Education

The development of a project-based learning model integrating a deep learning pedagogical approach within the IPAS project subject

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Abstract

This research aimed to develop a teaching module grounded in the Project-Based Learning (PjBL) model and integrated with a deep learning pedagogical approach for the IPAS Project subject, specifically focusing on the topic of Substances and Their Changes, such that the resulting module would satisfy the criteria of validity, practicality, and effectiveness. The study employed a Research and Development (R&D) methodology utilizing the 4D development model and was conducted at SMK Negeri 1 Modoinding. The findings revealed that the developed teaching module met the established criteria, being classified as highly valid, practical, and effective. Specifically, material expert validation yielded a percentage of 97.92%, falling into the highly valid category, while media expert validation achieved a percentage of 87.00%, falling into the valid category. Regarding practicality, teacher responses indicated that the module was very practical, and student responses yielded a percentage of 89.14%, also classified as very practical. Furthermore, the effectiveness of the module was demonstrated by a student learning mastery percentage of 85%, which falls into the very effective category.

Keywords: Project-Based Learning, Deep learning, Teaching module, IPAS project, Substances and their changes

Introduction

The evolution of 21st-century education necessitates a fundamental reorientation in the ways learning is designed and implemented within school settings, as instruction that remains predominantly focused on factual mastery is no longer considered sufficient; rather, it must actively enable learners to develop deep conceptual understanding, establish meaningful connections with real-life contexts, and apply their knowledge to solve authentic problems. A substantial body of educational research has demonstrated that procedural, teacher-centered instructional approaches tend to produce only superficial comprehension, thereby hindering students' ability to transfer acquired knowledge to novel situations—a challenge that becomes particularly acute in science and integrated science (IPAS) subjects, which demand strong analytical and applicative competencies. In response to these challenges, national education policy has underscored the imperative of transforming pedagogical approaches, as articulated in Ministerial Regulation of Basic and Secondary Education (Permendikdasmen) Number 13 of 2025, which explicitly positions *Deep Learning* as a strategic approach to enhancing the quality of instruction across educational units. Deep Learning is conceptualized as a learning process that enables students to experience education in a conscious, meaningful, and enjoyable manner, such that they not only grasp *what* they are studying but also understand *how* and *why* that knowledge is relevant. This approach emphasizes the integration of the processes of understanding, applying, and reflecting as a unified learning experience.(Kovač *et al.*, 2025; Mirra & Garcia, 2021; Mokalu *et al.*, 2022; Nurhasanah *et al.*, 2025; Sliwka *et al.*, 2024) [19, 24, 28, 31, 40] Nevertheless, the policy of Deep Learning cannot achieve optimal impact without the concurrent support of appropriate instructional models and teaching materials. One model that is conceptually aligned with Deep Learning is Project-Based Learning (PjBL), which positions students as active subjects in the learning process through engagement in authentic projects that demand inquiry, collaboration, decision-making, and reflection. A growing body of research over the past five years has indicated that, when systematically designed and implemented, PjBL is capable of enhancing students' conceptual understanding, higher-order thinking skills, and learning engagement.(Arundaa *et al.*, 2023; Mantiri *et al.*, 2025; Miller & Krajcik, 2019; Mokalu *et al.*, 2025; Nurhasanah *et al.*, 2025; Paat *et al.*, 2024; Taufik *et al.*, 2025) [4, 21, 23, 27, 31, 33, 42].

The application of PjBL holds particularly strong relevance in the context of the IPAS Project subject, especially with respect to the topic of Substances and Their Changes, because this topic not only encompasses abstract concepts regarding the properties of substances and physical versus chemical changes but also directly pertains to everyday phenomena and vocational work environments. Consequently, instruction that relies solely on lectures or repetitive exercises is insufficient to foster deep conceptual understanding; project-based learning allows students to observe, experiment with, and analyze real-world changes in substances, thereby rendering concepts more meaningful and contextually grounded. Despite its potential, the implementation of PjBL integrated with a Deep Learning approach in vocational high schools (SMKs) continues to encounter multiple obstacles. Based on preliminary observations at SMK Negeri 1 Modoinding, which included interviews with IPAS teachers, it was found that instruction remains dominated by conventional approaches, while project activities have not been designed in a systematic and sustained manner. Teachers reported that the lack of teaching modules tailored to the characteristics of both PjBL and Deep Learning constitutes one of the primary barriers to developing more meaningful learning experiences. From the students' perspective, interview results revealed that learners frequently experience difficulties in fully comprehending the topic of Substances and Their Changes, tending instead to memorize concepts without genuinely understanding the relationships among those concepts or their application in daily life and vocational contexts. Furthermore, students stated that learning would become more engaging and comprehensible if they were actively involved through well-structured projects, experiments, and discussions. These findings indicate a gap between students' learning needs and the instructional practices currently occurring in the classroom.(Cahyawati *et al*., 2026; Mokalu *et al*., 2023a; Taufik *et al*., 2025; Tumbel *et al*., 2021a) [6, 25, 42, 43].

Such problems suggest that the primary need is not merely the adoption of a particular instructional model but rather the development of a teaching module specifically designed to integrate PjBL with the Deep Learning approach. A teaching module serves a strategic role as a primary guide for teachers in designing learning sequences, project activities, assessments, and student learning reflections. An effective teaching module must be capable of facilitating a conscious, meaningful, and enjoyable learning process while simultaneously remaining user-friendly for teachers and appropriate for the characteristics of vocational high school students. Within the context of educational research, the development of a teaching module requires comprehensive feasibility testing, as feasibility is determined not only by the appropriateness of content and instructional design but also by content and construct validity, practicality during classroom implementation, and effectiveness in improving student learning outcomes. Recent studies have shown that validated and practical PjBL-based teaching modules tend to be more effective in enhancing conceptual understanding and higher-order thinking skills compared to conventional instructional materials. Based on the foregoing elaboration, the researcher is motivated to develop a Project-Based Learning model that incorporates the Deep Learning approach, operationalized in the form of a teaching module for the IPAS Project subject on the topic of Substances and Their Changes. The present study focuses on examining the feasibility of the developed teaching module in terms of validity, practicality, and effectiveness, with the expectation that it will make a tangible contribution to improving the quality of IPAS instruction at SMK Negeri 1 Modoinding while also supporting the implementation of the Deep Learning policy as mandated by Permendikdasmen Number 13 of 2025. (Cahyawati *et al*., 2026; Hadi *et al*., 2026; Mokalu *et al*., 2024; Onsu *et al*., 2023; Paat *et al*., 2025) [6, 10, 26, 32, 34].

Research methodology

A. Type and design of the study

This study constitutes a Research and Development (R&D) investigation aimed at producing an educational product in the form of a teaching module founded upon the Project-Based Learning (PjBL) model while simultaneously employing a deep learning pedagogical approach within the context of the IPAS Project subject, specifically addressing the topic of Substances and Their Changes; moreover, in addition to generating the product itself, this research also seeks to examine the feasibility of the developed teaching module as evaluated from the perspectives of validity, practicality, and effectiveness. The Research and Development (R&D) approach was selected for the context of this study because its nature extends beyond mere theory testing to systematically and empirically encompass the processes of designing, developing, and evaluating learning products, such that the teaching module developed through this R&D process is expected not only to be theoretically consistent but also to remain relevant, classroom-applicable, and supported by empirical evidence regarding its benefits within authentic learning contexts (Ade Rahayu, 2025) [1]. The development model employed in this study is the 4D model (Define, Design, Develop, and Disseminate), which was chosen because it provides systematic, structured, and applicable stages for the development of instructional materials, particularly teaching modules. The selection of the 4D model for developing the teaching module was grounded in findings from recent studies indicating that this model remains relevant and effective for developing instructional materials across diverse educational contexts; for instance, demonstrated that developing e-module instructional materials using the 4D model through the stages of needs definition, instructional design, product development, and expert validation resulted in modules possessing high feasibility levels and practical usability in learning settings. Similarly, a study by (Hl *et al*., 2023) [12] employing the 4D model for developing instructional materials in a learning methodology course found that the 4D stages assisted researchers in designing, testing, and modifying instructional materials so as to support the enhancement of students' critical thinking skills. Furthermore, a more recent investigation (Ade Rahayu, 2025; Aziz *et al*., 2023; Hl *et al*., 2023) [1, 5, 12].

B. Time and location of the research

This research was conducted at SMK Negeri 1 Modoinding during the even semester of the 2025/2026 academic year, encompassing the activities of needs analysis, design, development, validation, and teaching module trials.

C. Research subjects

The subjects of this research in the development of the teaching module included the following: expert validators, consisting of both IPAS content experts and instructional media experts, whose validation aimed to assess the appropriateness of the module's content, construction, and language; IPAS Project teachers, who acted as module users to provide assessments regarding the practicality of using the module in instruction; and students of SMK Negeri 1 Modoinding, who served as trial subjects for the teaching module in both limited and field trials, with the limited trial involving nine students to determine the module's readability, clarity of instructions, and initial student responses to the developed module, while the field trial involved twenty students to obtain data on the practicality and effectiveness of the teaching module under more authentic learning conditions.

D. Data collection techniques and instruments

The data collection techniques in this study included validation questionnaires used to obtain validity data on the teaching module from experts, practicality questionnaires used to determine the ease of module use by teachers and students, learning achievement tests used to measure the module's effectiveness on student learning outcomes, and interviews and observations used as supporting data to strengthen the research findings. The development and use of diverse research instruments for the teaching module on the IPAS Project topic of Substances and Their Changes were based on fulfilling feasibility aspects that theoretically and empirically refer to recent literature published within the last five years, wherein theoretical validity testing through material expert and media expert validation sheets was intended to ensure the accuracy of scientific concepts free from misconceptions, the appropriateness of visual presentation and linguistic structure, and the alignment of materials with the latest learning outcomes under the Merdeka Curriculum, consistent with the principles of content feasibility, readability, and instructional design that is adaptive to the dynamics of national curriculum policy (Domits *et al*., 2025; Islamiati *et al*., 2024; Nikmah & Prasetyo, 2025) [8, 13, 29]. Furthermore, the integration of Project-Based Learning (PjBL) indicators into the instructional implementation observation sheets and practicality questionnaires was based on the importance of testing structured syntax to stimulate critical thinking abilities, independence, and collaborative skills among vocational high school students (Dewi, 2022; Tumbel *et al*., 2021b) [7, 43]. Meanwhile, instrument items assessing the integration of the deep learning approach were directed toward evaluating the module's capacity to facilitate reflection, conscious interaction, and the construction of meaningful conceptual understanding for students through the interrogation of real-world, everyday problems (Haq & Prasetiyo, 2025; Liao *et al*., 2024; Mokalu *et al*., 2023b) [11, 20, 25] Finally, the use of teacher and student practicality questionnaire sheets was comprehensively designed as a parameter to measure the usability, navigational ease, time allocation efficiency, and operational flexibility of the module when actually implemented in the classroom setting (Meike Paat *et al*., 2024; Novian Indah Sari *et al*., 2025; Patibang *et al*., 2025a) [22, 30, 35].

E. Data analysis techniques

The data obtained in this study were analyzed using both descriptive quantitative and qualitative methods; quantitative analysis for the validity and practicality of the teaching module generally employed mean scores and percentages of user responses, thereby indicating the extent to which the module met feasibility criteria prior to wider implementation. For example, research on the development of context-based teaching modules has shown that validity scores from expert assessments and practicality scores from teacher and student responses reached the categories of highly valid and highly practical based on mean scores and percentages analyzed quantitatively, an approach that strengthens evidence that descriptive quantitative techniques can produce valid depictions of product feasibility before effectiveness testing is conducted. Data analysis for effectiveness was generally performed by comparing student learning outcomes before and after using the teaching module, so as to ascertain whether module use significantly improved conceptual understanding and learning achievement; studies on teaching module development that assessed effectiveness through mean scores and percentages of student learning mastery indicated that validated and practical modules tend to be effective in enhancing student learning outcomes in experimental classes. Consequently, the combination of quantitative and qualitative analyses provides a strong foundation for assessing teaching module feasibility in terms of validity, practicality, and effectiveness in an integrated manner. (Akbar *et al*., 2024; Kiki Fatmawati *et al*., 2023; Kosakoy *et al*., 2025; Sanudin *et al*., 2023) [3, 17, 18, 39].

a) Teaching module validity analysis

Data on teaching module validity were obtained from the assessment results of expert validators through validation questionnaires, wherein each assessment item was scored using a Likert scale with a range of 1 to 4 to avoid neutral bias. The validity score of the teaching module was calculated using the percentage formula: P1 = (Obtained Score / Maximum Score) × 100%. The resulting validity percentage was then converted into the validity level categories presented in Table 1.

Table 1: Categories of validity levels

Percentage score	Validity category
$P1 \geq 90\%$	Highly valid
$76\% \leq P1 < 90\%$	Valid
$60\% \leq P1 < 76\%$	Moderately valid
$55\% \leq P1 < 60\%$	Less valid
$P1 < 55\%$	Invalid

***Source:** (Adhiatma *et al*., 2025)

The teaching module was declared feasible from the validity aspect when it fell into either the Valid or Highly Valid category.

b) Teaching module practicality analysis

Data on teaching module practicality were obtained from teacher and student response questionnaires administered after the module was used in instruction, and the data were analyzed by calculating the practicality percentage using the formula: Percentage = (Total Obtained Score / Total Maximum Score) × 100%, where P represents the practicality percentage, ΣX represents the total score obtained, and ΣXmax represents the maximum total score. The resulting practicality percentage was then interpreted based on the categories shown in Table 2.

Table 2: Categories of practicality levels

Percentage	Practicality category
81% – 100%	Very Practical
61% – 80%	Practical
41% – 60%	Moderately Practical
21% – 40%	Impractical
0% – 20%	Very Impractical

****Source*: Riduwan as cited in (Isnaini *et al*., 2022, pp. 161-162) [14]**

The teaching module was declared practical when it fell into either the practical or very practical category.

c) Teaching module effectiveness analysis

The effectiveness of the teaching module was analyzed based on student learning outcomes after using the module, with the analysis conducted by calculating the mean learning achievement score and the percentage of learning mastery. The mean learning achievement score was calculated using the formula: $\bar{X} = \Sigma X / N$, where $\bar{X}$ represents the mean learning achievement score, ΣX represents the sum of all student scores, and N represents the number of students. The percentage of learning mastery was calculated using the formula: P = (Pa / Pb) × 100%, where P represents the percentage of student mastery, Pa represents the number of students who achieved mastery, and Pb represents the total number of students. The criteria for interval percentages of learning activity, indicating effectiveness levels, are presented in Table 3.

Table 3: Categories of effectiveness levels

No.	Percentage	Effectiveness category
1.	81% – 100%	Very Effective
2.	61% – 80%	Effective
3.	41% – 60%	Moderately Effective
4.	21% – 40%	Less Effective
5.	0% – 20%	Very Ineffective

Source: Sugiyono as cited in Arifah, Lian, & Riyanti (2025, p. 564)

The teaching module was declared effective when it reached either the effective or very effective category.

d) Qualitative data analysis

Qualitative data in the form of suggestions, comments, and feedback from validators, teachers, and students were analyzed using data reduction, data presentation, and conclusion-drawing techniques, and such data were used as the basis for revising the teaching module in order to further optimize the quality of the product.

Results

A. Overview of the research

This study constitutes a Research and Development (R&D) investigation aimed at producing a teaching module grounded in Project-Based Learning (PjBL) while simultaneously employing a deep learning pedagogical approach within the context of the IPAS Project subject, specifically addressing the topic of Substances and Their Changes. The development model employed was the 4D model, comprising the stages of Define, Design, Develop, and Disseminate. The module development was conducted systematically, progressing from needs analysis, product design, expert validation, limited trials, to field trials, in order to determine the validity, practicality, and effectiveness of the developed teaching module.

B. Stages of the 4D development model

a) Define stage

The define stage was undertaken to obtain an initial overview of learning needs, student characteristics, school conditions, and the problems encountered in the IPAS Project instruction on the topic of Substances and Their Changes.

- **Initial-final analysis:** Based on the results of observations and interviews with the IPAS Project teacher at SMK Negeri 1 Modoinding, it was found that instruction remained predominantly teacher-centered and had not yet facilitated active student engagement. The teacher also reported that project activities had not been implemented systematically due to the limited availability of teaching modules aligned with the characteristics of PjBL and deep learning. Furthermore, students experienced difficulties in fully comprehending the concepts of substances and their changes because instruction emphasized rote memorization rather than direct learning experiences. This condition aligns with the assertion (Isnaini *et al*., 2022) [14] misconceptions regarding substances and their changes frequently arise when learning relies solely on verbal explanations without exploratory experiences. (Gilbert & Watts, 1983; Isnaini *et al*., 2022; Tumbel *et al*., 2021) [9, 14, 43].
- **Learner analysis:** Tenth-grade students at SMK Negeri 1 Modoinding were characterized by their active nature and preference for practice-based learning; however, their critical thinking abilities and conceptual understanding still required improvement. Consequently, learning activities involving experiments, discussions, and simple projects were necessary to provide students with more meaningful learning experiences.
- **Task analysis:** Task analysis was conducted based on the learning outcomes of the IPAS Project subject at Phase E concerning the topic of Substances and Their Changes. The developed materials encompassed the following: classification of substances, physical properties of substances, chemical properties of substances, physical and chemical changes, separation of mixtures, and the application of concepts related to changes in substances in everyday life. Learning activities were designed in the form of experiments and mini-projects, including simple filtration, salt crystallization, and the use of hibiscus flower petals as a natural indicator.
- **Concept analysis:** The main concepts in the module were systematically arranged, progressing from basic concepts of substances to their applications in everyday life, such

that students could build their understanding gradually and in depth.

- **Learning objectives analysis:** Learning objectives were formulated based on the learning outcomes and the characteristics of the PjBL model combined with the deep learning approach, with these objectives being directed toward the ability to understand concepts, conduct scientific inquiry, think critically, and produce simple products.

b) Design stage

The design stage was undertaken to develop the initial blueprint of the teaching module.

- **Test development:** Tests were developed in the form of a pre-test and a post-test to measure the improvement in student learning outcomes after using the teaching module, with the items designed to assess conceptual understanding, analysis, and application of the concept of changes in substances in everyday life.
- **Media selection:** The instructional media employed included the teaching module itself, student worksheets (LKPD), PowerPoint instructional materials, simple experimental tools, and project materials based on the surrounding environment. The PowerPoint materials were designed using illustrations, colors, and contextual examples to render them more engaging and comprehensible for students.
- **Format selection:** The teaching module format was organized based on the components of the Merdeka Curriculum, which included module identity, learning objectives, learning activities, assessment, student worksheets, reflection, and project appendices. The PjBL syntax was also integrated into each learning activity, consisting of: determining the fundamental question, designing the project plan, creating a schedule, monitoring project progress, testing results, and evaluating the experience.
- **Initial product design:** The initial products generated at this stage comprised the IPAS Project teaching module, student worksheets, PowerPoint instructional materials, validation instruments, practicality questionnaires, observation instruments, and learning achievement tests.

c) Develop stage

The develop stage was conducted through expert validation, product revision, limited trials, and field trials.

i. Expert validation

- **Material expert validation:** Material expert validation was performed to assess content appropriateness, conceptual accuracy, integration of PjBL, and alignment with the deep learning approach. The expert conducting the material validation was Dr. Fransiska Harahap, M.Si., Head of the Department of Science Education, FMIPAK, Universitas Negeri Manado (UNIMA). The results of the material expert validation are presented in Table 4.

Table 4: Summary of material expert validation results

Aspect assessed	Obtained score	Maximum score	Percentage (%)	Category
Content appropriateness	47	48	97.92	Highly valid
PjBL integration	24	24	100.00	Highly valid
Deep learning alignment	23	24	95.83	Highly valid
Total	94	96	97.92	Highly valid

The validator provided several suggestions, including that the PjBL syntax should be explicitly written in the student worksheets, and that the physical products resulting from PjBL should be highlighted as the learning outcomes.

- **Media expert validation:** Media expert validation was conducted to assess aspects of appearance, readability, design, and practicality of the instructional media. The expert conducting the media validation was Prof. Dr. Herry Sumampouw, M.Si., Professor in the Department of Biology, FMIPAK, UNIMA. The results of the media expert validation are presented in Table 5.

Table 5: Summary of media expert validation results

Aspect assessed	Obtained score	Maximum score	Percentage (%)	Category
Display and design	35	40	87.50	Valid
Readability and language	28	32	87.50	Valid
Usability and practicality	24	28	85.71	Valid
Total	87	100	87.00	Valid

The validator offered several suggestions, including the use of contemporary examples for observational materials and strengthening the formulation of guiding questions and learning objectives.

ii. Product revision: Based on the feedback from the validators, several revisions were undertaken, namely: the explicit addition of PjBL syntax to each student worksheet in accordance with the project learning stages; clarification of the physical products to be generated during learning; updating several observational materials and learning examples with contexts closer to students' everyday lives; and revision of the guiding questions and learning objectives.

iii. **Limited trial:** The limited trial was conducted with nine students to determine the level of practicality of the module prior to its implementation on a broader scale. The results of the student practicality questionnaire in the limited trial are summarized in Table 6.

Table 6: Results of student practicality questionnaire in the limited trial (N=9)

Aspect assessed	Obtained score	Maximum score	Percentage (%)	Category
Ease of understanding	158	180	87.78	Very practical
Clarity of instructions	82	90	91.11	Very practical
Engagement of project activities	76	90	84.44	Practical
Usefulness for learning	85	90	94.44	Very Practical
Mean	401	450	89.06	Very practical

Students stated that the module was easy to understand, the project activities were engaging, the experiments were easy to perform, and learning was more enjoyable compared to previous instruction.

iv. **Field trial:** The field trial was conducted with 20 tenth-grade students of SMK Negeri 1 Modoinding.

- **Teacher practicality:** The results of the teacher questionnaire indicated that the module received a "very practical" assessment, with a mean percentage of 91.25%. The teacher stated that the module was easy to use, facilitated the implementation of PjBL, supported deep learning, and was appropriate to school conditions.
- **Student practicality:** The results of the student practicality questionnaire in the field trial are presented in Table 7.

Table 7: Develop stage was conducted through expert validation, product revision, limited trials, and field

Aspect assessed	Obtained score	Maximum score	Percentage (%)	Category
Ease of understanding	345	400	86.25	Practical
Clarity of instructions	182	200	91.00	Very practical
Engagement of project activities	178	200	89.00	Practical
Usefulness for learning	188	200	94.00	Very practical
Collaboration and active involvement	171	200	85.50	Practical
Mean	1064	1200	89.14	Very practical

Students felt more active in learning because they were directly involved in experiments, collaborated in groups, and could connect the material to their everyday lives.

- **Learning observation results:** Learning observations demonstrated that the PjBL syntax could be implemented well. Students appeared actively engaged in discussions, performed experiments, and presented their project results. Aspects of deep learning were also observed through active student engagement, the ability to connect the material to real-life contexts, and an increase in student curiosity during the learning process.

d. Disseminate stage

The dissemination stage was conducted in a limited manner through the use of the module in the research class, discussions with the IPAS Project teacher, and presentation of the development results to the school. The developed module is expected to serve as an alternative instructional material for the IPAS Project subject based on PjBL and deep learning at SMK Negeri 1 Modoinding.

C. Effectiveness of the Teaching Module

The effectiveness of the module was measured through student post-test results after instruction using the teaching module. Based on the post-test results, 17 students achieved learning mastery, while 3 students had not yet reached mastery, with the minimum mastery criterion (KKM) set at 70. The percentage of learning mastery was calculated using the formula: Mastery = (17/20) × 100% = 85%. These results are summarized in Table 8.

Table 8: Summary of student learning mastery (N=20)

Description	Number of students	Percentage (%)	Category
Students achieving mastery (≥ KKM 70)	17	85	Very effective
Students not achieving mastery (< KKM 70)	3	15	-
Total	20	100	-

The results indicated that the percentage of student learning mastery reached 85%, falling into the "very effective" category. Accordingly, the developed teaching module was declared effective for use in the IPAS Project instruction on the topic of Substances and Their Changes. Beyond the improvement in learning outcomes, the effectiveness of the module was also evidenced by increased student engagement, collaborative abilities, critical thinking skills, and conceptual understanding through project activities and experiments.

Discussion

A. Validity of the teaching module

The results of expert validation indicated that the developed teaching module possessed a very high level of validity, as demonstrated by material expert validation achieving a percentage of 97.92% (highly valid) and media expert validation achieving 87.00% (valid). These findings demonstrate that the content, instructional design, integration of PjBL syntax, and deep learning approach were aligned with the learning needs of the IPAS Project subject at the vocational high school level. The main strength of the module lay in the integration of scientific concepts with authentic project activities, such that students not only studied theory but also conducted simple experiments relevant to everyday life. This condition is consistent with the assertion that PjBL is capable of creating meaningful and contextual learning. The integration of deep learning was also evident through the application of conscious, meaningful, and enjoyable elements in each learning activity, with students being encouraged to observe, analyze, and reflect actively on their learning experiences. Nevertheless, the validators still provided several notes for improvement, particularly in strengthening the PjBL syntax and its tangible products, as well as using more current learning examples, indicating that the developed product still required refinement to further enhance its academic quality.(Khumairoh *et al*., 2025; Patibang *et al*., 2025b; Permata Nugrahani *et al*., 2026; Sondakh *et al*., 2021) [16, 36, 37, 41].

B. Practicality of the teaching module

The practicality test results showed that the teaching module was very practical for use by both teachers and students. The teacher assessed the module with a mean practicality percentage of 91.25% (very practical), stating that the module was easy to use, systematic, and helpful in implementing project-based learning, while the use of simple tools and materials for experimental activities further facilitated the teacher's classroom implementation. Meanwhile, students in the field trial provided a mean practicality percentage of 89.14% (very practical), indicating that learning became more engaging because they were directly involved in project activities; activities such as filtration, salt crystallization, and making natural indicators enabled students to understand the concept of changes in substances more easily than simply reading textbooks. This practicality indicates that the developed module was appropriate to the characteristics of vocational high school students, who tend to prefer practical and contextual learning. Furthermore, the clear structure of the module assisted students in learning independently, and the student worksheets integrated into the learning process facilitated students in making observations, recording data, and drawing conclusions.(Juliana *et al*., 2024; Onsu *et al*., n.d.; Raras Setyo Retno *et al*., 2025) [15, 38].

C. Effectiveness of the teaching module

The research results demonstrated that using the teaching module significantly improved student learning outcomes. Prior to using the module, the majority of student pre-test scores remained below the minimum mastery criterion. After instruction using the module, 17 out of 20 students achieved learning mastery, with a mastery percentage of 85%, which falls into the "very effective" category. This improvement in learning outcomes was influenced by several factors. First, project-based learning provided direct learning experiences for students, who did not merely receive information but conducted experiments and directly observed real phenomena. Second, the deep learning approach helped students understand the relationships between concepts and everyday life, rendering learning more meaningful and comprehensible. Third, collaborative project activities encouraged students to be more active in discussions and idea exchange, a learning situation that helped students build conceptual understanding collectively. These findings support the assertion of Rahmandani, Hamzah, Handayani, and Kurniawan (2025) that deep learning can enhance students' conceptual understanding, critical thinking, and learning engagement. Although the mastery rate was already high, three students still did not reach the minimum mastery criterion, which may be attributable to differences in prior knowledge, suboptimal learning engagement, and limited ability to understand abstract concepts. Overall, however, the research results indicate that the teaching module based on Project-Based Learning with a deep learning approach is effective for use in the IPAS Project instruction on the topic of Substances and Their Changes at SMK Negeri 1 Modoinding.

Conclusion

Based on the research and development of a Project-Based Learning (PjBL) teaching module integrated with a deep learning approach for the IPAS Project subject on Substances and Their Changes at SMK Negeri 1 Modoinding, three main conclusions are drawn. First, regarding validity, the module was declared highly valid and feasible, with material expert validation achieving 97.92% (highly valid) and media expert validation achieving 87.00% (valid). Second, concerning practicality, the module fell into the very practical category, as evidenced by teacher assessments and student questionnaire results of 89.06% in the limited trial and 89.14% in the field trial. Third, in terms of effectiveness, the module proved effective in improving student learning outcomes, with 17 out of 20 students (85%) achieving learning mastery. Accordingly, the developed PjBL-based teaching module incorporating the deep learning approach is considered a feasible alternative instructional resource for the IPAS Project subject at the vocational high school level.

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