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NEEDS ANALYSIS FOR STUDENT WORKSHEETS BASED ON PROBLEM-BASED LEARNING ON THE CASE OF SMOKE AND GAS LAW FOR CHEMISTRY EDUCATION STUDENTS AT SRIWIJAYA UNIVERSITY

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ABSTRACT

This study is a descriptive quantitative study aimed at analyzing the needs for instructional materials in the form of a Problem-Based Learning (PBL) Student Worksheet for the Physical Chemistry I course. The method employed is the analysis phase of the ADDIE model, conducted through interviews with lecturers, student questionnaires, and curriculum analysis. The results showed that 100% of students enjoyed and were enthusiastic about attending the Physical Chemistry I course; however, only 34.1% were able to understand the gas law concepts using the existing teaching materials. Furthermore, 78% of students reported difficulties understanding the language used in the materials; 65.9% stated that the materials were not systematically structured and did not apply the PBL approach; and 75.6% found it difficult to understand the Gas Equation of State. The needs analysis indicates the need to develop a PBL-based Worksheet that incorporates local contexts, such as haze phenomena in South Sumatra, to facilitate the application of gas law concepts, enabling students to understand them more easily and relate them to real-world phenomena.

ABSTRAK

Penelitian ini merupakan penelitian deskriptif kuantitatif yang bertujuan menganalisis kebutuhan bahan ajar berupa Lembar Kerja Mahasiswa (LKM) berbasis Problem-Based Learning (PBL) pada mata kuliah Kimia Fisika I. Metode yang digunakan merujuk pada tahapan analyze model pengembangan ADDIE, melalui wawancara dengan dosen, kuesioner mahasiswa, dan analisis kurikulum. Hasil penelitian menunjukkan 100% mahasiswa menyukai dan antusias mengikuti kuliah Kimia Fisika I, namun hanya 34,1% mampu memahami konsep hukum gas menggunakan bahan ajar yang ada. Sebanyak 78% mahasiswa mengalami kesulitan memahami bahasa bahan ajar, 65,9% menilai bahan ajar belum tersusun sistematis dan belum menerapkan pendekatan PBL, serta 75,6% mengalami kesulitan memahami Persamaan Keadaan Gas. Analisis kebutuhan menunjukkan perlunya pengembangan LKM berbasis PBL dengan konteks lokal, seperti kabut asap di Sumatera Selatan, untuk membelajarkan konsep hukum gas secara aplikatif sehingga mahasiswa dapat memahami konsep dengan lebih mudah dan relevan dengan fenomena nyata.

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INTRODUCTION

Advances in science and technology should be integrated into all chemistry learning activities, including the Physical Chemistry 1 course. This course is a mandatory course worth 3 credits for prospective Chemistry teachers in the Chemistry Education Study Program at Sriwijaya University.

After completing this course, students are expected to possess several core competencies, namely: (1) understanding and explaining the basic concepts of the laws of thermodynamics and their applications; (2) solving problems related to equations of state, the laws of thermodynamics, entropy, and chemical equilibrium; and (3) analyzing the phenomena of energy changes in chemical systems based on thermodynamic principles. All of these competencies aim to enable prospective chemistry teachers to design effective learning using various approaches, strategies, methods, and techniques in accordance with national education standards while utilizing IPTEK in the process (Eviota & Liangco, 2023).

One of the key topics in Physical Chemistry 1 is Gas Law, which serves as the foundation for understanding various chemical and physical phenomena in everyday life (Atkins et al., 2023; Kartika et al., 2025). This topic is closely related to conceptual and applied problem-solving, such as the relationship between pressure, volume, temperature, and the amount of substance. Therefore, a learning model is needed that not only conveys theory but also actively engages students in discovering and applying concepts through problem-solving (Paoli et al., 2024; Solé et al., 2024).

According to Ali & Hartono (2024), one effective approach to developing thinking, communication, and conceptual linking skills is Problem-Based Learning (PBL). The application of PBL in Physical Chemistry 1 allows students to develop scientific thinking skills, enhance their conceptual understanding of gas laws, and relate learning to real-life situations relevant to everyday life.

Based on this description, a needs analysis of teaching materials is needed for the Physical Chemistry 1 course in the Chemistry Education Study Program at Sriwijaya University, specifically the Gas Law topic. This analysis is crucial because Physical Chemistry learning currently tends to focus on memorizing formulas and concepts without connecting them to real-world phenomena, such as the haze and changes in air quality in South Sumatra (Muliyati et al., 2024). As a result, students often struggle to understand the scientific meaning behind the gas law equations and their application in everyday life.

The teaching materials to be developed in this research are Student Worksheets based on Problem-Based Learning (PBL). Student worksheets containing learning activity guidelines, source materials, and problem-solving steps, structured based on the core competencies students must achieve. Through the PBL approach, students are expected to learn actively, think critically, and relate the concepts of gas law to contextual phenomena around them, thereby making the learning process more meaningful and applicable (Novitasari et al., 2024; Romadoni & Akhsan 2022).

Several previous studies have demonstrated the effectiveness of contextual and problem-based approaches in chemistry learning. Lestari et al., (2024) found that applying problem-based learning (PBL) to Boyle's gas law improved critical thinking skills and produced highly practical worksheets. Suharman et al., (2024) developed a green chemistry-based Physical Chemistry student worksheets integrated with the case method, which proved valid and effective. Meanwhile, Dekhkonova & Yakubova (2025) reported that learning the ideal gas law through laboratory experiments and simulations was effective in improving students' conceptual understanding. Therefore, this study is crucial to analyze the need for developing contextual PBL-based Student Worksheet so that gas law learning in

Physical Chemistry 1 can be more applicable, meaningful, and relevant to real-world phenomena in the students' environment.

Based on these issues, this study aims to analyze the need for contextual Problem-Based Learning (PBL)-based Student Worksheets for undergraduate students in the Chemistry Education Study Program at Sriwijaya University, specifically in Physical Chemistry 1, covering the ideal gas law and real gas laws. The needs analysis stage of the ADDIE model is conducted, yielding results that serve as the basis for developing a contextual PBL-based Student Worksheet on the haze phenomenon to improve students' conceptual understanding of gas laws.

METHODS

Research Location and Time

This research was conducted from June to September 2025. The research was conducted at the Chemistry Education Study Program, Faculty of Teacher Training and Education, Sriwijaya University.

Research Procedure

This research falls within the category of development research, using the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model, combined with Tessmer's (1998) formative evaluation (Ibrahim et al., 2022). However, this research was limited to the needs analysis stage as the basis for developing contextual Problem-Based Learning (PBL) Student Worksheets on the topic of ideal and absolute gas equations in the Physical Chemistry 1 course.

The research participants were students of the Chemistry Education Study Program at Sriwijaya University who were currently enrolled in or had completed the Physical Chemistry 1 course. The research objective was to design a contextual PBL student worksheet for the haze case. The research was conducted from June to September 2025, with the lecturers who taught the course.

The needs analysis phase encompassed three main aspects: (1) Lecturer needs analysis, conducted through unstructured interviews with lecturers teaching the course to identify learning difficulties and the need for innovative teaching materials. (2) Student needs analysis, conducted through an online questionnaire (Google Form) distributed to students enrolled in the 2022 Physical Chemistry 1 class to assess their learning experiences, challenges, and expectations regarding the Student Worksheet. Then, (3) Curriculum and materials analysis, conducted through a review of the Lesson Plan (LP) and curriculum documents to determine core competencies, learning outcome indicators, and the suitability of the gas law material to local contexts, such as the haze phenomenon and changes in air pressure in South Sumatra.

Data Collection Techniques

Data collection techniques in this study included interviews, questionnaires, and curriculum reviews, which were used to assess the need to develop a contextual PBL-based student worksheet on the topics of ideal and absolute gas equations.

Unstructured interviews were conducted with the lecturer teaching Physical Chemistry 1 and the Physical Chemistry Laboratory Assistant to identify learning difficulties and the need for innovative Problem-Based Learning (PBL)-based teaching materials.

A questionnaire was distributed to students enrolled in the 2023 Physical Chemistry I course via Google Forms to obtain data on their learning experiences, challenges, and expectations regarding the development of contextual PBL-based Student Worksheets.

A curriculum review was conducted of the Semester Learning Plan (LP) and the Physical Chemistry I curriculum to determine learning outcomes and competency indicators, and to assess the suitability of the gas law material for local contexts, such as the haze phenomenon in South Sumatra.

Data Analysis Techniques

Data obtained from interviews and questionnaires were analyzed descriptively and qualitatively to identify problems and needs in learning Physical Chemistry I. The interview data were reduced, presented in narrative form, and conclusions drawn regarding learning material needs. The questionnaire data were processed by calculating percentages for each response option to illustrate the distribution of student responses to the learning materials used. The results of the analyses using these two techniques were combined with those of the curriculum review to determine the direction of development for contextual Problem-Based Learning (PBL)-based Student Worksheets.

RESULT AND DISCUSSION

Lecturer Needs Analysis

Interviews with the lecturers in Physical Chemistry 1 revealed that the teaching materials used were still theoretical and lacked contextualization. Local phenomena, such as the haze in South Sumatra, had never been utilized as a learning context, even though they were highly relevant for linking gas law theory to real-world variables such as temperature, pressure, and pollutant concentration. Lecturers emphasized the need for contextual Problem-Based Learning (PBL)-based student worksheets that could improve students' critical thinking skills and their ability to solve real-world problems (Juliantari & Wibawa, 2024; Kahar et al., 2025).

Student Needs Analysis

The results of a questionnaire surveying students in the Chemistry Education Study Program at Sriwijaya University indicated that the majority (75.6%) found the Gas Equation of State material difficult to understand, whereas only 24.4% found it easy. This obstacle was related to the currently available teaching materials, which mostly consisted of textbooks and theoretical materials that lacked relevance to real-world phenomena in the surrounding environment, such as haze, changes in air pressure, and extreme temperatures in South Sumatra. As a result, the concept of gas law is difficult to relate to students' everyday experiences (Lubis et al., 2023; Nursaid et al., 2023). The results of the student questionnaire are presented in Table 1.

Table 1 Results of the Student Needs Analysis Questionnaire

No.	Questions	Answer		Percentages	
		YES	NO	YES	NO
1	Do you like the Physical Chemistry I course?	40	1	97,6%	2,4%
2	Are you enthusiastic about taking the Physical Chemistry I course?	40	1	97,6%	2,4%
3	Are there any teaching materials available for the previous Physical Chemistry I course?	41	0	100%	0%
4	Do you understand the material concepts in the Physical Chemistry I course with the available teaching materials?	14	27	34,1%	65,9%
5	Is the language in the existing materials easy to understand?	9	32	22%	78%
6	Are the teaching materials arranged systematically and present the PBL method?	14	27	34,1%	65,9%
7	Are you having difficulty understanding the Gas Equation of State presented by the lecturer?	31	10	75,6%	24,4%
8	Is the material on the Equation of State of Gases easy to understand?	10	31	24,4%	75,6%
9	Do real-life examples accompany the teaching materials?	25	16	61%	39%
10	Do you need conceptual PBL teaching materials (real cases) to help you understand the Physical Chemistry 1 course on the Gas Equation of State material?	41	0	100%	0%
11	Do you need practical, engaging teaching materials, such as Student Worksheets, to help students understand the Gas Equation of State?	41	0	100%	0%
12	Do you agree that teaching materials are developed in the form of a Physical Chemistry I PBL-Student worksheet on Gas State Equations material?	41	0	100%	0%

Curriculum Analysis

An analysis of the curriculum and lesson plan for Physical Chemistry 1 indicates that the course requires students to master comprehensive learning outcomes, including six Graduate Profile Outcomes, three Course Learning Outcomes, and six Sub-learning Outcomes. The topic of ideal and real gas laws is fundamental material that forms the basis for understanding advanced concepts in thermodynamics (Foust III 2021; Simão et al., 2024). However, the abstract nature of the material often hinders students' ability to connect theory to real-world environmental phenomena, underscoring the need for more applicable, contextual teaching materials.

The ADDIE learning development model introduced by Dick and Carey (1996) is a widely used approach due to its systematic and adaptable workflow. This model includes five essential stages: analysis, design, development, implementation, and evaluation. Overall, the stages in this model guide developers by first identifying learning needs and problems, then designing and creating appropriate teaching materials, implementing the learning process using these products, and finally evaluating the implementation results to determine effectiveness and make improvements in the next stage (Fathurohman et al., 2021; Suharman et al. 2024). The ADDIE model with Tessmer evaluation can be seen in Figure 1.

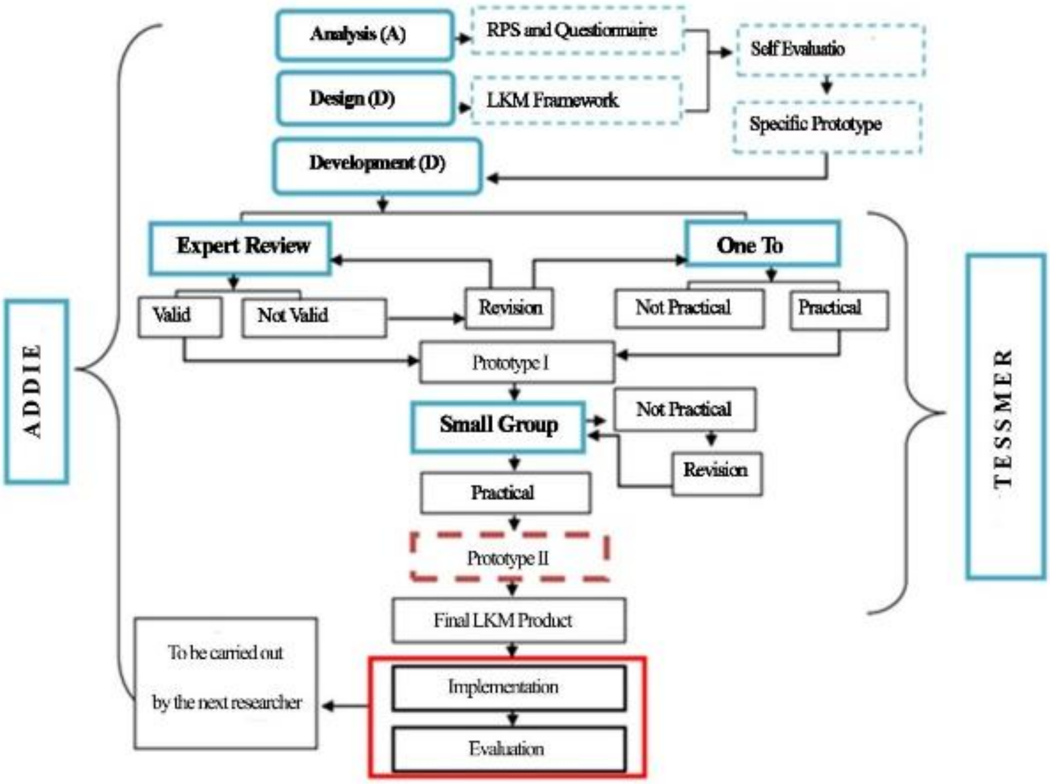

Figure 1. ADDIE Model with Tessmer Evaluation

The analysis stage is the initial step in the development process, aimed at identifying needs and determining the direction for the development of appropriate teaching materials. In this study, the analysis covered three main aspects: student needs, lecturers' needs, and curriculum analysis. A needs analysis was conducted to understand the students' learning experiences, difficulties encountered, and expectations for more engaging and contextual teaching materials in the Physical Chemistry 1 course. The lecturers' needs analysis aimed to explore their perspectives and the challenges they encounter in the learning process, including the limited teaching materials that connect gas law concepts to real-world phenomena in the surrounding environment. Meanwhile, the curriculum analysis was conducted by reviewing the Semester Learning Plan (LP) and course learning outcomes to ensure that the developed teaching materials were aligned with the established competencies (Eviota & Liangco, 2023). These three analyses served as the basis for designing contextual Problem-Based Learning (PBL)-based Student Worksheets, making them more relevant to the learning needs and characteristics of Chemistry Education students at Sriwijaya University.

Based on questionnaire results administered to students in the Chemistry Education Study Program at Sriwijaya University, their understanding of the Gas Equation of State remained relatively low. A total of 75.6% of students reported difficulties learning the concept, whereas only 24.4% reported encountering no significant obstacles. This is believed to be due to the theoretical nature of the teaching materials and their dominance by textbooks. The learning materials rarely touch on phenomena relevant to students' lives, such as haze, air pressure variations, and the extreme temperature changes that frequently occur in South Sumatra. Consequently, students struggle to connect gas law theory to real-world events in their environment (Lubis et al., 2023; Nursaid et al., 2023).

The students' difficulties are exacerbated by the incoherent structure of the teaching materials and the use of complex language, resulting in 78% of students finding the material challenging to understand. Furthermore, only 61% of students found real-world examples in the teaching materials, whereas 39% reported that the materials lacked relevant context. This situation means that, although high, student interest and enthusiasm do not fully translate into optimal conceptual understanding and adequate problem-solving skills (Harefa, 2023).

Interviews with lecturers teaching Physical Chemistry 1 indicate that the teaching materials remain theoretical and do not connect concepts to real-world contexts. Local phenomena, such as the haze in South Sumatra, have not been used in instruction, even though they could be used to explain the relationship among pressure, temperature, and gas particle concentration in accordance with gas laws. Lecturers emphasize the importance of developing contextual Problem-Based Learning (PBL)-based Student Worksheets to enable students to develop critical thinking and scientific problem-solving skills relevant to real-life situations (Kahar et al., 2025).

Based on a review of the Physical Chemistry 1 curriculum and the Semester Learning Plan (LP), the course comprises six Graduate Profile Outcomes, three Course Learning Outcomes, and six Sub-CPMK. The ideal gas law and the real gas law are fundamental to understanding advanced concepts in thermodynamics (Simão et al., 2024).

However, the abstract nature of the material often makes it difficult for students to connect theory to phenomena in their environment. Therefore, teaching materials that are more applicable, contextual, and relevant to real-world problems are needed so that students can understand the concept of gas law more deeply and meaningfully.

Based on the analysis of student, lecturer, and curriculum needs, there is an urgent need to develop contextual PBL-based Student Worksheets for the Gas Equation of State topic. These student worksheets are intended to help students understand abstract concepts more practically through real-world cases, improve critical thinking and problem-solving skills, and enhance scientific literacy, thereby supporting optimal achievement of the learning outcomes required by the Independent Curriculum.

Problem-Based Learning (PBL) is an effective learning method for developing critical thinking, communication, and conceptual connection skills through solving real-world problems (Ali & Hartono, 2024). The essence of PBL is the presentation of authentic problems that encourage students to investigate, from data collection to conclusion (Agusdianita et al., 2023). This approach is student-centered, where students actively seek information and find solutions independently (Putri, 2023). Thus, PBL not only improves conceptual understanding but also enhances students' ability to apply theory in real-world contexts, making learning more relevant and meaningful.

The steps in the Problem-Based Learning (PBL) method include several stages. First, students are introduced to the problem under study to clarify the context and learning objectives. Second, students are organized into groups or individually to prepare learning strategies and assign tasks. Third, students are guided in conducting investigations, either independently or in groups, to gather information and analyze data. Fourth, students develop their findings and present them in a report or presentation. Fifth, the entire problem-solving process is analyzed and evaluated to assess conceptual understanding, critical thinking skills, and the effectiveness of the methods used (Muhartini et al., 2023).

Student-centered learning, authentic problems, self-directed learning, collaborative small groups, and the teacher as facilitator are the main characteristics of Problem-Based Learning (PBL). This is based on Barrow's theory. PBL emphasizes student-centered learning, in which students are the primary agents in constructing their own knowledge.

The problems presented are authentic, enabling students to understand the context and relate them to real-life or professional situations. Students actively seek information through independent learning and work in small groups to discuss and collaboratively build knowledge, while the teacher serves as a facilitator, monitoring and encouraging the achievement of learning objectives. This approach encourages the development of critical thinking skills, problem-solving abilities, and meaningful learning for students (Husna et al., 2025; Siswanti & Indrajit, 2023).

The advantages of Problem-Based Learning (PBL) encompass several aspects. First, PBL encourages students to solve problems in real-world contexts and construct knowledge independently through learning activities. Second, the focus on problems allows students to study only relevant material, thereby reducing the burden of memorizing unnecessary information. Third, PBL facilitates scientific activities through group work, encourages the use of diverse sources of knowledge, such as books, the internet, interviews, and observations, and trains students to assess their learning progress and to develop scientific communication skills through discussions or presentations. Furthermore, individual learning difficulties can be overcome with peer support within the group (Darmayanti et al., 2022; Muhartini et al., 2023).

Disadvantages of PBL include the fact that not all materials are suitable for this method, as some topics require an active role for the teacher in delivering the material. In classes with diverse student abilities, assignments can be challenging. PBL is less suitable for elementary education because students' group-work skills are still limited, and it typically takes longer, which may not cover all planned content. Furthermore, teachers need strong motivational and facilitation skills to ensure that students work effectively in groups, and the necessary learning resources are not always readily available (Darmayanti et al., 2022; Muhartini et al., 2023).

Developing Student Worksheets based on Problem-Based Learning (PBL) is crucial for fostering higher-order thinking Skills (HOTS), namely application, analysis, synthesis, and evaluation. With student worksheets designed using PBL, students not only understand chemistry material theoretically but are also trained to think critically, solve problems creatively, and relate chemical concepts to real-world phenomena in their environment. Mastery of HOTS is crucial for prospective chemistry teachers in facing the increasingly complex challenges of education and life, enabling them to design lessons, make decisions, and apply chemical knowledge effectively in the future (Syahri & Ahyana, 2021).

Bloom's Taxonomy serves as an important framework for developing High-Order Thinking Skills (HOTS), which encompass the abilities to analyze, evaluate, and create. This higher-order thinking differs from simply memorizing facts, as students are required to understand, connect, and apply concepts in new situations (Listiani & Rachmawati, 2022). In the context of Physical Chemistry, HOTS skills are crucial for students to relate gas laws to real-world phenomena, such as changes in temperature, pressure, or smog. Therefore, developing contextual Problem-Based Learning (PBL)-based Student Worksheets is crucial, as it enables students to think critically, solve problems, and be prepared to face the challenges of the future chemistry teaching profession.

Higher-order thinking skills (HOTS) are based on Bloom's taxonomy, which classifies cognitive processes from lowest to highest. Bloom's six levels include: knowing, understanding, applying, analyzing, synthesizing, and evaluating. The initial level (knowing and understanding) is considered Low-Order Thinking Skills (LOTS), while the following four levels (application, analysis, synthesis, and evaluation) are considered HOTS. HOTS occurs when individuals connect new information with stored knowledge, reorganize and develop it to achieve goals or solve complex problems (Suparman, 2021; Suryani, 2022). In the context of learning Physical Chemistry, the development of Student Worksheets based on Problem-Based Learning (PBL) is necessary to enable students to practice HOTS effectively, connect gas law concepts to real phenomena, and be prepared to face the challenges of learning and the chemistry teaching profession in the future.

CONCLUSION

Based on the analysis of student, lecturer, and curriculum needs, it can be concluded that the majority of students (97.6%) enjoyed and were enthusiastic about taking the Physical Chemistry I course. Although 100% of students reported that previous teaching materials were available, only 34.1% felt able to understand the gas law concept using those materials. The main obstacles lay in the difficult-to-understand language of the teaching materials (78%), the unsystematic arrangement of the teaching materials and the failure to apply the PBL method (65.9%), and the difficulty in understanding the Gas Equation of State (75.6%). In addition, only 61% of students found real-world examples in the teaching materials, so the material's relevance to real phenomena remained limited. The results of interviews with lecturers and curriculum analysis emphasized the need to develop more applicable and contextual teaching materials. Therefore, the development of Problem-Based Learning (PBL) Student Worksheets based on a local context, such as the haze in South Sumatra, is essential to facilitate a more effective understanding of the gas law concept, improve critical thinking skills, problem-solving abilities, and support the achievement of learning outcomes according to the curriculum requirements.

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