Empowering Minds in Discord-Integrated Case-Driven Flipped Classroom Model for Advancing Computational Thinking and Problem-Solving Skills

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***Abstract*—The primary objective of this study is to explore and implement an innovative learning model that integrates a Case-driven Flipped Classroom with the online communication platform Discord, aimed at enhancing students' computational thinking and problem-solving skills in higher education. This research addresses the gap in utilizing online communication technology in case-based learning to improve student competencies. The research methodology employs a systematic and detailed approach, including needs analysis, curriculum analysis, and student characteristics, to develop and validate the model. The study participants consist of 126 students enrolled in the Algorithms and Programming course in the Informatics Engineering Education program. A sample of 65 students was selected using a proportional random sampling technique. Researchers collected data through learning outcome measurements, classroom observations, questionnaires, and student feedback. They measured learning outcomes using the same pre-test and post-test instrument administered in the 12th week. They assessed student engagement and understanding through classroom observations and student feedback, indicating a qualitative approach in this research. The main findings of this study demonstrate that the learning model significantly enhances students' understanding of computational concepts and problem-solving abilities. Additionally, this research provides a strong foundation for further implementing similar models in educational settings, integrating online communication technology with relevant instructional approaches, thereby contributing to the literature on learning innovation in higher education.**

***Keywords*—flipped classroom, case, computational thinking, Discord, problem-solving**

I. Introduction

Along with the development of the current industrial revolution 4.0, the world is moving towards a socio-technological-digital era, where everything becomes unlimited with unlimited computing and data, as influenced by the development of the internet and digital technology [1, 2]. Higher and vocational education should actively anticipate the swift technical advancements, as exemplified in the Industrial Revolution 4.0 era. It has changed the work process, curriculum, and educational methods, which are expected to align with the highly competitive industrial world and the development of technology and information [3, 4].

In order to align with current industrial developments, higher education and vocational training programs expect graduates to possess thinking skills, including computational thinking and problem-solving. They consider these talents among the most critical thinking skills required in the 21st century [5], and these are life skills that must be instilled through education [6].

Tests administered by the Programme for International Student Assessment (PISA) under the Organization for Economic Cooperation and Development (OECD) have revealed a lack of problem-solving skills in Indonesia; 18% of students attained at least Level 2 proficiency in mathematics, significantly less than on average across OECD countries (OECD average: 69%). According to the 2022 PISA results, in Indonesia, 15-year-olds score 383 points in science, below the OECD average of 485 [7]. The 2022 average math, reading, and science results declined compared to 2018. This will affect students' computational thinking skills [8], related to these two skills [9].

The continued implementation of a conventional, teacher-centred education system has led to a lack of skills among students in Indonesia. This method has not effectively improved skills and is less relevant to 21st-century learning needs [10]. In response to this issue, the Ministry of Education recommends using case-based and project-based learning methods in educational institutions. However, these methods have not optimally enhanced students' computational thinking and problem-solving skills.

Researchers propose the Case-driven Flipped Classroom Model as an innovative educational solution to address this gap. This model aims to enhance students' Computational Thinking (CT) and Problem-Solving Skills (PSS). It is an innovative approach that combines the flipped classroom method with case-based learning and technology integration. This model provides students a more engaging and meaningful learning experience by incorporating case studies and leveraging digital tools. This approach aligns with 21st-century educational standards, integrating digital learning and technology to create a modern, effective learning environment [11, 12].

The flipped classroom embodies the fundamental principles of new teaching methods. Mobile technologies, such as cell phones and tablets, can directly impact learning processes and outcomes, offering new chances for influence [13]. The flipped classroom model is utilized across multiple

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academic fields, such as mathematics, social sciences, and humanities, at various educational levels in numerous nations [14–16]. Consequently, innumerable educators in higher education are contemplating the necessity of revamping their teaching approach by implementing the flipped classroom model. This solution is offered because it has several advantages that are deemed adequate for implementation. The Ministry of Education recommends the case method as an excellent approach for teaching basic algorithms and programming. Additionally, flipped classrooms have recently proven effective in improving problem-solving skills [17], collaboration, and performance [15, 18]. Moreover, integrating technology in the flipped classroom has emphasized enhancing students' proficiency levels [19].

This study aims to develop a case-based Flipped Classroom model and evaluate its effectiveness in improving students' Computational Thinking (CT) and Problem-Solving (PS) skills. Regarding the difference between critical and computational thinking, this research focuses on Computational Thinking (CT) rather than critical thinking. Computational thinking involves problem-solving skills that include understanding and applying computational concepts, which are different from critical thinking skills in general.

The research focus of this study was developing and implementing a Case-driven Flipped Classroom Model integrated with Discord to enhance computational thinking skills in vocational education. The conceptual framework was grounded in the systematic investigation methodology of Research and Development, which is essential for creating and evaluating the efficacy of new educational models.

Accordingly, this empirical and experimental study explicitly targets Computational Thinking (CT) and Problem-Solving (PS) abilities rather than critical thinking. Additionally, the study included hypothesis testing and using control and experimental groups to measure the impact of the model on students' skills. Ultimately, the novelty of this study lies in the innovative integration between the case-based Flipped Classroom Model and the medium of contention technology, which can potentially bring about tremendous transformation.

The benefits of this research extend beyond enriching instructional models for vocational education; it also offers a practical and user-friendly approach that experts and large-scale field tests have validated. This research significantly advances educational technology and instructional design knowledge, providing a robust framework for future studies and implementation.

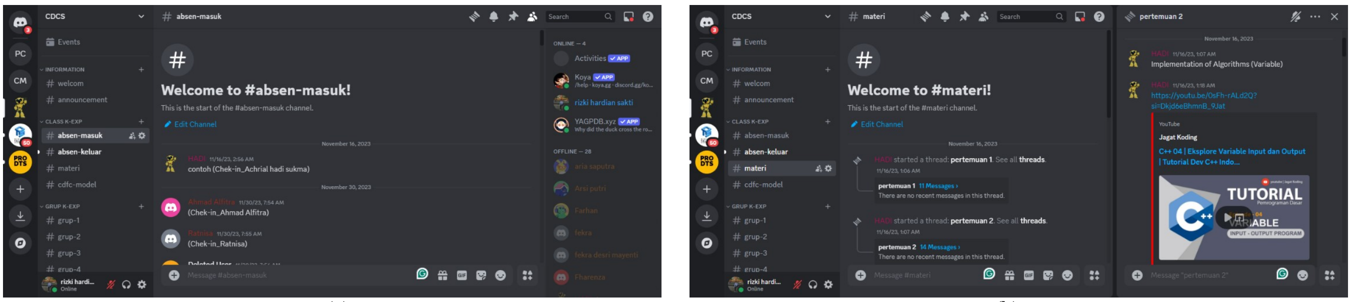
II. CASE-DRIVEN FLIPPED CLASSROOM INTEGRATED WITH DISCORD

A. *Flipped Classroom*

The flipped classroom is an instructional model that reverses the conventional sequence of classroom instruction, transferring learning materials, typically taught in the classroom, to outside the classroom through resources like learning videos accessible before class meetings [20]. This approach shifts students' roles from passive recipients to active participants in learning by utilizing in-class sessions for interactive activities such as discussion, collaboration, and in-depth problem-solving [21]. In a flipped classroom, lecturers act as facilitators and supporters while students gain more control over their learning process.

This model is grounded in problem-based learning, which engages students by presenting contextual challenges and is supported by the theory of constructivism [22]. Constructivism posits that students construct knowledge through real-world problem-solving efforts [23]. Research indicates that flipped classrooms, especially those integrated with task-based instructional methods and assessments, have successfully enhanced student engagement and learning outcomes.

In order to address the gaps in traditional instructional approaches, educators recommend implementing the Case-driven Flipped Classroom Model. This model aims to enhance students' critical thinking (CT) and problem-solving skills (PSS). It enables students to acquire knowledge before attending in-class sessions, where they can [24, 25]. The flipped classroom model in this study utilizes the Discord application, as presented in Fig. 1.



(a) (b)

Fig. 1. (a) Discord application; (b) Discord group to provide flipped classroom model treatment.

Jerome Bruner's cognitive constructivism learning theory underpins the Case-driven Flipped Classroom Model by emphasizing the importance of guiding students to understand a subject's fundamental concepts [26]. This model supports knowledge construction through students' experiences, enabling them to explore subject matter independently before class and engage in collaborative activities that promote critical thinking and idea sharing during class.

Fig. 1 demonstrates, in the flipped classroom setting, students retrieve educational resources such as videos, reading materials, or online content before the in-class session, allowing them to process this information and build a solid understanding framework. This paradigm not only reinforces cognitive roles in learning but also transforms the educator's role from a transmitter of knowledge to a facilitator of learning, with students becoming active learners who participate fully in the learning process. This approach, grounded in the Borg and Gall research model, offers a structured method for developing and validating educational innovations, ensuring their effectiveness and relevance in enhancing student learning outcomes.

B. Computational Thinking Skills

Computational Thinking (CT) is a fundamental skill for solving problems, designing systems, and understanding human behaviour by drawing on concepts fundamental to computer science. CT involves a set of problem-solving methods that express problems and their solutions in ways that a computer could execute [27]. Critical components of CT include pattern abstraction and generalization, systematic information processing, symbol and representation systems, algorithmic control flow, structured problem decomposition, iterative, recursive, parallel thinking, conditional logic, and efficiency and performance constraints [27].

Research has shown that integrating CT into educational models can significantly improve students' understanding of computational concepts and their ability to tackle problem-solving challenges [28]. For instance, Gong *et al.* [22] explored the key influencing factors on college students' CT skills through flipped classroom instruction and found that such instructional approaches can enhance students' programming logic and modelling skills.

C. Problem-Solving Skills

Problem-solving skills are critical for students to navigate complex and dynamic environments. These skills involve identifying, formulating, and solving problems using analytical, algorithmic, and logical approaches [29]. Problem-solving is closely related to CT, as both require systematic thinking and the application of computational concepts to real-world situations.

The Programme for International Student Assessment (PISA) has highlighted the importance of problem-solving skills, revealing that Indonesian students' scores fall below the OECD average, indicating a need for improved educational strategies to enhance these skills. Integrating case studies with flipped classroom models helps students develop these skills by offering practical applications and collaborative learning experiences [19].

Educational models incorporating CT and problem-solving skills, such as the Case-Driven Flipped Classroom model, effectively enhance these skills. These models encourage students to engage with real-world problems, apply computational concepts, and collaborate with peers, improving learning outcomes [30]. Using platforms like Discord for online communication further supports collaborative learning of these skills.

In conclusion, the literature indicates that integrating CT and problem-solving skills into educational models can significantly enhance students' abilities in these areas. The Case-Driven Flipped Classroom model, supported by online communication tools, provides a promising approach to achieving these educational goals.

III. Methodology

Methodology is the systematic and detailed approach to design, conduct, and evaluate research [31, 32]. It involves the steps or procedures taken to collect and analyze data to achieve the research objectives, which include several elements, including the research approach, types of data collected, data collection techniques, and data analysis.

A. Research Type and Development Procedures

This study employs a Research and Development (R&D) approach, systematically investigating to create and evaluate specific items for efficacy [33, 34]. The primary objective was to develop and implement a Case-driven Flipped Classroom model integrated with Discord. During the practicality testing phase, these methods were used to assess the feasibility and user-friendliness of the model. Research plays a crucial role in developing new learning models, as it is essential for evaluating their effectiveness and ensuring their applicability to the broader community [35]. The development process followed the Borg and Gall model, which was streamlined into five stages: problem identification and needs analysis, product development, expert validation, practicality and prototype testing, and large-scale field testing with final product validation [36]. This structured approach ensures that the research is conducted systematically and rigorously, resulting in an educational model validated by experts and tested for reliability and effectiveness.

B. Treatment Procedures

This treatment aimed to showcase the efficacy of integrating Discord into a Case-driven flipped classroom. The study employed a quasi-experimental design, utilizing advanced data analysis techniques such as Structural Equation Modeling (SEM), t-tests, and Multivariate Analysis of Covariance (MANCOVA) to assess the impact of the model on students' computational thinking and problem-solving skills. This approach aimed to establish causal relationships between variables. Researchers proportionally and randomly assigned participants to two groups: an experimental group that experienced the integrated learning model and a control group that received conventional teaching methods, including lectures [37, 38]. Both groups took a pre-test one week before the ten-week treatment phase. During this phase, the experimental group was instructed to use a Case-driven flipped classroom approach with Discord, while the control group continued with traditional teaching methods. This design ensured a comprehensive analysis by considering prior knowledge and learning styles.

The duration of treatment was ten weeks, following the advice given by Chen *et al*. [39] recommend this duration to effectively assess treatment factors' impact on computational thinking and problem-solving skills. Following the completion of the treatment phase, a post-test was administered in week 12 using the same instrument as the pre-test, allowing for a comparative analysis of outcomes between the experimental and control groups.

C. Population and Sampling

The study included 126 students from diverse educational backgrounds, each bringing distinct mindsets—these students enrolled in the Algorithms and Programming course within the Informatics Engineering Education program. A proportional random sampling method was employed to select 65 participants from this population, ensuring that each subgroup had an equal opportunity to be included in the sample [40] (Table 1).

$$n_i = \frac{N_i}{N} \times n$$

Table 1. Research sample

Group	Total Population	Sample Calculation	Sample Quantity
IE 1	31	(31/126) × 65	16
IE 2	31	(31/126) × 65	16
IE 3	32	(32/126) × 65	16
IE 4	32	(32/126) × 65	17
Total	120		65

D. *Research Instruments*

The research instruments were questionnaires to assess validity, inventory to measure problem-solving skills, and rubrics to measure computational thinking skills. The choice instrument tailored the study objectives, research questions, and the nature of the acquired data.

E. *Validity Questionnaire*

In this study, experts validated the developed instruments using an expert judgment strategy, followed by feasibility testing by validators. In constructing the questionnaire, each item was developed and arranged based on the indicators constructed for each aspect of the results, as depicts in Table 2.

Table 2. Validity questionnaires

No.	Indicator	Total
1.	Model Rationale	Two items
2.	Model Supporting Theory	Four items
3.	Model Syntax	Six items
4.	Social System	Five items
5.	Reaction Principle	Five items
6.	Support System	Six items
7.	Instructional and Accompanying Impact	Five items
8.	Learning Implementation	Seven items

F. *Problem-Solving Inventory*

The instrument used to measure problem-solving skills in this study was the Problem Solving Inventory (PSI) [41]. The selection of PSI was based on its function of assessing problem-solving abilities. The PSI has been utilized in over 100 investigations and is considered one of the most extensively employed instruments, as illustrates in Table 3.

Table 3. Problem-solving inventory

No.	Indicator	Number of Items
1	Problem-Solving Self-Confidence	14 items
2	Avoidance Style Approach	7 items
3	Self-Control	6 items

G. *Computational Thinking Rubric*

The instrument used to measure computational thinking skills was the computational thinking skills assessment rubric developed by George Mason University. This rubric was used and intended for students in the field of engineering [42], as depicts in Table 4.

Table 4. Computational thinking rubric

Indicator	Description
Pattern abstraction and generalization	Analyze a collection of patterns and articulate them concisely and effectively.
Methodical data analysis	Applying heuristics to comprehend an occurrence
Symbol and representation system	Describing events that are often abstract with simplified concretes
Algorithmic notion of control flow	Manage data using specific procedures.
Structured problem decomposition	Break complex problems or systems into more understandable parts.
Iterative, recursive, and parallel thinking	The process of iteratively repeating thoughts to achieve a goal, recursively thinking through thoughts, and the capacity to concentrate thoughts in a specific direction
Conditional logic	A causal relationship refers to a condition where the happening of one event is contingent upon the happening of another event.
Limitations on efficiency and performance	Assessing the inhibiting and advantageous factors implicated in a procedure
Methodical debugging and error identification	Employ a systematic approach to identify and minimize flaws.

H. *Pilot Study*

A pilot study is the initial research phase to evaluate the validity and reliability of research instruments, including questionnaires, interviews, and observations. This phase included face-to-face interviews with diverse participants to gain in-depth insights. Validity ensures that the instruments measure what they are intended to measure, while reliability ensures consistent results [43]. The researcher assessed the validity of the instruments in this study using the Intraclass Correlation Coefficient (ICC), considering a coefficient greater than 0.500 as satisfactory. The reliability of the instruments was evaluated using Cronbach's Alpha formula [44], as depicts in Table 5.

Table 5. Pilot study analysis

Instruments and Type		ICC	Cronbach's alpha
Validation Instrument	Questionnaire	0.728	0.884
Problem-Solving Instrument	Inventory	0.913	0.724
Computational Thinking Instrument	Rubric	0.832	0.723

I. *Data Analysis Technique and Hypothesis Development*

This research was analyzed quantitatively using percentage, mean, standard deviation, and parametric analysis. This study's validity test was analyzed using the Sequential Equation Model (SEM), which was processed using Smart PLS. The hypothesis test was evaluated by employing the t-test and MANCOVA. The hypothesis development in this study was:

$H1_0$: There was no statistically significant difference in the mean scores of students' computational thinking skills from the pre-test to the post-test.

$H2_0$: There was no statistically significant difference in the mean scores of students' problem-solving skills from the pre-test to the post-test.

$H3_0$: No statistically significant difference is observed in the mean scores of students' computational thinking between the control and experimental groups.

$H4_0$: No statistically significant difference is observed in the mean scores of students' problem-solving skills between the control and experimental groups.

$H5_0$: No statistically significant gender-based difference exists between the control and experimental groups' mean students' computational thinking and problem-solving skills scores.

Generalization of the findings of this study includes a more diverse sample population and replicating the study across different higher education backgrounds and scientific interests. This provides more comprehensive validation of the effectiveness and applicability of the model, thereby strengthening the rigour and generalisability of the study.

IV. Results and Discussion

A. Needs Analysis

This research began with data collection before developing the Discord-integrated Case-driven Flipped Classroom Model. The defining stage was the primary phase of model development. This stage was the foundation for developing the Discord-integrated Case-driven Flipped Classroom Model for educational purposes. The researchers used the findings of the conducted analysis as guidelines and factors to consider when constructing the model. They conducted learning needs and student analysis during this phase, as depicts in Table 6.

Table 6. Needs analysis results

Item	5	4	3	2	1
Do you agree that learning is conducted online on campus	14 (35%)	22 (55%)	4 (10%)	0 (0%)	0 (0%)
Do you agree with the learning process using smartphones, androids, and laptops?	14 (35%)	21 (52.5%)	5 (12.5%)	0 (0%)	0 (0%)
Do you agree that algorithms and programming courses are blended?	18 (45%)	17 (42.5%)	5 (12.5%)	0 (0%)	0 (0%)
Do you agree that blended algorithms and programming courses can enrich the algorithms and programming course material?	17 (42.5%)	16 (40%)	7 (17.5%)	0 (0%)	0 (0%)
Do you agree that the internet is used as a learning resource for algorithms and programming course materials?	13 (32.5%)	25 (62.5%)	2 (5%)	0 (0%)	0 (0%)
Do you agree that the LMS helps the algorithm and programming lecture process?	15 (37.5%)	18 (45%)	7 (17.5%)	0 (0%)	0 (0%)
Algorithms and programming course materials using modules, diktats, and guidebooks improve your understanding.	18 (45%)	17 (42.5%)	5 (12.5%)	0 (0%)	0 (0%)
You understand the algorithms and programming course material well in face-to-face classes.	16 (40%)	18 (45%)	6 (15%)	0 (0%)	0 (0%)
In the learning process of algorithms and programming courses using other media (audio, visual, or audio-visual)	16 (40%)	20 (50%)	4 (10%)	0 (0%)	0 (0%)
Learning algorithms and programming courses using media that can show how things work, such as pictures, videos, or material in more detail / real.	15 (37.5%)	21 (52.5%)	4 (10%)	0 (0%)	0 (0%)
Is the application used appropriately to support teaching and learning activities?	14 (35%)	19 (47.5%)	7 (17.5%)	0 (0%)	0 (0%)
The existing media makes it easy to get additional material from the course concerned.	15 (37.5%)	19 (47.5%)	6 (15%)	0 (0%)	0 (0%)
An Internet discussion forum is a place to discuss with college friends	18 (45%)	19 (47.5%)	3 (7.5%)	0 (0%)	0 (0%)
Do you agree to participate in the blended learning training	11 (27.5%)	24 (60%)	5 (12.5%)	0 (0%)	0 (0%)
The need for a guidebook in utilizing online learning	16 (40%)	19 (47.5%)	5 (12.5%)	0 (0%)	0 (0%)

Table 5 explains the needs analysis results obtained from the questionnaire responses. The analysis revealed that 85% of students agreed that learning was conducted using technology, including Discord as a learning management system (LMS), and 86.5% of students also agreed that learning algorithms and programming were blended. Additionally, a significant portion of students (71%) indicated that the existing models and media were insufficient to support teaching and learning activities; therefore, they supported the development of learning models integrated with technology.

The curriculum analysis aimed to identify the specific materials for implementing the case-driven flipped classroom. This process started with examining the topics or learning materials, SLOs, and CPMK and then outlining the learning objectives and materials students needed to understand. The case-driven flipped classroom model was tested in an algorithm and programming course, covering topics such as Pascal programming algorithms, input/output variables, assignments, data types, expressions and operators, If-else statements, functions and procedures, iterative loops, and the use of array data types for data retrieval and organization. This course aimed to equip students with fundamental programming concepts, enabling them to solve problems by developing problem-solving algorithms and translating these into specific programming languages.

Curriculum analysis was a critical step in developing the case-driven flipped classroom model. It involved an in-depth evaluation of the curriculum's structure, content, and organization to ensure that the proposed learning model could effectively meet educational purposes. It identified relevant educational purposes and standards to ensure the learning model supported achieving the goals. We reviewed the curriculum to ensure the proposed concepts and materials were aligned. Additionally, we gained an in-depth understanding of the skills and competencies expected of students, such as computational thinking and problem-solving skills. This learning model also supported the development of critical skills, creativity, collaboration, and communication. Based on the review of the relationship between subjects or learning units in the curriculum, it can be concluded that the learning model can facilitate integration across subjects and build meaningful connections between concepts. By considering the relevance of learning material to the real world and students' lives, it can be ensured that the learning model creates a relevant and meaningful context for students, linking material to real situations or practical applications.

The study analyzed the characteristics and developmental stage of students participating in the Discord-integrated Case-driven Flipped Classroom Model, who were first-year students aged 17 to 20. According to Piaget's theory, individuals in this age group are typically in the formal operational stage of cognitive development, marking a shift from concrete operational thinking. This stage is characterized by the ability to engage with complex and abstract problems, considering multiple perspectives and potential outcomes. Merrett [45] supports this view, suggesting that individuals in the formal operational stage can think critically and construct their knowledge to solve intricate problems.

The investigation into student analysis within the case-driven flipped classroom model integrated with Discord encompassed various aspects crucial for assessing its implementation success and areas needing improvement. The study assesses various aspects critical to the effectiveness of the Discord-integrated Case-driven Flipped Classroom Model. This includes evaluating student engagement in flipped classroom activities and Discord discussions, with plans to enhance engagement through incentives and interactive learning methods. Additionally, this study focuses on assessing students' comprehension of the material through case studies, with planned interventions aimed at addressing comprehension challenges, such as tutoring sessions, supplementary resources, and support materials that can assist students requiring additional guidance, thereby providing beneficial materials such as video tutorials, additional exercises, or self-assessment quizzes. Moreover, the study evaluates students' problem-solving abilities in practical scenarios, aiming to strengthen these skills further by developing supplementary exercises and case studies [46].

The study examines several critical aspects of the Discord-integrated Case-driven Flipped Classroom Model. It evaluates the collaboration and interaction among students facilitated by the Discord platform, aiming to enhance these interactions through structured discussions and collaborative activities. The research also focuses on the effective use of Discord features, such as Text Channels, Voice Channels, Screen Sharing, Bot Integration, and Role Management, which are effective for learning and suggest additional training or guidance where needed, especially in feedback and self-evaluation. Furthermore, it explores the success of regular feedback sessions for constructive dialogue between students and instructors, proposing improvements to strengthen the feedback culture [47]. Additionally, the study assesses students' ability to learn independently within the flipped classroom model, recommending the development of supplementary resources for those requiring further support. Lastly, it underscores the significance of case studies in fostering learning outcomes, emphasizing their importance in the educational process.

The success of the Case-driven Flipped Classroom Model is evident in the student's ability to relate theoretical concepts to the provided cases. To enhance this, educators should implement a greater variety of real-life case studies. In terms of motivation, students demonstrate high levels of engagement and participation [48, 49]. Identifying factors that further boost motivation, such as the context of cases or challenging tasks, can enhance this aspect. The model has successfully increased students' understanding and application of concepts, suggesting positive impacts on learning outcomes. However, ongoing evaluation of the curriculum and teaching methods is necessary to meet learning objectives.

Regarding mental well-being, it is crucial to assess whether this learning model has a positive impact and provide additional support or resources if signs of high mental load are observed. Instructors' feedback has been effective, but there is room for improvement by increasing faculty training in flipped classroom strategies. Lastly, evaluating this learning model's time efficiency is essential, focusing on identifying areas where time can be optimized or extended [50].

B. *Product Development*

The development phase of the case-driven Flipped Classroom concept was integrated with the flipped classroom learning model, LMS learning media, and case learning methods. The qualities employed in the Case-driven Flipped Classroom model pertained to the characteristics of a flipped classroom [51]. The Case-driven model was developed based on the flipped classroom learning model developed by Bergmann & Sams and Rosiene & Rosiene [52, 53].

Fig. 2 illustrates about the syntax of the Case-driven Flipped Classroom model, which incorporated all the flipped classroom learning model components.

1) The warm-up activity included Lecturer and Tutorial activities. At this stage, the lecturer provided a briefing on the learning through video or virtual face-to-face, and various programming concepts and techniques were introduced, explained, and demonstrated with examples to students. Lecturers provided materials and videos to students on the LMS; students were required to read and understand the material.
2) In this activity, students had to read the material and watch the video on the LMS at home before doing assignments and practice in in-class sessions.
3) In the Case Execution phase, students engaged in group activities to analyze the case and discuss potential solutions. This was followed by formulating an action plan through collaborative discussions within the group. Students identified requirements, developed algorithms, and implemented them in C#, integrating various

techniques learned from lectures and exercises. Students independently tackled practical exercises to apply and reinforce theoretical concepts during the individual exploration. Group discussions and teamwork facilitated active learning. Additionally, students prepared case reports detailing their problem-solving processes, presenting their concepts or algorithms using flowcharts or pseudo-code and verifying the accuracy of their solutions by examining the program output.

4) Assessment. In this stage, the lecturer assessed the performance and presentations presented by the students related to the proposed case solution. This oral presentation was required, and immediate feedback/comments were directly given to students toward their work, as well as quizzes to assess student achievement at various stages during learning. This provided a formative assessment of their learning progress.
5) Reflection. Students wrote reflections related to the learning they experienced.

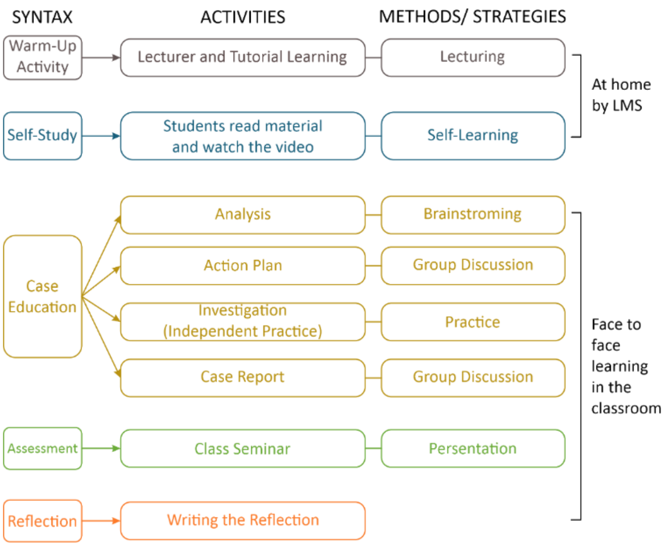


Fig. 2. The syntax of case-driven flipped classroom model.

While offering numerous advantages, the flipped classroom model also presents certain disadvantages that must be addressed. Integrating it with case studies through a case-driven approach can mitigate some drawbacks by enriching the learning experience and providing additional contextual and applicative dimensions [54]. This integration helps to overcome potential shortcomings in the flipped classroom model, as the case studies serve as an experiential component of the in-class sessions [55]. The Case-driven Flipped Classroom concept effectively combines the flipped classroom learning model, Learning Management System (LMS) materials, and case-based learning methods, enhancing the educational experience [56]. The qualities employed in the Case-driven Flipped Classroom model align with the fundamental characteristics of the flipped classroom, offering a robust framework for improving student engagement and learning outcomes [57].

The research results can be replicated across various disciplines in an academic environment by adapting the case studies to fit each field's specific content and learning objectives. For instance, in mathematics, case studies could involve real-world problems that require the application of mathematical theories and principles [58]. In social sciences, case studies might focus on analyzing historical events or social phenomena, encouraging students to apply theoretical concepts to practical scenarios [59]. Case studies could involve critical analysis of literary works or philosophical debates in the humanities, fostering more profound understanding and critical thinking skills [60]. By tailoring the case-driven approach to the unique requirements of different disciplines, educators can leverage the benefits of the flipped classroom model to enhance student learning and engagement across a wide range of academic fields.

C. Validation by Experts

Before being implemented, this Case-driven Flipped Classroom model was tested for feasibility based on experts' judgments. The testing result stated that the Case-driven Flipped Classroom model in this study was valid as the validator stated it and that no more revisions were needed.

Table 7. Validation results of the case-driven flipped classroom model

Indicator	∑s	V	Category
Model Rationale	15	0.75	Valid
Model Supporting Theory	14	0.7	Valid
Model Syntax	15	0.75	Valid
Social System	15.4	0.77	Valid
Reaction Principle	15.6	0.78	Valid
Support System	14.83	0.74	Valid
Instructional and Accompanying Impact	14.6	0.73	Valid
Learning Implementation	14.7	0.74	Valid

Table 7 shows the validation results from experts on the Case-driven Flipped Classroom model. It depicts that the Case-driven Flipped Classroom model has a validity value of 0.75 for the model rationale, a validity value of 0.7 for the model supporting theory, a validity value of 0.75 for model syntax, a validity value of 0.77 for the social system aspect, a validity value of 0.78 for the reaction principle aspect, a validity value of 0.74 for the support system aspect, a validity value of 0.73 for the instructional impact and accompanying impact aspect, and a validity value of 0.74 for the learning implementation aspect. Therefore, it is inferred that the Case-driven Flipped Classroom model is valid based on its rationale, model supporting theory, model syntax, social system, reaction principle, support system, instructional and accompanying impact, and learning implementation.

After passing the content validation test, the construct validation test was proceeded. This process ensured that the developed model was in the goodness-of-fit model category. According to Jackson *et al.* [61] and Lawrence S. Meyers *et al.* [62], Goodness-of-fit values should be derived from chi-square (X2), which is a fit test for categorical variables to measure the fit of a measure of how well a statistical model fits a set of observations.

Fig. 3 depicts the construct validation of the result of data analysis for Warm-up Activity syntax, Self-Study, Case Execution, Assessment, and Reflection. Specifically, the Chi-Square (χ) value for Warm-up Activity syntax is 2.46 with 5 degrees of freedom (df), corresponding to 5 question items. Therefore, the χ/df ratio is 0.49, which is < 2, indicating the validity of the Warm-up Activity syntax. Similarly, the Chi-Square (χ) value for Self-Study syntax is 3.16, with a χ/df ratio of 0.63 (< 2), confirming the validity of Self-Study syntax. In the Case Execution syntax, the Chi-Square (χ) value is 3.8, with a χ/df ratio of 0.76 (< 2), indicating its validity. For the Assessment syntax, the Chi-Square (χ) value is 5.38, resulting in a χ/df ratio of 1.08 (< 2), affirming the validity of the Assessment syntax. Lastly, the Chi-Square (χ) value for the Reflection syntax is 2.28, with a χ/df ratio of 0.46 (< 2), confirming the validity of the Reflection syntax.

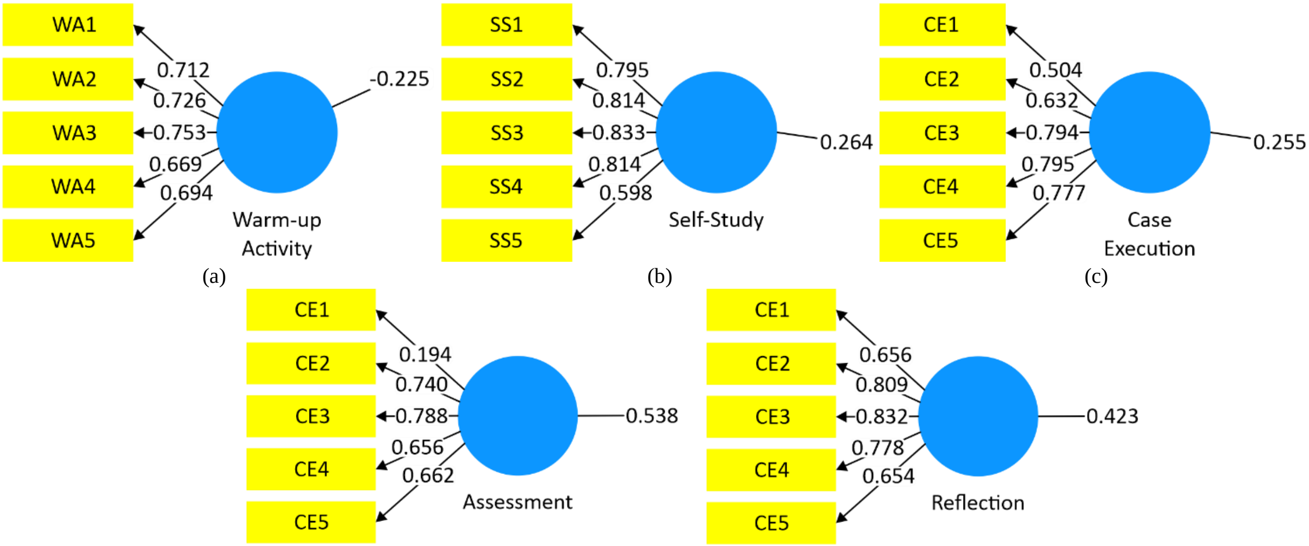


Fig. 3. Construct validation results syntax (a) warm-up activity, (b) self-study, (c) case execution, (d) assessment, and (e) reflection.

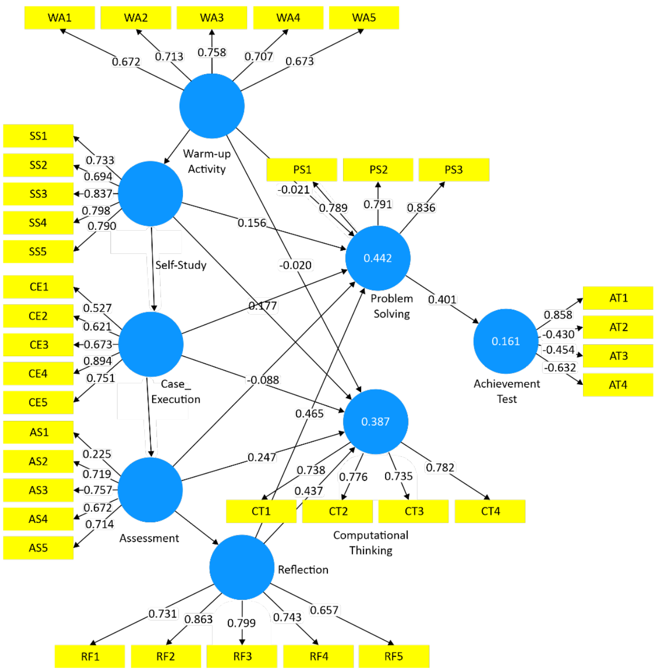


Fig. 4. Results of overall construct validation of syntax.

According to Fig. 4, the data analysis for construct validation syntax reveals a Chi-Square (χ) value of 2.46 with 37 degrees of freedom (df) across 37 question items. Thus, the χ/df ratio is 0.46, which is < 2, indicating the overall validity of the syntax. These results align with previous research conducted by Martínez-Gómez *et al.* [63], emphasizing the importance of validation as a crucial step to ensure the model's reliability for achieving intended learning objectives. Validation also assesses the model's capacity to accommodate changes in the field or user requirements [64].

D. *Practicality Test and Product Version*

This phase aims to assess the initial setup and feasibility of the product, ensuring that researchers have successfully developed it. Practical tests and iterative product versions are conducted during this stage. The outcomes from these preliminary experiments serve as checkpoints for refining the product under development. This iterative process continues until a finalized project product is ready for comprehensive testing. Within this phase, a field test was conducted to evaluate the implementation practicality of the Case-driven Flipped Classroom model. Its practicality and ease of implementation determine practicality. Data collected for the practicality assessment included questionnaire responses from lecturers and students enrolled in algorithms and programming courses, who evaluated the feasibility of the Case-driven Flipped Classroom model.

Table 8. Practicality test results

Indicator	Total Score	Percentage	Category
Lecturer Response			
Attractiveness	12	80	Practical
Development Process	12.5	83.33	Practical
User-friendliness	11	73.33	Practical
Functioning and Usability	85.56	85.56	Practical
Reliability	83.33	83.33	Practical
Student Response			
Student Interest	111.8	86	Very Practical
Implementation Process	111.2	85.38	Very Practical
Liveliness	111.6	86.15	Very Practical
Independence	111.3	85.64	Very Practical

Based on Table 8, the practicality test of the Case-driven Flipped Classroom model by lecturers showed the following results: 80% for attractiveness (categorized as practical), 83.33% for the development process (categorized as practical), 73.33% for user-friendliness (categorized as practical), 85.56% for functioning and usability (categorized as practical), and 83.33% for reliability (categorized as practical). These findings suggest that the Case-driven

Flipped Classroom model is practical in attractiveness, development process, user-friendliness, functioning and usability, and reliability.

In comparison, the practicality test of the Case-driven Flipped Classroom model by students revealed the following: 86% for student interest (categorized as very practical), 85.38% for the implementation process (categorized as very practical), 86.15% for activeness (categorized as very practical), and 85.64% for independence (categorized as very practical). These results indicate that the Case-driven Flipped Classroom model is efficient regarding student interest, implementation process, activeness, and independence. Consequently, ensuring the reliability and usability of the technological tools used in the learning process, including the functionality and friendliness of platforms like Discord, is crucial.

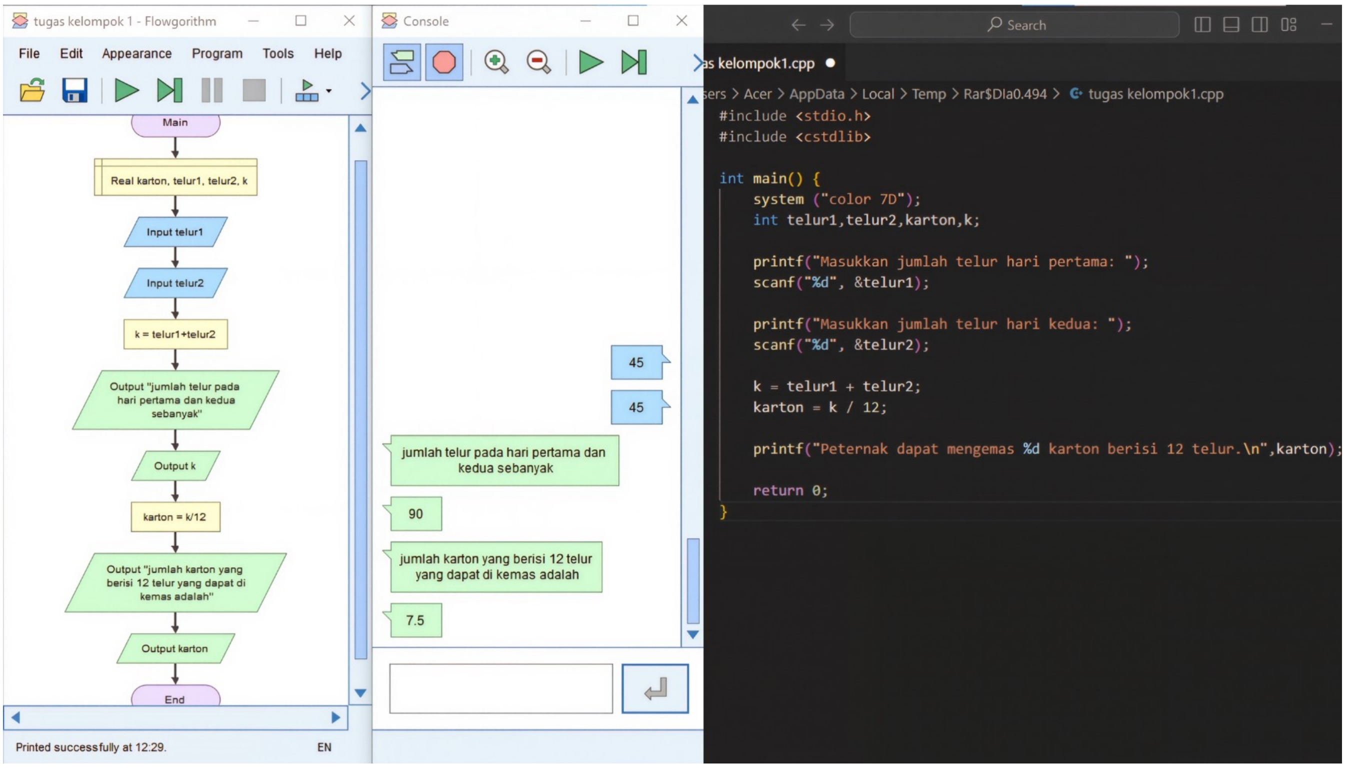
E. Large-Scale Field Test and Final Product Test (Effectiveness Test)

The subsequent phase involved implementing the Discord-integrated Case-driven Flipped Classroom Model within the algorithm and programming course to assess its influence on students' computational thinking and problem-solving abilities. This research adopted a quasi-experimental methodology, employing a pre-test and post-test design with a control-experimental group setup. According to Z. Unal and A. Unal [65], pre-test and post-test designs are commonly used to establish causal relationships between variables, primarily when two groups are randomly assigned—one receiving conventional treatment and the other receiving the experimental treatment.

In this study, the control group followed a traditional lecture-based approach, while the experimental group engaged with the Discord-integrated Case-driven Flipped Classroom Model. Throughout the intervention, students in the experimental group actively participated in discussions, problem-solving activities, and collaborative exercises facilitated through Discord.

To evaluate the impact of this approach, students' computational thinking and problem-solving skills were measured using structured assessments before and after the intervention. The data analysis included statistical comparisons between the pre-test and post-test scores of both groups to determine the effectiveness of the proposed model.

As part of the learning process, students utilized various programming tools to enhance their understanding of algorithms and coding concepts. Fig. 5 illustrates students' engagement with Flowgorithm (a), a visual tool for designing and analyzing flowcharts, and C++ (b), a programming language used for implementing and testing their algorithmic solutions. These tools played a crucial role in supporting students' ability to translate logical processes into functional code, reinforcing their computational thinking skills.

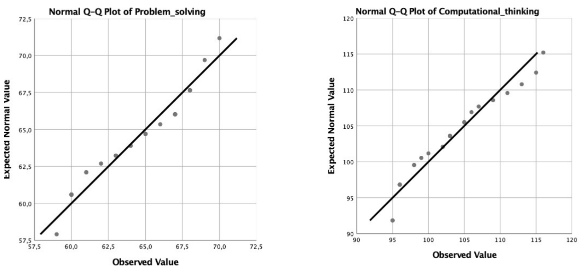


(a) (b)

Fig. 5. Student use of Flowgorithm (a) and C++ (b).

The results showed that the Discord-integrated Case-driven Flipped Classroom Model positively impacted both skills, and before executing the parametric test, precondition tests of analysis, including normality and homogeneity tests using the QQ plot method, were conducted to ensure data distribution and variance consistency; if these prerequisites were met, the analysis proceeded with parametric statistical tests, including the t-test to compare mean differences between the control and experimental groups and MANCOVA to examine the simultaneous effects of the intervention on students' problem-solving and computational thinking skills.

The results of these tests provided insights into the effectiveness of the Discord-integrated Case-driven Flipped Classroom Model in enhancing students' learning outcomes. Fig. 6 presents the QQ normality test plots, illustrating the distribution patterns for problem-solving skills (a) and computational thinking skills (b), which were essential in determining the appropriateness of parametric statistical analyses.



(a) (b)

Fig. 6. Plot QQ normality Test of problem-solving skill (a) and computational thinking skill (b).

Fig. 6 shows, the data distribution was assessed for its normality using the Shapiro-Wilk test. The post-test mean scores of the problem-solving test did not show a statistically significant difference from the mean scores of the average population [$p > 0.05$, $W = 102.69$]. The post-test mean scores of the Computational Thinking test did not differ significantly from those of the regular population [$p > 0.05$, $W = 64.53$]. Furthermore, the distribution of post-test mean scores on the Achievement Test did not exhibit a statistically significant deviation from the typical population distribution [$p > 0.05$, $W = 87.07$]. Therefore, it assumed the sample data distribution and further statistical analysis was conducted using parametric tests.

Table 9. Homogeneity test

Variables	Levene's Test	P value
Problem-solving	0.837	0.365
Computational Thinking	0.147	0.703

After the normality test, the data was tested for homogeneity, as illustrates in Table 9. This study used Levene's Test to compare the two pre-test data for each variable in both groups. The variance of pre-test Problem solving, Computational Thinking, and Achievement Test students statistically showed no significant difference ($p > 0.05$) between the experimental and control groups. Therefore, the assumption could be used to conduct a t-test and MANCOVA.

Table 10. Presentation of problem-solving skill data in the experimental class

Indicator	5	4	3	2	1	M	SD
Confidence in Problem Solving	95 (73.1%)	20 (19.2%)	6 (7.7%)	0 (0%)	0 (0%)	30.3	44.0
Avoidance Style Approach	80 (61.5%)	32 (30.8%)	3 (3.8%)	2 (3.8%)	0 (0%)	29.3	36.6
Self-Control	95 (73.1%)	16 (15.4%)	9 (11.5%)	0 (0%)	0 (0%)	30.0	43.8

The results of data analysis on the impact of the Case-driven Flipped Classroom Model on Problem Solving Skills showed that the percentage of "very often" is the highest in all indicators (Table 10). The indicator "Confidence in Problem Solving" has the highest mean of 30.3 (*SD* = 44), with 95% of students confident in solving problems. The lowest mean of the three indicators is the "Avoidance Style Approach," which is 29.3 (*SD* = 36.6), indicating that 80% of students often use the avoidance style approach.

Table 11. T-test analysis of problem-solving skill

Observations	Groups	*N*	Paired Sample T-test			
			Mean Differences	*t*	*df*	*P*
Pretest-Posttest analysis of Problem-Solving Skill instrument	Experimental	27	31.6	14.446	25	0.000
	Control	25	6	1.134	24	0,200
			Independent Sample T-test			
			M	*t*	*df*	*P*
Post-test comparison analysis of Problem-Solving Skill instrument	Experimental	27	102.69	13.875	49	0.000
	Control	25	76.36			

Table 11 shows a significant difference in Problem-Solving Skills between both groups [$df = 49$, $t = 13.875$, *p*-value = 0.00, $p < 0.05$]. The experimental group performed better in improving problem-solving skills than the control group. Higher post-test scores after implementing the Case-driven Flipped Classroom Model evidenced this improvement. Statistical analysis, explicitly examining the p-value (where values less than 0.05 indicate rejection of the null hypothesis), confirmed significant differences in post-test scores between the two groups. The introduction of the Case-driven Flipped Classroom Model positively impacted students' problem-solving abilities by providing opportunities to apply theoretical knowledge in practical contexts. Engaging with real-life case studies enabled students to enhance their contextual problem-solving skills and proficiency in analyzing complex situations. This approach facilitated their ability to analyze information, identify issues, and develop appropriate solutions [18].

The research findings of this study underscore the unique and innovative aspects of the Case-driven Flipped Classroom Model, particularly its integration with the online communication platform Discord. Unlike traditional flipped classroom approaches, this model allows students to prepare before class and use in-class sessions for discussion and collaboration. It also leverages real-life case studies to deepen their understanding of computational concepts and problem-solving skills [66]. This integration creates a dynamic learning environment where students can exchange ideas and collaboratively find solutions to complex problems, enhancing their computational thinking abilities.

Furthermore, the model emphasizes student responsibility and independence, encouraging them to tackle problems independently and with their peers' support. This approach fosters self-regulation and engagement and prepares students for real-world challenges by bridging the theoretical knowledge and practical application gap.[67].

Research from K. S. Chen *et al.* [68] highlights that flipped learning is unique and allows for extended reflection time, enabling students to consider proposed solutions, evaluate their effectiveness, and continuously learn from their experiences. This model facilitates in-class discussions and presentations, where students receive immediate feedback from lecturers and classmates, continuously enhancing their problem-solving skills. Additionally, integrating platforms such as Discord in the learning model introduces a novel dimension of online communication and collaboration, further supporting the exchange of ideas and problem-solving through technology [69]. This innovative approach encourages a holistic perspective on problem-solving, where students focus on technical aspects and consider their proposed solutions' social impact, ethics, and broader implications [70].

Table 12. Presentation of computational thinking skill data in experimental classes

Indicator	5	4	3	2	1	M	SD
Pattern abstraction and generalization	85 (65.4%)	32 (30.8%)	3 (3.8%)	0 (0%)	0 (0%)	24	36.7
Systematic information processing	90 (69.2%)	28 (26.9%)	3 (3.8%)	0 (0%)	0 (0%)	24.2	38.6
Symbol and representation system	85 (65.4%)	32 (30.8%)	0 (0%)	2 (3.8%)	0 (0%)	23.8	36.8
Algorithmic notion of control flow	100 (76.9%)	16 (15.4%)	3 (3.8%)	2 (3.8%)	0 (0%)	24.2	42.8
Structured problem decomposition	105 (80.8%)	12 (11.5%)	3 (3.8%)	2 (3.8%)	0 (0%)	24.4	45.3
Iterative, recursive, and parallel thinking	90 (69.2%)	20 (19.2%)	9 (11.5%)	0 (0%)	0 (0%)	23.8	37.9
Conditional logic	95 (73.1%)	24 (23.1%)	3 (3.8%)	0 (0%)	0 (0%)	24.4	40.7
Efficiency and performance constraints	100 (76.9%)	24 (23.1%)	0 (0%)	0 (0%)	0 (0%)	24.8	43.3
Systematic debugging and error detection	95 (73.1%)	20 (19.2%)	6 (7.7%)	0 (0%)	0 (0%)	24.2	40.4

The results of data analysis on the impact of the Case-driven Flipped Classroom Model on Computational Thinking Skills show that the percentage of "very often" is the highest across all indicators (Table 12). The indicator "Efficiency and performance constraints" has the highest mean of 24.8 (*SD* = 43.3), with 76.9% of students slightly constrained in efficiency and performance. Furthermore, the lowest mean of the nine indicators is "Symbol and representation system" and "Iterative, recursive, and parallel thinking" at 23.8 (*SD* = 36.8 and *SD* = 37.9), indicating that 85% of students understand the symbol and presentation system and 90% of students already have iterative, recursive and parallel thinking.

Table 13. T-test analysis of computational thinking skill

Observations	Groups	*N*	Paired Sample T-test			
			Mean Differences	*t*	*df*	*P*
Pretest-Posttest analysis of Computational Thinking Skill instrument	Experimental	27	19.46	14.903	25	0.000
	Control	25	4.84	1.947	24	0.100
			Independent Sample T-test			
			M	*t*	*df*	*P*
Post-test comparison analysis of Computational Thinking Skill instrument	Experimental	27	64.53	16.597	49	0.000
	Control	25	49.84			

Table 13 shows a significant difference in Computational Thinking Skills between both groups [$df = 49$, $t = 16.597$, p-value = 0.00, $p < 0.05$]. The experimental group performed better than the control group in improving computational thinking skills. As a result, the treatment's impact appeared in the post-test scores after applying the Case-driven Flipped Classroom Model to the experimental group. The p-value indicates this effect; a p-value smaller than 0.05 rejects the null hypothesis. Based on these statistics, H0 is rejected, signifying a difference in post-test scores between both groups. The findings demonstrate that implementing the Case-driven Flipped Classroom Model in learning positively influences students' Computational Thinking Skills.

Through computational thinking, students can use data in case studies to analyze, process, and extract relevant information. Learning through case studies and flipped classroom models can help students develop programming logic, including understanding sequencing, branching, and looping in coding [22]. Encouraging students to think abstractly when designing solution models for the given cases helps them build modelling skills. Applying computational thinking enables students to analyze their design solutions, identify weaknesses or inefficiencies, and optimize them [71]. A flipped classroom model that relies on collaboration can help students learn in groups and practice programming skills through collaborative experiences. Students can also better understand the software development framework and how computational concepts are integrated in this process [72].

Table 14. MANCOVA analysis results

Variables	F	Mean Square	P value
Problem-solving	101,612	4215,273	0,000
Computational Thinking	118,322	1315,137	0,000

Table 14 shows the F and p-value of each variable. The MANCOVA test statistically shows significant differences. In Problem-solving [$F(1, 47) = 101.612$, $p < 0.005$], the null hypothesis was rejected, indicating a statistically significant difference in the mean score of the problem-solving test between the control group and the experimental group. There is a statistically significant difference in the outcome of Computational Thinking [$F(1, 49) = 118.322$, $p < 0.05$]. Consequently, the null hypothesis is rejected, indicating a statistically significant difference in the mean score of Computational Thinking between the control and experimental groups. The findings of the Achievement Test also indicated a statistically significant difference [$F(1, 49) = 57.135$, $p < 0.05$].

Consequently, the null hypothesis is rejected, indicating a statistically significant difference in the mean score of the Achievement Test between the control and experimental groups. These data reflect that students instructed using the Case-driven Flipped Classroom Model have higher scores on Problem-solving, Computational Thinking, and Achievement

Tests than students taught using conventional methods. This aligns with the research conducted by Aşıksoy & Sorakin [73], which explains that the cases integrated into this model allow students to apply computational concepts in real-world situations. The theoretical framework underpinning this study, grounded in Piaget's theory of cognitive development [74], supports the notion that students in the formal operational stage can engage with complex and abstract problems, enhancing their analytical, algorithmic, and logical skills through practical application. Additionally, integrating real-life cases allows students to identify, formulate, and solve computing-related problems, further reinforcing their computational thinking abilities. In a flipped classroom environment, students can develop their problem-solving skills with guidance and support from lecturers, as evidenced by the significant improvements observed in the experimental group [75].

The value of this research to both academicians and practitioners is substantial. For academicians, it provides empirical evidence on the effectiveness of integrating modern technology with innovative teaching models, contributing to the body of knowledge in educational technology and instructional design. For practitioners, the study offers a practical and user-friendly approach validated by experts and large-scale field tests, demonstrating significant improvements in student engagement and understanding.

V. Conclusion

This study presents several significant findings on implementing a case-based flipped classroom model integrated with Discord to enhance computational thinking and problem-solving skills. The research demonstrates that this model positively impacts students' understanding of the material and their learning participation, leading to increased engagement and active involvement in the learning process. The integration of Discord as a communication platform facilitates discussion and collaboration among students, thereby improving their grasp of computational concepts. Moreover, the case-based flipped classroom model effectively supports the development of students' problem-solving skills by allowing them to apply learned concepts to real-world situations.

This innovative approach introduces a novel dimension of online communication and collaboration, encouraging a holistic perspective on problem-solving that includes technical, social, ethical, and broader implications. The study contributes to the existing body of knowledge by enriching learning models for vocational education and providing empirical evidence on the effectiveness of integrating modern technology with innovative teaching methods. This research lays a strong foundation for further implementing similar models in educational settings, advancing the literature on learning innovation in higher education.

In light of these findings, the academic community is encouraged to engage in actionable, practical scholarship by adopting and adapting the Case-driven Flipped Classroom model in various educational contexts. This approach fosters a deeper understanding of computational concepts and equips students with essential problem-solving skills, preparing them for real-world challenges. By embracing this model, educators can contribute to the evolution of instructional methodologies, ensuring that learning remains dynamic, relevant, and impactful.

The study has several limitations that should be addressed in future research. Firstly, it focuses solely on the impact of the Discord-integrated Case-driven Flipped Classroom Model on computational thinking without exploring its effects on other skills. Future research should investigate the model's influence on a broader range of competencies to provide a more comprehensive understanding of its educational benefits. Additionally, the generalizability of the findings is limited due to the specific sample population used in the study. In order to enhance the robustness and applicability of the results, future studies should include a more diverse sample population and replicate the research across different higher education backgrounds and scientific interests.

Based on these limitations, the following recommendations for further research are suggested: Future studies should evaluate the impact of the Case-driven Flipped Classroom model on various skills beyond computational thinking, such as critical thinking, creativity, and collaboration. Researchers should aim to include participants from a wide range of educational backgrounds and disciplines to validate the model's effectiveness across different contexts. Conducting longitudinal studies could provide insights into the long-term effects of the model on student learning and skill development. Additionally, exploring the integration of the model with other emerging technologies could offer additional benefits and enhance the learning experience. By addressing these areas, future research can build on the current study's findings and contribute to developing innovative educational models.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Rizki Hardian Sakti: Writing – original draft, Writing – review & editing, Conceptualization, Data curation, Visualization, Sofware. Nizwardi Jalinus: Writing – review & editing, Methodology, Formal analysis, Supervision. Sukardi: Writing – review & editing, Formal analysis, Supervision, Validation. Kyaw Zay Ya: Writing – review & editing, Methodology, Data curation, Sofware, Validation. Chau Trung Tin: Writing – review & editing, Formal analysis, Software, Visualization. Rizky Ema Wulansari: Writing – review & editing, Data curation, Methodology, Project administration, Resources.

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