p-value > .05 indicating there was no significant difference between those initial scores. This means that in the beginning of the study, both groups were lack of science process skills. However, those similar initial scores of the groups also informs that the sampling technique applied in this study was correct as it recruited students with prior similar abilities.

Table 1. Descriptive Test Results

	N	Minimum	Maximum	Means of SPS	Std. Deviation
Initial SPS of experiment group	36	33.00	63.00	47.6667	8.28079
Final SPS of experiment group	36	70.00	90.00	79.5000	5.46940
Initial SPS of Control group	36	33.00	60.00	46.8100	7.52100
Final SPS of Control group	36	53.00	80.00	65.8300	7.47000
Valid N (listwise)	36				

Besides the initial scores, table 1 also shows final scores of the groups. It is seen that the experiment group had higher final score (79.5) than the control group (65.83). Compared to the initial scores, it is obvious that the experiment group experienced higher SPS improvement (from 47.66 to 79.5) with N-Gain score 60.83% than the control group (from 46.81 to 65.83) with N-Gain score 35.76%. These indicate the use of scaffolding impacted on higher improvement of students' SPS than without using it.

The effect of provided scaffolding guidance in the project-based learning models on the students' science process skills (SPS)

Having those SPS improvements in mind, one may not claim that those results were produced by the scaffolding. To do so, some t-tests need to be conducted. However, prior to conduct the t-test, the normality and the homogeneity of the data need to be assessed. The normality and homogeneity tests were conducted using SPSS verse 23. The results showed that the data were normally distributed and homogeneous (p-value > .05). These permit the use of parametric t-tests in investigating the effects of the scaffolding on the student' science process skills.

Given that the data were normal and homogeneous, two t-tests were implemented in this study. The tests were the paired sample t-test and the independent t-test. The first test aims to investigate the effect of the treatment in each group in improving the final test from the initial test. The second test aims to investigate the effect of the different treatmen in the two groups on the final SPS scores. The first test results are presented below.

The improvement of the SPS score in each group before and after the treatment

The improvement of the SPS score in each group was measured using the paired t-test and the results can be seen in Table 2. Based on the results of the test, it is seen that there was a significant difference between the initial and final score of the experiment group (p-value = .000 < .05) with 31.83 of mean difference (from 47.66 to 79.5). This was similar with the results of the control group which show that there was also a significant difference between the initial and final scores of the control group (p-value = .000 < .05) with 19.02 of mean difference (from 46.81 to 65.83). Those results indicate that there were significant improvements in students' SPS scores between before and after the teaching activities in each group. However, in relation to the N-Gain scores above, disregard with both improvements, this confirm that the experiment group had a higher improvement than the control group.

Table 2. The Results of the Paired Sample t-Test

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Means difference	std. Deviation	std. Error Means	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Initial SPS of Experiment group and Final SPS of Experiment group	-31.83333	5.96418	0.99403	-33.85132	-29.81535	-32.025	35	0.000
Pair 2	Initial SPS of Control group and Final SPS of Control group	-19.028	7.272	1.212	-21.488	-16.567	-15.699	35	0.000

The effect of the scaffolding provision on the final SPS scores

The effect of the scaffolding provision was also investigated using the independent t-test. This test was carried by using the final SPS scores of the two groups and the results can be seen in Table 3. Data in table 3 show that there was an effect of the scaffolding provision in the project-based learning on the students' SPS (p-value = .000 < .05). This means that there was a significant difference (13.67) in final SPS scores between the two groups (between 79.5 and 65.83) and that was due to the use of the scaffolding guidance.

Table 3. Independent Sample t Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Differences	std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Students' Science Process Skills	Equal variances assumed	3.203	0.078	8.857	70	0.000	13.667	1.543	10.589	16.744
	Equal variances not assumed			8.857	64.149	0.000	13.667	1.543	10.584	16.749

The results showing that the use of scaffolding was effective in improving the student's science process skills was understandable. According to Ledibane et al., (2018) that by having scaffolding, students have assistance and helps from outside him/herself. This may from teachers, relatives, classmates, etc. Such help enables them to perform learning tasks easier. According to Fisher & Frey (2010), that scaffolding may reduce the challenges the students face in the lesson. When a teacher provides students with questioning the teacher may check their initial understanding. This means that the teacher is trying to remind the students to the prerequisite concepts they need to solve the problems of learning they are doing. When a teacher provides students with prompting such as reading a book, guideline, formula, chart, etc., this means that the teacher is facilitating them to increase their cognition process. When a teacher provides students with cueing, this means that the teachers is trying to divert students' attention to focus on more specific information, errors, or partial understanding. When a teacher provides students with explaining, this means the teacher is trying to make students to have better understanding quickly.

However, guidance and feedbacks from teachers for students should not be immediate. This must be delayed to encourage contributions from different students and horizontal interactions between students (Ledibane et al., 2018). Teachers need to change roles from dominant content experts to teachers who are open-minded and willing to implement new approaches into the classroom, such as scaffolding (Boonmoh & Jumpakate, 2019).

Research conducted by Yusnidar et al., (2023) shows that the scaffolding context is implemented by providing assistance to students in the early stages of learning and reducing assistance when students are able to do it themselves. This has a positive impact on students' problem-solving abilities and can improve student achievement and activate thinking skills during learning.

The scaffolding strategy provided by the teacher to guide students can be through key questions to test the ideas, arguments and reasons students produce in order to develop a project. Other scaffolding strategies that teachers can use include providing instructions, encouragement, explaining the problem and the steps for solving it, providing examples so that students can grow independently (N. L. I. M. Yanti et al., 2023).

Therefore, scaffolding will be very effective if used in the Zone of Proximal Development (ZPD), the potential development zone. This zone is a zone that can be assisted by adults who are more capable of solving material problems, projects or problems presented without reducing the level of difficulty of the task. ZPD is also a zone where there is interaction between learners and educators (Rusdi, 2018). In other words, successful coordination with a partner, or assisted performance, leads learners to reach beyond what they can achieve on their own, to participate in new situations and tackle new tasks, or, in the case of second language learners, to learn new ways of using the language. This kind of support means that a teacher or a more experienced peer in the language classroom can provide learners with scaffolding to support their learning (Boonmoh & Jumpakate, 2019).

This opinion is in accordance with Ji & Luo (2019) which states that scaffolding teaching shows that teachers prepare scaffolding for students at the ZPD, meaning that teachers provide appropriate assistance and support for students to complete their own learning tasks, so that they can climb the scaffolding and step over the ZPD from the actual development level to reach the potential cognitive development level and grow into independent learners, and finally the teacher withdraws from the scaffold. In short, scaffolding teaching means that teachers guide teaching through scaffolds, allowing students to master, construct and internalize the knowledge and skills they have learned so that they can perform higher-level cognitive activities. In other words, students are encouraged to ask questions, provide feedback and support their peers in learning new material. Scaffolded instruction can minimize the level of learner frustration (Van Der Stuyf, 2002).

The results of Monica and Olatubosun's study (2013) proved that students exposed to scaffolding strategies performed significantly better than their peers exposed to traditional methods. Purwanti et al., (2023) stated that the scaffolding strategy in science learning can help the learning process by providing some assistance in the early stages of learning, then reducing the assistance and giving students the opportunity to take on greater responsibility after they are able to do it themselves. so that students are active in the learning process which is oriented towards equipping students with high-level thinking skills and collaboration skills.

Another scaffolding strategy is peer tutoring. Putri et al., (2023) in their research found that the use of a scaffolding learning program with peer tutoring makes it easier for students to understand learning concepts so that the actual knowledge that students have can develop to reach the potential of their knowledge to solve learning problems/tasks, as well as train students to develop scientific communication skills. they. The complexity of the teacher's role in creating a good learning climate requires learning strategies that suit students' needs by providing guidance/assistance (scaffold) to students to be able to practice communication and thinking skills by developing problem solving, working together with tutors and group teams, and following the stages. scaffolding learning with peer tutoring.

Simons and Klein (2007) in their study revealed that students from the latter two groups produced more organized projects. That is, the findings imply that scaffolding can enhance inquiry and performance (Boonmoh & Jumpakate, 2019).

The difference in the results obtained from the treatment in the experimental and control group lies on the provision of scaffolding assistance in each syntax of the PjBL model. As is known, this PjBL model invites students to be actively involved in learning and applying material to a project and is also an innovative student-centered method (Parmani et al., 2019; Parmani et al., 2019; Bahriah et al., 2017). However, to maximize learning and optimize students' abilities, stimulation in the form of assistance is needed to encourage students to understand the material being taught.

In addition, there are other positive impacts of providing scaffolding assistance applied with the PjBL model in the learning process in the classroom to train students' ability to think critically, think creatively and solve problems, and improve science process skills, especially in chemistry subjects on acid and base materials. This is because the PjBL model invites students to carry out activities such as observing, classifying, designing projects, communicating, and forming scientific attitudes.

Özgelen (2012) explains that scientific thinking skills are science process skills that are useful in solving problems and formulating the results obtained. Hasanah & Utami (2017) added that the development of science and technology is increasingly advanced and relative. So that educators not only teach concepts but are more complex with concrete examples. Toplis and Allen also argue that science skills are a substantial part of the curriculum for developed countries (Hardiyanti et al., 2017).

The results of the analysis in Suhanda & Suryanto (2018) research on students' responses concluded that project-based learning was able to avoid students from feeling bored, and had a positive impact on increasing observation, communication and applying the concepts they had. Then project-based learning can also improve aspects of science process skills. Each aspect of SPS is interrelated, the aspect of observing will have an impact on improving the aspects of asking questions and predicting. Aspects of asking questions and predicting can have an impact on improving aspects of formulating hypotheses and designing experiments. The results of project work can improve skills in applying concepts and communication.

Bedard also stated that PjBL can develop critical thinking skills, creativity, and encourage collaboration with groups. Project-based learning is able to train students to think critically scientifically. The process is learning from one's own experience, constructing knowledge and then giving meaning to that knowledge so that critical thinking will become a necessity that students must have (Sri et al., 2021).

Nuha et al., (2023)also stated in their research that science process skills can be developed by conditioning science learning and optimizing collaborative activities. Azmi & Festiyed (2023 in their research also found that project-based learning has a positive influence on improving 4C skills (critical thinking, creativity, collaboration and communication).

The Project Based Learning (PjBL) model can be used as an alternative learning model to be applied in the learning process so that the learning outcomes obtained by students are maximized and also improve scientific and collaborative process skills (Mursalim et al., 2023). Apart from that, project-based learning emphasizes students being active because learning answers the challenges of 21st century learning. Project-based learning influences students' critical thinking abilities, where students' critical thinking abilities increase after being required in science subjects. Project-based learning can increase independence so that it can foster a sense of self-confidence and responsibility for the work being done (Selasmawati & Lidyasari, 2023).

Figure 2. Making Natural Acid-Base Indicators

Research by N. Yanti et al., (2023) also proves that the use of the PjBL model has a significant influence on students' collaboration abilities and creative thinking abilities. In the aspect of creative thinking skills, PjBL provides opportunities for students to think critically and innovatively to solve problems or produce new products.

The concept map learning technique at the decision-making stage in project-based learning is able to improve critical thinking skills, especially students' argumentation skills, because it helps students focus on finding and connecting concepts based on evidence and data from investigations. This is because PjBL requires students to think independently, analyze information and generate new ideas. Apart from that, PjBL also encourages students to think outside the box and not be afraid to try new things (Rakhmatdi et al., 2023; N. Yanti et al., 2023).

Ennis said that critical thinking skills (CTS) are reasonable reflective thinking that focuses on deciding what to believe or do. CTS skills are considered as self-regulation in deciding that has a purpose that results in interpretation, analysis, evaluation, and inference as well as real, conceptual, methodical, criteria, or contextual considerations of the decisions taken (Insani et al., 2018).

Meanwhile, creative thinking is a skill to develop, discover, or make new constructive combinations based on existing data, information, or elements, with a different point of view that arises as a manifestation of a perceived problem, resulting in something useful. Previous research shows that creative thinking is influenced by a variety of circumstances, including the extent to which individuals are able to collaborate and are motivated to solve problems. Most studies show that there are differences in students' creativity for achievement when the classroom environment is manipulated (Diawati et al., 2017). Rosaria et al., (2023) Rosaria et al., (2023) also found that project-based learning is able to increase students' scientific creativity because it can be beneficial for students in the current era of globalization.

So, it can be concluded that PjBL scaffolding helps to train abilities such as science literacy, critical thinking, and creative thinking to develop science process skills. The science process skills need to be improved not only because they need to be trained, but also students need good initial skills related to understanding the use of chemical tools and concepts. Moreover, the learning process at this time focuses more on students to be active in the learning process by expressing and developing ideas from the results of their thinking in solving problems or problems given by educators.

Conclusion

Based on the results of the study it can be stated that the science process skills of the experiment students who learnt the concepts of acid and base using the scaffolding-assisted PjBL was higher than the control group who learnt it only using PjBL. Thus, it can be said that there is an effect of the provision of the scaffolding-assisted PjBL model on the improvement of the students' science process skills. The effect can be seen in the entire learning process of the experiment students who have performed better skills of doing the science process skills.

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