

Development of TPACK-Based PjBL Teaching Modules on Substances and Their Changes in Vocational Schools: A Study of Class X TKR 3 at SMKN 3 Makassar

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ABSTRACT

This study arises from the need to develop more innovative and effective teaching modules that help students understand the concepts of substances and their transformations at SMKN 3 Makassar. This study aims to develop a Project-Based Learning (PjBL) teaching module with a valid, practical, and effective Technological Pedagogical Content Knowledge (TPACK) approach. The module was developed using the ADDIE model, which includes the stages of analysis, design, development, implementation, and evaluation. The results of validation by two validators indicated that the module fell into the highly valid category, with a validity score of 1 based on the contingency table. The practicality level of the module was assessed through a questionnaire completed by 36 students, resulting in a percentage of 97.22% in the very practical category. Additionally, a teacher provided a very practical assessment, also scoring 100%. The effectiveness of the module was determined by learning outcomes, where 80.5% of the total 36 students achieved mastery according to the specified criteria; therefore, the module was deemed very effective. Overall, the PjBL and TPACK-based teaching module developed is suitable for use in learning and can improve students' understanding and engagement with the material on substances and their changes.

Keywords: *Teaching Module, Project-Based Learning, Technological Pedagogical Content Knowledge, Validity, Practicality, Effectiveness, Substances and Their Changes.*

1) INTRODUCTION

Education plays a crucial role in shaping individuals to become ethical, moral, independent, and critical thinkers. Ki Hajar Dewantara emphasized that education is a process of guiding learners toward attaining the highest levels of well-being and happiness. This implies that education is not merely a means of delivering knowledge, but also an effort to humanize individuals and uphold the dignity of every person (Ujud et al., 2023). In Islamic teachings, the importance of education is emphasized in the Qur'an, Surah Al-Mujadilah verse 11, which calls upon believers to make room in gatherings of knowledge and to rise when instructed. The verse highlights that Allah elevates the status of those who believe and possess knowledge, while also reminding that all human deeds are always within His awareness. According to Tafsir Al-Adhim, anyone who facilitates the affairs of their fellow believers

will receive a reward from Allah a teaching that aligns with Islamic values regarding the significance of knowledge as a path toward a dignified and meaningful life (Katsir, 2007).

To realize educational goals that align with Islamic values and the ideas of national education figures, it is essential to implement learning strategies that are applicable and relevant to real-life contexts. One such strategy is the use of teaching modules designed to suit the characteristics of the subject matter and the needs of the learners. An effective teaching module must be responsive to technological advancements in order to address contemporary challenges. The presence of innovative modules is expected to strengthen conceptual understanding, bridge theory and practice, and enhance the overall quality of the learning process.

The implementation of teaching modules is highly relevant in IPAS learning, particularly on the topic of substances and their changes. This topic serves as a fundamental concept that plays an important role in shaping students' scientific thinking and investigative skills. It covers the characteristics of substances, physical and chemical changes, and the application of these concepts in everyday life. A deep understanding of this material is essential to support the mastery of more complex scientific concepts, enhance critical thinking skills, and cultivate students' awareness of the importance of science in various fields such as industry, environment, and health. Therefore, the delivery of engaging and meaningful learning materials is crucial to ensure that students can understand the concepts more effectively.

Initial observations at SMKN 3 Makassar indicate that the learning process for the topic of substances and their changes still faces several challenges. Students experience difficulties in understanding abstract concepts because the instruction remains largely theoretical and lacks variation. This condition leads to low student interest and motivation. In addition, the teaching modules used are still traditional and not yet innovative. The limited integration of technology also results in students being less actively engaged in learning activities. These issues demonstrate the need for a renewed learning approach that is more aligned with the needs of today's learners.

As an effort to address these issues, the development of a Project-Based Learning (PjBL) teaching module integrated with the Technological Pedagogical Content Knowledge (TPACK) approach can serve as an effective solution. The PjBL model provides students with opportunities to work on projects that are relevant to their daily lives, thereby increasing active engagement and helping to deepen their conceptual understanding (Zhang, 2023). At the same time, the integration of TPACK

enables the effective use of technology in the learning process, allowing abstract concepts to be visualized more clearly and engagingly (Mario et al., 2023).

The effectiveness of this approach is supported by various previous studies. Amelia found that the development of a TPACK-based e-module was able to enhance student engagement and understanding at MIN 4 South Aceh (Amelia, 2022). Research conducted by Triwahyudi, Sutrisno, and Yusnaidar also demonstrated that the application of TPACK in chemistry learning materials can improve the overall quality of the learning process (Triwahyudi, 2021). In addition, Sari and colleagues developed a PjBL-based module for physics education students and found that it could enhance learners' critical thinking skills and creativity (Sari et al., 2019).

A TPACK-based PjBL module offers several advantages over conventional modules. It not only deepens conceptual understanding but also encourages students to develop logical thinking skills, collaborate effectively, and engage in problem-solving. The integration of technology makes the learning process more interactive and engaging, ultimately improving student motivation and learning outcomes. Considering these challenges, the researcher finds it necessary to develop a Project-Based Learning module based on the TPACK approach for the topic of substances and their changes for Grade X TKR 3 SMKN 3 Makassar students.

This study focuses on the development process of a module that incorporates content, pedagogy, and technology aspects. The purpose of this research is to identify the stages of developing the teaching module and to assess the validity, practicality, and effectiveness of the resulting module for use in the learning process.

2) METHODS

This study employs a Research and Development (R&D) model aimed at producing an instructional product in the form of a teaching module that meets the standards of validity, practicality, and effectiveness. The selection of the R&D model is based on its ability to facilitate the systematic processes of designing, testing, and refining the product (S et al., 2023). In general, research and development is a scientific process designed to create new innovations through the identification of needs, the design of models or learning tools, field testing, product revision, and dissemination. This procedure not only produces new products but also evaluates their benefits and impact on the learning process. Thus, this approach is considered the most appropriate for developing a teaching module that is relevant to students' needs while also addressing the challenges of contemporary learning.

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The product development procedure in this study refers to the ADDIE model, which consists of five core stages: Analysis, Design, Development, Implementation, and Evaluation (Almelhi, 2021). The analysis stage focuses on identifying learning needs, mapping students' characteristics, and observing learning problems related to the topic of substances and their changes. The initial analysis revealed that students experienced difficulties in understanding abstract concepts due to the limited media and learning resources used by the teacher. Based on these findings, the design stage was carried out by formulating the structure of the teaching module, which consists of the introduction, core, and closing sections. The introduction includes general information, learner characteristics, learning objectives, the applied learning model, and competency mapping. The core section contains explanations of the material, experimental or project-based activities, and exercises to assess student understanding. Meanwhile, the closing section includes enrichment activities, a glossary, and other supporting appendices.

After the design stage was completed, the development stage focused on constructing the module content, designing visual elements, and adjusting the layout to align with students' characteristics. The developed product was then validated by subject-matter experts and media experts to ensure content appropriateness, conceptual accuracy, linguistic clarity, and overall design feasibility. Subsequently, the implementation stage was carried out through a limited trial in Class X TKR 3 at SMKN 3 Makassar to observe how the module performed in an actual learning situation. The data collected during the implementation served as the basis for the evaluation stage, which involved revising the product and assessing the module's effectiveness in improving students' understanding.

In line with this process, the subject of this study consisted of the subject teacher and the students of Class X TKR 3, while the PjBL-based teaching module integrated with the TPACK approach served as the object being developed. The teacher provided assessments related to the module's validity and practicality, whereas the students gave responses regarding its ease of use and completed tests to measure its effectiveness.

To obtain the required data, several instruments were used in this study, namely observation sheets, questionnaires, and learning outcome tests. The observation sheets were validated by two experts to ensure that the instruments met the appropriate assessment standards. Teacher and student questionnaires were used to determine the practicality level of the module, covering aspects such as ease of use, clarity of instructions, and the module's usefulness in the learning process. The learning

outcome test was employed to assess the effectiveness of the module in improving students' achievement. A learning product is considered to be of high quality if it meets three criteria validity, practicality, and effectiveness as outlined by Van Akker (Nurmia, Damopolii, and Halimah, 2021).

Finally, the data analysis technique was carried out in three main stages. First, the validity analysis employed the Gregory index by constructing a 2×2 contingency table based on the assessments of two validators(Hanani & Nuryono, 2025).

Table 1: *Contingency Table for Calculating the Index*

2×2 Matrix		Evaluator 1	
		Less Relevant (1-2)	Highly Relevant (3-4)
Evaluator 2	Less Relevant (1-2)	A	B
	Highly Relevant (3-4)	C	D

$$V = \frac{D}{A+B+C+D} \quad (1)$$

Description:

V : Construct Validation

A : Both raters disagree (Weak–Weak)

B : Rater 1 agrees, rater 2 disagrees (Weak–Strong)

C : Rater 1 disagreed, while Rater 2 agreed (Weak–Strong)

D : Both raters agreed (Strong–Strong)

Second, the practicality analysis was carried out by converting the scores into a five-point scale to determine whether the module fell into the category of very practical, practical, fairly practical, less practical, or not practical(Hanani & Nuryono, 2025).

Table 2: *Guidelines for Five-Point Scale Conversion*

Score Interval	Category
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$\bar{x} > Mi + 1,8 Sbi$	Very Practical
$Mi + 0,6 Sbi < \bar{x} \leq Mi + 1,8 Sbi$	Practical
$Mi - 0,6 Sbi < \bar{x} \leq Mi + 0,6 Sbi$	Fairly Practical
$Mi - 1,8 Sbi < \bar{x} \leq Mi - 0,6 Sbi$	Less Practical
$\bar{x} \leq Mi - 1,8 Sbi$	Not Practical

Description:

Mi : Ideal Mean

: $\frac{1}{2}$ (Ideal Maximum Score + Ideal Minimum Score)

Sbi : Ideal Standard Deviation

: $\frac{1}{6}$ (Ideal Maximum Score – Ideal Minimum Score)

$\bar{x}$: Average Score

Total Ideal Maximum Score = Highest Score (5) × Number of Items

Total Ideal Minimum Score = Lowest Score (1) × Number of Items

Third, the effectiveness analysis was conducted by calculating both individual and classical mastery. Students are considered to have achieved individual mastery if they obtain a minimum score of 75, while classical mastery is achieved if at least 70% of the students reach this score. The resulting percentage of mastery is then interpreted to determine the level of effectiveness of the developed module.

Table 3: *Student Mastery Category*

Interval	Categori
$X \geq ATP$	Complete
$X < ATP$	Incomplete

3) RESULTS AND DISCUSSION

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a) Analysis

In the analysis stage, students' learning needs, their characteristics, and the subject matter were identified. Based on observations and interviews with the subject teacher, it was found that students still had difficulties in understanding abstract concepts related to substances and their changes because the learning resources used were not interactive and did not utilize technology. Therefore, an innovative teaching module is needed, incorporating a Project-Based Learning approach and technology integration in accordance with TPACK principles.

b) Design

In the module design phase, the most important aspects included media selection, material presentation format, and the development of the initial module version. The media was chosen according to the characteristics of the material and the instructional design, with the researcher selecting printed media in the form of a teaching module because it aligns with the curriculum and students' needs. For the module format, quality aspects such as layout, font type and size, spacing, and paper orientation were considered, specifically: Cambria font, size 12, A4 portrait paper, and a standard 2.54 cm margin. After determining the module structure, the researcher reviewed and adjusted the content layout to ensure the module was accurate and visually appealing, covering the cover, general information, core components, and appendices. Before the limited trial, the module was validated by two validators to assess feasibility across four aspects: content presentation, material accuracy, graphics, and language. Prototype I was developed from the initial design, reviewed by experts, and their feedback was used for revisions. Prototype II, after improvements, was then finalized as the final product.

c) Develop

During the development phase, the designed and developed product underwent validity testing through a validation process conducted by two experts. The feasibility of the module for use in the learning process was determined based on the assessments provided by these validators. The description of the validation analysis results for the developed teaching module, organized by each assessment aspect, is presented in Table 4.

Table 4: *Teaching Module Validation Results*

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No.	Validation Aspect	V	Description
1	Content Validity	1	Very High Validity
2	Construct Validity (Presentation Component)	1	Very High Validity
3	Construct Validity (Graphics Component)	1	Very High Validity
4	Language Validity	1	Very High Validity
Total Average Score		1	Very High Validity

Based on data analysis, the PjBL teaching module based on TPACK on the topic of matter and its changes has a total average validity score of 1, falling into the “Very High Validity” category (>0.8). Thus, the teaching module meets all validity criteria. The validators also provided revision notes as recommendations for product improvement, as detailed in Table 5.

Table 5: *Validator Comments and Suggestions*

No.	Aspect	Comments	
		Validator 1	Validator 2
1	Content	In the appendix containing reading materials for teachers and students, the content should not be too dense or lengthy to make it easier for students to understand.	Align the content with the PjBL approach. During practical activities, each group should perform the same tasks so that comparisons of students' work can be clearly observed.
2	Presentation Components	Learning activities should be aligned with the material, meaning the content to be delivered needs to match the available time or number of lesson hours.	The evaluation questions given to students should correspond to the practices they have carried out and should not focus too much on low-cognitive-level material.
3	Graphics Components	Improve the layout and formatting. Provide appropriate spacing between sections and pay attention to the proportion of images.	Pay attention to the proportion of images in the appendix of reading materials for teachers and students.
4	Language	In the assessment rubric, the evaluation criteria should be clarified, so that there is a clear distinction between the	The ability to motivate students to respond to messages or information, as well as to encourage critical thinking, is not yet optimally demonstrated.

No.	Aspect	Comments	
		Validator 1	Validator 2
		categories of poor, fair, good, and very good.	

d) Implementation

This stage is a continuation of the previous development process. After undergoing revisions, all the media designs that had been developed were then implemented. The module-based learning materials were used in an actual classroom setting. The purpose of this trial was to evaluate the practicality and usefulness of the teaching materials. The limited trial was conducted by involving the subject teacher and 36 students from Class X TKR 3 at SMKN 3 Makassar.

The results of the practicality data analysis based on teacher and student responses are presented in Table 6 and Table 7.

Table 6: *Recapitulation of Teacher Responses on the Practicality of Using the PjBL Teaching Module Based on TPACK*

No	Range	f	%	Description
1	$x \leq 12,6$	0	0	Not Practical
2	$12,6 < x \leq 18,2$	0	0	Less Practical
3	$18,2 < x \leq 23,8$	0	0	Fairly Practical
4	$23,8 < x \leq 29,4$	0	0	Practical
5	$x > 29,4$	1	100	Very Practical
Total		1	100	Very Practical

Based on Table 6, the teacher response questionnaire for X TKR 3 SMKN 3 Makassar shows a score of $x > 29,4$, indicating that the PjBL teaching module based on TPACK is considered very practical, with a percentage of 100%.

Table 7: *Recapitulation of Student Responses on the Practicality of Using the PjBL Teaching Module Based on TPACK*

No.	Range	f	%	Description
1	$x \leq 17,994$	0	0	Not Practical
2	$17,994 < x \leq 26$	0	0	Less Practical

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No.	Range	f	%	Description
3	$26 < x \leq 34$	1	2,78	Fairly Practical
4	$34 < x \leq 42$	0	0	Practical
5	$x > 42$	35	97,22	Very Practical
Total		36	100	Sangat Praktis

The analysis in Table 7 shows that the PjBL teaching module based on TPACK was rated as very practical by 97.22% of students and fairly practical by 2.78% of students, thereby meeting the practicality criteria

e) Evaluation

The final stage in the ADDIE model is evaluation, which serves to improve the quality of the teaching materials. At this stage, the researcher provided 25 multiple-choice questions to the students with a completion time of 90 minutes, where each correct answer was given a score of 4. This evaluation aims to assess the quality of the teaching module and determine the level of students' understanding after using the developed product.

Table 8: *Student Learning Outcomes Using the PjBL Teaching Module Based on TPACK*

No.	Interval	F	%	Category
1	$X \geq ATP$	29	80,5	Complete
2	$X < ATP$	7	19,5	Incomplete

4) CONCLUSIONS

Based on the results of the research and development, it can be concluded that the Project-Based Learning (PjBL) teaching module based on TPACK on the topic of Matter and Its Changes for class X TKR 3 SMKN 3 Makassar has met the criteria for validity, practicality, and effectiveness. This teaching module has been validated by experts, rated as very practical based on teacher and student responses, and proven effective in improving learning outcomes and students' problem-solving skills. The implementation of this module helps students gain a deeper understanding of physics concepts while fostering critical, creative, and analytical thinking skills. Therefore, this PjBL teaching module

based on TPACK can be used as an innovative learning tool to enhance the quality of physics education at the vocational high school level.

This study is limited in terms of generalizability, as the results apply only to one school and one subject. Therefore, future research is recommended to be conducted in multiple schools and across different subjects to enhance external validity. In addition, future studies should explore the impact of the PjBL teaching module based on TPACK on other variables, such as learning motivation, students' attitudes toward physics, and critical thinking skills, in order to gain a more comprehensive understanding of the effects of this teaching module.

REFERENCES

- Almelhi, A. M. (2021). Effectiveness of the ADDIE Model within an E-Learning Environment in Developing Creative Writing in EFL Students. 14(2), 20–36. <https://doi.org/10.5539/elt.v14n2p20>
- Amelia, D. (2022). Pengembangan E-Modul Berbasis Tpack pada Tema 4 Subtema 1 di Kelas V MIN 4 Aceh Selatan. 1–132.
- Hanani, A. K., & Nuryono, W. (2025). Validitas Modul Pelatihan Keterampilan Interpersonal Sebagai Upaya Pencegahan Penyalahgunaan Narkoba Pada Peserta Didik. 7(2).
- Katsir, I. (2007). Tafsirul Qur'an al-'Adhim. Al Kitab Al Ilmi.
- Mario, J., Iglesias, O., Cabero-almenara, J., & Palacios-rodríguez, A. (2023). Development of the teacher's technological pedagogical content knowledge (TPACK) from the Lesson Study: A systematic review. February. <https://doi.org/10.3389/feduc.2023.1078913>
- Nurmia, Muljono Damopolii, Andi Halimah, S. (2021). Pengembangan Perangkat Pembelajaran tematik berbasis Scientific Approach pada Tema “Indahnya Kebersamaan” Dengan Subtema ‘kebersamaan Budaya Bangsa’ Jurnal Ilmiah Madrasah Ibtidaiyah.” 01(2), 72–78.
- S, M. F., Anggereni, S., Jusman, Ashar, H., & Dani, A. U. (2023). Pengembangan Multimedia Dalam Pembelajaran IPA Menggunakan Adobe Animate Pada Pokok Bahasan Tata Surya Kelas VII Mts As'adiyah No.34 Doping. Al-Khazini: Jurnal Pendidikan Fisika, 3(2), 93–104. <https://doi.org/10.24252/al-khazini.v3i2.41433>
- Sari, L. P., Hatchi, I., & Siregar, D. A. (2019). Pengembangan Modul Ajar Berbasis Project Based Learning (PjBL) yang Praktis Bagi Mahasiswa Calon Guru Fisika. Jurnal Education and Development, 7(3), 87. <https://doi.org/10.37081/ed.v7i3.1188>
- Triwahyudi, S. (2021). Pengembangan perangkat pembelajaran berbasis TPACK pada materi kimia SMA. Chempublish Journal, 6(1), 46–53. <https://doi.org/10.22437/chp.v6i1.11679>
- Ujud, S., Nur, T. D., Yusuf, Y., Saibi, N., & Ramli, M. R. (2023). Penerapan Model Pembelajaran Discovery Learning Untuk Meningkatkan Hasil Belajar Siswa Sma Negeri 10 Kota Ternate Kelas X Pada Materi Pencemaran Lingkungan. Jurnal Bioedukasi, 6(2), 337–347. <https://doi.org/10.33387/bioedu.v6i2.7305>

Zhang, L. (2023). A study of the impact of project-based learning on student learning effects: a meta-analysis study. July, 1–14. <https://doi.org/10.3389/fpsyg.2023.1202728>.