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Development of Student Activity Sheets (LAPD) Oriented to Project Based Learning (PjBL) to Improve Chemical Literacy Skills on Redox Material

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Abstract
In the era of 21st century skills, the literacy scores of Indonesian students according to the results of the PISA study (2022) are still relatively low. The existence of learning loss after the covid-19 pandemic has had an impact on reducing learning outcomes and students' chemical literacy skills on redox material. This research aims to produce LAPD oriented to project based learning to improve chemical literacy skills on redox material. The method used is Research and Development (R&D) with a 4D model (define, design, develop, disseminate), but is limited to the develop stage. In this research, a limited trial was conducted on 29 students in 11th Grde Science 2 class, at a private school in Mojokerto, who had received redox material. Data analysis was carried out descriptively quantitatively. The validity (content and construct) of LAPD is valid, obtaining a mode of 4 with a good category. The practicality of LAPD is practical, the results of the student response questionnaire obtained a percentage of 96.78% with a very good category. The effectiveness of LAPD is effective, the n-gain of the chemical literacy test with a high category of 93.10% and a medium category of 6.90%; and the results of the paired sample t-test obtained a Sig.2-tailed value of 0.000 < 0.05 so that H_0 is rejected and H_1 is accepted. Thus, it can be concluded that LAPD oriented to project based learning to improve chemical literacy skills on redox material, worthy of use.

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INTRODUCTION

In the 21st century, developed nations don't only rely on natural wealth and large populations. A developed nations is characterized by a civilized and educated society. Education that implements chemical literacy is an important aspect in forming quality human resources. Chemical literacy can help students make decisions to solve the challenges of science and technology progress, environmental damage, global warming, energy crises, and moral/ethical crises. It also helps students understand environmental issues and encourages active participation of students in greening actions, waste management, use of eco-friendly alternative energy, and innovations in chemical discoveries in various fields. Then, to improve the quality of education and overcome learning loss during the Covid-19 pandemic, the Ministry of Education and Culture launched the "Merdeka Curriculum" in conjunction with the "Merdeka Belajar" program through Permendikbudristek no. 7 of 2022 concerning content standards. Merdeka curriculum supports students' chemical literacy in developing their potential (soft skills and character) through project-based learning and the Pancasila student profile (P3). One of the steps to achieve "Merdeka Belajar" is to develop an integrated literacy culture, start from the family, school, and community environments. Six forms of literacy are required in the 21st

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century are reading and writing literacy, numeracy literacy, scientific literacy, digital literacy, financial literacy, and civic literacy (Tim GLN Kemendikbud, 2017).

Based on the results of the PISA study (2022), an international student assessment program carried out over a three year period by the Organization for Economic Cooperation and Development (OECD), shows that the average mathematics, reading, and science scores of Indonesian students reached 366, 359, and 383. Indonesia is ranked 67th out of 81 participating countries based on the average OECD global score of 483–488. The literacy skills of Indonesian students are classified as low at level 1a (OECD, 2023). Supported by research by Wardhana et al. (2022), which states that Indonesian students' scientific literacy skills are at level 2. Scientific literacy is the skills to use scientific knowledge and processes, identify questions, explain phenomena, and draw conclusions based on scientific data and facts (Toharudin et al., 2011). Chemical literacy as part of scientific literacy consists of four domains, including: chemical knowledge, chemistry in context, high order thinking skills (HOTS), and affective aspects. (Shwartz et al., 2006).

Chemical literacy skills can be improved through student-centered chemistry learning. This refers to constructivist learning theory (Piaget, Vygotsky, and Dewey), which states that cognitive development occurs when students actively construct understanding and knowledge through real experiences and social or environmental interactions (Danoebroto, 2015). It is also based on the Ausubel theory of meaningful learning and the Bruner theory of discovery learning, which states that learning material must have logical meaning and relevant ideas must be contained in the cognitive structure of students, involving the processes of apperception and discovery (Dahar, 2011). However, chemistry learning in schools is often less than optimal because: 1) learning is teacher-centered; 2) the chemistry learning model is still conventional; 3) low scientific reading and writing skills; 4) students aren't yet familiar with test questions and teaching materials integrated with 21st century chemical literacy (Simamora, 2022).

Chemistry is a science that studies natural phenomena related to structure, properties of matter (substances), changes in matter and energy (Artini & Wijaya, 2020). Atomic level (microscopic) studies help understand various real (macroscopic) phenomena. One of the chemical materials that requires a multi-representational understanding is redox material, where there is logical and contextual meaning, meaning that the redox concept (conceptual) is related to phenomena in everyday life (factual), such as: corrosion/rusting, battery voltaic cells, fermentation, combustion, and electroplating on metal. Redox material is abstract at the submicroscopic level. Students are required to understand the occurrence of reduction and oxidation reactions without actual view of electrons or oxygen transfer, and the concept of determining oxidation numbers requires good mathematical calculation skills (Treagust, 2018).

Learning redox chemistry requires teaching materials. Teaching materials are a set of material that is systematically arranged, both written and unwritten, used as a guide for teachers and students in the learning process to achieve a competency. Teaching materials have at least several components, including: learning instructions for students and teachers, competencies to be achieved, material content, supporting information, exercises, activity sheets, assessments (Depdiknas, 2008). Student activity sheets (LAPD) are printed teaching materials in the form of a collection of sheets of paper containing material, summaries and instructions for implementing learning tasks that must be carried out by students with reference to the learning outcomes (CP) that must be achieved (Prastowo, 2016).

The facts in the field are that most teachers often use teaching materials (LAPD) that have been around for a long time, without making innovations to develop their own. In fact, only teachers who teach in class are able to understand the target characteristics which include student, environmental, social, cultural and geographical characteristics. Apart from that, the current

LAPD has not had any updates regarding the current state of education which is intensively implementing chemical literacy and learning models that are in accordance with the essence of the merdeka curriculum, one of which is Project based learning (PjBL).

PjBL is an innovative learning model that is student centered, using an authentic problem as the first step in collecting and integrating new knowledge based on previously existing knowledge, through real activities or collaborative projects (Mitarlis et al ., 2017). According to Rusmini et al. (2021), PjBL is a solution for practicum activities that were initially carried out in the laboratory to become practicum activities at home that are linked to real life. Apart from that, PjBL has an impact on increasing students' HOTS in order to achieve 21st century learning goals which involve the 4C principles, namely: critical thinking and problem solving, creative thinking, communication, and collaboration (Rusydiana et al., 2021).

Project based learning has a correlation with chemical literacy, where the scientific method in the PjBL stage facilitates students solving authentic problems in real life through collaboration and integration of various disciplines, and supports HOTS and chemical literacy (Wasis et al., 2020). According to Mitarlis et al. (2017), PjBL consists of six stages/phases, namely: 1) starting with essential questions, 2) designing the project, 3) preparing a schedule, 4) monitoring students and project progress, 5) testing results (reports and presentations of project results), 6) evaluation and reflection. Phase 1 supports the context and HOTS domains, which students explain everyday issues in both personal/local/global contexts, identify issues to formulate problems. Phase 2 supports the knowledge and HOTS domains, which students conduct literature studies and use scientific evidence to design projects. Phase 3 supports the affective domain, which students create project schedules collaboratively to foster interest in chemistry. Phases 4-6 support the knowledge, HOTS, and affective domains, which students use scientific evidence and the knowledge they have to carry out projects that motivate them to be interested in chemistry and have environmental awareness.

Based on the results of pre-research conducted at a private school in Mojokerto, with 29 students as respondents, it shows that 83% of students consider chemistry subjects difficult to understand and 79% of students consider redox material not interesting to study, because there is a lot of memorizing formulas and operations. mathematics, lots of scientific terms, abstract in nature, difficulty understanding concepts and teacher explanations, material is too complex and related, forgetting one of the prerequisite materials will make it difficult to understand redox material. 72% of students do not understand the benefits and applications of redox material, because they rarely do practicums related to redox due to limited facilities and infrastructure. Therefore, we need teaching materials that can attract students' interest in learning chemistry and facilitate learning of redox material using experiment methods.

Based on several previous relevant research, such as research by Riyadhin & Mitarlis (2018), it was shown that the LAPD developed related to scientific literacy on redox material didn't use a learning model such as PjBL which was in accordance with the characteristics of the current merdeka curriculum, and an average pretest score of 42.22 and a posttest of 83.56 was obtained. Then, in research by Fadhilah & Hidayah (2020) which used blended learning on redox material, none of the students achieved a minimum completion of $\geq$ 75, and students' chemical literacy skills were still low, indicated by the highest score in the knowledge domain of 56.91% (content), 22.55% (procedural), and 20.54% (epistemic).

Based on the background above, it is necessary to conduct research on "Development of Student Activity Sheets (LAPD) Oriented to Project Based Learning (PjBL) to Improve Chemical Literacy Skills on Redox Material”. This research aims to determine the feasibility of the LAPD developed based on aspects of validity, practicality, and effectiveness.

METHOD

Research Design

This research refers to the Research and Development (R&D) method which is suitable for producing an educational product such as teaching materials or LAPD, as well as testing the feasibility of the product which includes validity, practicality, and effectiveness (Sugiyono, 2019). The research design used is a four-D (4D) development model adapted from Thiagarajan & Semmel (1974), the 4D model consists of stages: define, design, develop, and disseminate. However, this research was limited to the develop stage (Ibrahim & Wahyukartiningsih, 2014).

Date, Place, and Research Subjects

This research was carried out in the even semester 2023/2024, May to June 2024. The preliminary study stage was carried out in the Chemistry Education Department, Faculty of Mathematics and Natural Sciences, Universitas Negeri Surabaya. The develop stage was carried out at a private school in Mojokerto. The subject of this research is a student activity sheets (LAPD) oriented to project based learning (PjBL) to improve chemical literacy skills on redox material. Trialed on 29 students in 11th Grade Science 2 class, who had received redox material.

Instruments and Data Collection

Data collection in this research was carried out using questionnaire, observation, and test. The questionnaire method includes: 1) review in the form of suggestions and comments from one chemistry lecturer regarding the content and construct validity of the LAPD, using a review sheet; 2) validation in the form of assessments from validators (two chemistry lecturers and one chemistry teacher) regarding the content and construct validity of the LAPD, using a validation sheet; and 3) student responses regarding the practicality of LAPD using a student response questionnaire sheet. Observation methods include observation of student activities and observation of learning implementation, which are carried out by five external observers using observation sheets. Test methods include learning outcome (cognitive) test and chemical literacy skills test, carried out by students in one class (without a comparison class/group) using pretest-posttest sheets. Pretest and posttest were conducted before and after learning using the developed LAPD.

Data Analysis

Validation data in the form of validator assessment scores which include aspects of content and construct validity of LAPD, is ordinal data that can't be carried out mathematical operations (added, subtracted, multiplied and divided), so it is analyzed by determining the mode. Scoring based on the Likert scale score is shown in Table 1.

Table 1. Validation Likert Scale Scores

Score	Category
1	Not good
2	Less good
3	Quite good
4	Good
5	Very good

(Riduwan, 2016)

Based on Table 1, the validity of the developed LAPD can be interpreted as valid, if the content and construct validity aspects obtain a mode ≥ 4 in the good to very good category (Lutfi, 2021).

Practicality data was obtained from the results of observations of student activities, observations of learning implementation, and student response questionnaires. Scoring of observations of student activities and observations of learning implementation based on the Likert scale scores is shown in Table 2.

Table 2. Observation Likert Scale Score

Implementation of Activities	Score	Category
Yes	5	Very good
	4	Good
	3	Quite good
	2	Less good
	1	Not good
No	0	–

(Riduwan, 2016)

Based on Table 2, the scores obtained are analyzed by determining the mode. The practicality of the developed LAPD can be interpreted as practical, if aspects of student activity and learning implementation obtain a mode ≥ 4 in the good to very good category (Lutfi, 2021).

While, scoring of student response questionnaire based on the Guttman scale scores is shown in Table 3.

Table 3. Guttman Scale Scores

Response	Answer	Score
Negative	Yes	0
	No	1
Positive	Yes	1
	No	0

(Riduwan, 2016)

Based on Table 3, the scores obtained are analyzed by using the formula as follow.

$$\text{\% Student Response} = \frac{\sum \text{Score Obtained}}{\sum \text{Respondents}} \times 100\%$$

The percentage of student response questionnaire scores has the category shown in Table 4.

Table 4. Student Response Questionnaire Category

Percentage (%)	Category
0 – 20	Impractical
21 – 40	Less Practical
41 – 60	Quite Practical
61 – 80	Practical
81 – 100	Very Practical

(Riduwan, 2016)

Based on Table 4, the practicality of the developed LAPD can be interpreted as practical, if the percentage obtained is ≥ 61% in the good to very good category.

Effectiveness data was obtained from the pretest-posttest results of chemical literacy skills and learning outcomes (cognitive). The pretest-posttest data was analyzed descriptively quantitatively using n-gain to determine whether there was a significant increase or difference in scores. The n-gain formula is presented as follow.

$$\text{N-gain score (g)} = \frac{\text{Posttest score} - \text{Pretest score}}{\text{Maximum score} - \text{Pretest score}}$$

Then, the n-gain score obtained is interpreted based on Table 5.

Table 5. N-Gain Score Interpretation

Score (g)	Category
$g < 0.3$	Low
$0.7 \geq g \geq 0.3$	Medium
$g > 0.7$	High

(Hake, 1998)

Based on Table 5, the effectiveness of the developed LAPD can be interpreted as effective if an n-gain score is obtained $(g) \geq 0.3$ in the medium category, up to $g > 0.7$ in the high category.

Apart from that, the effectiveness of the LAPD being developed was also analyzed using the paired sample t-test (parametric statistics) or the wilcoxon test (non-parametric statistics). The t-test aims to see the significance of the difference in the average (mean) between the pretest and posttest scores. The requirement for the t test is that the data must be normally distributed, tested using the shapiro wilk normality test. Decision making in the normality test is as follows: (1) if the Sig.value > 0.05 then the data is normally distributed, (2) if the Sig.value < 0.05 then the data is not normally distributed.

If the data is not normally distributed, continue with the wilcoxon test. However, if the data is normally distributed then the paired sample t-test can be continued which includes the stages of determining the hypothesis, testing, and decision making. The determination of the hypothesis is as follows (Sugiyono, 2019).

$$H_0: \mu_1 \leq \mu_2 \quad \text{dan} \quad H_1: \mu_1 > \mu_2$$

H_0: The chemical literacy posttest score after using the developed LAPD is smaller or the same as the chemical literacy pretest score before using the developed LAPD.

H_1: The chemical literacy posttest score after using the developed LAPD is greater than the chemical literacy pretest score before using the developed LAPD.

Based on the significance level & calculated t value read in the t-test results, decision making is shown in Table 6.

Table 6. T-Test Decision Making

Paired Sample-T Test Results	Description
(Sig.2-tailed) < 0.05 and t count > t table	H_0 is rejected and H_1 is accepted, indicating that there is an increase in students' chemical literacy skills on redox material after using the developed LAPD.
(Sig.2-tailed) > 0.05 and t count < t table	H_0 is accepted and H_1 is rejected, indicating that there is no increase in students' chemical literacy skills on redox material after using the developed LAPD.

(Sugiyono, 2019)

RESULTS AND DISCUSSION

Define Stage

The define stage aims to define learning requirements which consist of five steps, namely: front-end analysis, learner analysis, task analysis, concept analysis, and specification of learning objectives (Thiagarajan & Semmel, 1974). The first step is a front-end analysis, to find out facts about conditions in the field in chemistry learning, such as problems in schools, the curriculum and demands of the 21st century. Through observation, interviews with chemistry teachers, and distributing pre-research questionnaires to students. The second step is learner analysis, to determine the characteristics of students, including: academic ability, age and cognitive development. The redox material in the merdeka curriculum at the school is taught to 11^{th} Garede students, who are on average 15-18 years old. According to Piaget's theory of cognitive development, this age is in the formal operational stage, that is, a person begins to be able to think abstractly, symbolically, systematically, and logically, in solving problems through experiment (Danoebroto, 2015). In this case, students are considered capable of designing projects independently (Rusmini et al., 2021). Apart from that, students' learning outcomes (cognitive) and chemical literacy skills are very low, so they need to be improved. The third step is task analysis, to determine the tasks in the LAPD according to the learning outcomes (CP) of phase F of the merdeka curriculum (Kemendikbudristek, 2022). In order to support the achievement of student competency on redox material. The fourth step is concept analysis, to identify the redox concepts that will be taught, arranged hierarchically into a concept map. The fifth step is specifications of learning objective, to create a flow of learning objectives (ATP) based on learning outcomes (CP) and learning objectives (TP) for redox material.

Design Stage

The design stage aims to design the LAPD being developed. This stage includes preparing the test, selecting the form of teaching materials, selecting the format, and initial design (Thiagarajan & Semmel, 1974). The preparation of learning outcomes test (cognitive) and chemical literacy skills test requires a grid of test questions and assessment rubrics, needs to be adapted to the CP, TP, ATP of redox material in the merdeka curriculum phase F. The learning outcomes (cognitive) test is a multiple choice type that contains Bloom's cognitive taxonomy levels C3-C6 referring to Anderson & Krathwohl (2015), to measure student HOTS. The essay type chemical literacy test is adapted to the characteristics of PISA questions, the chemical literacy domain, and the level of scientific literacy (Eliza & Yusmaita, 2021). Selection of forms of teaching materials with concept analysis, task analysis, and student characteristics. Printed teaching materials, namely LAPD, are used by students to improve chemical literacy skills on redox material, so that students can understand redox concepts and their applications in real life through experiments or collaborative projects. The choice of LAPD format refers to Depdiknas (2008), including: 1) cover; 2) introductory remarks; 3) table of contents; 4) LAPD identity; 5) CP, TP, ATP; 6) instructions for use; 7) concept map; 8) summary of material; 9) apperception; 10) activity sheet; and 11) bibliography. The initial design in preparing the LAPD needs to pay attention to didactic, construction, and technical requirements (Prastowo, 2016).

Develop Stage

The develop stage aims to produce a final product (LAPD) that is suitable for use, based on aspects of validity, practicality and effectiveness. This stage includes: review and validation by expert, as well as limited trials on students.

Validity

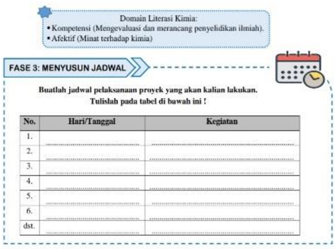
Validity is the score obtained from the results of LAPD validation by experts. Validity consists of two types, namely content validity and construct validity (Lutfi, 2021). The first step, the initial design of the LAPD (draft I) was reviewed by a chemistry lecturer to obtain suggestions and comments as material for revising the LAPD. The second step, the LAPD after the revision (draft II) was validated by two chemistry lecturers and one chemistry teacher, to obtain a content and construct validity score of LAPD. The third step, LAPD after validation revision (draft III) is ready to be trialed on a limited basis. The example of LAPD (draft III) is shown in Figure 1.

Figure 1. Initial Cover and Project Cover on Student Activity Sheet (LAPD)

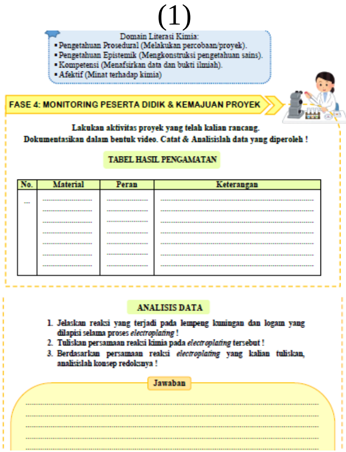
Then, the student activity sheet (LAPD) oriented to project based learning (PjBL) has six phases, shown in Figure 2.

(1)

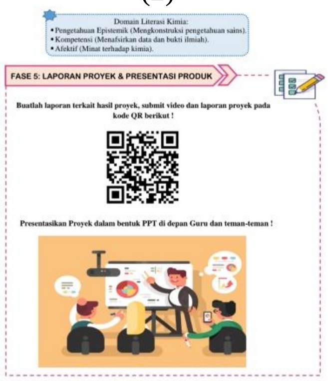
(2)



(3)



(4)



(5)

(6)

Figure 2. Project Based Learning Phase on Student Activity Sheets (LAPD)

Validity assessment uses a Likert scale score of 1-5 (Riduwan, 2016). Validity data is a type of ordinal data that cannot be carried out with mathematical operations. The results of the assessment of the content and construct validity of the LAPD by experts are shown in Table 7.

Table 7. Validity Results of Student Activity Sheets LAPD

Validity	No.	Assessment Aspects	Mode	Category
Content	1.	Conformity to Learning Outcomes (LO/CP)	4	Good
	2.	Conformity to the Chemical Literacy Domain	4	Good
	3.	Content Truth (Material Substance)	4	Good
	4.	Systematics (LAPD Components & PjBL Syntax)	4	Good
Construct	1.	Language	4	Good
	2.	Presentation	4	Good
	3.	Graphics	4	Good

Based on Table 7, there are four aspects of LAPD content validity, namely: conformity to learning outcomes (LO/CP), conformity to the chemical literacy domain, content truth (material substance), and systematics (LAPD components & PjBL syntax). These four aspects received a score mode of 4 in the good category, so they were interpreted as valid. Then, there are three aspects to the construct validity of the LAPD, namely: language, presentation, and graphics. These three aspects received a score mode of 4 in the good category, so they were interpreted as valid. This is in accordance with Lutfi (2021) which stated that the validity of a developed LAPD can be interpreted as valid if it obtains a score mode ≥ 4 in the good to very good category. The validity results in this research are in line with Riyadhin & Mitarlis (2018), showing that the feasibility of the worksheet developed obtained a content feasibility of 78.51%; linguistics 82.22%; graphics 82.22%; and presentation 83.34%. The validity aspects used in this research are in line with BSNP (2014) which describes the feasibility of LAPD including four aspects, namely: content, language, presentation, and graphics. Also in line with Prastowo (2016) which describes the requirements for preparing LAPD including didactic, construction, and technical requirements.

Limited Trial

After validation and revision, a limited trial was carried out which aimed to obtain practicality and effectiveness data regarding the LAPD developed. The practicality of the LAPD developed was reviewed based on the results of student response questionnaires, and supported by the results of observations of learning implementation and observations of student activities. The effectiveness of the LAPD developed was reviewed based on the results of the pretest-posttest of learning outcomes (cognitive) and chemical literacy skills.

Practicality

Student response questionnaires were given to students after learning using the developed LAPD, in order to obtain student responses regarding the practicality of LAPD. There are two types of statements in the response questionnaire, namely positive and negative statements, which can be answered "Yes" or "No". Scoring is based on the Guttman scale score (Riduwan, 2016). The data from the results of the student response questionnaire are shown in Table 8.

Table 8. Student Response Questionnaire Results

Assessment Aspects	Percentage (%)	Category
Clarity of material in LAPD, and its relationship to increasing student understanding.	93.10	Very good
Implementing chemical literacy learning using the PjBL model.	97.04	Very good
Ease of students in using LAPD.	98.62	Very good
Average	**96.78**	**Very good**

Based on Table 8, it shows that the clarity of the material in LAPD and its relation to increasing students' understanding obtained a percentage of 93.10% in the very good category; the implementation of chemical literacy learning using the PjBL model obtained a percentage of 97.04% in the very good category; The ease of students in using LAPD obtained a percentage of 98.62% in the very good category. Overall, the average percentage of response questionnaire results was 96.78% in the very good category. Relevant with research by Riyadhin & Mitarlis (2018), showing that the average percentage of student response questionnaire results was 89.80% in the very satisfactory category. This is in accordance with Lutfi (2021) which stated that the practicality of a developed LAPD can be interpreted as practical if it obtains a practicality percentage of ≥ 61% in the good to very good category.

The student response questionnaire were supported by the results of observations of the implementation of learning during three meetings using the developed LAPD. The activities observed are the activities of teachers and students, referring to the syntax of the Project Based Learning (PjBL) model. Observation scoring uses a Likert scale score of 1-5 (Riduwan, 2016). The results of observations of learning implementation are shown in Table 9.

Table 9. Observation Results of Learning Implementation

No.	Learning Activity / Syntax	Observation Results of Learning Implementation			Mode
		1st Meeting	2nd Meeting	3rd Meeting	
1.	Introduction	5	5	5	5
2.	Core Activity				
	Phase 1: Start with Essential Questions	5	-	-	5
	Phase 2: Designing Projects	5	-	-	5
	Phase 3: Create a Schedule	5	-	-	5
	Phase 4: Monitoring Students and Project Progress	-	5	-	5
	Phase 5: Reporting and Presenting Project Results	-	-	4	4
	Phase 6: Evaluation and Reflection	-	-	5	5
3.	Closing	5	5	5	5

Based on Table 9, it is known that the implementation of learning during three meetings with project based learning (PjBL) syntax, in each phase obtained a mode of 5 in the very good category. Except for phase 5, it got a mode of 4 in the good category. The practicality of the developed LAPD is interpreted as practical, in terms of obtaining a mode score ≥ 4 in the good to very good category. Shows that teachers and students have implemented project based learning (PjBL) on redox material well.

Then, the practicality of the LAPD developed was also reviewed based on the results of observations of student activities, namely activities that were in accordance with chemical literacy skills refers to the chemical literacy domain. Observation scoring uses a Likert scale score of 1-5 (Riduwan, 2016). The results of observations of student activities are shown in Table 10.

Table 10. Observation Results of Student Activities

Meeting	Mode	Category
1	5	Very good
2	5	Very good
3	5	Very good

Based on Table 10, student activities at the 1st meeting, 2nd meeting, and 3rd meeting, each received a score of 5 in the very good category. The practicality of the developed LAPD is interpreted as practical, in terms of obtaining a mode score ≥ 4 in the good to very good category. Shows that student activities in accordance with chemical literacy skills have been carried out very good. These student activities include: (1) reading phenomena/news quotes on the LAPD, (2) conducting literature studies from various sources, (3) formulating problems related to phenomena/problems, (4) discussing in groups to design projects, (5) collaborate to prepare the project schedule, (6) carry out the collaborative project according to the project plan, (7) record the results of project observations, (8) present the project results, (9) respond to questions during the presentation, (10) summarize the results of project activities, (11) reflect PjBL learning. Apart from that, the results of observing student activities are relevant to research by Zahro & Mitarlis (2021) which shows that the results of observing student activities in learning using LAPD PjBL obtained a percentage of the first, second, and third meetings, respectively 95.83%, 92.50 %, and 89.58% in the very practical category.

Effectiveness

The pretest and posttest questions on learning outcomes (cognitive) were of the multiple choice type with 15 questions. Each question item has a different taxonomy bloom cognitive level, starting from C3-C6 to find out students' HOTS. The learning outcomes (cognitive) score for each question item are shown in Figure 3.

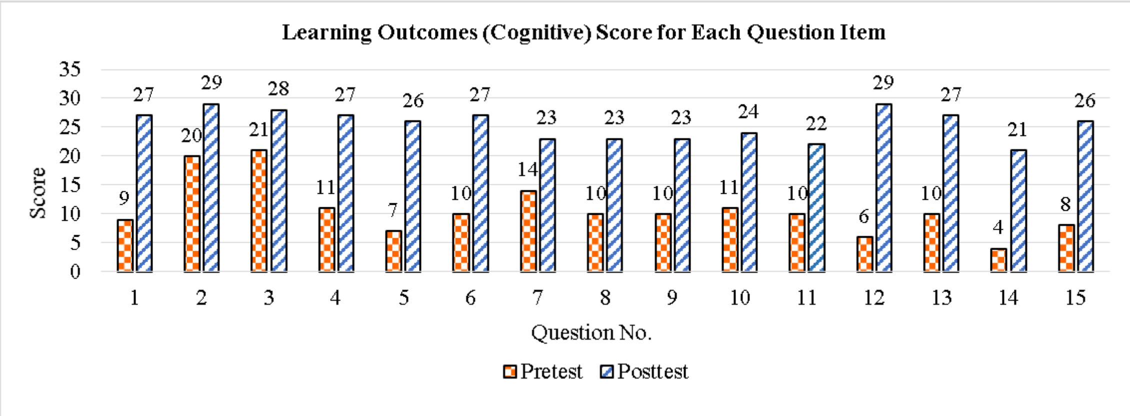


Figure 3. Learning Outcomes (Cognitive) Score for Each Question Item

Based on Figure 3, in the pretest there were 2 questions with a score of ≥ 20. Meanwhile, 13 questions that received a score of < 20 were at the cognitive taxonomy bloom level C4-C6 (High Order Thinking Skills/HOTS), except for questions number 7 and 8 is at cognitive level C3 (Middle Order Thinking Skills/MOTS). This shows that students have not been able to solve HOTS level questions, because they aren't used to working on HOTS questions, lack understanding of redox material, and there are misconceptions. Meanwhile, in MOTS questions number 7 and 8, students made many errors in answering, due to factors that they didn't understand the question sentence and weren't careful in calculating redox stoichiometry which involved mathematical operations. Students' difficulties in solving HOTS questions can be overcome with chemical representations: macroscopic, microscopic/submicroscopic, and symbolic (Sukmawati, 2019). The learning outcomes (cognitive) score of 11^{th} Grade Science 2 class students is shown in Figure 4.

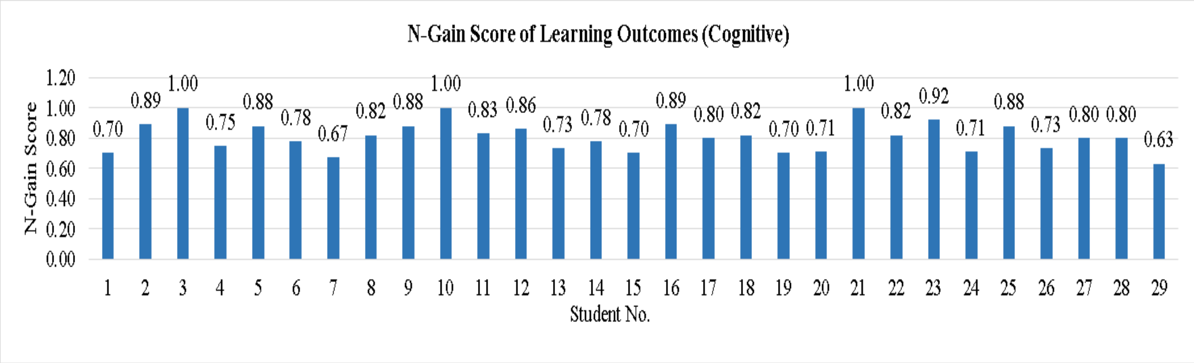


Figure 4. N-Gain Score of Learning Outcomes (Cognitive)

Based on Figure 4, an increase in the learning outcomes (cognitive) of 11th Grade Science 2 class students is shown by the n-gain in the high category of 82.76% (24 students) and the medium category of 17.24% (5 students). Relevant to research by Ma'sumah & Mitarlis (2021), it shows that developed LAPD with the PjBL model can improve learning outcomes (cognitive) with an average n-gain score of 0.83 in the high category.

The results of the learning outcomes (cognitive) test were also analyzed using SPSS version 25. Initially a Shapiro Wilk normality test was carried out with a significance level of 5%, a Sig value was obtained, pretest of 0.071 and posttest of 0.002. There is one data or sample with a Sig value < 0.05, namely the posttest, indicating that the data is not normally distributed. According to Sugiyono (2019), the Wilcoxon test (non-parametric statistics) is used as an alternative to the paired sample t-test, if the data is not normally distributed. The Wilcoxon test results for learning outcomes (cognitive) are shown in Table 11.

Table 11. Results of the Wilcoxon Test for Learning Outcomes (Cognitive)

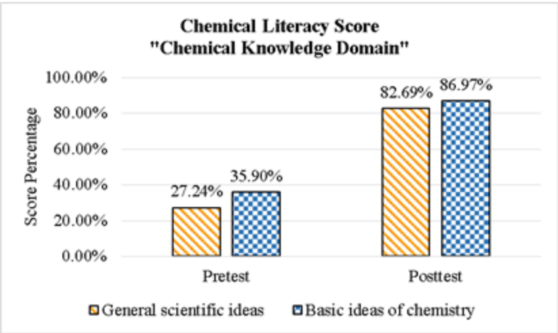
Test Statistics[a]	
	POSTTEST - PRETEST
Z	-4.715[b]
Asymp. Sig. (2-tailed)	.000

a. Wilcoxon Signed Ranks Test
b. Based on negative ranks.

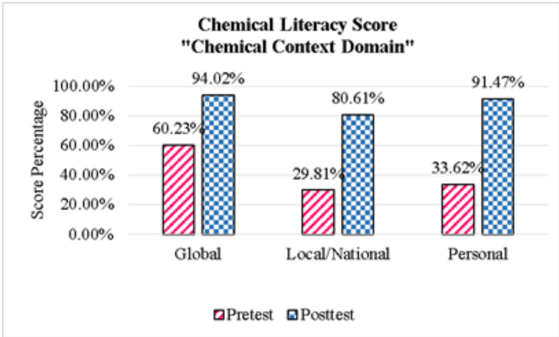
Based on Table 11, the Asymp.Sig.2-tailed value obtained is 0.000 < 0.05, so H_0 is rejected and H_1 is accepted, indicating an increase in students' learning (cognitive) outcomes on redox material after learning using the developed LAPD.

The chemical literacy pretest and posttest questions were essay type with a total of 5 questions, which matched the characteristics of PISA questions. Each question item has a different on scientific literacy level, cognitive level, and chemical literacy domain. There are four domains of chemical literacy according to Shwartz (2006), namely the domain of chemical knowledge, chemistry in context, higher order thinking skills (HOTS), and affective (Rahayu, 2017). The pretest and posttest results of chemical literacy skills in each domain and aspect are shown in Figure 5.

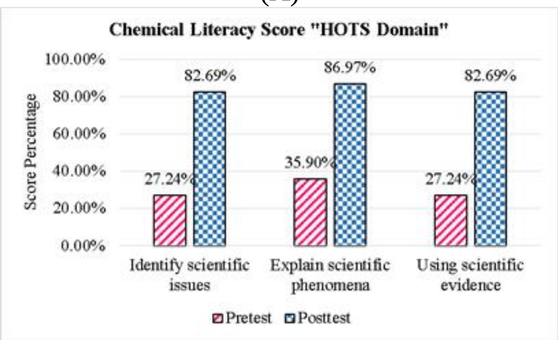
Based on Figure 5, there is an increase in pretest and posttest scores in four chemical literacy domains. In the chemical knowledge domain (A), aspects of general scientific ideas (procedural and epistemic knowledge) obtained a pretest score of 27.24%, posttest 82.69%, and n-gain 0.76 in the high category. Meanwhile, the main ideas aspect of chemistry (content knowledge) obtained a pretest score of 35.90%, posttest 86.97%, and n-gain 0.80 in the high category. The percentage of pretest-posttest scores for general scientific ideas is lower than the main ideas for chemistry. Because initially students were unable to design experimental procedures that suited the content and context. In line with research by Fadhilah & Hidayah (2020), it shows that students' scientific literacy skills scores in the knowledge domain: content 56.91%, procedural 22.55%, and epistemic 20.54%. Knowledge of redox content is included in the content of physical systems, which includes: chemical structure, chemical changes in matter, chemical reactions, energy and their transformations (OECD, 2019). In accordance with the learning outcomes (CP) phase F which reads "using chemical energy transformations in everyday life" (BSKAP, 2022).



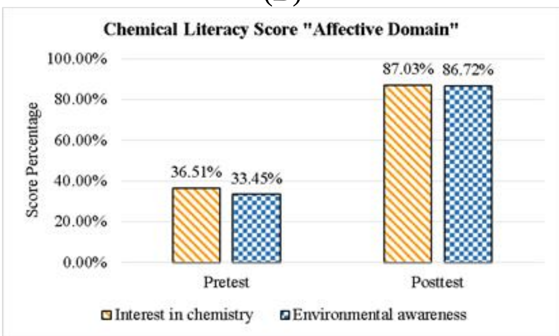
(A)



(B)



(C)



(D)

Figure 5. Chemical Literacy Domain Score: (A) Chemical Knowledge (B) Chemical Context (C) HOTS (D) Affective

In the chemical context domain (B), the global context raised the issue of fireworks obtained a pretest score of 60.23%, posttest 94.02%, and n-gain 0.85 in the high category. Shows that it is easier for students to understand redox concepts related to global issues that are commonly discussed by the public or known through news, infographics and direct experience of use. In line with research by Rahayu (2019) which states that socio-scientific issues (SSI) are included in a global context, causing students to learn the relationships between scientific disciplines and increase understanding of concepts. The local/national context raised the issue of batik waste and tofu with formalin obtained a pretest score of 29.81%, posttest 80.61%, and n-gain 0.72 in the high category. Shows that students do not understand the redox concept related to local/national issues because students rarely encounter it directly or it is less relevant to the characteristics of the environment around them, so their knowledge and application of this is still limited or low.

Supported by research of Laksono (2018) which shows low chemical literacy abilities in the context aspect obtaining a score of <70% regarding the application and principles of waste management. The personal context raised the issue of rancidity of cooking oil and rust, obtaining a pretest score of 33.62%, posttest 91.47%, and n-gain 0.87 in the high category. Shows that it is easier for students to understand redox concepts related to personal issues because they experience or are directly involved in activities in everyday life. This context refers to the OECD (2019) which shows that the scope of the scientific context of PISA scientific literacy includes global (danger); local/national (environmental quality, health and disease); private (natural resources).

In the HOTS domain (C), the aspect of identifying scientific issues and using scientific evidence obtained a pretest score of 27.24%, posttest 82.69%, and n-gain 0.76 in the high category. The aspect of explaining scientific phenomena obtained a pretest score of 35.90%, posttest 86.97%, and n-gain 0.80 in the high category. HOTS refers to students' skills in analyzing, evaluating, creating and solving problems. These skills have the characteristics of being logical, critical, evaluative, creative and solution (Wasis et al., 2020). Students who use the PjBL model have higher HOTS than those who use the direct learning model (Simamora, 2022).

In the affective domain (D), the aspect of interest in chemistry obtained a pretest score of 36.51%, posttest 87.03%, and n-gain 0.80 in the high category. Supported by the results of the student response questionnaire on the 10th statement "Using LAPD doesn’t make me use chemical literacy more often in chemistry learning", where 28 students answered "No" getting a percentage of 96.55% in the very good category. The environmental awareness aspect obtained a pretest score of 33.45%, posttest 86.72%, and n-gain 0.80 in the high category. Supported by the results of the questionnaire, students' responses to the 9th statement "Using LAPD trains me to be responsible and raise awareness about the environment" obtained a percentage of 100% in the very good category. OECD (2019) describes environmental awareness as a condition where students have environmental knowledge and an attitude of caring about the environment.

Based on the analysis of each chemical literacy question item, the chemical literacy level of 11th Grade Science 2 class students is known as shown in Figure 6.

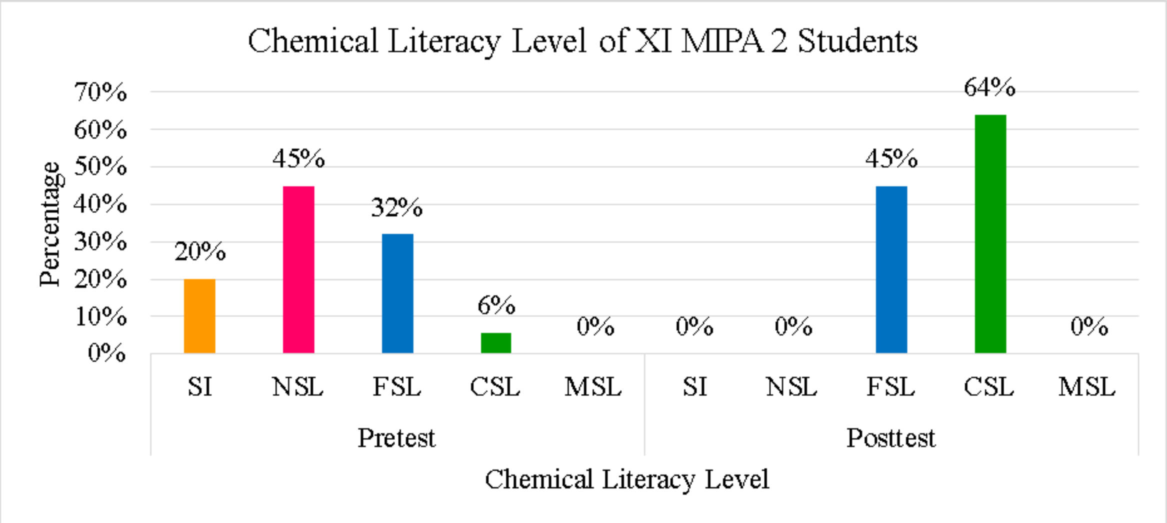


Figure 6. Chemical Literacy Level of XI MIPA 2 Students

Based on Figure 6, the chemical literacy level of 11th Grade Science 2 class students before learning using the developed LAPD was at a nominal level of scientific literacy of 45%, functional scientific literacy of 32%, scientific illiteracy of 20%, and conceptual scientific literacy of 6%. Then there was an increase in the posttest to a level of functional scientific literacy of 45% and conceptual scientific literacy of 64%. In line with research by Thummathong & Thathong (2018) which shows that students' chemistry literacy levels are at a low level of 61.9%, medium 33.5%, and high 4.6%. This means that the increase in students' chemical literacy level has not yet reached the highest level of chemical literacy, namely multi-dimensional scientific literacy. This is because students often have misconceptions about redox material and have limitations in connecting redox concepts with scientific disciplines, technology and issues in everyday life in more complex contexts. Apart from that, the chemical literacy skills score of 11^{th} Grade Science 2 class students is shown in Figure 7.

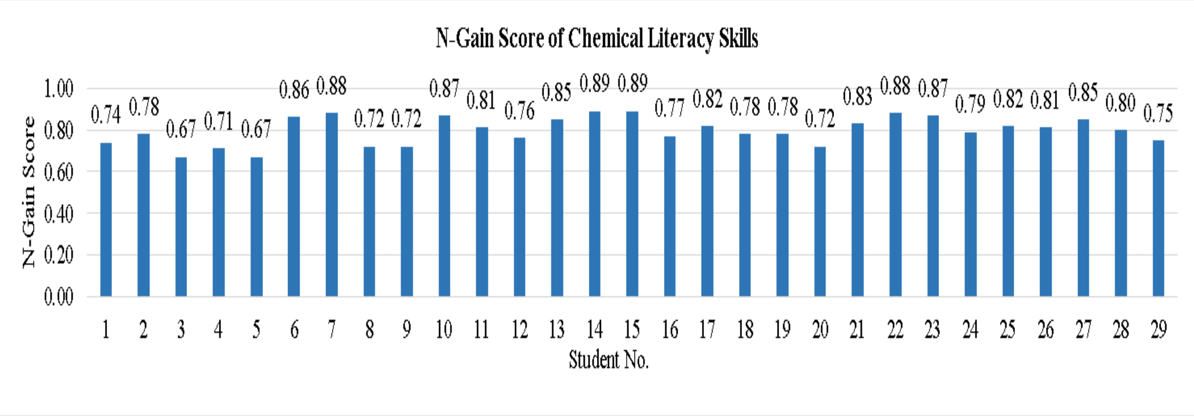


Figure 7. N-Gain Score of Chemical Literacy Skills

Based on Figure 7, an increase in the chemical literacy skills of 11^{th} Grade Science 2 class students is shown by the n-gain score in the high category of 93.10% (27 students) and the medium category of 6.90% (2 students). Relevant with research by El-Haqq & Mitarlis (2024), showing an increase in scientific literacy skills in terms of the n-gain score in the high category of 84% (21 students) and the medium category of 16% (4 students). Research by Ulandari & Mitarlis (2021) shows that the use of the developed LAPD can improve scientific literacy skills in terms of the average n-gain of 0.88 in the high category. Also, research by Wardani & Mitarlis (2018) shows an increase in scientific literacy skills in terms of the average n-gain of 0.78 in the high category. This shows that the use of LAPD oriented to project based learning (PjBL) is effective in improving students' chemical literacy skills.

The results of the chemical literacy skills test were also analyzed using SPSS version 25. Initially a Shapiro Wilk normality test was carried out with a significance level of 5%, a Sig value was obtained, pretest of 0.313 and posttest of 0.059. Shows that the data is normally distributed or meets the t test requirements, namely the Sig value. > 0.05 (Sugiyono, 2019). The results of the paired sample t-test for chemical literacy skills are shown in Table 12.

Table 12. Results of the Paired Sample T-Test for Chemical Literacy Skills

		Mean	Std.Deviation	Std.Error Mean	95% Confidence Interval of the Difference Lower	95% Confidence Interval of the Difference Upper	t	df	Sig.(2-tailed)
Pair 1	PRETEST-POSTTEST	-51.06897	9.75021	1.81057	-54.77775	-47.36019	-28.206	28	.000

Based on Table 12, the results of the paired sample t-test were obtained with a Sig.2-tailed value, namely 0.000 < 0.05 and a calculated t value > t table, namely 28.206 > 2.048. So, H_0 is rejected and H_1 is accepted, meaning that there is an increase in students' chemical literacy skills on redox material after learning using the developed LAPD. The increase in the chemical literacy posttest score was because students had a better understanding of the concept of redox material than before and were accustomed to solving contextual redox problems that required HOTS and problem solving, which students had learned how to solve it, just like when using LAPD oriented to project-based learning. Then, the results of the t-test in this research are in line with the research of Putri & Rinaningsih (2021) which showed that the use of LAPD has strong effectiveness in improving chemical literacy skills, as indicated by the results of the paired sample t-test (Sig.2tailed value) is 0.000 < 0.05; the calculated t value > t table is 15.991 > 2.06866. The increase in chemical literacy skills test results in 25 relevant studies was 38.409% with an effect size value of 3.1981% which is classified as effective in the strong category.

Thus, based on the results of the paired sample t-test or wilcoxon test, and the n-gain test, the effectiveness of the LAPD developed can be interpreted as effective, in terms of the Sig.2tailed value < 0.05 and the n-gain (g) score ≥ 0.3 in the medium category, up to g > 0.7 in the high category.

CONCLUSION

Based on the research results that have been obtained, it can be concluded that "Student Activity Sheets (LAPD) Oriented to Project Based Learning (PjBL) to Improve Chemical Literacy Skills on Redox Material" is declared suitable for use, viewed from the following aspects. The validity of developed LAPD is interpreted as valid, based on aspects of content and construct validity, which obtained mode 4 in the good category. The practicality of developed LAPD is interpreted as practical, based on: (1) the results of observation of student activities and observation of learning implementation obtained mode 5 in the very good category; (2) the results of the student response questionnaire obtained a percentage of 96.78% in the very good category. The effectiveness of developed LAPD is interpreted as effective, there is an increase in learning outcomes (cognitive) and chemical literacy skills, based on: (1) the results of the paired sample t-test on the chemical literacy test results with α = 5%, obtained a Sig.2-tailed value of 0.000 < 0.05 and t value > t table (28.206 > 2.048); (2) Wilcoxon test results on learning outcomes (cognitive) test results with α = 5%, obtained a Sig.2-tailed value of 0.000 < 0.05; (3) the learning outcomes test (cognitive) obtained an n-gain in the high category of 82.76% and the medium category of 17.24%; and (4) the chemical literacy skills test obtained an n-gain in the high category of 93.10% and the medium category of 6.90%.

RECOMMENDATIONS

Based on the research that has been carried out, there are several suggestions, including: 1) Further research that focuses on improving chemical literacy skills, can use chemistry lesson topics, learning models, or different types of experiments; 2) Further research that focuses on scientific/ chemical literacy can develop literacy questions according to PISA with other types, besides essay; 3) Further research that focuses on the project based learning (PjBL) model can estimate the time allocation related to student projects, so that optimal results are obtained.

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