jurnal βeta kimia
e-ISSN: 2807-7938 (online) dan p-ISSN: 2807-7962 (print)
Volume 5, Number 2, November 2025
http://ejurnal.undana.ac.id/index.php/jbk

Development of Student Worksheets on Thermochemistry Material Based on Problem-Based Learning (PBL) for Phase F

Anjela A. Pong, Vinsensia H.B. Hayon, Erly G. Boelan*

Department of Chemistry Education, Faculty of Teacher Training and Education, Widya Mandira Catholic University, Kupang
**e-mail correspondence: earlygrizca@gmail.com*

ARTICLE INFO

Article history:
Received:
11 April 2025
Revised:
05 July 2025
Accepted:
10 September 2025

Keywords:

Development, Student Worksheet, Thermochemistry, Problem-Based Learning

ABSTRACT

This study aims to evaluate the validity of Student Worksheets (LKPD) in thermochemistry material designed using a Problem-Based Learning (PBL) approach, assess the implementation of learning using the PBL model, and examine students' responses to the developed worksheets. The research employed the 4-D development model, although it was limited to the development stage only. The study involved 26 students from class XI.3 at SMA Negeri 1 Semau Selatan as the research subjects. Data collection methods included interviews, validation, and the distribution of questionnaires. The results of the study revealed that: (1) the developed Student Worksheets was considered highly valid, with average scores from material expert validators I and II at 93.05% and 98.6%, respectively, and from media expert validators I and II at 91.65% and 94.45%, respectively; (2) all aspects of classroom learning using the PBL model were implemented successfully; and (3) students' responses to the LKPD were very positive, with an average score of 90%.

How to cite: Pong, A. A., Hayon, V. H. B., Boelan, E. G.(2025). Development of Student Worksheets on Thermochemistry Material Based on Problem-Based Learning (PBL) for Phase F, 5(2), 9-15. https://doi.org/10.35508/jbk.v5i2.21210

INTRODUCTION

Education is a fundamental foundation in developing skills, knowledge, morals, and individual character while strengthening national unity. Education is not merely related to academic instruction but also involves character formation and preparing individuals to face life challenges. According to Saptono [1], education is an essential need for every individual and is closely related to almost all aspects of human activity in daily life. Despite its noble objectives, education often faces various challenges in its implementation. One common problem is the frequent curriculum changes that create confusion among stakeholders, including parents, students, and teachers [2]. Nasution [3] stated that curriculum reform has systemic effects, not only on teaching materials but also on educators and administrators.

Since independence, Indonesia has undergone approximately ten curriculum reforms. The most significant reform occurred in 2020 as a response to the global health crisis caused by COVID-19. This crisis forced the education sector in Indonesia to adapt through the implementation of an emergency curriculum. Subsequently, further adjustments led to the Merdeka Curriculum, which allows schools greater flexibility to align learning with local contexts, student characteristics, and global developments. According to Aprima and Sari [4],

differentiated learning, which considers students' readiness, interests, and talents, is one of the prioritized approaches in the Merdeka Curriculum.

Student Worksheets serve as a vital tool in supporting the success of the learning process [5]. LKPDs encourage students to be more active learners and enhance their creative problem-solving abilities. They also support the Problem-Based Learning (PBL) model, which emphasizes student engagement in contextual problem-solving [6]. Audin et al. [7] highlight that the PBL model allows students to think critically, collaborate with peers, and develop communication skills essential for 21st-century learning.

Chemistry, particularly thermochemistry, requires critical and analytical understanding. Thermochemistry, which studies energy changes in chemical reactions, is often perceived as abstract and challenging. According to Annafi and Mulyani [8], mastering thermochemistry requires students to be trained in critical, rational, and creative thinking. Hence, implementing a PBL model in thermochemistry lessons can help students better grasp concepts and apply them to real-life situations.

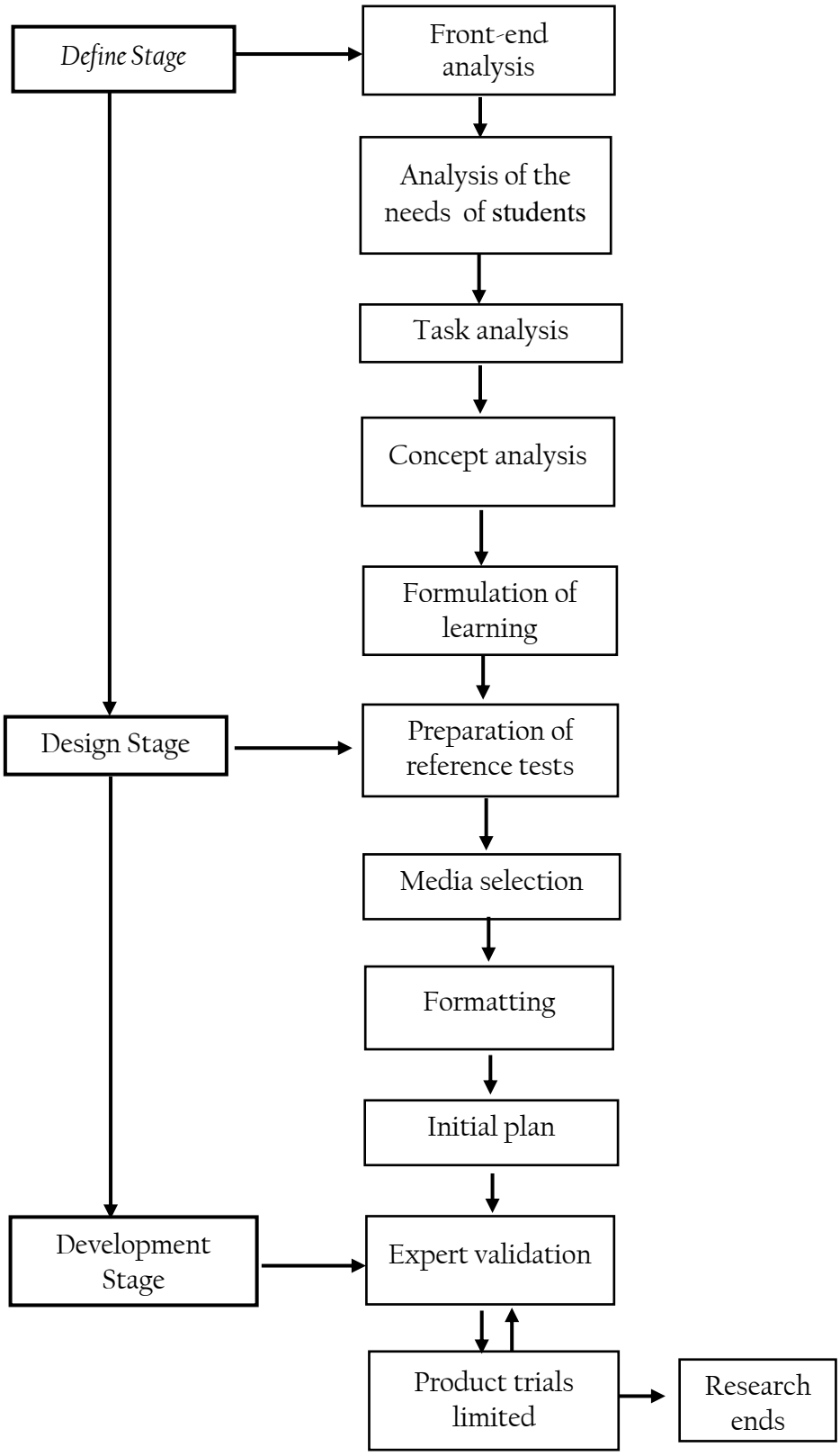
Previous research by Astuti et al. [9] found that the PBL model was more effective than the Discovery Learning (DL) model in improving students' understanding and skills. However, DL, though beneficial for enhancing creativity through direct experience, often requires more time and is less efficient in achieving learning goals. Based on an interview with a chemistry teacher at SMA Negeri 1 Semau Selatan, Andera Saputra Sari, S.Pd, Gr, challenges were identified in implementing DL due to issues with efficiency and student engagement.

Therefore, this study focuses on developing a Problem-Based Learning (PBL)-based Student worksheet for thermochemistry at SMA Negeri 1 Semau Selatan. The study aims to evaluate the validity of the developed Student Worksheets, the implementation of learning, and students' responses after using it in class XI.3.

RESEARCH METHODS

This study employed a research and development (R&D) approach utilizing the 4-D development model; however, it was limited to the development stage. The research was conducted at SMA Negeri 1 Semau Selatan in May 2024, involving a sample of 26 students from class XI.3 during the 2023/2024 academic year.

Data collection techniques included interviews, validity testing, and the administration of questionnaires. The research process comprised three main stages: *define*, *design*, and *development*. The selection of this model aimed to produce a learning tool that could be validated and subsequently implemented to observe improvements in students' learning outcomes on thermochemistry topics. Figure 3.3 below illustrates the stages of the development research process.



The instruments used in this study consisted of the student worksheet validation sheet, the observation sheet for the implementation of PBL-based learning, and the student response questionnaire. The student worksheet validation sheet was employed to collect expert opinions and feedback from validators. The observation sheet for learning implementation was used to gather data on the execution of PBL-based learning based on the teaching modules utilized. This observation instrument specifically adopted the format of a problem-based learning

implementation observation sheet. Meanwhile, the student response questionnaire was designed to collect students' feedback and perceptions regarding the developed student worksheet.

The data analysis techniques employed in this study consisted of three main components: the validation analysis of the PBL-based Student worksheet, the analysis of learning implementation, and the analysis of student responses. The PBL-based student worksheet validation analysis aimed to assess the validity of the worksheet as evaluated by material and media experts. The learning implementation analysis was conducted to evaluate the effectiveness of the PBL-based learning process derived from the teaching modules, with a focus on the success rate of the implemented activities. Meanwhile, the student response analysis aimed to assess students' perceptions and feedback regarding the application of the PBL-based student worksheet. The student worksheet validation analysis employed Equation (1), the learning implementation analysis utilized Equation (2), and the student response analysis used Equation (3).

$$\text{Validity percentage} = \frac{total\ score\ obtained}{maximum\ score} x100\% \quad (1)$$

$$\text{Implementation of learning} = \frac{average\ number\ of\ aspects\ implemented}{number\ of\ aspects\ observed} x100\% \quad (2)$$

$$\text{Response(R)} = \frac{total\ score\ obtained}{maximum\ score} x100\% \quad (3)$$

The validation analysis of the Student worksheet was conducted after the completion of the instrument testing and evaluation stage. The PBL-based student worksheet validation was analyzed using the validity percentage formula presented in Equation (1), as proposed by Akbar [10], and further described in Table 1.

Table 1. Validity Assessment Criteria

Percentage range (%)	Rating categories
76-100	Highly Valid
51-75.99	Valid
26-50.99	Less Valid
0-25.99	Invalid

The analysis of learning implementation was conducted both during the learning process, to monitor its execution, and after the completion of learning activities, to evaluate the extent to which the learning objectives were achieved and to provide feedback for future improvement. The implementation of learning was analyzed using the learning implementation formula presented in Equation (2), as proposed by Tahirman [11], and further detailed in Table 2.

Table 2. Learning Implementation Criteria

Score interval	Criterion
1	Implemented
0	Not Implemented

The analysis of student responses was analyzed using equation 3 above, as explained in table 3.

Table 3. Categories of Student Responses

Present Interval (%)	Category
85-100	Excellent
70-84.99	Good
40-69.99	Pretty Good
0-39.99	Bad

RESULTS AND DISCUSSION

Validation of Student Worksheets

Validation was conducted to collect opinions and feedback from expert validators. These validators consisted of material experts and media experts who possessed extensive expertise in their respective fields. Based on the results of data analysis, the average scores obtained were as follows: material expert validator I, 93.05%; material expert validator II, 98.6%; media expert validator I, 91.65%; and media expert validator II, 94.45%. These results indicate that the developed student worksheet falls into the *very valid* category. The validation process involved four experts in total—two material validators and two media validators. The primary purpose of the student worksheet validation was to gather expert judgments on specific aspects of the worksheet and ensure that their feedback was integrated into the development of the learning materials. Accordingly, the student worksheet was developed to enhance students' cognitive abilities and academic achievement, enabling them to comprehend the subject matter more effectively and in greater depth..

The validation of the student worksheet material aspect encompassed nine evaluation criteria: (1) the alignment of the presented material with the lesson plan, (2) the correspondence between students' activities and learning objectives, (3) the authenticity of the problems or phenomena presented, (4) the clarity of the thermochemistry content, (5) the structure of the student worksheet reflecting the PBL model, (6) the completeness and relevance of the material, (7) the appropriateness of the questions with learning objectives, (8) the clarity and readability of the language used, and (9) the suitability of the time allocation. The validation of both the material and media aspects was conducted in two stages. The results of the student worksheet validation are presented in Table 4.

Table 4. Data from student worksheet Validation Analysis

Types of validators	Stages		Average
	1	2	
Validator material expert I	86.1%	100%	93.05
Validator Material Expert II	97.2%	100%	98.6%
Media Expert Validator I	88.9%	94.4%	91.65%
Media Expert Validator II	88.9%	100%	94.45%

Implementation of learning

The implementation of learning activities using the Problem-Based Learning (PBL) model in the classroom was observed across three main components: the introductory, core, and closing phases. Based on the data analysis results, the researcher obtained the maximum score (100) for all three components, indicating that every aspect of the learning process was executed effectively. This finding demonstrates that classroom instruction was conducted in alignment with the prepared teaching modules.

During the introductory phase, the implementation of learning included several stages, namely praying, checking student attendance, providing apperception, and motivating students. The purpose of this preliminary activity was to establish an effective initial learning environment and to prepare students to engage in the learning process optimally.

The core phase of instruction under the PBL model consisted of five key steps: (1) introducing the problem to students, (2) organizing students for learning, (3) guiding the investigative process, (4) developing and presenting solutions, and (5) analyzing and evaluating problem-solving

strategies. At this stage, students engaged with the learning materials through a PBL-based approach, while teachers created engaging learning situations to foster motivation. The instructional content was contextualized by linking it to real-life examples to enhance students' understanding and relevance of the material.

In the closing phase of PBL-based learning, the teacher summarized the material covered, assigned homework, and concluded the session with a prayer and closing remarks. The closing activity within the PBL model emphasizes two primary components: (1) validation of the concepts, laws, or principles constructed by students, and (2) enrichment of the subject matter already mastered [12]. In this study, the teacher reaffirmed the concepts learned to ensure their accuracy and validity, while enrichment was facilitated through follow-up assignments provided to students.

Based on the analysis of the learning implementation, the obtained score of 100 was categorized as *very good*, indicating that the PBL-based learning process was carried out successfully and effectively.

Learner response

The data obtained from the analysis of students' responses to the developed Student worksheet are presented in Table 5 below:

Table 5. Overall Student Response Analysis Data

No.	Participant Name	Score obtained	Maximum Score	P(%)	Category
1.	AMP	35	40	87.5	Excellent
2.	ASN	38	40	95	Excellent
3.	AK	37	40	92.5	Excellent
4.	EAB	37	40	92.5	Excellent
5.	FL	37	40	92.5	Excellent
6.	FRL	39	40	97.5	Excellent
7.	FM	35	40	87.5	Excellent
8.	GT	37	40	92.5	Excellent
9.	GTH	34	40	85	Excellent
10.	JBS	38	40	95	Excellent
11.	NS	37	40	92.5	Excellent
12.	NP	39	40	97.5	Excellent
13.	MH	32	40	80	Good
14.	NS	36	40	90	Excellent
15.	RL	35	40	87.5	Excellent
16.	RLA	36	40	90	Excellent
17.	RB	33	40	82.5	Good
18.	SR	37	40	92.5	Excellent
19.	TGS	34	40	85	Excellent
20.	VSU	39	40	97,5	Excellent
21.	YAL	32	40	80	Good
22.	YB	37	40	92.5	Excellent
23.	YL	38	40	95	Excellent
24	YLTL	35	40	87.5	Excellent
25.	YLO	35	40	87.5	Excellent
26.	YH	34	40	85	Excellent
		936	1.040	90	Excellent

The average student response to the developed Student worksheet was 90%, which falls within the *very good* category. This indicates that students demonstrated a highly positive attitude toward the use of the student worksheet. The score suggests that the materials and activities presented in the student worksheet were effective in capturing students' interest and facilitating their understanding. Therefore, the developed student worksheet can be considered effective in supporting the learning process and achieving the intended learning objectives. Furthermore, the excellent response reflects students' high level of satisfaction with both the delivery of the material and the organization of the learning activities.

CONCLUSION

Based on the data obtained from the research findings and the preceding discussion, it can be concluded that the developed Student worksheet demonstrated excellent feasibility for practical implementation. In the material aspect, validator I provided a *very valid* assessment with an average score of 93.05%, while validator II also rated it as *very valid* with an average score of 98.6%. In terms of the media aspect, validator I assigned an average score of 91.65%, categorized as *very valid*, and validator II gave an assessment with an average score of 94.45%, which was likewise classified as *very valid*. Furthermore, the implementation of Problem-Based Learning (PBL) in teaching thermochemistry to students of class XI.3 at SMA Negeri 1 Semau Selatan was evaluated as *very good*, with all learning components successfully executed. In addition, students' responses to the PBL-based student worksheet on thermochemistry material were highly positive, indicating that the developed worksheet was effective in supporting the learning process and enhancing student engagement and achievement.

REFERENCES

[1] Saptono, A. (2017). The Influence of Teacher Creativity in Learning and Students' Emotional Intelligence on Economic Learning Achievement of Class X Students at SMA Negeri 89 Jakarta. Econosains, 14(1), 105–112.
[2] Megawanti, P. (2012). Problems in Basic Education in Indonesia. Pendidikan MIPA, 2(3), 227–234.
[3] Nasution. (2009). Asas-asas Kurikulum. Jakarta: Bumi Aksara.
[4] Aprima, D. & Sari, S. (2022). Analysis of the Application of Differentiated Learning in the Implementation of the Merdeka Curriculum in Elementary Mathematics Lessons. Media Jurnal Ilmiah Pendidikan, 95–101.
[5] Suryaman, M. (2020). Orientation of Merdeka Belajar Curriculum Development.
[6] Ariana, D. (2016). Development of Student Worksheets Based on Discovery-Based Learning (DBL) Equipped with Higher Order Thinking Skills (HOTS) for Class XI MAN Students, 2(1), 1–23.
[7] Audin, S. et al. (2023). Development of Student Worksheets (LKPD) Using Problem-Based Learning (PBL) Model on Elasticity and Hooke's Law for SMA/MA Class XI Students, 8(2), 90–98.
[8] Annafi, N., & Mulyani, S. D. (2015). Development of Guided Inquiry-Based Student Worksheets on Thermochemistry for Class XI SMA/MA, 4(3), 21–28.
[9] Astuti. (2021). Development of Problem-Based Learning (PBL) Student Worksheets to Improve Students' Critical Thinking and Learning Outcomes. Jurnal Guru Kita, 2(3), 108.
[10] Akbar, S. (2013). Learning Instrument Tools. Bandung: Rosdakarya.
[11] Tahirman, W. (2013). Effectiveness of Mathematics Learning Through Open-Ended Problem Approach for Grade VIII Students of SMP Negeri 1 Larompong, Luwu Regency.
[12] Nurul Khotim, S. N. & H. H. (2015). Development of Problem-Based Chemistry Modules on Acid-Base Material. Chemistry in Education, 4(2).