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Design of TPACK Based PBL Student Worksheet to Enhance Creative Thinking Skills

Roudlotul Jannah[1*], Utiya Azizah[1], Sukarmin[1], Suyono[1], Zainul Arifin Imam Supardi[1], Muhammad Satriawan[1]

[1]*Department of Mathematics and Natural Science, Universitas Negeri Surabaya, Indonesia*

**Correspondence Author: roudlotul.23031@mhs.unesa.ac.id*

ABSTRACT
This study aimed to develop a Problem-Based Learning (PBL) Student Worksheet (LKPD) based on the Technological, Pedagogical, and Content Knowledge (TPACK) framework to enhance students' creative thinking skills in the topic of reaction rates. The designed LKPD is intended to provide a challenging and meaningful learning experience, fostering students' critical and creative problem-solving abilities in the context of reaction rate concepts. The PBL approach facilitates active student engagement, while the TPACK framework ensures the integration of technology, pedagogy, and content knowledge in the learning process. The research employed the 4D development model, focusing on the Define, Design, and Develop (expert validation) stages. Data for the Define stage were collected from a Chemistry teacher and Grade XI students at SMA Ta'miriyah Surabaya to conduct a needs analysis. Descriptive qualitative analysis was applied to examine the needs analysis outcomes and the LKPD design blueprint. The results indicate that the developed LKPD possesses a clear structure and is highly relevant for fostering students' creative thinking skills. Expert validators classified the LKPD as "Highly Valid." In conclusion, the developed LKPD is feasible as a contextual learning resource and has strong potential to enhance students' creative thinking skills in integrated science learning.

Keywords: student *worksheet, problem based learning, TPACK, creative thinking.*

INTRODUCTION

In the era of the Industrial Revolution 4.0, education faces significant challenges in equipping students with essential 21st-century skills, including critical thinking, communication, collaboration, and creative thinking, commonly referred to as the 4Cs. Among these, creative thinking skills are crucial as they enable students to thoroughly understand problems and generate various innovative solutions through multiple strategies. According to Filsaime (2008), creative thinking comprises four main components: (1) fluency in generating ideas; (2) flexibility in providing alternative solutions; (3) originality in creating novel ideas; and (4) elaboration in developing answers in detail. Despite its importance, creative thinking is still not widely implemented in school chemistry learning, particularly in topics that require a deep conceptual understanding, such as reaction rates (Hu & Bi, 2025). Therefore, fostering this skill is highly essential for problem-solving and is expected to be applied across all subjects, including Chemistry.

Chemistry is a scientific discipline that examines the properties, composition, and structure of matter, as well as the energy changes involved in its transformation processes (Rocke, 2020).

The domain of chemistry can be conceptualized through the chemist's triangle, which consists of three interconnected levels: the macroscopic domain, which is directly observable; the sub-microscopic domain, which is abstract and includes atoms, ions, molecules, and structures; and the symbolic domain, which encompasses chemical equations, formulas, mathematical notations, and graphs (Sutrisno et al., 2020). Reaction rate is one of the chemistry topics that involves many abstract concepts, particularly related to factors influencing reaction rates and collision frequency (Khairunnisa & Sudrajat, 2023). Musya'idah et al. (2016) note that reaction rate topics are characterized by mathematical calculations, the use of multiple representations, and the interpretation of relationships through graphs, encompassing macroscopic, microscopic, and symbolic representations. In practice, many students struggle with learning chemistry, as the subject is often perceived as challenging and intimidating (Utari, Fadhilah, & Fitriani, 2018). Specifically, students frequently encounter difficulties in understanding the changes in reaction rate over time and their correlation with reaction duration (Ni'mah, Subandi, & Munzil, 2020).

Constructivist learning theory emphasizes that student success depends not only on the learning environment but also on their capacity to construct knowledge independently through real experiences. This perspective underscores the importance of active student participation in the learning process, with teachers functioning as facilitators who provide opportunities for students to solve authentic problems relevant to their environment (Nur, 2004). One effective strategy to foster meaningful learning and student engagement is Problem-Based Learning (PBL) (Barrows, 1996; Bridges et al., 1995; Funa & Prudente, 2021; Ngereja et al., 2020; Savery, 2006; Uluçınar, 2023).

According to Arends (2008), the implementation of PBL follows five phases: (1) orienting students to the problem; (2) organizing students for research; (3) facilitating independent and group investigations; (4) developing and presenting results; and (5) analyzing and evaluating the problem-solving process. The problems used in PBL are derived from real-world contexts, which actively and contextually promote the development of creative thinking skills. Supporting this, Hanifah and Hidayah (2004) demonstrated that a PBL-oriented module designed to train creative thinking skills in reaction rate material resulted in an increase in students' creative thinking, with an average N-Gain value of 0.65, categorized as moderate.

Despite these benefits, interviews with chemistry teachers at Ta'miriyah High School in Surabaya revealed several challenges in classroom chemistry learning. Although students show interest in the subject, their average comprehension level remains around 70%. Students particularly struggle with material requiring logical and abstract reasoning, such as reaction rates. Additionally, reaction rate material has not been implemented effectively within the curriculum, even though it is highly relevant for understanding scientific processes with real-world implications, such as climate change and environmental pollution. A notable challenge is the limited teacher knowledge in applying the Technological, Pedagogical, and Content Knowledge (TPACK) framework, which integrates technology, pedagogy, and content knowledge in learning (Hew et al., 2019; Niederhauser & Lindstrom, 2018; Mishra & Koehler, 2006; Shulman, 1986).

The TPACK framework is particularly valuable for 21st-century learning, especially in developing creative thinking skills. Within TPACK, technology enables students to actively engage in learning through access to digital resources such as scientific simulations, interactive videos, and virtual experimental tools relevant to reaction rate studies. Technology also stimulates students' creativity in problem-solving by allowing the use of experimental design software or applications that encourage exploration of real-world problems. The pedagogical component of TPACK assists teachers in selecting effective instructional methods, such as PBL, to contextualize the practice of creative thinking skills. This approach allows students the freedom to explore ideas and connect theoretical concepts with practical applications. Hardanti et al. (2024) highlight that e-modules developed with TPACK integration provide interactive, in-depth, relevant, and learner-centered experiences by combining technology, pedagogy, and content knowledge.

The content dimension of TPACK ensures that the material is delivered accurately and meaningfully, promoting a deep understanding of complex scientific topics. In reaction rate material, students' comprehension of factors influencing reaction rates—such as concentration, temperature, and catalysts—becomes more significant when presented in real contexts and supported by technology that enables virtual experimentation.

Current research emphasizes the improvement of PBL teaching modules and the application of TPACK-based PBL in various science education contexts. However, no study has specifically examined the trends of TPACK-based PBL implementation to develop creative thinking skills in chemistry learning. Therefore, this study aims to explore the latest trends in chemistry education. Understanding these trends can better prepare educators and researchers to develop TPACK-based PBL approaches that enhance students' 21st-century competencies, particularly creativity and a profound understanding of chemical concepts.

METHODOLOGY

This study employed a development research method, commonly referred to as Research and Development (R&D), which is widely used for the development and validation of educational products. The development process followed the 4D model proposed by Thiagarajan, which consists of four stages: Define, Design, Develop, and Disseminate (Sugiyono, 2015). The research focused on the design of a Problem-Based Learning (PBL) Student Worksheet (LKPD) based on the Technological, Pedagogical, and Content Knowledge (TPACK) framework, specifically for the topic of reaction rates. The study was conducted at SMA Ta'miriyah Surabaya. The subjects and informants for the Define stage included one Chemistry teacher, who was involved in interviews and classroom observations to understand teaching practices and challenges, and Grade XI students, who participated in the needs analysis to identify learning difficulties and interests. These subjects were selected as they represent the population directly experiencing the challenges identified in the preliminary study.

The primary data collected during the Define stage were qualitative in nature, derived from needs analysis, curriculum analysis, and student analysis. These data were essential for identifying specific learning problems, aligning the LKPD design with the Merdeka Curriculum, and ensuring that the developed worksheet addressed the needs and characteristics of the students. Supporting data were obtained from a review of relevant literature and theoretical frameworks, which provided the foundation for structuring the LKPD content and the underlying scientific methods.

Data collection methods included observation of the learning process, interviews with the chemistry teacher to explore learning challenges and the limited implementation of TPACK, and document analysis of the Merdeka Curriculum, Learning Outcomes, and existing teaching materials. The research instrument utilized was an expert validation questionnaire, which assessed the LKPD across content, construct, and display aspects. The expert validators evaluated the feasibility of the LKPD using a scoring system based on predetermined criteria:

Table 1. Validity Assessment Rubric for Student Worksheet

Score	Criteria
4	Highly Valid
3	Valid
2	Moderately Valid
1	Not Valid

(Riduwan, 2016)

RESULT AND DISCUSSION

The primary aim of this study was to develop a Problem-Based Learning (PBL) Student Worksheet (LKPD) based on the Technological, Pedagogical, and Content Knowledge (TPACK) framework, with the goal of enhancing students' creative thinking skills in the topic of reaction rates. A key contribution of this research is the provision of a contextual and relevant LKPD design that systematically integrates technology, pedagogy, and content knowledge—an aspect that is currently limited in the learning process at SMA Ta'miriyah Surabaya. The findings of this study, presented in the following sections, indicate that the developed LKPD possesses a clear structure and demonstrates high relevance in fostering students' creative thinking abilities.

The application of the TPACK framework proves highly advantageous in 21st-century learning contexts, particularly for the development of creative thinking skills. This finding is consistent with the study conducted by Syahida et al. (2023), which demonstrated that learning activities designed using the TPACK approach can effectively enhance students' creative thinking capabilities. Moreover, the integration of TPACK with the PBL model has been shown to contribute to improved learning outcomes, as supported by Tanjung et al. (2022).

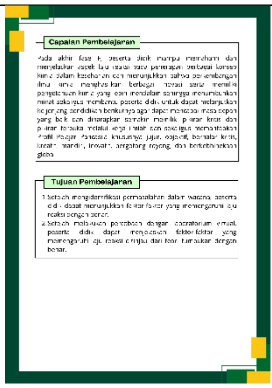
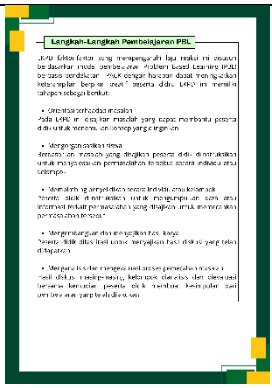
Define Stage

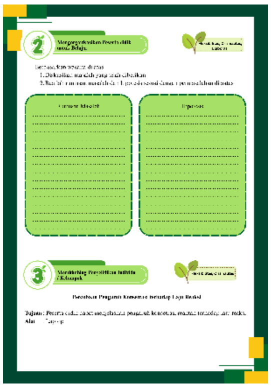
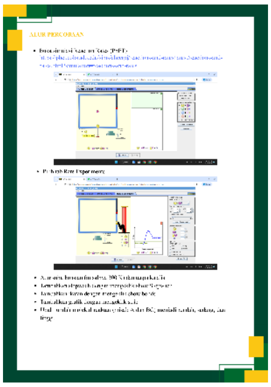
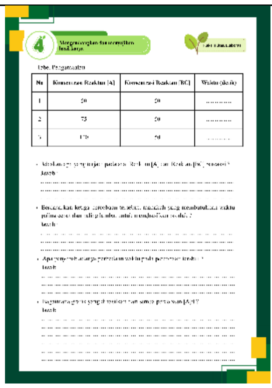
The purpose of the Define stage is to identify the specific needs within the learning process through several key steps. The first step is curriculum analysis, which focuses on examining the curriculum implemented at the school. Based on the Merdeka Curriculum, the topic of Reaction Rate is taught to Grade XI students during the second semester of senior high school. The second step is student analysis, conducted to serve as a reference for developing the LKPD. The study subjects are Grade XI students at SMA Ta'miriyah Surabaya, where observations and interviews with chemistry teachers revealed that although science-track students show interest in chemistry, their average understanding is around 70%, mainly due to the lecture-based and teacher-centered learning methods that limit students' creative thinking opportunities. The next step is task analysis, which identifies the specific tasks students are expected to perform in the LKPD to ensure that the activities align with the Reaction Rate topic and encompass all phases of the Problem-Based Learning (PBL) model based on the TPACK framework. Following this is concept analysis, which involves identifying key concepts to create a systematic main concept framework relevant to the topic, including the preparation of a layout and mind map to guide the LKPD structure. Finally, learning objectives formulation analysis is conducted to ensure that the learning objectives align with the established Learning Outcomes, maintaining consistency with the intended goals throughout the LKPD development process.

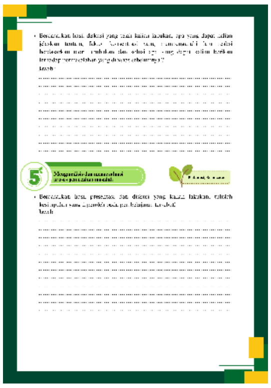
Design Stage

In the Design stage, the teaching module is developed through systematic planning that includes several key steps. The first step involves organizing the material, which serves as the main content for students and includes the development of exercises and practice tasks to help them apply and strengthen their understanding. The next step is selecting appropriate media that align with the learning objectives to effectively support the achievement of the intended learning outcomes, providing students with interactive and meaningful learning experiences. The final step is choosing the format of the teaching module, which entails designing the learning content, selecting suitable learning strategies, and determining the presentation format. The chosen design should be engaging, simplify the learning process, and assist students in comprehending the material effectively throughout the learning activities.

Table 2. The Design Illustration of The Worksheet on The Concept of Reaction Rates to Train Students' Creative Thinking Skills.

Design	Description	Objective
	This worksheet is designed for groups of 4 students and focuses on the reaction rates.	
	The worksheet includes learning outcomes and objectives related to the topic of reaction rates.	
	Additionally, the worksheet provides a brief overview of the concept of reaction rates.	
	Problem Based Learning Syntax: 1. Orientation of Students to the Problem The teacher introduces relevant, engaging, and thought-provoking problems. The problems should be authentic, complex, and challenging,	1. Stimulates students' interest and builds initial understanding of the problem to be solved.

Design	Description	Objective
	motivating students to explore and seek solutions.	
 	2. Organizing Students for Learning The teacher helps students formulate questions that need to be answered and create a research plan. Students can work in groups to discuss strategies and divide tasks. 3. Guiding Investigation The teacher acts as a facilitator, providing guidance, answering questions, and motivating students to stay focused on the problem-solving process. Students work independently or in groups to explore possible solutions.	2. Encourages students to think creatively and develop systematic steps for solving the problem. 3. Encourages independent learning, collaboration, and the use of various information sources.
	4. Developing and Presenting the Final Product Students prepare reports on their research or experiments and present their findings to the class or other audiences	4. Develops scientific communication, presentation, and critical and creative thinking skills.

Design	Description	Objective
	5. Analyzing and Evaluating the Learning Process Teachers and students reflect together on the learning process, reviewing the effectiveness of the strategies used and analyzing the results of the developed solutions.	5. Identifies strengths and weaknesses in the learning process and enhances understanding of the topic studied.

Discussion on Design, Creative Thinking, and TPACK Integration

The LKPD design successfully integrates the five phases of Problem-Based Learning (PBL) with the TPACK framework, with the specific aim of enhancing students' creative thinking skills, including fluency, flexibility, originality, and elaboration. The "Orientation of Students to the Problem" phase is implemented by presenting a real-world problem through an online video, thereby incorporating the Technological Knowledge component of TPACK. This contextualized problem-solving approach is essential for promoting students' creative thinking.

The LKPD design aligns with the findings of Hardanti et al. (2024), which highlight that the integration of TPACK results in learning materials that are interactive, in-depth, and learner-centered. During the investigation phase, students are encouraged to utilize digital resources and virtual experiments, combining Technology and Content Knowledge to explore factors influencing reaction rates. This process allows students to develop and present multiple solutions, thereby fostering flexibility and elaboration in their thinking. These results confirm the LKPD's effectiveness in enhancing students' creative thinking skills.

Develop Stage

Following the completion of the LKPD design in the Design stage, the Develop stage was carried out to conduct initial product validation. This stage aimed to assess the feasibility and validity of the LKPD before implementation in the classroom. The research instrument employed was an expert validation questionnaire, which evaluated the LKPD in terms of content, construct, and presentation aspects. Product validation was conducted by two expert validators: a Content Expert and an Instructional Design Expert, both of whom possess relevant competencies in their respective fields. The validation process involved providing the draft LKPD along with the questionnaire to the validators, who assessed the feasibility of the LKPD based on a four-point scale: Highly Valid (4), Valid (3), Moderately Valid (2), and Not Valid (1). In addition to scoring, the validators provided detailed suggestions and feedback, which were used to refine and revise the LKPD during the product revision stage.

Table 3. The Result of Validation LKPD

Aspect	Criteria
Content	Highly Valid
Construct	Highly Valid

The results from the Develop stage indicated that the LKPD design was categorized as "Highly Valid" by both expert validators, suggesting that the LKPD is feasible for classroom use following minor revisions.

Novelty of Research

The novelty of this study lies in the deliberate integration of TPACK components within a Problem-Based Learning (PBL) LKPD specifically designed for the abstract topic of Reaction Rates, targeting the enhancement of students' creative thinking skills. While previous research has predominantly examined PBL or TPACK independently, this LKPD design offers a unified and structured learning tool that enables chemistry teachers to implement 21st-century learning more effectively.

Implications and Limitations

The successful development of this LKPD carries significant implications for chemistry education. Practically, it provides teachers with a student-centered and contextually relevant tool, supporting them in overcoming challenges related to the integration of technology through TPACK. For students, it encourages a transition from passive to active learning, which is critical for cultivating both critical and creative thinking skills. However, this study is limited to the Develop stage of the 4D model, focusing solely on expert validation, and did not extend to small-scale trials or field testing to assess practical effectiveness with students. Therefore, future research is recommended to advance through the full Develop and Disseminate stages, including trials and effectiveness evaluation, to verify the LKPD's impact on enhancing students' creative thinking skills in classroom settings.

CONCLUSION

This study successfully developed a Problem-Based Learning (PBL) Student Worksheet (LKPD) integrated with the Technological, Pedagogical, and Content Knowledge (TPACK) framework, aimed at enhancing students' creative thinking skills in the topic of reaction rates. Based on findings from the Define, Design, and Develop (expert validation) stages, the LKPD demonstrates a clear and systematic structure, as well as high relevance for fostering students' creative thinking abilities. The Develop stage results indicated that the LKPD was categorized as "Highly Valid" by both expert validators. By employing the PBL approach, the LKPD encourages students to actively engage in learning through the resolution of contextual problems, while the application of the TPACK framework ensures the effective integration of technology, pedagogy, and content knowledge. Overall, this LKPD design is feasible for use as a learning resource and has substantial potential to support students in developing both critical and creative thinking skills, as well as achieving a deeper understanding of reaction rate concepts.

REFERENCES

Arends, Richard I. (2018). *Learning to Teach: Belajar untuk Mengajar*. Yogyakarta: Pustaka Pelajar.

Barrows, H.S. (1996) . Problem-based learning in medicine and beyond: a brief overview. New Dir. Teach. Learn. 1996 (68), 3–12. https://doi.org/10.1002/tl.37219966804.

Bridges, E.M., Hallinger, P.,with ERIC Clearinghouse on Educational Management. (1995) . Implementing problem based learning in leadership development. In: ERIC Clearinghouse on Educational Management. University of Oregon.

Filsaime, D. K. (2008). *Mengembangkan kreativitas dalam pembelajaran sains*. Kencana Prenada Media Group

Funa, A.A., Prudente, M.S., (2021). Effectiveness of problem-based learning on secondary students' achievement in science: a meta-analysis. Int. J. Instr. 14 (4), 69–84. https://doi.org/10.29333/iji.2021.1445a.

Hardanti, P., Murtinugraha, R. E., & Arthur, R. (2024). Studi literatur: Pemanfaatan pendekatan TPACK (Technological, Pedagogical, and Content Knowledge) pada pengembangan e-modul pembelajaran. *Jurnal Teknologi Pendidikan*, *1*(3).

Hew KF, Lan M, Tang Y, Jia C, Lo CK. (2019). Where is the 'theory' within the field of educational technology research? Br J Educ Technol ,50(3):956–71. https:// doi.org/10.1111/bjet.12770. scientific critical thinking in science education. *Thinking Skills and Creativity*, *55*, 101695. https://doi.org/https://doi.org/10.1016/j.tsc.2024.101695

Khairunnisa, & Sudrajat, A. (2023). Pengembangan Instrumen Tes Diagnostik Five-Tier untuk Mengidentifikasi Miskonsepsi Siswa Kelas XI pada Materi Laju Reaksi. *PENDIPA Journal of Science Education*, 7(2), 127-136.

Musya'idah, Effendy, & Santoso. (2016). Prosiding Seminar Nasional Pendidikan IPA Pascasarjana UM, (pp. POGIL, Analogi Model FAR, KBI, dan Laju Reaksi). Malang.

Niederhauser DS, Lindstrom DL. (2018). Instructional technology integration models and frameworks: diffusion, competencies, attitudes, and dispositions. In: Voogt J, Knezek G, Christensen R, Lai KW, editors. Handbook of information technology in primary and secondary education. Springer International Publishing, p. 1–21. https://doi.org/10.1007/978-3-319-53803-7_23-1

Ngereja, B., Hussein, B., Andersen, B., (2020). Does project-based learning (PBL) promote student learning? A performance evaluation. Educ. Sci. 10 (11), 330. https://doi.org/10.3390/educsci10110330

Mishra P, Koehler MJ. (2006). Technological pedagogical content knowledge: a framework for teacher knowledge. Teach Coll Rec , 108(6):1017–54. https://doi.org/10.1111/j.1467-9620.2006.00684.x

Riduwan. (2016). Skala Pengukuran Variabel-variabel penelitian. Bandung: Alfabeta.

Rocke, A. J. (2020). Chemistry Encyclopedia Britannica.

Savery, J.R., (2006). Overview of problem-based learning: definitions and distinctions. Interdiscip. J. Probl.-Based Learn. 1 (1). https://doi.org/10.7771/1541-5015.1002

Shulman L. (1986). Those who understand: knowledge growth in teaching. Educ Res, 15(2):4–14. https://doi.org/10.2307/1175860

Sugiyono. (2015). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Bandung : ALFABETA.

Syahidah. Fitya, Hardi. Endang, Sutresna. Yoyon. (2023) Pengaruh Penerapan Model Pembelajaran Mind Mapping Berbasis Tpack Terhadap Kemampuan Berpikir Kreatif Siswa. *Jurnal keguruan dan ilmu Pendidikan*. Vol 4, No 1

Thiagarajan, Sivasailam, dkk. (1974). *Instructional Development for Training Teachers of Exceptional Children*. Washinton DC: National Center for Improvement Educational System

Uluçınar, U., (2023). The effect of problem-based learning in science education on academic achievement: a meta-analytical study. Sci. Educ. Int. 34 (2), 72–85. https://www.icaseonline.net/journal/index.php/sei/article/view/505\