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Enhancing Higher-Order Thinking Skills through Case-Project-Based Learning in Algorithms and Data Structures Courses

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Abstract: This research highlights the importance of developing higher-order thinking skills in the context of education in Indonesia, particularly to prepare students for the challenges of the 21st century. Issues in algorithm and data structure learning at higher education institutions, such as using conventional learning models and the lack of practical experience, create a gap between theory and practice that negatively impacts students' ability to solve complex problems. To address this issue, this study aims to develop a new learning model called case project-based learning using the Borg and Gall development method simplified by Puslitjaknov. Data were collected using a questionnaire to assess the validity and practicality of the case-project-based learning model. Validation results by experts demonstrated that this model is highly valid from the various aspects tested, where the average V-Aiken validation model book, syntax, and guidebook obtained an average of 0.86, and the teaching materials aspect obtained an average V-Aiken of 0.87. The practicality test of the case-project-based learning model applied in algorithm and data structure learning involving lecturers and students provides a clear overview of the effectiveness and practicality of using this model. This model is suitable for implementation in higher education to bridge the gap between theory and practice, prepare students to face real-world challenges and enhance students' motivation and problem-solving skills.

Keywords: algorithms and data structures, case-project-based learning, development, practicality, validation.

透過演算法和資料結構課程中的案例項目學習增強高階思維能力

摘要：這項研究強調了在印尼教育背景下培養高階思維技能的重要性，特別是讓學生為21世紀的挑戰做好準備。高等教育機構在演算法和資料結構學習中存在的問題，例如使用傳統的學習模式和缺乏實踐經驗，造成理論與實踐之間的差距，對學生解決複雜問題的能力產生負面影響。為了解決這個問題，本研究旨在使用普斯利賈克諾夫簡化的博格和癮開發方法來開發一種新的學習模型，稱為基於案例專案的學習。使用問卷收集資料來評估基於案例項目的學習模型的有效性和實用性。專家驗證結果表明，該模型從測試的各個方面都具有較高的

有效性，其中V艾肯驗證模型書籍、語法和指南的平均V艾肯獲得平均0.86，教材方面獲得平均V艾肯0.87。透過對基於案例項目的學習模式在教師和學生的演算法和資料結構學習中的實用性測試，清楚地了解了該模式的有效性和實用性。此模式適合在高等教育中實施，以彌合理論與實踐之間的差距，幫助學生做好面對現實世界挑戰的準備，並增強學生的動力和解決問題的能力。

关键词：演算法和資料結構，基於案例專案的學習、開發、實用性、驗證。

1. Introduction

In the context of education in Indonesia, developing higher-order thinking skills (HOTS) is crucial for students to excel academically and prepare them for the challenges of the 21st century [1]. HOTS encompass critical thinking, creativity, communication skills, collaboration, and self-confidence, all essential competencies for students to thrive in a rapidly changing world. Higher-order Thinking Skills (HOTS) involve expansive thinking to identify new challenges. HOTS require individuals to remember or comprehend information and apply, analyze, evaluate, and create new information [2].

Minister of Education and Culture Muhadjir Effendy's statement on education assessment focusing on HOTS provides insight into the government's initiatives aimed at enhancing the quality of education. Contemporary education faces increasingly complex demands, where students are expected not only to master academic concepts but also to develop critical, analytical, and creative thinking skills. These skills are known as HOTS and are essential for students to cope with real-world challenges [3, 4].

Teachers must frame HOTS as a progression from lower-order thinking activities to higher-order thinking activities, considering the diverse backgrounds of students. HOTS encompass analysis, reflection, reasoning, application of concepts, and creation, all of which are integral to students' success in addressing real-world problems. This aligns with the objectives of related courses such as Algorithms and Data Structures. Studying algorithms and data structures aids in developing efficient solutions for challenges and provides educators with a foundation for structured, systematic, and logical thinking when solving real-world issues [5, 6].

In this course, students are taught to design problem-solving solutions by creating algorithms and implementing them into computer programs using appropriate data structures. According to [7], algorithms and data structures are fundamental courses in computer science and software engineering programs taught at many universities worldwide. The characteristics of this course are abstract and complex, making it challenging for many students to learn [8].

Based on previous research, several persistent issues have been identified in the teaching and learning algorithms and data structures. These challenges include the suboptimal effectiveness of traditional teaching methods that are predominantly used [9]. Additionally, students often lack practical experience during coursework [10]. There is a noticeable gap between students' theoretical understanding and their ability to apply this knowledge in practice, as well as deficiencies in both their soft and hard skills [11]. Consequently, these issues lead to lower average grades and difficulties completing final projects or theses [12-14].

Additionally, most first-year programming students lack the motivation to learn programming [15]. The inability of graduates to solve complex problems and to apply fundamental knowledge to practical situations adversely affects their chances of success [16]. Challenges in learning algorithms, such as problem decomposition, can hinder the development of critical and high-order thinking skills among learners [17]. The primary cause of difficulty in learning programming is the lack of generic problem-solving skills, which hinders the development of critical and high-order thinking skills in students [18].

One of the ways educators can enhance critical thinking skills and HOTS is by using pedagogical approaches and instructional models. These approaches and models have a significant impact on the development of critical thinking and HOTS in students [19, 20]. However, conventional methods in the educational context often face challenges in optimizing HOTS development [21-23].

Therefore, a learning model capable of enhancing HOTS is required, such as the project-based learning (PjBL) model. The PBL model significantly improves critical thinking skills and HOTS of students. This model emphasizes problem-solving, higher-order thinking processes, and creativity [24-28]. Other studies have consistently affirmed that project-based learning enhances students' problem-solving abilities, HOTS, and creativity [29, 30]. These findings indicate that consistent implementation of PBL has a significant positive impact on enhancing students' critical thinking skills.

Several studies have revealed that this model has deficiencies or weaknesses. Aldabbus [31] identified several shortcomings of the PjBL model. These include students focusing solely on completing the project without learning from the project process, a lack of understanding of the material, and insufficient skills for collaborative work. In the PBL learning process, students face difficulties in collaborative work [32], issues with unequal contributions from some students [33], a lack of communication skills within groups [34], challenges for educators in assessing each team member's contribution [35], gaps between theoretical understanding and practical application [36] and difficulties in defining ideas and fundamental questions [37]. Therefore, innovations in the learning approach are needed to address the existing weaknesses of the project-based learning model. Innovations in teaching are crucial for developing effective learning models [38, 39]. This is essential to achieve the goals of 21st-century learning more effectively [40].

To enhance HOTS and address the weaknesses in the project-based learning model, a new model called case-project-based learning was developed. In this model, learners identify and transform cases into learning projects. Each learner has the opportunity to understand the material meaningfully and collaborate, considering different learning styles.

The case study model can help address several weaknesses of the project-based learning model. In this approach, learners engage with complex and in-depth real-life situations, which enhance their understanding of the material [41]. It also helps learners develop critical analysis and problem-solving skills [42]. This model fosters collaborative learning through group discussions and considering diverse perspectives [43]. Moreover, the case study approach bridges the gap between theory and practice, thus enhancing the overall learning experience [44-47].

This model focuses on university students and is well-suited for higher education to encourage students to actively construct and apply their knowledge in the future while developing skills to tackle educational challenges. The model uses case studies to enhance problem-solving, critical, and creative thinking skills and promote cooperation and independence.

The case-project-based learning model is an appropriate instructional concept for learners to enhance critical thinking skills and improve HOTS. This model supports 21st-century learning by requiring students to use critical thinking abilities to solve problems and to use technology as a learning aid.

Developing the case-project-based learning model is essential for addressing the deficiencies in critical thinking skills among learners and demonstrating a positive impact on students in terms of academic achievement and thinking skills. Case-project-based learning enhances knowledge and critical thinking skills and supports the development of problem-solving, teamwork, and communication skills. This learning model can improve critical thinking, creativity, communication, and collaboration. Therefore, it is essential to examine the development and validity of a case-project-based learning model.

2. Methodology

This research constitutes Research and Development (R&D) activities. The development of the case-project-based learning model used the Borg and Gall development method, which was simplified by [48]. The stages include product analysis, initial product development, expert validation and revision, and small- and large-scale field testing. However, large-scale field testing was not conducted in this research. To assess the practicality of the developed model, a small-scale field test was conducted. The outcome of this study is a case-project-based learning model designed to enhance critical thinking skills and improve HOTS.

The sample for this study consisted of 15 students from the Faculty of Teacher Training and Education, Information Technology Education program at the University of Kampung, who were enrolled in the Algorithm and Data Structure course in the first semester of the academic year 2023/2024. Data were collected using a questionnaire to assess the validity of the case-project-based learning model. This questionnaire was distributed to instructional model experts, subject matter experts, language experts, and students.

The validity instrument comprises several aspects: (1) a case-project-based learning model book; (2) model syntax; (3) teaching materials; and (4) guidelines. The following is the validation grid of the case-project-based learning model, which was evaluated by experts. Below are the validation instrument grids.

Table 1 Validation grid of model book aspect (The authors)

Aspects of validation	Indicators
Model book	Model rationality
	Supporting theory
	Model syntax
	Social system
	Reaction principles

Table 2 Validation grid of model syntax aspect (The authors)

Aspects of validation	Indicators
Model syntax	Determining cases and group formation
	Understanding teaching material concepts
	Brainstorming
	Findings presentation
	Scheduling
	Project design
	Project task execution
	Project report presentation
	Evaluation

Table 3 Validation aspect grid for teaching materials (The authors)

Aspects of validation	Indicators
Teaching materials	Material organization
	Writing format
	Language usage
	Content aspects
	Evaluation system

Table 4 Validation aspect grid of the guidebook (The authors)

Aspects of Validation	Indicators
Lecturer's guide	Writing format
	Language
	Introduction
	Content presentation
	Evaluation system
Student's guide	Writing format
	Language
	Introduction
	Content presentation
	Evaluation system

The validity percentage was obtained using the V-Aiken formula, as elucidated by [49]. Table 5 presents the interpretation of the validity of the developed model based on the validity criteria.

$$V = \frac{\sum S}{[n(c-1)]} \quad (1)$$

Table 5 Interpretation of the V-Aiken results (The authors)

Score range (V)	Validity level
V ≤ 0.4	Less valid
0.4-0.8	Quite valid
V ≥ 0.8	Very valid

The evaluation of practicality involves analyzing feedback from students on the implementation of the model case-project-based learning. The evaluation involves calculating the final score (NA) based on the obtained score (S) and the maximum score (M). The percentage of practicality was obtained using the formula proposed by [50].

$$NA = \frac{S}{M} \; x \; 100\% \quad (2)$$

To determine the practicality level of the case-project-based learning model, the criteria are outlined in the following table:

Table 6 Practicality category (The authors)

Scale	Score
86–100	Very practical
76–85	Practical
60–75	Fairly practical
55–59	Less practical
0–54	Very less practical

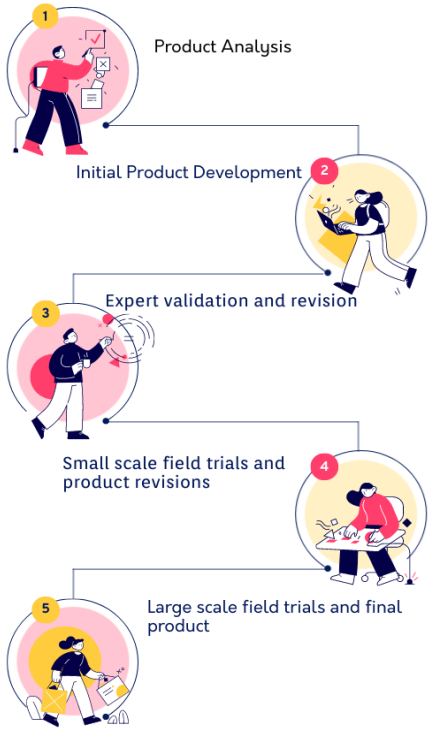

Fig. 1 Borg and Gall's instructional design model [48]

3. Development and Research Results

3.1. Product Analysis

In the analysis phase, four preliminary investigation activities were conducted regarding: the instructional model employed the learning objectives and content, student characteristics, and learning resources. The results indicate that classroom instruction is still predominantly characterized by the exposition of concepts through conventional lectures (teacher-centered learning), thereby limiting student engagement to passive observation. Instructional media in the form of slide presentations and examples provided by instructors are deemed less appealing to students, resulting in suboptimal understanding and minimal practical experiences throughout the course. Additionally, deficiencies exist in facilities and infrastructure, such as inadequate laboratory equipment, and constraints on face-to-face learning time in classroom and laboratory settings.

The student component is also a significant component of the learning process. The majority of students do not originate from vocational high schools (SMK), and a significant proportion is newly introduced to the field of programming. This creates a disparity between students' competencies and skills in applying theory and practice. The proposed solution is the implementation of the case-project-based learning model.

3.2. Initial Product Development

This research yields a novel instructional model, namely, the case-project-based learning model, which combines two primary approaches: the case study

model and PjBL. The PjBL model emphasizes contextual learning experiences that enable students to acquire knowledge through various means, such as asking inquiries (inquiry) and solving problems, thus enhancing critical thinking skills and HOTS. Meanwhile, case study learning is initiated to bridge the gap between theory and practice. In the case study model, learners can delve into complex real-life situations and acquire a deeper understanding of the subject. This helps develop analytical skills and problem-solving abilities, which are crucial aspects of critical thinking.

The design process in the case-project-based learning model comprises a model book with implementation steps (syntax), a textbook on algorithm and data structure, and guides for both instructors and students. Below is a description of the cover of the product for the case-project-based learning model.

Fig. 2 Case-project-based learning model development product cover (The authors)

3.2.1. Case-Project-Based Learning Model

This paper introduces the concept of case-project-based learning, a pedagogical approach developed to enhance students' critical thinking and HOTS. The development of the case-project-based learning model is rooted in the case-study method proposed by [51] and [52], along with the PjBL stages articulated by [53]. The model of case-project-based learning is synthesized through a sequence of steps: (1) Establishing the case and forming groups, (2) Understanding the instructional material, (3) Brainstorming, (4) Presenting findings, (5) Scheduling, (6) Designing the project, (7) Executing the project tasks, (8) Presenting the project report, and (9) Evaluation.

3.2.2. Teaching Materials

The teaching materials for the course "Algorithms and Data Structures" is organized into five chapters and are designed to be covered over 14 sessions within a single semester. This book comprehensively addresses algorithmic concepts from fundamental to advanced levels, and it is accompanied by practical case examples. In addition, it includes exercises that test understanding and honing skills in algorithm design and the application of data structures.

3.2.3. Guidebooks

The instructor and student guidebooks were integral to this research. These guidebooks are designed to assist instructors and students in implementing the case-project-based learning model in the classroom. Both guidebooks include detailed schematics of the developed model. Additionally, they contain a syllabus, evaluation system, and a breakdown of activities for each developed syntax tailored for both instructors and students. The instructor's guidebook also includes exercises, assessment rubrics, evaluation criteria, and instruments for assessing 4C skills (creativity, critical thinking, communication, and collaboration).

3.3. Expert Validation and Revision

The development of the case-project-based learning model was validated by six experts, who evaluated various aspects, including (1) the model book, (2) the model's syntax, (3) the textbook, and (4) the instructor and student guides. For the model book aspect, the evaluated indicators included: model rationale, supporting theory, model syntax, social system, reaction principles, support system, and instructional and accompanying impacts. The validation results for the model book aspect are presented in Table 7.

Table 7 The results of validating the model book for case-project based learning (The authors)

Indicators	Average V-Aiken score	Explanation
Rational model	0.86	Very valid
Supporting theory	0.87	Very valid
Model syntax	0.87	Very valid
Social systems	0.85	Very valid
Reaction principles	0.87	Very valid
Support system	0.88	Very valid
Instructional impact and accompaniment	0.87	Very valid
Average V-Aiken score	0.86	Very valid

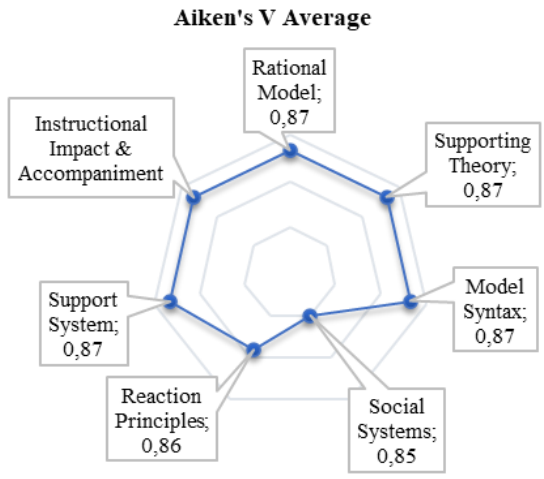

Fig. 3 Validation of case-project-based learning model book aspects (The authors)

Based on the information provided from the above analysis, the validation results for the aspects of the case-project-based learning model achieved an average V-Aiken index score of ≥0.8. This indicates that all the indicators in the book model's validation aspect are highly valid. This indicates that the book is suitable for use according to expert assessment.

Furthermore, the aspects validated in this study are crucial in the development of the case-project-based learning model. The syntax in the instructional model represents a descriptive stage that elucidates how the process begins or what occurs after each learning activity.

In the syntax aspect, there are nine indicators to be assessed by experts: (1) Case setting and group formation, (2) Understanding teaching materials concepts, (3) Brainstorming, (4) Presentation of findings, (5) Scheduling, (6) Project design, (7) Project task implementation, (8) Project report presentation, and (9) Evaluation. The validation results for the syntax aspect are displayed in Table 7.

Table 8 Validation of the syntax aspect of the model (The authors)

Indicators	Average V-Aiken score	Explanation
Definition of cases and forming groups	0.87	Very valid
Understanding the concept of teaching materials	0.86	Very valid
Brainstorming	0.88	Very valid
Findings presentation	0.87	Very valid
Arranging a schedule	0.86	Very valid
Design project	0.87	Very valid
Project tasks	0.86	Very valid
Project report presentation	0.87	Very valid
Evaluation	0.85	Very valid
Average V-Aiken score	0.86	Very valid

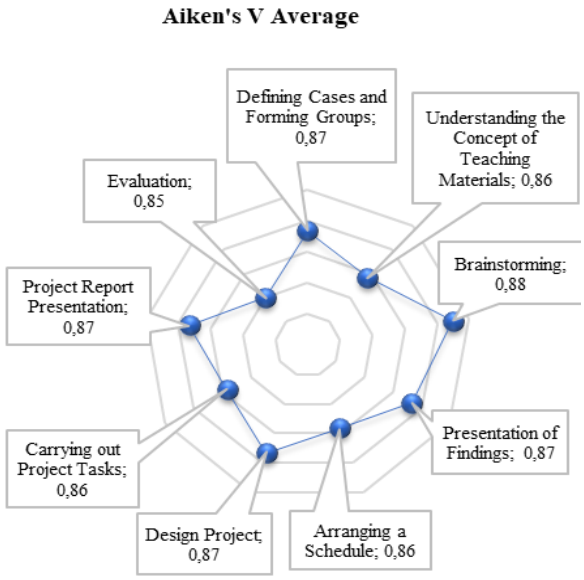

Fig. 4 Validation of the syntax aspect of the model (The authors)

Based on the analysis focusing on the validation of the model syntax, an average Aiken V score of ≥ 0.8 was obtained for each indicator. This average Aiken's V score indicates that each indicator in the model syntax, validated by experts, falls into a highly valid category. Thus, the developed model can be considered to have excellent validity in terms of syntax validation.

The next aspect validated by experts is the instructional material. The validation of instructional materials by experts ensures the quality and effectiveness of teaching materials during the learning process. Experts will examine the suitability of teaching materials to the curriculum, the accuracy and depth of the content, and the readability and comprehensibility of the content. Validators also assess the relevance of the material to the learners' needs and context, as well as the coherence and consistency of the material. Additionally, they ensure that the teaching materials provide effective evaluation tools and exercises, while also considering feedback for improvement. This validation ensures that teaching materials assist learners in achieving learning objectives and enhance the quality of education.

Validation of the instructional material aspect by experts encompasses several indicators to ensure its quality and effectiveness, including (1) Material organization, (2) Writing format, (3) Language usage, (4) Content aspect, and (5) Evaluation System. The following gives an overview of the validation results for the instructional material aspect.

Table 9 Validation of the instructional material aspect (The authors)

Indicators	Average V-Aiken score	Explanation
Material organization	0.87	Very valid
Writing format	0.88	Very valid
Language use	0.87	Very valid
Content aspect	0.88	Very valid
Evaluation system	0.86	Very valid
Average V-Aiken score	0.87	Very valid

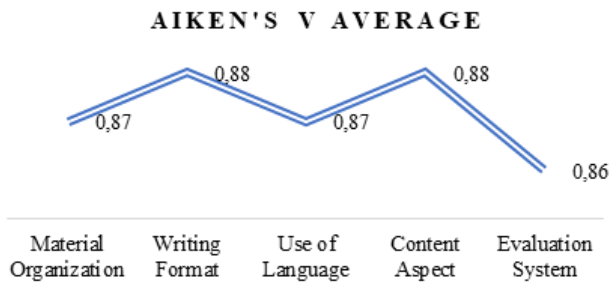

Fig. 5 Validation of the instructional material aspect (The authors)

Based on the analysis of the instructional material aspect's validity, all validated indicators demonstrated exceptionally high validity. The "Material organization" indicator had an average score of 0.87, which was deemed "Highly valid." Similarly, both the "Writing format" and "Content aspect" indicators obtained average scores of 0.88, indicating their classification as "Highly valid" as well. Furthermore, the "Language usage" indicator with an average score of 0.87 and the "Evaluation system" with an average score of 0.86 also fell into the "Highly valid" category. Therefore, it can be concluded that all the assessed indicators exhibit an extremely high level of validity, reflecting their remarkable reliability and quality across all the measured aspects. These findings demonstrate that the instructional materials developed for algorithms and data structure courses possess a remarkably high level of validity and are well-suited for use.

The final aspect validated by the six experts is the guidebook. Validating the guidebook aspect involves evaluating and ensuring that all essential elements in the guidebook meet established standards and align with the intended purpose of use.

In this guidebook validation instrument, there are five indicators to be assessed: (1) writing style, (2) Language, (3) Content presentation, and (4) Evaluation system. Table 9 presents the results of the guidebook aspect validation.

Table 10 Validation of the guidebook aspect (The authors)

Indicators	**Aiken's average vs. lecturer's guide**	**Aiken' s average vs. student guide**	**Explanation**
Writing format	0.87	0.86	Very valid
Language	0.88	0.86	Very valid
Introduction	0.86	0.84	Very valid
Content presentation	0.84	0.85	Very valid
Evaluation system	0.87	0.88	Very valid
Average V-Aiken score	0.86	0.86	Very valid

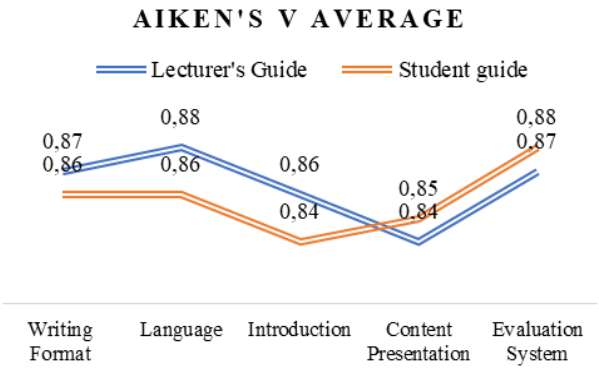

Fig. 6 Validation of the guidebook aspects (The authors)

Based on the validation data of guidebook aspects, all indicators in both the faculty and student guides were deemed highly valid with Aiken's values ≥0.8. The average writing format was 0.87 (faculty) and 0.86 (students), language 0.88 (faculty) and 0.86 (students), Introduction 0.86 (faculty) and 0.84 (students), content presentation 0.84 (faculty) and 0.85 (students), and evaluation system 0.87 (faculty) and 0.88 (students). These results indicate that each aspect of the guidebook was highly validated by experts, and it is concluded that the guidebook product of the case project-based learning model is suitable for application in subsequent stages.

The validation results indicate that all components of the model fall within the category of high validity in terms of content and construct, as assessed from various aspects of model books, model syntax, teaching books, and guidebooks.

The outcomes of the validity tests unequivocally affirm the robustness of the case-project-based learning model, which accords it a commendable level of validity. This underscores the seamless integration of the proposed model with established learning model theories. In accordance with the criteria delineated by [54] the proposed model not only meets but surpasses the benchmarks of effective learning models. These criteria encompass focus, syntax, response principles, social systems, support systems, implementation strategies, and their consequences.

Furthermore, the case-project-based learning model demonstrates a harmonious alignment with these criteria, demonstrating its efficacy in terms of fostering holistic learning experiences. By meticulously adhering to established principles and methodologies, the model serves as a beacon of innovation and excellence in pedagogy. Comprehensive approach ensures that learners are equipped with the requisite skills and competencies to thrive in today's dynamic educational landscape.

In essence, the case-project-based learning model demonstrates the transformative potential of innovative pedagogical approaches. This validation not only affirms its efficacy but also underscores its pivotal role in shaping the future of education, facilitating meaningful learning outcomes, and nurturing learners'

intellectual growth.

Additionally, the case-project-based learning model demonstrated high validity in enhancing critical thinking skills and HOTS. The validity of this model encompasses activities that support concept comprehension in each syntax. Therefore, the validity of the case-project-based learning model includes, among others: meeting the criteria for effective learning models, the ability to enhance critical thinking skills and HOTS, and being oriented toward case-study- and project-based learning models. The syntax within the case-study and project-based learning models includes indicators of concept comprehension and serves as a solution to bridge the gap between theory and practice.

3.4. Small-Scale Field Trials and Product Revisions

At this stage, the product, which has been developed through initial processes and expert validation, followed by revisions, is tested on a small scale. The results of this field trial will then be evaluated, and further revisions will be made as necessary to ensure the quality and effectiveness of the product. A trial was conducted to assess the practicality of the proposed model. This stage involves analyzing student feedback regarding the implementation of the case-project-based learning model.

Table 11 Practicality test of student responses (The authors)

Validation aspect	Percentage, %	Category
Practicality of the learning model	82.22	Practical
Practicality of the teaching module	85.78	Practical
Practicality of the lecturer's guidebook	85.33	Practical
Average percentage (%)	84.44	Practical

From the results of the practicality test of the case-project-based learning model in teaching algorithms and data structures on a small scale involving students, it can be concluded that the assessment of the practicality aspects of the learning model, teaching module, and guidebook shows an average percentage of 84.44%. These results indicate that the case-project-based learning model is highly practical for use in teaching algorithms and data structures.

In the conducted research, the practicality test of the case-project-based learning model was applied to the teaching of algorithms and data structures, involving students on a small scale. The results of this practicality test provide a clear picture of the effectiveness and ease of use of the proposed case project-based learning model.

From the students' perspective, the assessment results show an average score of 84.44%. This indicates that students found the case-project-based learning model very practical and effective in helping them understand the material on algorithms and data structures. Students appreciated the interactive and project-based learning approach because it allowed them to apply concepts learned in real-world contexts. Furthermore, students found the teaching modules and guides very helpful in the learning process because they presented the materials clearly and systematically.

4. Conclusion

Developing higher-order thinking skills (HOTS) is paramount in Indonesian education to equip students for the challenges of the 21st century. HOTS encompass critical thinking, analytical, creative, and collaborative skills that are essential for both academic success and real-world application. Challenges in the teaching of Algorithms and Data Structures at the tertiary level, such as the utilization of conventional learning models, lack of practical experience, and the gap between theory and practice, have a detrimental impact on students' ability to tackle complex problems. To address these issues, developing learning models that enable students to enhance their HOTS and problem-solving capacities is imperative.

This study introduces a novel study approach called "Case-Project-Based Learning" designed to enhance HOTS. Integrating elements from case study and project-based learning, this model allows students to dive deeply into real-life scenarios and tackle actual projects.

The study contributes significantly to educational practice by applying the case-project-based learning model to the "Algorithm and Data Structure" course. The primary innovation lies in the fusion of case study methodology with project-based learning, which fosters critical thinking, collaborative problem-solving, and analytical skills among students. The validation results demonstrated high validity across various dimensions, with an average V-Aiken validation score of 0.86 for the model's textbooks, syntax, and instructional guides and 0.87 for teaching materials, affirming its suitability for adoption in higher education. From the results of the practicality test of the case-project-based learning model in teaching algorithms and data structures on a small scale, it was found that the case-project-based learning model is practical in terms of the practicality aspect of the learning model, teaching modules, and guidebooks, with an average percentage of 84.44%. This approach effectively bridges the gap between theoretical concepts and practical applications, equipping students to confront real-life challenges while enhancing their motivation and problem-solving abilities.

This research enriches the academic literature by presenting empirical evidence that the case-project-based learning model is both practical and effective in developing HOTS, particularly in courses such as "Algorithms and Data Structure."

Recommendations for future studies include adopting the case-project-based learning model across

various subjects and educational contexts, as well as developing more accurate assessment tools to measure its effectiveness in enhancing HOTS. Further research could explore the long-term impacts of this approach on students' professional careers in computer science and their readiness for the workforce.

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