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The development of steam-based LKPD - PjBL acid-base solution material to improve creative thinking ability

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Abstract

This study aims to determine the validity, practicality, and effectiveness of STEAM–PjBL-based LKPD products. The research method used is research and development (R&D) with the ADDIE development model. The developed LKPD was tested on 24 class XI IPA 2 MAN 1 Banjarmasin students. The results showed that the LKPD developed was included in the very valid category in content, presentation, language, and design assessment, with an average score of 95.5%. The LKPD that was developed also fulfilled practicality aspects with very practical categories on individual readability tests, small group readability tests, student response questionnaires, and teacher responses, as well as observation sheets on teacher abilities in managing classes. LKPD has also fulfilled the aspect of effectiveness, as seen from the results of the average N-gain percentage of 76%. So that students' creative thinking skills are included in the high category. The results of this study indicate that the product developed, namely the STEAM-PjBL-based LKPD, has met the aspects of validity, practicality, and effectiveness.

Keywords: LKPD; STEAM – PjBL; Creative Thinking; Acid-Base.

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INTRODUCTION

The 21st-century skills that a person must master are problem-solving and creative thinking. It is always hoped that these skills will be developed in every lesson so that students can face the challenges of the global world (Suryandari et al., 2018). A good education can improve the quality of human resources. The 4Cs (creativity, critical thinking, collaboration, and communication) are essential skills in education. According to Meador (1997), creative thinking has four indicator aspects, namely (1) Fluency, (2) Flexibility, (3) Originality, and (4) Elaboration. According to Hamid et al. (2021), and Salamah & Sumarsilah (2018), creative thinking is the process of a person generating an original, aesthetic, and constructive idea from known facts and experiences. This new idea is an innovation and development of previous

experience that has never been realized. Creative thinking skills are one of the levels of high-level thinking needed in social life (Fajaruddin, 2022).

Creative thinking is a student skill that must be taught and developed to improve their ability to solve problems creatively (Sinurat et al., 2022). Developing creative thinking is also stated in the National Education System Law Number 20 2003. The goal of national education is the development of the potential of students to become human beings who are devoted to God Almighty, have noble character, are knowledgeable, healthy, capable, creative, independent, and become democratic and responsible citizens. Strengthening creative thinking in the learning process at school internalizes students' traits or tendencies to be creative (Damayanti et al., 2020).

Humans always face problems, so creativity is needed. Creative thinking adjustments can be taught in education (Malik et al., 2023). Educational institutions are the right place to develop students' creative thinking abilities. One of the goals of education is to transform students into creative humans. Creative people are original in their thinking, develop new ideas, and elaborate on a concept (Pangestu, 2021).

Creative thinking today is still low (Umami et al., 2021), revealing that Indonesia in the results of a survey conducted by International Benchmarking such as PISA (Program for International Student Assessment) in 2018 showed that Indonesia was ranked 72nd out of 77 countries in science and mathematics. TIMSS (Trends in International Mathematics and Science Study) also shows that Indonesia ranks 69th out of 76 countries. The TIMSS and PISA results show that students are less creative. This is because PISA and TIMSS questions are characterized by situational questions requiring reasoning and creativity requiring reasoning and creativity (Sari & Afriansyah, 2022).

Research by Romayanti et al. (2020) said that students are less interested and curious in learning, which affects their creative thinking abilities. One way to improve creative thinking skills is to learn actively and effectively. This can be achieved by developing STEAM–PjBL based LKPD (Students' Worksheet) teaching materials. The LKPD (Students' Worksheet) is developed on the conditions and situations of learning activities (Apriani et al., 2021). Previous studies show that integrating STEAM–PjBL into the learning process can improve the quality of teaching and learning (Sigit et al., 2022).

The appropriate learning model for overcoming problems in creative thinking is project-based learning (Aprilia et al., 2023). PjBL is a model that uses projects as the core of its learning (Furi et al., 2018). The PjBL learning model allows teachers to direct their lessons through project work (Ambiyar et al., 2020). PjBL is a student-focused learning model that provides students with valuable learning experiences. PjBL is constructivist and collaborative learning that allows students to work together to solve a problem (Rohman et al., 2022).

The STEAM approach is an approach that combines five scientific disciplines that teachers can apply in different learning environments. STEAM offers activities that involve students in design and engineering tasks to explore students' science and mathematics skills through creativity, expression, and visual aspects that also

support logical thinking (Rohman et al., 2022). The STEAM method can be integrated into a project-based learning model by presenting children with daily activity problems that must be solved in groups (Harjanty & Muzdalifah, 2022). The advantages of STEAM-integrated PjBL were also stated by Santi et al. (2020), who stated that the PjBL model could improve 21st-century skills by integrating it with the STEAM approach. A study by (Annisa et al. (2018) shows that applying STEAM – PjBL can improve creative thinking skills in chemistry material. Integrating the STEAM learning model with PjBL strengthens creative thinking more effectively (Hehakaya et al., 2022). Integration STEAM with the PjBL model has been successfully used to develop students' soft skills related to 21st-century skills (Aprilia et al., 2018).

STEAM-integrated project-based LKPD can activate active and practical learning activities, help students understand learning material well, and help students understand subjects well and develop creative thinking skills to face real problems in the environment (Izzania et al., 2021). The results of this research are supported by Fitriyah and Ramadani (2021), which reveals that the STEAM-based PjBL model can significantly improve creative thinking abilities. This aligns with research by Siew & Ambo (2020) and Hanif et al. (2019), who said that STEAM–PjBL is a teaching and learning model that is reliable, valid, appropriate, and effective for increasing creativity. Applying the STEAM–PjBL approach has stimulated students' creative thinking (Budiyono et al., 2020).

According to Sudarmo (2016), chemistry is a branch of natural science that studies the structure and properties of matter (substances), changes in matter (substances), and the energy associated with these changes. Chemistry is closely related to life so that humans can see and experience something related to chemistry daily (Hamid, 2018). According to some students, the subject matter of acids and bases is too much and difficult to understand (Kaukaba et al., 2022). The material of acid and base solutions is very closely related to everyday concepts. Hence, learning chemistry is a mental activity that requires high thinking abilities and creative ideas from students in learning (Annisa et al., 2018).

The LKPD developed is based on STEAM – PjBL to improve creative thinking skills, where students will carry out practical work on natural indicators of acid-base solutions, and the materials used are easy to find in the environment. Then, students use the Canva application to create a project in the form of a poster. Students can develop creative thinking when making projects because they need creative ideas in project planning. Thus, the development of STEAM – PjBL -based LKPD can be a solution to improve students' creative thinking abilities. This is in line with research by Chistyakov et al. (2023), who say that STEAM–PjBL positively affects teaching, learning, motivation, and student engagement. Apart from that, PjBL can also improve learning based on competency and creativity. Creative thinking skills have been formed while students work on learning tasks (Demitra et al., 2023).

METHODS

Research and development (R&D) methods are used in the design of the LKPD being developed. The LKPD is designed based on STEAM-PjBL and aims to measure students' creative thinking abilities by conducting a pretest and posttest before and after using the LKPD. This research uses the ADDIE development model, which consists of the following five parts: a) Analysis, b) Design, c) Development, d) Implementation, and e) Evaluation.

The data collection techniques used in this research are tests and non-tests, namely interviews and questionnaires. The data obtained was then analyzed to test validity, practicality, and effectiveness. The formula (1) and criteria for assessing media validity used are as follows (Table 1).

$$\text{Validation score} = \frac{number\ of\ scores\ obtained}{number\ of\ maximum\ score\ (total)} \times 100\% = \cdots\% \quad (1)$$

Table 1. Validity level criteria and test instruments

Interval Score	Validity Criteria	Note
85 < V ≤ 100	Very Valid	No Revision
70 < V < 85	Valid	Minor Revision
50 < V < 70	Less Valid	Major Revision
V < 50	Invalid	Cannot be used

(Aiken, 1985; Yunita *et al.*, 2021).

For the validity of the test instrument, use the formula of Aiken's V statistics and it is formulated as follows (2).

$$V = \frac{\Sigma s}{\{n(c-1)\}} \quad (2)$$

Notes:

s = r-lo
r = number given by an appraiser
lo = lowest validity assessment number (in this case = 1)
c = highest validity assessment number (in this case = 5)
n = number of assessors

A test instrument is reliable if it provides consistent results when tested many times. Reliability is measured using Alpha Cronbach's formula, which is as follows (3).

$$r_{11} = \frac{k}{(k-1)}\left(1 - \frac{\Sigma\sigma b^2}{\sigma t^2}\right) \quad (3)$$

Note:

r_{11} : Instrument reliability
k : Number of question items
$\Sigma\sigma b^2$: The amount of variance in the scores for each question item
σt^2 : Total score variance

The criteria for a research instrument are said to be reliable using the Alpha Cronbach technique if the reliability coefficient is > 0. The Alpha Cronbach reliability interval is presented in Table 2 below.

Table 2. Alpha cronbach's reliability interval

Interval *Alpha Cronbach* (α)	Reliability Criteria
$0.90 \leq \alpha \leq 1$	Very High
$0.70 \leq \alpha < 0.90$	High
$0.50 \leq \alpha < 0.70$	Medium
$\alpha < 0.50$	Low

(Irmawati *et al.*, 2021).

Practicality data analysis is based on readability surveys, teacher and student response questionnaires, and teacher ability questionnaires in managing the classroom. The formula (4) and criteria for assessing practicality are as follows (Table 3).

$$\text{Practicality score of teaching materials} = \frac{number\ of\ scores\ obtained}{number\ of\ maximum\ score\ (total)} \times 100\% \quad (4)$$

Table 3. Practicality level criteria

Interval Score	Practicality Criteria	Note
$81\% < \times \leq 100\%$	Very Practical	Used without revision
$61\% < \times \leq 80\%$	Practical	Can be used with minor revisions
$41\% < \times \leq 60\%$	Quite Practical	It is recommended not to use
$21\% < \times \leq 40\%$	Less Practical	Can not be used
$00{,}00\% < \times \leq 20\%$	Impractical	Can not be used

(Arikunto, 2013; Riyana *et al.*, 2022).

Effectiveness analysis uses test instruments to measure students' creative thinking abilities. The percentage calculation is based on the analysis of each indicator by evaluating the results before and after testing. The assessment formula (5) and criteria are as below (Table4).

$$\text{SKBK} = \frac{T}{T_t} \times 100\% \quad (5)$$

Note:

%SKBK = percentage of creative thinking ability score
T = total score obtained by students
T_t = total score

Table 4. Criteria for creative thinking ability

Interval Score	Criteria
81% - 100%	Very creative
61% - 80%	Creative
41% - 60%	Quite Creative
21% - 40%	Less Creative
< 21%	Very Less Creative

(Anggela *et al*., 2022).

N-gain is calculated by the formula developed by (Hake, 1998) (6).

$$g = \frac{Xposttest - Xpretest}{Xmax - Xpretest} \quad (6)$$

Note:

g	:	*Gain* score
$X_{pre\text{-}test}$	:	*Pre-test* Score
$X_{postest}$	:	*Post-test* Score
X_{max}	:	Maximum Score

N-gain is calculated after obtaining the gain value for each student's data. The N-gain value is then interpreted based on the criteria in table 5 below.

Table 5. *N-Gain* data creative thinking ability

N-gain (g)	Criteria
g < 0,3 or expressed as a percentage g < 30%	Low
0,3 < (g) < 0,7 or expressed as a percentage 30% < (g) < 70%	Medium
g > 0,7 or expressed as a percentage g > 70%	High

(Maulidy & Mitarlis, 2022).

RESULT AND DISCUSSION

The development results in a STEAM-PjBL-based LKPD (Students' Worksheet) product on acid-base solution material to improve students' creative thinking abilities. This research was conducted to evaluate validity, practicality, and effectiveness. LKPD (Students' Worksheet) is a benchmark for improving students' creative thinking abilities.

Analysis stage

The analysis stage of this research is analyzing the need to develop teaching materials. Some of the analyses carried out are as follows.

a) Needs analysis

In the needs analysis, researchers surveyed students and chemistry teachers at MAN 1 Banjarmasin to determine the need for developing teaching materials regarding the influence of printed teaching materials on students' thinking abilities.

b) Problem identification

In identifying the problem, the researcher receives the results of the needs analysis; the results obtained include:

(1) Teaching materials in the form of LKPD **(**Students' Worksheet**)** are not optimally maximized in the learning process.
(2) The LKPD teaching materials provided by the teacher are less attractive because the LKPD display is only in text format so students are less interested and enthusiastic in learning.

Planning Stage (Design)
The planning stage in developing an LKPD is selecting an acid-base solution LKPD design, developed based on the feasibility and use of appropriate materials. The planning stages are as follows:
1) Preparation of 8 parts of the LKPD design, namely: (1) cover; (2) foreword; (3) brief explanation of PjBL, STEAM, and creative thinking; (4) concept map; (5) explanation of KD, indicators and learning objectives; (6) short material; and (7) PjBL stage; (8) bibliography. The cover design and foreword can be seen in the Figure 1.

Figure 1. Cover design and foreword

The following figure is a brief explanation of STEAM – PjBL and creative thinking and a concept map, as well as an explanation of KD, indicators, and learning objectives, which can be seen in the Figure 2.

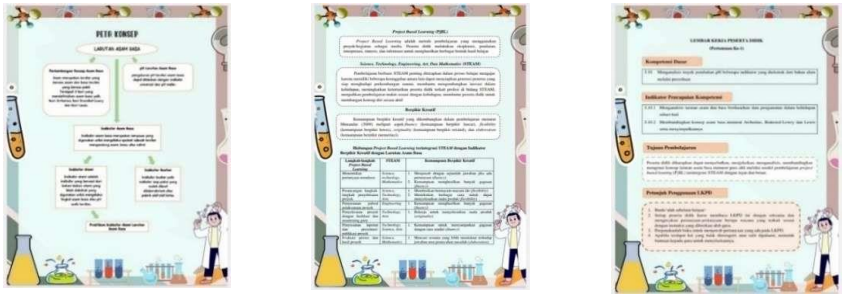

Figure 2. Concept map design, definition of STEAM–PjBL and kd as well as indicators and learning objectives

The next figure is a LKPD design with short material, PjBL steps and a bibliography can be seen in the Figure 3.

Figure 3. Material design, PjBL syntax, and bibliography

Development Stage

The development stage creates a final LKPD draft based on input from experts or validators. This stage is divided into two parts: expert validation and readability testing (Table 6).

Table 6. LKPD validation results by validator

Assessment Aspects	Validator I	II	III	IV	V	Average	Validation Score	Note
Contents	60	58	55	53	57	56,6	94,34%	Very valid
Presentation	45	43	41	43	45	43,4	96,45%	Very valid
Language	70	67	64	63	70	66,8	94,86%	Very valid
Design	40	39	35	39	40	38,6	96,5%	Very valid
Rata-rata							**95,5%**	**Very valid**

Table 6 above shows that the LKPD (Students' Worksheet) reached an overall percentage of 95.5%. Based on a validity value of 95.5%, it is classified in the "very valid" category for use as teaching material in the teaching and learning process. The validity of the test instrument in the form of discourses that measure students' creative thinking abilities is four discourses by the indicators of creative thinking abilities, which are analyzed using the Aiken coefficient. The average score obtained is 0.94, so it can be said that the question is "valid. Meanwhile, the reliability test of the test instrument was carried out on 23 chemistry education students. The results obtained were 0.65, so it can be said that these questions are suitable for use in research. The percentage results from the readability questionnaire can be seen in table 7 below.

Table 7. Results of individual trial readability questionnaire review aspects

Review Aspects	Obtained Score	Maximum Score	Percentage
Display and content	50	60	83,4%
Material content and language	70	75	93,4%
Average	**60**	**67,5**	**88,89%**

The percentages obtained from the small group readability test are shown in table 8 below.

Table 8. Results of small group test readability questionnaire review aspects

Review Aspects	Obtained Score	Maximum Score	Percentage
Display and content	93	100	93%
Material content and language	113	125	90,4%
Average	**103**	**113**	**92%**

Table 8 above shows the results of 88.89% for individual readability of the developed LKPD. Meanwhile, the results were 92% on the small group readability questionnaire. Based on these percentages, both percentages show that the LKPD is very practical in the "very good" category.

Implementation Stage

The implementation stage was carried out to determine the practicality of the LKPD being developed, namely with teacher and student response questionnaires and teacher observation sheets in classroom management. Teacher response questionnaires were distributed after the learning process. The results of the teachers' responses are shown in Table 9 below.

Table 9. Results of teacher response

Respondent	Average Score	Maximum Score	Note
1	4,8	5,0	Very Good
Average	**96%**		Very Good

The results of filling out the teacher response questionnaire gave an average score of 4.8 with a percentage of 96%, which was included in the "very practical" category. The results of student responses can be seen in Table 10 below.

Table 10. Results od students' response

No.	Respondent	Average	Assessment Criteria
1.	1	4,3	Very Positive
2.	2	4,5	Very Positive
3.	3	4,0	Positive
4.	4	4,4	Very Positive
5.	5	4,5	Very Positive
6.	6	4,3	Very Positive
7.	7	4,3	Very Positive
8.	8	4,5	Very Positive
9.	9	4,6	Very Positive
10.	10	4,6	Very Positive
11.	11	4,6	Very Positive
12.	12	4,6	Very Positive
13.	13	4,5	Very Positive
14.	14	4,5	Very Positive

No.	Respondent	Average	Assessment Criteria
15.	15	4,3	Very Positive
16.	16	4,4	Very Positive
17.	17	4,8	Very Positive
18.	18	4,1	Positive
19.	19	4,6	Very Positive
20.	20	4,6	Very Positive
21.	21	4,7	Very Positive
22.	22	4,4	Very Positive
23.	23	4,8	Very Positive
24.	24	4,8	Very Positive
	Average	**4,5**	**Very Positive**
		89,75	

The results of the student response questionnaire reached an average of 4.5 with a percentage of 89.75%, which was included in the "very practical" category.

Table 11. Teacher results in managing the class

Activity	Learning 1		Learning 2	
	Percentage Score	Category	Percentage Score	Category
Introduction	90%	Very Good	93%	Very Good
Syntax 1: define the basic question	83%	Very Good	86%	Very Good
Syntax 2: designing project completion steps	93%	Very Good	100%	Very Good
Syntax 3: preparation of the project implementation schedule	80%	Good	86%	Very Good
Syntax 4: project completion with teacher facilitation and monitoring	93%	Very Good	100%	Very Good
Syntax 5: preparation of reports and presentations/project publications	80%	Good	90%	Very Good
Syntax 6: evaluate project processes and results	90%	Very Good	96%	Very Good
Closing	88%	Very Good	93%	Very Good
Time Allocation	86%	Very Good	93%	Very Good
Average Percentage	**87%**	**Very Good**	**93%**	**Very Good**

Based on Table 11 above, it can be seen that the assessment given by the observer for lesson 1 was 87% and for lesson 2 93%, which shows that the teacher's ability to manage the class is in the "very good" category. So, it can be said that the LKPD developed is included in the "very practical" category.

Figure 4. Learning implementation process

Figure 5. Student posters' design using the canva application

Figure 4 is a teaching and learning activity carried out in class XI IPA MAN 1 Banjarmasin, and figure 5 is a student project, namely a poster. This poster design shows students' creativity very well. Students try new things and are not afraid to experiment in creating poster designs. This is in line with research by Sutaphan & Yuenyong (2023), that assessment can focus on students' creative thinking skills which can be seen through their project design process. Project-based learning has the potential to enable students to research, plan, design, and reflect on the creation of projects.

Evaluation Stage

The evaluation stage is the final stage in the ADDIE development model; at this stage, an evaluation is carried out on the LKPD developed in the learning process activities by initial expectations or not. This evaluation stage includes formative evaluation and summative evaluation. Formative evaluation is carried out when the

LKPD is validated by validators, student response questionnaires, and when research is ongoing. Then a summative evaluation was carried out after the research was completed, namely finding out the effect of the LKPD on improving students' thinking abilities after students used the LKPD during the learning process.

Table 12. ***N-gain*** **score per aspect**

Creative Thinking	Question Number	Pre-test	Post-test	N-Gain	N-Gain (%)	Category
Fluency	1	40,83	88,34	0,,80	80%	High
Flexibility	2	37,5	84,16	0,74	74%	High
Originality	3	36,67	83,34	0,73	73%	High
Elaboration	4	39,16	86,67	0,78	78%	High

1) Fluency

The students' ability level on the pre-test was 40.83, and the score on the post-test was 88.34 with an N-gain value of 80%. This percentage of N-gain value is in the "high" category (Table 12). The fluency indicator is used in creative thinking ability test questions; it is hoped that students can answer the questions with as many ideas as possible accompanied by reasons. This is in line with research by Febrianingsih (2022), the aspect of fluency in thinking, namely being able to answer questions by providing ideas relevant to the problem and complete and precise answers. According to Rohmantika & Pratiwi (2022), the fluency aspect of students can answer questions with supporting ideas.

2) Flexibility

The students' ability level on the pre-test was 37.5, and the score on the post-test was 84.34 with an N-gain value of 74%. This percentage of N-gain value is in the "high" category. The flexibility indicator is used in creative thinking ability test questions. It is hoped that students can answer test questions by offering different solutions. This is in line with research by Saleh et al. (2023), flexibility, namely the ability to produce various thoughts or answers, see the situation from several perspectives, look for different options or ways, and apply different strategies or ways of thinking. Creative people tend to have flexible thought processes. It is easy to let go of old thought patterns and replace them with new ones.

3) Originality (Authenticity)

The students' achievement level on the pre-test was 36.67, and the score on the post-test was 83.34, with an N-gain value of 73%. This percentage of N-gain value is in the "high" category. Creative Thinking Test questions use originality indicators, which are expected to be able to answer questions by creating unique new ideas. This is in line with research by Saleh et al. (2023), that the capacity to generate renewable ideas. According to Rohmantika & Pratiwi (2022), the originality aspect is where students are required to solve problems with their ideas and sentences.

4) Elaboration

The students' achievement level on the pre-test was 39.16, and the score on the post-test was 86.67 with an N-gain value of 78%. This percentage of N-gain value is in the "high" category. The creative thinking ability test questions use development

indicators, which are expected to be able to answer questions by developing ideas that students accept. This is in line with research by Febrianingsih (2022), namely the elaboration aspect when students can answer questions with correct and detailed answers.

CONCLUSION

The results of research development state that the LKPD developed can be applied in teaching and learning activities and is said to be valid from content, presentation, language and design. Validation results from validators with a percentage of 95.5%. The results of developing LKPD are very practical, with a percentage of 88.89% in individual trials, a percentage of 92% in small group trials, a percentage of 89.75% in student response questionnaires, a percentage of 96% in teacher response questionnaires, a percentage of 87.03% with an average of 4.35 (very good) on teacher observations in managing the class. The LKPD developed meets the effective category for improving students' creative thinking abilities with an N-gain value per aspect, namely 80% in the fluency aspect, 74% in the flexibility aspect, 73% in the originality aspect, and 78% in the elaboration aspect and an average N-gain value of 76%.

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