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Developing a Problem-Based Student Worksheet Integrated with Scientific Literacy in Thermochemistry

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Abstract: *The purpose of this study was to determine the feasibility and student response to the development of a Problem-Based Integrated Science Literacy Student Worksheet (LKPD) for Thermochemistry. The study used Research and Development (R&D) with the 4D development model (Define, Design, Develop, Disseminate). Purposive sampling was used to select 35 students from class XI IPA 1 of SMA Negeri 1 Bangun Purba as the experimental class. The instruments used were a BSNP-based feasibility assessment sheet and a student response questionnaire. The results showed that the developed LKPD was valid and highly suitable for use. This was demonstrated by the average feasibility score of 3.62. The results of the student response questionnaire showed an average score of 3.65, indicating a high level of student interest. It can be concluded that the development of a Problem-Based Integrated Science Literacy Student Worksheet (LKPD) integrated with science literacy is highly effective as a supplementary teaching material in schools because it can improve students' critical thinking skills and motivation to learn thermochemistry.*

Keywords: *teaching material development; LKPD; problem-based learning; scientific literacy; thermochemistry*

INTRODUCTION

Facing the 21st century, identifying student competencies that need to be developed is crucial. Students must hone their skills and enhance their learning to be able to address global challenges, such as critical thinking skills, effective communication skills, innovation skills, and problem-solving skills through negotiation and collaboration (Panggabean et al., 2022).

According to the Ministry of Education and Culture the independent curriculum focuses on student competencies at each stage, enabling students to learn material in greater depth, meaning, and enjoyment (Ruaya et al., 2022). In the curriculum, chemistry learning materials tend to be conceptual and theoretical, focusing on explaining scientific concepts rather than their application. This leads to students being less motivated to learn, resulting in inadequate chemistry learning (Panggabean et al., 2023).

Chemistry and critical thinking skills are inseparable, as chemistry is understood through critical thinking, and vice versa.

Critical thinking can be cultivated through chemistry learning (Sinuraya et al., 2024).

One chemistry topic that students find difficult is thermochemistry. Thermochemistry is a subject that studies the heat and thermal changes that accompany chemical and physical reactions or processes (Sinaga & Sagala, 2021).

Student worksheets (LKPD) are teaching materials containing assignments that each student must complete (Nuroctaviani et al., 2023). Teachers use LKPD to facilitate the learning process. The material in these LKPD must align with the core competencies being achieved (Putri et al., 2024). Integrated Problem-Based Science Literacy LKPD are used to train critical thinking skills and encourage student engagement in the learning process (Purba et al., 2024).

PBL (*Problem Based Learning*) is a learning method in which students learn through inspiration, group thinking, and the use of related information. (Pulungan & Sitepu, 2021). PBL integrated with scientific literacy significantly supports the chemistry learning process. Scientific literacy is the ability to engage with science-related issues and scientific ideas as a reflective citizen (Wajipalu et al., 2025). This is supported by research findings using problem-based student worksheets (LKPD), which showed an increase in students' problem-solving abilities from 57% to 96% (Sari et al., 2024).

LITERATURE REVIEW

Student worksheets (LKPD)

Student worksheets (LKPD) are sheets containing assignments that students must complete. Using LKPD will provide students with ample opportunities to actively participate in the learning process, both individually and in discussion groups (Lestari et al., 2022). Student worksheets (LKPD) play a crucial role in the learning process, assisting teachers in guiding and directing students to discover concepts through a series of learning activities. The developed LKPD must be tailored to the students' needs. They should be attractive, practical, and enhance innovation, thereby reducing the difficulties students face in learning (Yase et al., 2020)

Student worksheets (LKPD) are designed based on the Core Competencies (KD) that must be achieved and will assist teachers in implementing the learning process. LKPD is useful for maximizing students' active participation in learning activities (Hanifa & Andromeda, 2025).

Student worksheets (LKPD) have many advantages, including being a learning medium for students, increasing student activity in learning activities, and providing clear and practical material. However, LKPD also has several disadvantages: the practice questions contained in LKPD tend to be monotonous, and most print media only emphasize cognitive subjects (Artalia et al., 2022).

Problem Based Learning

Problem-based learning (PBL) emphasizes providing real-life problems that students must solve through independent investigation. This helps develop creative thinking skills in problem-solving, thereby forming solutions to these problems as essential knowledge and concepts for learning (Munthe & Suyanti, 2024). Problem-Based Learning (PBL) is a learning model that applies scientific concepts and principles, including environmental chemistry, and is also more suitable for learning through assessment (Hidayah et al., 2021)

The syntax of PBL is (1) Orienting students to problems; (2) Organizing students to learn; (3) Guiding individual and group investigations; (4) developing and presenting work results; (5) Analyzing and evaluating the problem-solving process (Roza & Damanik, 2022). In this model, the lesson focuses on a problem that must be solved by students, so that students have the responsibility to analyze and solve the problem with their own abilities, while the role of the educator is only to support and provide guidance (Meilasari et al., 2020).

The advantages of the PBL model are that it develops students' thinking and systematic thinking skills, making learning easier to understand. However, PBL also has disadvantages, such as students' lack of interest or belief that the problems being studied are difficult to solve. Consequently, they are reluctant to try, and it takes a significant amount of time

Scientific Literacy

Scientific literacy is defined as the ability to use scientific knowledge, identify questions, and draw conclusions based on evidence, in order to understand and make decisions regarding nature and the changes made to it through human activity (OECD, 2017). Scientific literacy plays an important role in decision-making on everyday life issues such as health, interaction with the environment, and determining the products used and their impact on the environment (Handayani et al., 2018). The Program for International Student Assessment (PISA) sets standards for measuring scientific literacy achievement in three areas: science process, science, and the context of scientific application. These three aspects serve as benchmarks for scientific literacy achievement (Simamora, 2022).

METHODS

This research is a research and development (R&D) study that aims to develop a product through systematic steps. This research uses a 4D development model, a learning tool development model developed by *S. Thiagarajan, Dorothy S. Semmel, and Melvyn I. Semmel*. This model consists of four stages: Define, Design, Develop, And Disseminate. This model was chosen to develop and design student worksheets (LKPD) based on problem-based learning integrated with scientific literacy on thermochemistry. This LKPD product is intended for students XI grade high school (SMA/MA) (Elpita et al., 2023).

The definition stage includes initial observations, syllabus analysis, student characteristic analysis, and material analysis. The design stage is carried out by preparing a media design that will be developed by preparing an initial draft of the Problem-Based Student Worksheet Integrated Science Literacy. The development stage involves testing the content and readability of the worksheets with relevant experts. The test results are then used for revisions to ensure the worksheets truly meet user needs. In the context of teaching materials development, the dissemination stage involves socializing the teaching materials through limited distribution to educators and students.

Three lecturers from the Chemistry Department of UNIMED were selected through purposive sampling as expert validators, three chemistry teachers, and one eleventh grade student from SMAN 1 Bangun Purba, selected through random sampling. The research object was the Integrated Problem-Based Student Worksheet (LKPD) with Scientific Literacy. Data collection techniques used the BSNP (LKPD feasibility test) instrument and a questionnaire to determine student responses to the Integrated Problem-Based Student Worksheet with Scientific Literacy.

Researchers analyzed the data descriptively and qualitatively to organize the questionnaire results regarding the feasibility of the developed LKPD. This was done by calculating an average score for each aspect assessed by summing the scores of all assessors' responses divided by the number of assessors. The validity criteria for the average analysis used can be seen in Table 1.

Table 1. Validation Criteria

Average	Validation Criteria
3.26 - 4.00	Very Worthy
2.51 - 3.25	Worthy
1.76 - 2.50	Less Worthy
1.00 - 1.75	Not Worthy

(Nurmasita et al., 2023)

Each aspect of the student questionnaire responses was analyzed to determine the average score for each aspect.

The assessment criteria for each aspect for students are listed in Table 2.

Table 2. Criteria for the average score of the student response questionnaire

Average	Validation Criteria
3.26 - 4.00	Very Good
2.51 - 3.25	Good
1.76 - 2.50	Not Good
1.00 - 1.75	Very Bad

(Farida et al., 2024)

RESULT AND DISCUSSION

This research and development was conducted through several stages to obtain research results from the development of Integrated Problem-Based Student Worksheets for Science Literacy on thermochemistry, including feasibility data according to the National Standardization Agency (BSNP) assessment instrument and student response data to the developed worksheets. This research was conducted using the 4D method (Define, Design, and Development), limited to the development stage, namely assessing student responses to determine student responses to the developed worksheets. The first development stage is the definition stage, which consists of analyzing the thermochemistry worksheets (LKPD) and formulating learning objectives in the form of descriptions of the material being developed. The analysis of the thermochemistry worksheets conducted by three teachers revealed that the language was adequate. In terms of content adequacy, LKPD 1 used a PBL learning model and was quite good, but lacked practice questions to support understanding of the subtopics being explained.

While LKPD 2 did not use a learning model, the descriptions of each subtopic contained problems related to daily life, supported by learning videos on YouTube. LKPD 3 also did not use a learning model, but each stage was structured and supplemented with short essay questions and image analysis. Therefore, based on the analysis above, in designing the integrated problem-based worksheets for scientific literacy on the thermochemistry material being developed, it was concluded that each component must be clearly visible, accompanied by a complete description of each subtopic.

To formulate learning objectives, an analysis of the Learning Objectives Flow was conducted to determine the material to be developed and to assess learning outcomes in thermochemistry. The sub-topics included in the developed worksheets (LKPD) included the law of conservation of energy, systems and environments, exothermic and endothermic reactions, and enthalpy and enthalpy changes. After determining the sub-topics to be developed, learning objectives were formulated to serve as a learning reference for each sub-topic presented in the integrated problem-based worksheets with scientific literacy.

The next development stage is design, which involves preparing a media plan to be developed using the Canva application. This stage of the design involves developing an initial draft of the student worksheet (LKPD). The LKPD to be developed is based on problem-based learning integrated with scientific literacy on thermochemistry. The steps for developing the LKPD are: (1) Developing the LKPD cover, foreword, table of contents, user instructions, problem-based learning syntax, scientific literacy aspects, learning objectives, and concept maps; (2) Determining the content with thermochemistry material, linking each subtopic to everyday life to ensure the collaboration between PBL syntax and scientific literacy aspects is met; (3) Creating a closing section with student evaluation and reflection.

The final stage is the development stage. In this final stage, the researchers have produced a product after conducting a feasibility test, and the product is declared suitable for use. The validators used in the feasibility test consisted of three lecturers from the Chemistry Department of UNIMED and two chemistry teachers from SMAN 1 Bangun Purba. he validation results by the expert validators are summarized in Table 3.

Table 3. LKPD Validation Results Based on Validator Review

No	Criteria	Average	Validation Criteria
1	Content Suitability	3.59	Valid (Very Worthy)
2.	Presentation Suitability	3.58	Valid (Very Worthy)
3.	Graphic Suitability	3.61	Valid (Very Worthy)
4.	Language Suitability	3.70	Valid (Very Worthy)

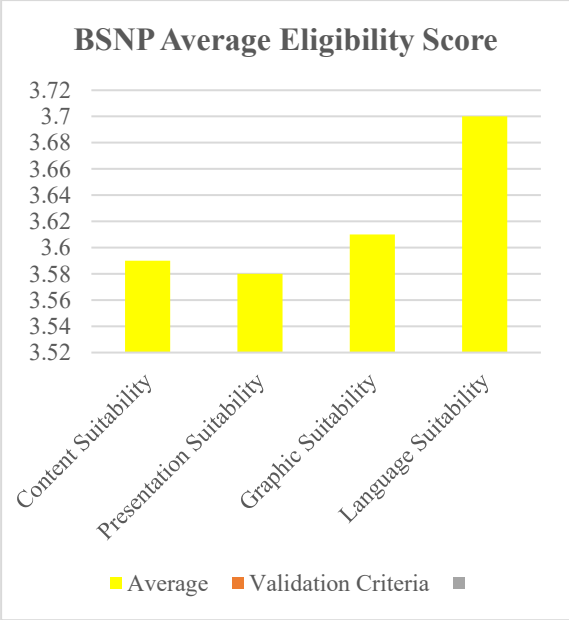

Figure 1. Assessment of LKPD Feasibility Based on Validator Review

Based on the data above, it can be seen that the validation results of the integrated problem-based student worksheet (LKPD) for scientific literacy on thermochemistry material meet the BSNP standards by expert validators with an average score of 3.62, indicating that the LKPD is valid and highly suitable for use as a teaching material to support chemistry learning, particularly thermochemistry.

The study of student worksheets (LKPD) used a student response questionnaire to determine the quality of the LKPD, assessing its content, presentation, and usefulness. The results of the student response questionnaire are presented in Table 4.

Table 4. Assessment of Student Responses to the Developed Student Worksheet

No	Assessment Indicators	Student Response
1.	Material Aspect	3.70
2.	Appearance Aspect	3.66
3.	Benefit Aspect	3.60
	Average	3.65

Based on the questionnaire data from student responses to the problem-based worksheet integrated with scientific literacy on thermochemistry, the average score was 3.65. Therefore, it can be concluded that students gave a positive assessment with a very good rating for the developed worksheet.

As expected, this worksheet allows students to more easily understand thermochemistry concepts.

CONCLUSION

The development of a problem-based, scientific literacy-based worksheet for thermochemistry was declared valid and suitable for use as teaching material in schools. This is evident from the validator's average score of 3.62, categorized as valid based on the National Standards for National Education Standards (BSNP) standards. Furthermore, a questionnaire survey of 35 students' responses to the problem-based, scientific literacy-integrated worksheet for thermochemistry yielded an average score of 3.65, indicating positive student responses and interest in the developed worksheet..

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