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Design of an Apperception Strategy to Activate Students' Prior Knowledge Using Visual Block Programming

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ABSTRACT

Purpose – This study aims to implement an Activating Prior Knowledge (APK) strategy supported by the OOPify visual block programming tool in Object-Oriented Programming (OOP) learning and to examine students' learning outcomes and learning responses following its implementation.

Methods – The study employed the Research and Development (R&D) method, consisting of preliminary study, product development, implementation, and evaluation. Data were collected through observations, interviews, Pre-Test–Post-Test assessments, and questionnaires. The data were analyzed using the Shapiro–Wilk normality test, the Wilcoxon Signed-Rank Test, Normalized Gain (N-Gain) analysis, and descriptive statistics.

Findings – The Wilcoxon Signed-Rank Test showed a statistically significant difference between the Pre-Test and Post-Test scores ($Z = -3.346$, $p = 0.001$). The N-Gain analysis indicated that students with low initial proficiency achieved the highest average N-Gain score of 0.493 (moderate category). In addition, the usability evaluation showed that OOPify obtained an overall usability score of 76.23%, indicating good usability and positive student perceptions.

Research implications – These findings provide preliminary evidence that integrating an Activating Prior Knowledge strategy with the OOPify visual block programming platform may support students' conceptual understanding and learning experiences. Because this study employed a one-group Pre-Test–Post-Test design, the observed differences should not be interpreted as definitive causal effects.

Originality – This study integrates the Activating Prior Knowledge strategy through the Know–Want to Know–Learned (KWL) approach and brainstorming activities with the OOPify visual block programming tool to support more meaningful learning of Object-Oriented Programming concepts.

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INTRODUCTION

The learning process still faces challenges in fostering deep conceptual understanding among students [1][2] In practice, students often acquire new information without connecting it to their prior knowledge, so the learning process tends to result in rote memorization rather than meaningful understanding [3][4][5]. This situation makes it difficult to integrate new concepts into students' cognitive structures and results in limited ability to apply knowledge in different contexts [6] , Meaningful learning is one of the primary goals of education because it enables students to build a deeper conceptual understanding by connecting prior knowledge with new information [7] .According to the theory of meaningful learning proposed by Ausubel [8] and Blown [9], the factor that most influences learning success is the students' pre-existing cognitive structure. Activating prior knowledge is an important strategy in the learning process because it helps students connect previously learned concepts with new material, thereby making learning more meaningful and easier to understand[10], Bellana et al. [11] and Brod et al. [12] explain that activating prior knowledge through activities that encourage students to recall and predict information before learning can increase cognitive engagement and strengthen the memory formation process. Thus, learning success is determined not only by the delivery of material but also by students' ability to build connections between prior knowledge and new concepts [13].

The importance of activating prior knowledge is increasingly relevant in Object-Oriented Programming (OOP) instruction because this subject matter is abstract, complex, and involves interrelated concepts[14][15]. Students are not only required to understand programming syntax but must also be able to grasp the relationships between concepts such as classes, objects, inheritance, encapsulation, and polymorphism—which are fundamental concepts in the Object-Oriented Programming paradigm [16][17][18] . Yamashita et al.[19] and Hijón-Neira et al.[20] also point out that students struggle to understand programming concepts because they find it difficult to visualize program workflows and the relationships between objects. Furthermore, Qi et al. [21] explain that programming instruction focused on mastering syntax tends to result in rote memorization without deep conceptual understanding. These findings indicate that Object-Oriented Programming (OOP) learning requires strategies that not only help students recall previous material but also enable them to visualize the relationships between concepts, thereby making them easier to understand [22][23].

Various studies have shown that strategies for activating prior knowledge can improve the quality of the learning process. Dong et al. [24] Ghabanchi and Behrooznia [25]applied strategies for activating prior knowledge to help students connect their prior knowledge with new material and found that these strategies increased student engagement and understanding during the learning process. Research Belouiza et al. [26] also shows that activating prior knowledge helps students build connections between concepts they have already learned and new information, thereby making learning more meaningful. However, these studies still focus on the application of activating prior knowledge as a general learning strategy and have not yet been specifically applied to programming instruction, which requires the visualization of abstract concepts.

On the other hand, various studies have also shown that visual block programming can help students understand programming concepts more easily through visual representations[27][28] . Zeevaarders & Aivaloglou [29], Leow & Huang [30] and Resnick et al.[31] through the development of Scratch, have shown that visual block programming can enhance students' motivation, creativity, and understanding of programming concepts. These findings are also supported by Hu, Chen, & Su [32] who, through a meta-analysis, found that the use of block-based visual programming such as Scratch has a positive impact on students' learning outcomes and engagement in programming education. Tsai et al.[33], Talan et al.[34] and Hu et al.[32] explain that visual block programming makes it easier for students to understand programming logic because users can arrange visual blocks without having to deal directly with complex syntax. Asakawa & Tanaka [35], Lai & Yang [36], and Kelleher & Pausch [37] also state that visual programming can lower learning barriers for beginners by shifting the focus of learning from writing syntax to understanding program logic. These findings align with those of Sobral [38] who states that block-based programming environments help beginners focus on problem-solving and program logic before moving on to writing textual syntax. However, these studies have focused more on the development of visual block programming media as a learning aid and have not yet integrated it with strategies for activating prior knowledge to help students build connections between their existing knowledge and the new concepts they are learning.

We conducted a survey and interviews with vocational high school teachers and students as a pilot study to strengthen the research foundation. The survey results showed that 42.9% of students experienced confusion when teachers posed questions at the beginning of a lesson, indicating that the students' prior knowledge had not been optimally activated. Interviews with teachers also revealed that students' low conceptual understanding was influenced by suboptimal apperception activities and a limited range of learning media capable of visualizing the relationships between concepts in Object-Oriented Programming material. These findings are consistent with research Vogt et al. [39], which states that the activation of prior knowledge supported by visual representations can help students build conceptual understanding, especially in abstract subjects. Furthermore, the teacher stated that media capable of presenting concepts visually has the potential to increase students' interest in learning while helping them understand abstract material. This is supported by research Moons & De Backer [40], which shows that a visual-based programming learning environment can help students understand programming concepts more effectively, as well as research Uysal [41], which explains that visualizing concepts in Object-Oriented Programming instruction can reduce cognitive load and improve students' understanding. Therefore, the findings of this pilot study reinforce the need to develop apperception as a method for Activating Prior Knowledge using the OOPify visual block programming medium to support Object-Oriented Programming instruction.

Based on previous studies, the activating prior knowledge strategy has been proven to enhance students' engagement and understanding during the learning process [24][26] On the other hand, the visual block programming approach has been widely used to help students understand programming concepts through simpler and more intuitive visual representations[31][32]. However, these approaches have generally been investigated separately. The preliminary study also revealed that students still experienced difficulties in understanding Object-Oriented Programming concepts due to limited activation of prior knowledge and insufficient instructional media for visualizing relationships among OOP concepts. Therefore, this study proposes a novel apperception framework that integrates the KWL strategy, brainstorming activities, and the OOPify visual block programming media into a unified instructional sequence to support meaningful Object-Oriented Programming learning. Based on the identified research gap, this study aims to develop and implement an apperception framework as an Activating Prior Knowledge (APK) strategy supported by the OOPify visual block programming media. Furthermore, this study evaluates the implementation of the proposed framework and examines changes in students' conceptual understanding, learning outcomes, and learning responses.

METHOD

This study employed the Research and Development (R&D) method using the ADDIE model developed by Branch [42]. The ADDIE model consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. This model was selected because it provides a systematic framework for developing instructional products, beginning with needs analysis and continuing through the evaluation of the developed product. The study was conducted at a vocational high school in West Java, Indonesia. Data were collected through questionnaires, as well as Pre-Test and Post-Test assessments.

Research Procedure

This study was conducted through a systematic procedure to ensure that each stage of the product development process was carried out in accordance with the research objectives. The research procedure followed the Research and Development (R&D) method using the ADDIE model, which was integrated into three main phases: the preliminary study, research and development, and documentation. The overall research procedure is illustrated in Figure 1.

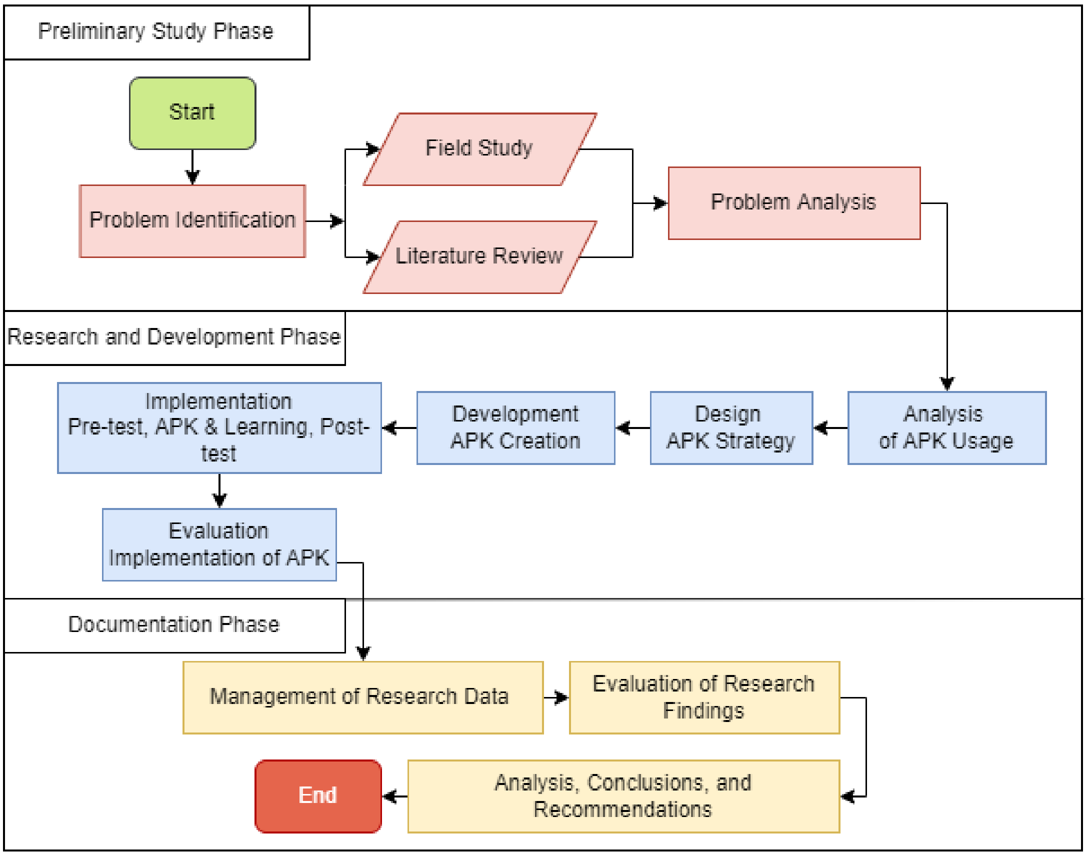

Figure 1. Research Procedure for the Apperception Framework Supported by Visual Block Programming

As shown in Figure 1, the research procedure began with the preliminary study phase, which included problem identification, a field study, and a literature review to obtain a comprehensive understanding of the existing learning conditions and instructional needs. Subsequently, the research and development phase involved the product development process based on the ADDIE model, consisting of the Analysis, Design, Development, Implementation, and Evaluation stages. The final phase was documentation, which included processing the research data, evaluating the research findings, and conducting data analysis and drawing conclusions as the basis for addressing the research objectives.

Preliminary Study Phase

The preliminary study phase was conducted through problem identification, a literature review, and a field study to obtain the information required as the basis for developing the research background and formulating the research problem. Problem identification was carried out by observing phenomena that indicated a gap between the ideal learning conditions and the actual conditions in the field, as well as determining the research focus on the effect of Activating Prior Knowledge on students' learning outcomes. Subsequently, the literature review involved examining various sources, including books, journal articles, and other relevant scholarly references, to strengthen the theoretical foundation of the study, particularly regarding the implementation of Activating Prior Knowledge during the initial stage of learning through the use of visual block programming as an instructional medium to improve learning outcomes. Meanwhile, the field study was conducted through interviews with the subject teacher and the distribution of questionnaires to students to obtain an overview of the existing learning conditions and the instructional needs that supported the implementation of the study.

Research and Development Phase

The research and development phase of this study focused on the design, development, and implementation of the Activating Prior Knowledge (APK) strategy supported by visual block programming in the learning process. This phase aimed to develop and implement an instructional framework intended to facilitate the activation of students' prior knowledge and support their learning process during Object-Oriented Programming instruction. The first stage of the research and development process was the analysis of APK implementation. At this stage, the researcher analyzed the initial learning conditions, students' characteristics, and instructional needs relevant to the learning material. This analysis included identifying students' prior knowledge, the learning difficulties they experienced, and the potential for implementing an APK strategy supported by visual block programming. The results of this analysis served as the basis for designing the APK strategy and integrating visual block programming into the learning activities.

The next stage was the design of the APK strategy. During this stage, the researcher designed the implementation procedures of the APK strategy throughout the learning process, from the introductory activities to the main learning activities. The strategy design included the formulation of apperception activities, the selection of Activating Prior Knowledge techniques (such as guiding questions, prediction activities, or preliminary discussions), and the integration of visual block programming as an instructional medium to facilitate concept visualization. The design was developed to align with the learning objectives and the intended learning outcome indicators.

After the APK strategy had been designed, the next stage was the development of the APK implementation. At this stage, the researcher developed the instructional materials required to support the implementation of the APK strategy, including lesson scenarios, student worksheets, and visual block programming materials used as learning media. This development aimed to ensure that the APK strategy could be implemented systematically and consistently throughout the learning process. The subsequent stage was the implementation of the APK strategy in classroom learning. The implementation began with the administration of a Pre-Test to determine students' initial abilities before the application of the APK strategy. The learning process was then conducted by implementing the developed Activating Prior Knowledge strategy with the support of visual block programming as an instructional medium. Upon completion of the learning activities, students were administered a Post-Test to measure changes in their learning outcomes following the implementation of the APK strategy.

The final stage was the evaluation of the APK implementation. At this stage, the researcher evaluated the effectiveness of the APK strategy based on the Pre-Test and Post-Test results, as well as observations of students' engagement and responses throughout the learning process. This evaluation aimed to determine the extent to which the implemented APK strategy was able to activate students' prior knowledge and improve their learning outcomes. Through these research and development stages, the Activating Prior Knowledge strategy developed in this study is expected to be implemented optimally in the learning process and to make a meaningful contribution to improving students' learning outcomes.

Documentation Phase

The documentation phase was carried out by organizing the research data after the product implementation and evaluation stages had been completed. The collected data were obtained from various research instruments, including student response questionnaires and the results of the learning intervention. Subsequently, the research findings were analyzed to evaluate the implementation of the developed learning media. As the final stage, conclusions were drawn, recommendations were formulated, and the research report was prepared. This phase focused on the comprehensive preparation of the final research report, covering the entire research process that had been conducted. It also included an in-depth analysis of all research findings, the formulation of conclusions that addressed the research objectives, and the development of recommendations based on the research findings and the limitations of the study.

Population and Sample

The population of this study consisted of vocational high school (SMK) students in Indonesia who were enrolled in the Object-Oriented Programming (OOP) course within the Software and Game Development (PPLG) specialization. However, considering the broad scope of the population as well as the limitations of time, cost, and research accessibility, the sample was drawn from a vocational high school in West Java Province, namely SMKN 4 Padalarang. The school was selected using purposive sampling because it offers the PPLG specialization, in which Object-Oriented Programming is part of the curriculum, making it appropriate for the purpose of this study, which was to develop and implement the OOPify visual block programming media based on the Activating Prior Knowledge strategy. In addition, the school provided access and institutional support for the research, enabling the development, implementation, and evaluation of the instructional media to be conducted effectively.

Initially, the study involved 35 students from Class XI PPLG A at SMKN 4 Padalarang. This sample size was selected because the study employed a Research and Development (R&D) approach, which focuses on product development and implementation testing within the target group rather than on generalizing the findings to the entire population. However, two students did not complete the full research procedure, as they did not participate in both the Pre-Test and Post-Test sessions. To ensure the validity of the Pre-Test–Post-Test comparison and the evaluation of the instructional intervention, only participants who completed the entire treatment sequence were included in the final data analysis. Consequently, the final analyzed sample consisted of 33 students who completed all stages of the study, including the Pre-Test, the implementation of the Activating Prior Knowledge strategy supported by the OOPify media, the Post-Test, and the completion of the questionnaires evaluating learning outcomes and students' responses to the developed instructional media.

Data Analysis

The data obtained in this study consisted of Pre-Test–Post-Test scores and students' responses to the Activating Prior Knowledge (APK) questionnaire. The quantitative data were analyzed using the Shapiro–Wilk normality test to determine whether the data met the assumption of normality. Since the data were not normally distributed, the Wilcoxon Signed-Rank Test was employed to examine whether there was a statistically significant difference in students' learning outcomes before and after the implementation of the Activating Prior Knowledge strategy supported by the OOPify visual block programming media. The effect size for the Wilcoxon Signed-Rank Test was calculated using the formula $r = |Z|/\sqrt{N}$ [43] to determine the magnitude of the observed difference. Furthermore, improvements in students' learning outcomes were analyzed using the Normalized Gain (N-Gain) to determine the magnitude of learning improvement based on the comparison between the Pre-Test and Post-Test scores. To provide a more comprehensive interpretation of the learning gains, the N-Gain analysis was also conducted based on students' initial ability levels, which were classified into high, medium, and low categories according to their Pre-Test scores. Meanwhile, the data obtained from the Activating Prior Knowledge (APK) questionnaire were analyzed descriptively using percentage statistics to describe students' responses to the implementation of the Activating Prior Knowledge strategy during the learning process.

Instruments

In this study, the instruments used for data collection consisted of a test instrument and questionnaires. The test instrument was designed to measure students' learning outcomes, while the questionnaires were used to collect data on students' responses to the implementation of the Activating Prior Knowledge (APK) strategy. Each instrument was developed based on indicators aligned with the research objectives. Research instruments are detailed in Table 1.

Table 1. Research Instrument Blueprint

Code	Instrument	Purpose	Number of Item
PR	Pre-Test	To assess students' prior knowledge	25
PO	Post-Test	To assess students' learning outcomes	25
A	Activating Prior Knowledge (APK) Questionnaire	To evaluate students' responses to the Activating Prior Knowledge strategy	10
UT	Usability Testing Questionnaire	To measure students' responses to the learning media	15

Table 1 summarizes the research instruments employed in this study along with their respective purposes and the number of items. The Pre-Test (PR) and Post-Test (PO), each consisting of 25 items, were administered to measure students' prior knowledge and learning outcomes in object-oriented programming before and after the implementation of the learning intervention. In addition, the Activating Prior Knowledge (APK) Questionnaire, comprising 10 items, was used to evaluate students' responses to the Activating Prior Knowledge strategy implemented during the learning process. To assess students' perceptions of the developed learning media, a Usability Testing (UT) Questionnaire consisting of 15 items was administered after the learning activities. Together, these instruments provided comprehensive data to evaluate students' initial knowledge, learning achievement, perceptions of the APK strategy, and the usability of the OOPify learning media.

Pre-Test (PR)

The Pre-Test (PR) instrument was used to assess students' prior knowledge before participating in learning activities that implemented apperception as an Activating Prior Knowledge strategy supported by the OOPify visual block programming media. The instrument consisted of a multiple-choice test developed based on the learning indicators of the Object-Oriented Programming (OOP) topic, enabling it to provide an overview of students' conceptual understanding prior to the instructional intervention. The blueprint of the Pre-Test instrument is presented in Table 2.

Table 2. Blueprint of the Pre-Test Instrument

Indicator	Item Numbers
Explaining the concept of Class	PR2, PR4
Explaining the concept of Object	PR1, PR10
Explaining the concept of Attribute	PR5, PR7
Explaining the concept of Method	PR3, PR6, PR8, PR9, PR11, PR13
Explaining the concept of Modifier	PR12, PR16
Explaining the concept of Encapsulation	PR14, PR15, PR17, PR18, PR19, PR20, PR21
Explaining the concept of Conditional Branching	PR22, PR23, PR24, PR25

Based on Table 2, the Pre-Test instrument consisted of 25 items developed based on seven learning indicators: the concepts of Class, Object, Attribute, Method, Modifier, Encapsulation, and Conditional Branching. Each indicator was represented by several items to comprehensively assess students' prior knowledge. The Pre-Test results were subsequently used as baseline data to measure improvements in students' learning outcomes following the instructional intervention.

Post-Test (PO)

The Post-Test (PO) instrument was used to assess students' learning outcomes after participating in learning activities that implemented apperception as an Activating Prior Knowledge strategy supported by the OOPify visual block programming media. The Post-Test was developed based on the same learning indicators as the Pre-Test to ensure that the results could be compared in order to determine improvements in students' learning outcomes. The blueprint of the Post-Test instrument is presented in Table 3.

Table 3. Blueprint of the Post-Test Instrument

Indicator	Item Numbers
Explaining the Concept of Class	PO7, PO10
Explaining the Concept of Object	PO2, PO3
Explaining the Concept of Attribute	PO4, PO5
Explaining the Concept of Method	PO1, PO6, PO8, PO9, PO11, PO12, PO13
Explaining the Concept of Modifier	PO16
Explaining the Concept of Encapsulation	PO14, PO15, PO17, PO18, PO19, PO20, PO21, PO22
Explaining the Concept of Conditional Branching	PO23, PO24, PO25

Based on Table 3, the Post-Test instrument consisted of 25 multiple-choice items developed based on the same learning indicators as the Pre-Test instrument. The use of identical indicators was intended to ensure that the assessment accurately reflected changes in students' conceptual understanding after participating in learning activities that implemented apperception as an Activating Prior Knowledge strategy supported by the OOPify visual block programming media.

Activating Prior Knowledge (APK) Questionnaire (A)

The Activating Prior Knowledge (APK) Questionnaire (A) was used to examine students' perceptions of the implementation of apperception as an Activating Prior Knowledge strategy during the learning process. This instrument was designed to evaluate the effectiveness of apperception activities in helping students activate their prior knowledge before learning new concepts. The blueprint of the Activating Prior Knowledge Questionnaire is presented in Table 4.

Table 4. Blueprint of the Activating Prior Knowledge (APK) Questionnaire

Indicator	Item Codes
Recalling Prior Knowledge or Previous Learning Experiences	A1, A7
Connecting Prior Knowledge with New Learning Material	A2, A4, A9
Enhancing Students' Focus and Readiness for Learning	A3
Supporting Students' Understanding of The Learning Material	A5, A10
Increasing Students' Self-Confidence and Learning Motivation	A6, A8

Based on Table 4, the Activating Prior Knowledge (APK) Questionnaire consisted of 10 statements grouped into five indicators: recalling prior knowledge, connecting prior knowledge with new learning material, enhancing students' focus and learning readiness, supporting students' understanding of the learning material, and increasing students' motivation and self-confidence. The data obtained from this questionnaire were used to examine students' perceptions of the implementation of apperception as an Activating Prior Knowledge strategy during the learning process.

Usability Testing Questionnaire (UT)

To evaluate students' perceptions of the developed OOPify learning media, a usability testing questionnaire was administered after the learning activities. The questionnaire was designed based on five widely recognized usability aspects: efficiency, learnability, satisfaction, errors, and memorability. It consisted of 15 statements rated using a four-point Likert scale, ranging from 1 (strongly disagree) to 4 (strongly agree). The instrument was intended to measure students' experiences in using OOPify, including its ease of use, effectiveness in supporting learning, user satisfaction, error handling, and the extent to which its interface and interaction could be remembered after use. The blueprint of the Activating Prior Knowledge Questionnaire is presented in Table 5.

Table 5. Blueprint of Usability Testing questionnaire

Usability Aspect	Code	Statement	Likert Scale (1–4)
Efficiency	UT.1	I can complete tasks or exercises quickly using OOPify.	☐ 1 ☐ 2 ☐ 3 ☐ 4
	UT.2	The time I need to understand the learning materials in OOPify is relatively short.	☐ 1 ☐ 2 ☐ 3 ☐ 4
	UT.3	OOPify's features help me achieve the learning objectives without difficulty.	☐ 1 ☐ 2 ☐ 3 ☐ 4

Usability Aspect	Code	Statement	Likert Scale (1–4)
Learnability	UT.4	I can easily understand how to use OOPify without requiring much guidance.	☐ 1 ☐ 2 ☐ 3 ☐ 4
	UT.5	The interface and menus of OOPify make it easy for me to recognize the function of each feature.	☐ 1 ☐ 2 ☐ 3 ☐ 4
	UT.6	I can quickly adapt when using OOPify for the first time.	☐ 1 ☐ 2 ☐ 3 ☐ 4
Satisfaction	UT.7	I am satisfied with using OOPify as a learning medium for Object-Oriented Programming (OOP).	☐ 1 ☐ 2 ☐ 3 ☐ 4
	UT.8	OOPify makes the learning process more enjoyable.	☐ 1 ☐ 2 ☐ 3 ☐ 4
	UT.9	I feel motivated to continue learning after using OOPify.	☐ 1 ☐ 2 ☐ 3 ☐ 4
Errors	UT.10	I rarely make mistakes while using OOPify.	☐ 1 ☐ 2 ☐ 3 ☐ 4
	UT.11	If I make a mistake, OOPify helps me recover from it easily.	☐ 1 ☐ 2 ☐ 3 ☐ 4
	UT.12	OOPify provides clear guidance when an error occurs.	☐ 1 ☐ 2 ☐ 3 ☐ 4
Memorability	UT.13	I can still remember how to use OOPify even after not using it for some time.	☐ 1 ☐ 2 ☐ 3 ☐ 4
	UT.14	The sequence of steps in OOPify is easy to remember.	☐ 1 ☐ 2 ☐ 3 ☐ 4
	UT.15	After learning to use OOPify once, I can use it again without difficulty.	☐ 1 ☐ 2 ☐ 3 ☐ 4

As presented in Table 5, each usability aspect was represented by three questionnaire items. The efficiency aspect evaluated whether OOPify enabled students to complete learning tasks effectively and within a reasonable amount of time. Learnability measured the ease with which students understood and adapted to the system during their initial use. Satisfaction assessed students' overall enjoyment and motivation when using OOPify as a learning medium. The errors aspect examined the frequency of user errors and the system's ability to provide clear guidance for recovery. Finally, memorability evaluated whether students could easily remember how to operate OOPify after a period without using it. Together, these five aspects provided a comprehensive evaluation of the usability of the developed learning media from the students' perspective.

Learning Implementation Flow of the Activating Prior Knowledge Strategy Supported by OOPify

The learning implementation was conducted over three instructional sessions involving both the teacher and the students, with the OOPify instructional media being utilized, as illustrated in Figure 2, to support the implementation of the Activating Prior Knowledge strategy in Object-Oriented Programming (OOP) learning. During the first session, the teacher administered a Pre-Test to identify students' prior knowledge, followed by the presentation of the fundamental concepts of Object-Oriented Programming and the facilitation of Student Worksheets (LKPD) activities. This stage was intended to establish a foundational understanding before implementing the Activating Prior Knowledge strategy. In the second session, the Activating Prior Knowledge framework was implemented through the integration of the KWL (Know–Want to Know–Learned) approach with brainstorming activities and case studies. Students identified their existing prior knowledge, discussed the given problems, and determined the concepts they still wished to learn. These activities were intended to connect students' prior knowledge with the new concepts to be studied. In the third session, students used the OOPify media to learn Object-Oriented Programming concepts through drag-and-drop visual block programming activities. They arranged blocks representing concepts such as Class, Constructor, Method, Modifier, Control, and Inheritance to construct correct solutions. After completing the learning activities, students completed the Learned section of the KWL chart as a learning reflection, completed the Student Worksheets (LKPD), and then took the Post-Test to measure their learning outcomes following the implementation of the instructional intervention. The overall implementation process is illustrated in Figure 2.

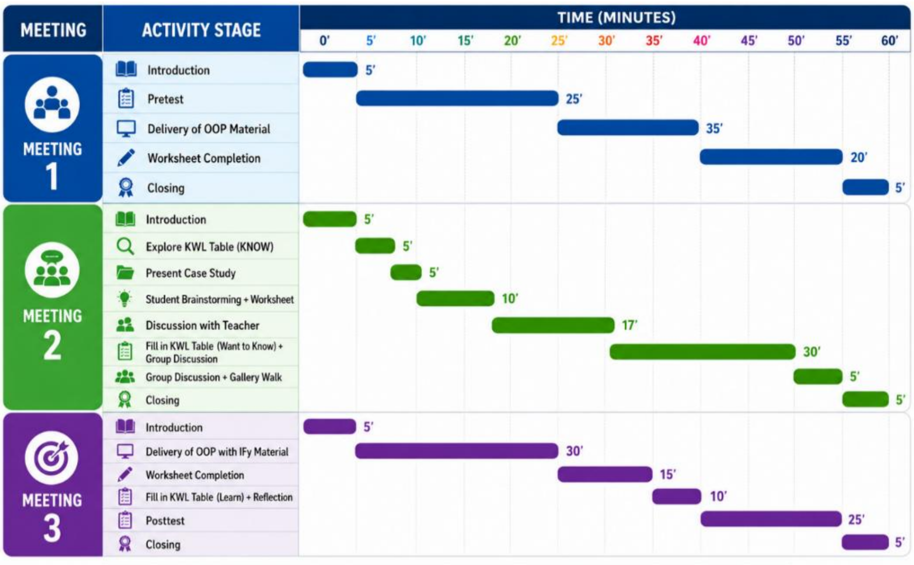

Figure 2. Implementation Flow of the Learning Framework Using the Activating Prior Knowledge Strategy

As illustrated in Figure 2, the learning implementation was conducted over three instructional sessions by applying the apperception framework as an Activating Prior Knowledge strategy supported by OOPify. During the second session, students began by completing the Know section of the KWL chart, followed by observing the given case study and participating in group brainstorming activities. The results of the group discussions were then communicated with the teacher to obtain conceptual clarification, after which students completed the Want to Know section before proceeding to further group discussions. Subsequently, during the third session, students continued the learning process using OOPify, completed the Student Worksheets (LKPD), and reflected on their learning by filling in the Learned section of the KWL chart before taking the Post-Test.

Development of OOPify

OOPify was developed as the instructional media produced in this study to support the learning of Object-Oriented Programming (OOP) through a visual block programming approach. The media was designed with an emphasis on presenting OOP concepts through interactive visual representations, enabling students to more easily understand the relationships among abstract concepts. The user interface and the main features of the developed OOPify media are presented in Figure 3.

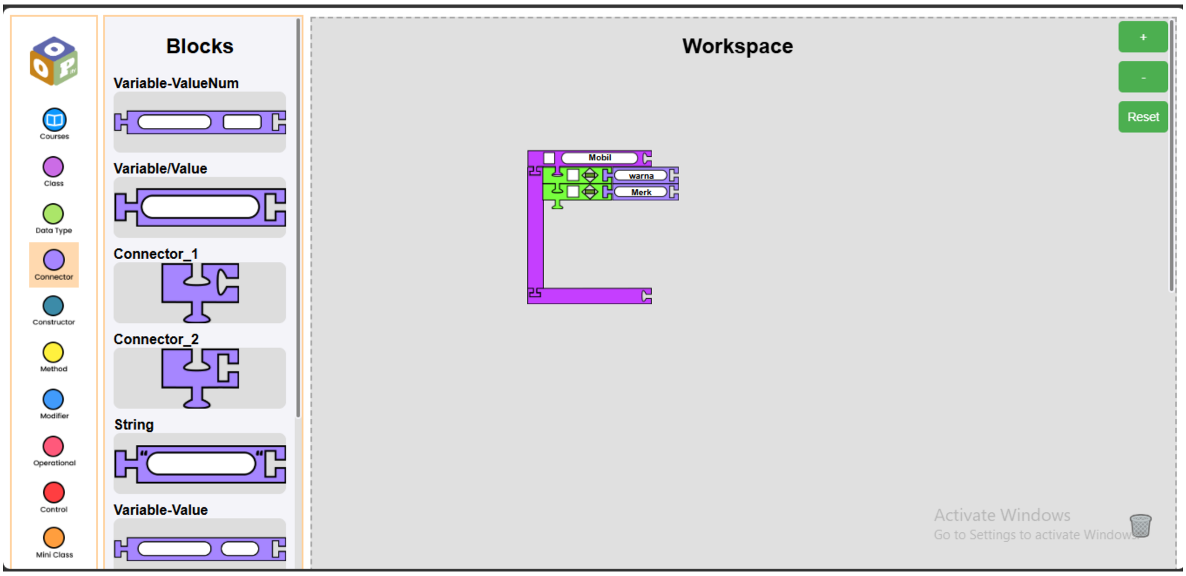

Figure 3. Initial Dashboard Interface of OOPify

As illustrated in Figure 3 OOPify [44] was developed as a visual block programming-based instructional tool designed to help students understand the fundamental concepts of Object-Oriented Programming (OOP) in a more concrete manner. The media presents programming concepts through visual blocks that can be arranged using a drag-and-drop mechanism, enabling students to focus more on the relationships among concepts rather than on writing programming syntax. The concepts represented in OOPify include Class, Constructor, Method, Modifier, Control, and Inheritance, which constitute the core topics of Object-Oriented Programming instruction. This visual approach is expected to support students in gradually developing their conceptual understanding while reducing the learning difficulties that commonly arise when studying the abstract concepts of OOP.

Implementation of the Activating Prior Knowledge Framework

As part of the instructional implementation, this study developed an Activating Prior Knowledge (APK) framework that integrates the KWL (Know–Want to Know–Learned) strategy, brainstorming activities, and the OOPify visual block programming media into a systematic instructional sequence. The framework was designed to help students activate their prior knowledge before learning new concepts, thereby making the learning process more structured and meaningful. Each stage of the framework was designed to encourage students to establish connections between their existing knowledge and the Object-Oriented Programming (OOP) concepts to be learned. The implementation flow of the Activating Prior Knowledge framework supported by OOPify used in this study is illustrated in Figure 4.

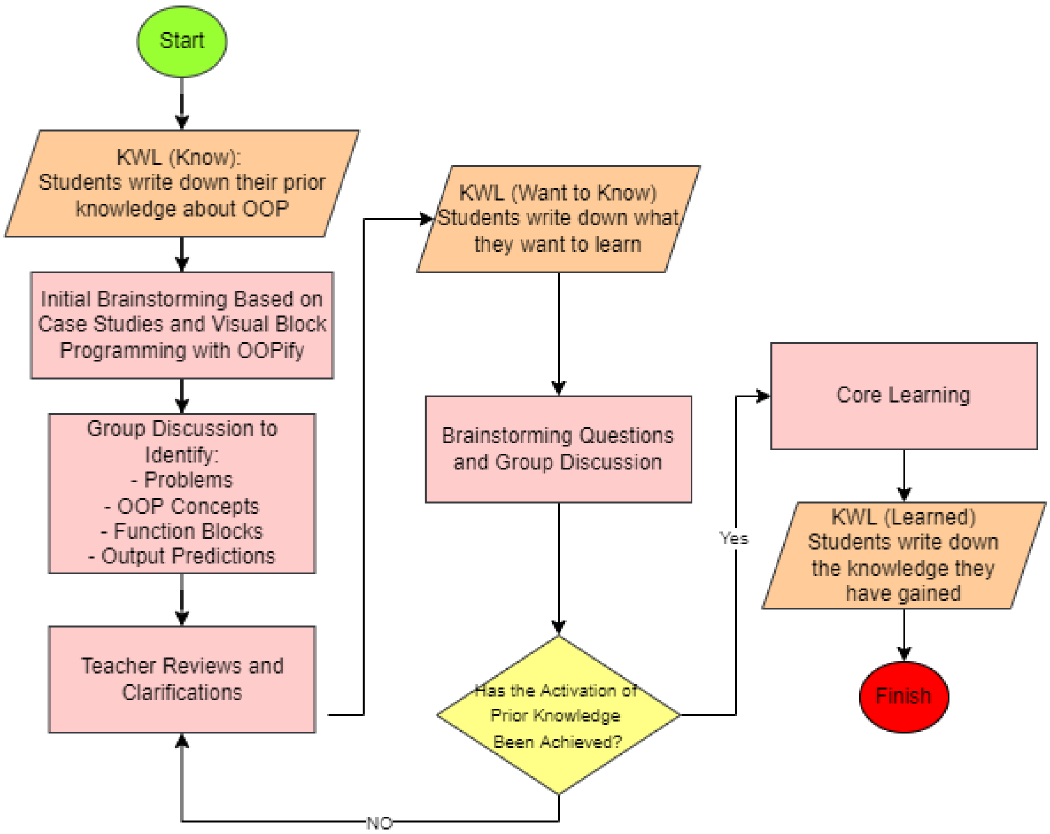

Figure 4. Framework of Apperception as an Activating Prior Knowledge Strategy Supported by OOPify

As illustrated in Figure 4 the apperception framework as an Activating Prior Knowledge strategy was designed by integrating the KWL (Know–Want to Know–Learned) strategy, brainstorming activities, and the OOPify visual block programming media. The learning process began with the Know stage, during which students documented their prior knowledge related to Object-Oriented Programming (OOP). Subsequently, through brainstorming activities based on case studies and supported by the OOPify visual block programming media, students worked collaboratively in groups to identify problems, recognize OOP concepts, determine the functions of the visual blocks, and predict the program output. The discussion outcomes were then reviewed and clarified by the teacher to ensure that students had developed an accurate conceptual understanding. Next, students proceeded to the Want to Know stage, where they identified the concepts they wished to learn in greater depth. This stage was followed by question-based brainstorming and group discussions. Once students' prior knowledge had been successfully activated, the learning process continued to the main instructional activities. At the end of the lesson, students completed the Learned section of the KWL chart by documenting the new knowledge they had acquired as a reflection on their learning outcomes.

RESULTS AND DISCUSSION

Descriptive Statistics of the Pre-Test and Post-test

Descriptive statistical analysis was conducted to provide an overview of students' learning outcomes before and after the implementation of the Activating Prior Knowledge strategy supported by the OOPify visual block programming media. The descriptive statistics presented include the sample size, mean, median, mode, standard deviation, minimum score, maximum score, and score range. These statistics provide a general description of the characteristics of the Pre-Test and post-test data prior to conducting inferential statistical analysis. The results of the descriptive statistical analysis of the Pre-Test and Post-Test scores are presented in Table 6.

Table 6. Descriptive Statistics of the Pre-Test and Post-test

Statistic	Pre-Test	Post-Test
Sample Size (N)	33	33
Mean	72.48	79.64
Median	76.00	80
Mode	76	88
Standard Deviation	13.37	11.46
Minimum	36	48
Maximum	92	100

Table 6 presents the descriptive statistics of the Pre-Test and post-test scores obtained from 33 students. The results indicate an increase in students' learning performance after the implementation of the activating prior knowledge strategy supported by OOPify. The mean score increased from 72.48 in the Pre-Test to 79.64 in the post-test, while the median increased from 76.00 to 80.00. Similarly, the mode shifted from 76 in the Pre-Test to 88 in the Post-Test, indicating that the most frequently achieved score was higher after the intervention. Furthermore, the post-test scores exhibited a lower standard deviation (SD = 11.46) than the Pre-Test (SD = 13.37), suggesting that students' learning outcomes became more homogeneous following the intervention. The score range also shifted upward, with the minimum score increasing from 36 to 48 and the maximum score rising from 92 to 100. Overall, these descriptive statistics indicate an improvement in students' learning outcomes after the learning intervention, although inferential statistical analysis is required to determine whether the observed improvement is statistically significant.

Development of the Activating Prior Knowledge Framework Supported by OOPify

The development of the apperception framework as an Activating Prior Knowledge (APK) strategy was conducted to provide a structured learning sequence that facilitates the activation of students' prior knowledge before introducing new Object-Oriented Programming (OOP) concepts. The framework was designed by integrating several instructional components that complement one another, enabling students to recall their existing knowledge, express their initial understanding, and gradually construct new concepts through interactive learning activities. The development process of the framework is illustrated in Figure 2. The framework integrates the KWL strategy, brainstorming activities, and the use of the OOPify visual block programming media to help students meaningfully connect their prior knowledge with newly acquired concepts. Through this sequence, students are encouraged not only to recall what they already know but also to identify what they want to learn and reflect on the knowledge they have gained at the end of the learning process.

Development of the OOPify Media

To support the implementation of the proposed Activating Prior Knowledge framework, the OOPify visual block programming media was developed as an instructional tool capable of representing abstract Object-Oriented Programming concepts in a more concrete and interactive form. The media was designed to reduce students' difficulties in understanding the relationships among OOP concepts by providing visual representations that can be manipulated directly during learning activities. The OOPify media, introduced in Figure 3, was developed by providing visual blocks that represent fundamental Object-Oriented Programming (OOP) concepts, including Class, Constructor, Method, and Encapsulation. The media is also equipped with a workspace, course modules, and a drag-and-drop mechanism that enables students to visualize the relationships among concepts in a more concrete and interactive manner. These features support students in constructing program structures while reinforcing their conceptual understanding through visual exploration rather than relying solely on textual programming syntax.

Recapitulation of the Research Data

The research data were collected through the implementation of learning activities that applied apperception as an Activating Prior Knowledge strategy supported by the OOPify visual block programming media. The data were obtained from the research instruments, including achievement tests and questionnaires. All collected data were subsequently compiled as the basis for the analysis to evaluate improvements in students' learning outcomes, the feasibility of the developed instructional media, and students' and teachers' responses to the implementation of the learning process. The recapitulation of the research data obtained from each instrument is presented in the following tables.

Pre-Test (PR) and Post-Test (PO) Data

The Pre-Test (PR) and Post-Test (PO) data were obtained from assessments administered to 33 students before and after the implementation of learning using apperception as an Activating Prior Knowledge strategy supported by the OOPify visual block programming media. The Pre-Test data were used to determine students' prior knowledge, whereas the Post-Test data were used to measure their learning outcomes after participating in the instructional intervention. The recapitulation of the Pre-Test and Post-Test scores for each participant is presented in Table 7.

Table 7. Pre-test (PR) and Post-test (PO) Data

Respondent	Pre-Test Correct Answers	Post-Test Correct Answers	N-Gain
R1	92	96	0.500
R2	92	92	0.000
R3	92	88	-0.500
R4	84	84	0.000
R5	80	88	0.400
R6	80	88	0.400
R7	80	52	-1.400
R8	80	88	0.400
R9	80	88	0.400
R10	80	64	-0.800
R11	80	88	0.400
R12	76	84	0.333
R13	76	84	0.333

Respondent	Pre-Test Correct Answers	Post-Test Correct Answers	N-Gain
R14	76	80	0.167
R15	76	88	0.500
R16	76	92	0.667
R17	76	84	0.333
R18	76	76	0.000
R19	76	76	0.000
R20	76	76	0.000
R21	72	80	0.286
R22	72	84	0.429
R23	72	68	-0.143
R24	68	76	0.250
R25	68	100	1.000
R26	68	64	-0.125
R27	68	72	0.125
R28	64	72	0.222
R29	64	72	0.222
R30	56	80	0.545
R31	40	80	0.667
R32	40	48	0.133
R33	36	76	0.625

Based on Table 7, the Pre-Test and Post-Test scores of each participant are presented to compare students' learning outcomes before and after the instructional intervention. Presenting both sets of scores in a single table facilitates the comparison of individual learning performance. The Pre-Test and Post-Test data were subsequently used as the basis for descriptive and inferential statistical analyses to examine changes in students' learning outcomes following the implementation of apperception as an Activating Prior Knowledge strategy supported by the OOPify visual block programming media.

Activating Prior Knowledge (APK) Questionnaire Data

The data from the Activating Prior Knowledge (APK) Questionnaire were collected after students had participated in the learning activities that implemented apperception as an Activating Prior Knowledge strategy. These data were used to investigate students' perceptions of the effectiveness of the apperception activities in supporting the learning process. The recapitulation of the Activating Prior Knowledge Questionnaire data is presented in Table 8.

Table 8. Activating Prior Knowledge (APK) Questionnaire Data

Respondent	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
R1	4	4	4	4	4	3	4	3	4	4
R2	4	4	4	4	4	4	4	4	4	4
R3	4	4	3	4	4	4	4	4	4	4
R4	4	4	4	4	4	4	4	4	4	4
R5	4	3	3	4	4	4	4	4	4	4
R6	3	4	3	2	3	4	2	2	3	3

Respondent	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10
R7	4	4	4	4	4	4	4	4	4	4
R8	4	4	3	4	3	3	3	2	3	3
R9	4	3	4	4	4	3	4	4	4	4
R10	4	4	4	4	4	4	4	4	4	4
R11	3	2	3	3	3	3	3	3	2	2
R12	4	4	3	4	4	3	3	3	3	3
R13	4	4	2	4	3	4	3	4	4	4
R14	4	4	4	4	4	3	4	4	4	3
R15	4	4	4	4	4	4	4	4	4	4
R16	4	4	3	3	4	4	3	4	4	4
R17	4	4	4	4	4	4	4	4	4	4
R18	4	3	3	4	3	3	4	3	3	3
R19	4	4	3	4	3	3	4	3	4	4
R20	4	3	3	4	3	2	3	3	4	3
R21	4	4	4	4	3	4	4	4	4	4
R22	4	4	4	4	4	4	4	4	4	4
R23	3	3	2	3	3	3	4	3	3	3
R24	4	3	3	4	3	3	3	3	3	3
R25	4	4	4	4	4	2	4	3	4	4
R26	3	4	3	3	4	3	4	3	4	3
R27	4	4	4	4	4	4	4	4	4	4
R28	4	4	2	3	3	4	2	4	4	2
R29	4	4	4	4	4	3	4	4	4	4
R30	4	4	4	4	4	4	4	4	4	4
R31	3	2	3	3	3	2	3	3	3	3
R32	4	4	4	4	4	4	4	4	4	4
R33	4	4	4	4	3	4	4	1	1	2

Based on Table 8, the questionnaire results present the scores for each indicator related to the implementation of apperception as an Activating Prior Knowledge strategy. These data provide an overview of students' perceptions regarding the implementation of apperception activities throughout the learning process. To facilitate the interpretation of students' responses, the Activating Prior Knowledge (APK) questionnaire results were summarized according to the five APK indicators. The percentage score for each indicator is presented in Table 9.

Table 9. Descriptive Results of the Activating Prior Knowledge (APK) Questionnaire

APK Indicator	Item Codes	Percentage (%)	Interpretation
Recalling Prior Knowledge or Previous Learning Experiences	A1, A7	93.56	Very Good
Connecting Prior Knowledge with New Learning Material	A2, A4, A9	92.42	Very Good
Enhancing Students' Focus and Readiness for Learning	A3	85.61	Very Good
Supporting Students' Understanding of the Learning Material	A5, A10	89.02	Very Good
Increasing Students' Self-Confidence and Learning Motivation	A6, A8	86.36	Very Good
Overall	A1–A10	90.08	Very Good

Table 9 summarizes the descriptive results of the Activating Prior Knowledge (APK) questionnaire based on the five indicators of the instrument. Overall, students reported highly positive perceptions toward the implementation of the APK strategy, with an overall percentage score of 90.08%, which falls into the very good category. The highest percentage was obtained for the indicator Recalling Prior Knowledge or Previous Learning Experiences (93.56%), followed by Connecting Prior Knowledge with New Learning Material (92.42%). The remaining indicators also achieved high scores, namely Supporting Students' Understanding of the Learning Material (89.02%), Increasing Students' Self-Confidence and Learning Motivation (86.36%), and Enhancing Students' Focus and Readiness for Learning (85.61%). These findings describe students' positive perceptions of the implementation of the APK strategy during the learning process and should not be interpreted as evidence of causal effectiveness.

Usability Testing Questionnaire (UT) Data

The usability testing questionnaire was administered after students completed the learning activities using OOPify to evaluate their perceptions of the developed learning media. The questionnaire consisted of 15 statements distributed across five usability aspects: Efficiency, Learnability, Satisfaction, Errors, and Memorability. Students responded to each statement using a four-point Likert scale, where 1 = Strongly Disagree, 2 = Disagree, 3 = Agree, and 4 = Strongly Agree. Table 10 presents the response frequency for each questionnaire item, along with the percentage score calculated for each usability aspect and the overall usability score. The usability testing questionnaire was completed by 34 students. This number is one higher than the 33 students included in the Pre-Test–Post-Test analysis, because one additional student was absent during the Post-Test session due to a permitted absence and was therefore excluded from the Pre-Test–Post-Test and N-Gain analyses, but was present and completed the usability questionnaire on a different occasion. Accordingly, the usability results reported in Table 10 are based on N = 34, independent of the N = 33 sample used for the learning-outcome analysis.

Table 10. Usability Testing Questionnaire (UT) Data

Usability Aspect	Code	Response Frequency (Likert Score)				Percentage (%)
		1	2	3	4	
	UT.1	1	8	18	7	
Efficiency	UT.2	1	10	15	8	74.75%
	UT.3	1	4	17	12	
	UT.4	4	13	9	8	
Learnability	UT.5	0	4	11	19	76.23%
	UT.6	0	8	15	11	
	UT.7	0	1	16	17	
satisfaction	UT.8	0	3	12	19	86.52%
	UT.9	0	4	11	19	
	UT.10	7	15	5	7	
Errors	UT.11	0	8	17	9	69.61%
	UT.12	1	8	16	9	
	UT.13	1	7	17	9	
Memorability	UT.14	0	7	16	11	74.02%
	UT.15	2	11	14	7	
Mean						76.23%

Based on Table 10, the usability evaluation of OOPify visual block programming media was analyzed based on five attributes proposed by Nielsen[45]: efficiency, learnability, satisfaction, errors, and memorability, with interpretation categories adapted from Riduwan[46]. The results show that OOPify achieved an overall usability score of 76.23%, indicating a good usability level. The satisfaction aspect obtained the highest score (86.52%), indicating that students had positive experiences and perceived OOPify as an engaging learning medium. The learnability aspect reached 76.23%, showing that students could easily understand the use of OOPify for learning Object-Oriented Programming concepts. Meanwhile, the efficiency and memorability aspects obtained scores of 74.75% and 74.02%, respectively, suggesting that the media was sufficiently effective and easy to remember after use. The errors aspect received the lowest score (69.61%), indicating that some students still encountered difficulties when arranging blocks or understanding certain functions. Overall, the findings indicate that OOPify provides a positive usability experience and can support students in understanding abstract Object-Oriented Programming concepts through visual representations.

Learning Outcomes

The analysis of students' learning outcomes began with a normality test to determine whether the Pre-Test and Post-Test scores met the assumptions required for parametric statistical analysis. Because the sample consisted of 33 students, the Shapiro–Wilk test was used to assess the normality of the data. The results are presented in Table 11.

Table 11. Shapiro–Wilk Normality Test Results

Variable	Statistic (W)	df	p-value	Interpretation
Pre-Test	0.847	33	0.000	Not normally distributed
Post-Test	0.935	33	0.048	Not normally distributed

Table 11 summarizes the Shapiro–Wilk normality test results for the Pre-Test and Post-Test scores. Both the Pre-Test ($W = 0.847$, $p < 0.001$) and Post-Test ($W = 0.935$, $p = 0.048$) yielded p-values below 0.05, indicating that the data were not normally distributed. Consequently, the Wilcoxon Signed-Rank Test was employed for the subsequent analysis of students' learning outcomes.

Wilcoxon Signed-Rank Test Results

The Wilcoxon Signed-Rank Test showed a statistically significant difference between students' Pre-Test and Post-Test scores ($Z = -3.346$, $p = 0.001$). Among the 33 participants, 23 students achieved higher Post-Test scores than their Pre-Test scores, five students obtained lower Post-Test scores, and five students showed no change. The effect size was large ($r = 0.58$), indicating that the observed difference between the Pre-Test and Post-Test scores was substantial. These findings indicate a statistically significant difference in students' learning outcomes following the implementation of the Activating Prior Knowledge strategy supported by OOPify.

Comparison of the Pre-Test and Post-Test Histograms

Before analyzing the improvement in students' learning outcomes using the Normalized Gain (N-Gain), the distributions of the Pre-Test and Post-Test scores were visually examined to observe changes in the score distribution patterns following the implementation of the instructional media. The distributions were visualized using histograms complemented by Kernel Density Estimation (KDE) curves to provide a clearer representation of the overall data distribution. The histograms of the Pre-Test and Post-Test score distributions are presented in Figure 5.

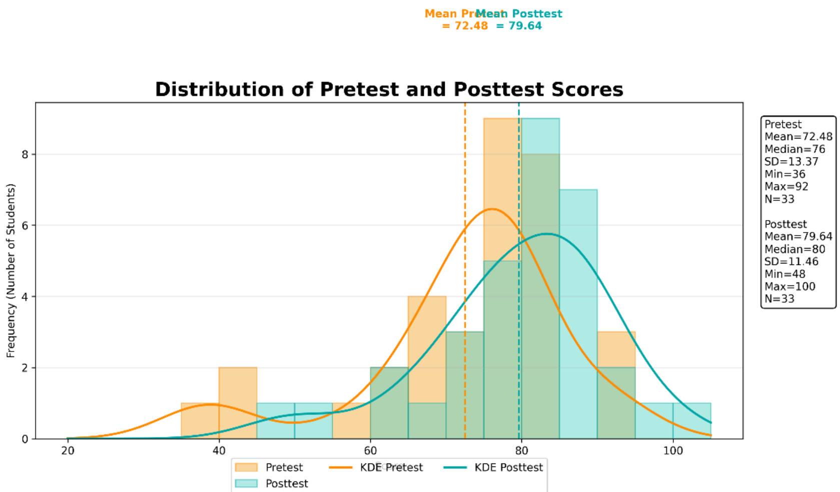

Figure 5. Histogram of the Pre-Test and Post-Test Score Distributions

Figure 5 illustrates the distribution of students' Pre-Test and Post-Test scores following the implementation of the activating prior knowledge strategy supported by OOPify. The Post-Test distribution is shifted toward higher scores than the Pre-Test distribution, indicating an overall improvement in students' learning performance. The mean score increased from 72.48 on the Pre-Test to 79.64 on the Post-Test, while the median also increased from 76 to 80. In addition, the Post-Test scores exhibited a slightly lower standard deviation (SD = 11.46) than the Pre-Test (SD = 13.37), suggesting a more consistent distribution of learning outcomes after the intervention. Overall, the histogram and KDE curves indicate a positive shift in students' performance, although the magnitude of improvement varied across individuals.

N-Gain Analysis

To provide a more comprehensive evaluation of students' learning improvement, the N-Gain analysis was conducted based on students' initial proficiency levels. Students were classified into three groups according to their Pre-Test scores using the mean (72.48) and standard deviation (13.37). The classification criteria were as follows:

- High initial proficiency: Pre-Test score > 72.48 + 13.37.
- Medium initial proficiency: 72.48+ 13.37≥ Pre-Test score ≥ 72.48- 13.37
- Low initial proficiency: Pre-Test score< 72.48- 13.37.

The descriptive statistics of each subgroup are presented in Table 12.

Table 12. N-Gain Analysis Based on Students' Initial Proficiency

Initial Proficiency	Statistic	Pre-Test	Post-Test	N-Gain
High	Mean	92	92	0.000
	Standard Deviation	0	4.0	0.500
	Maximum	92	96	0.500
	Minimum	92	88	-0.500
Medium	Mean	75	80	0.169
	Standard Deviation	5.4	10	0.456
	Maximum	84	100	1.000
	Minimum	64	52	-1.400
Low	Mean	43	71	0.493
	Standard Deviation	8.9	15	0.245
	Maximum	56	80	0.667
	Minimum	36	48	0.133

As presented in Table 12, students with low initial proficiency achieved the highest learning improvement, with an average N-Gain score of 0.493, which falls into the moderate category. Their mean score increased from 43 on the Pre-Test to 71 on the Post-Test. Students with medium initial proficiency obtained an average N-Gain score of 0.169, which falls into the low category, while students with high initial proficiency showed the lowest improvement, with an average N-Gain score of 0.000. These findings indicate that the proposed apperception framework supported by OOPify was particularly beneficial in facilitating learning gains among students with lower initial proficiency. To further illustrate the overall distribution of students' learning gains, the N-Gain scores were visualized using a histogram curve, as presented in Figure 6.

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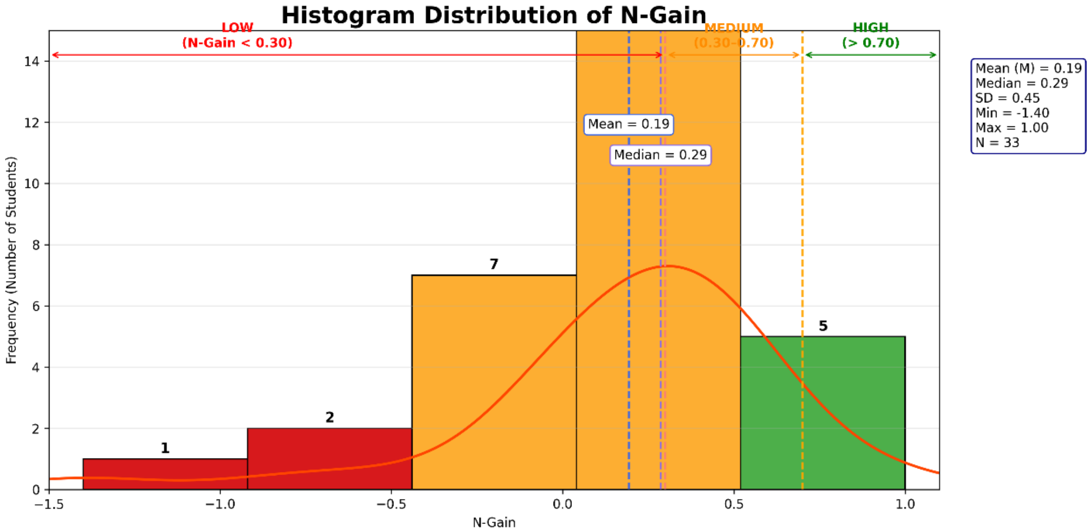

Figure 6. N-Gain Analysis Based on Students' Initial Ability Categories

Figure 6 presents the distribution of students' N-Gain scores following the implementation of the activating prior knowledge strategy supported by OOPify. The average N-Gain was 0.19, with a median of 0.29, indicating that the overall improvement in learning outcomes remained in the low category. Nevertheless, the distribution shows that most students achieved positive N-Gain scores, with the highest concentration within the 0.00–0.70 range, while only a few students experienced negative gains or reached the high-gain category (N-Gain > 0.70). These findings suggest that the intervention contributed to learning improvement for most students, although the magnitude of the improvement varied across individuals.

Discussion

The findings suggest that the implementation of apperception as an Activating Prior Knowledge strategy supported by the OOPify visual block programming media may have helped students connect their prior knowledge with new concepts, thereby making the learning process more meaningful [47][48][49]. Through the KWL (Know–Want to Know–Learned) strategy and brainstorming activities supported by OOPify's visualizations, students were provided with opportunities to activate their existing knowledge before learning new material. These findings are consistent with previous studies [50], which reported that activating prior knowledge enhances students' engagement in the learning process, as well as studies by Mladenović (2020) [51], which demonstrated that visual block programming facilitates the understanding of programming concepts through more concrete visual representations.

Based on the N-Gain analysis, the greatest improvement in learning outcomes was observed among students in the low initial proficiency group, with an average N-Gain score of 0.493, which falls within the moderate category. Students in the medium initial proficiency group obtained an average N-Gain score of 0.169, while students in the high initial proficiency group showed little improvement (N-Gain = 0.000). These findings indicate that students with lower prior knowledge experienced greater learning gains following the implementation of the learning activities. Nevertheless, because this study employed a one-group Pre-Test–Post-Test design, these differences should be interpreted as observed patterns rather than evidence of differential causal effects across ability groups.

The usability questionnaire results indicated that students generally reported positive perceptions of the OOPify visual block programming media. The overall usability score reached 76.23%, indicating a good level of usability. Among the five usability aspects, Satisfaction obtained the highest percentage (86.52%), suggesting that students found the learning media engaging and enjoyable to use during the learning process. The Learnability aspect achieved 76.23%, indicating that students were generally able to understand how to use OOPify with relative ease. Meanwhile, the Efficiency (74.75%) and Memorability (74.02%) aspects also received positive ratings, suggesting that students perceived the media as reasonably efficient to use and relatively easy to remember after learning activities. The Errors aspect obtained the lowest percentage (69.61%), indicating that some students still experienced minor difficulties while interacting with certain features of the media. Overall, these findings indicate that students reported positive perceptions of OOPify as a learning medium supporting the implementation of the Activating Prior Knowledge strategy. However, the usability results reflect students' perceptions of the developed media rather than objective evidence of its instructional effectiveness.

The Activating Prior Knowledge (APK) questionnaire also showed positive responses across all five indicators, with an overall percentage of 90.08% (Very Good). The highest score was obtained for the indicator "Recalling Prior Knowledge or Previous Learning Experiences" (93.56%), followed by "Connecting Prior Knowledge with New Learning Material" (92.42%). These findings indicate that students positively perceived the implementation of the Activating Prior Knowledge activities throughout the learning process. However, these questionnaire results represent students' perceptions of the learning activities rather than objective evidence of instructional effectiveness.

The findings of this study suggest that implementing apperception as an Activating Prior Knowledge strategy may serve not only as an introductory learning activity but also as an instructional approach for helping students establish connections between their existing knowledge and newly learned concepts. While the Wilcoxon Signed-Rank Test indicated a statistically significant difference between the Pre-Test and Post-Test scores, the N-Gain analysis revealed that students with lower prior knowledge achieved greater learning gains, suggesting that this strategy may provide stronger instructional scaffolding for students who experience difficulties in understanding Object-Oriented Programming concepts. This finding is consistent with Bittermann [52], who explained that prior knowledge is one of the primary predictors of successful learning because it enables students to organize new information within their existing knowledge structures. Furthermore, Hattan et al. [50], through a systematic review, reported that the effectiveness of prior knowledge activation depends on the activation strategies employed, such as the use of visual representations, analogies, and open-ended questions that encourage students to relate their previous experiences to new learning material. Schumacher and Stern also demonstrated that cognitively activating instruction enhances conceptual understanding by promoting prior knowledge activation and active knowledge construction[53]. In addition, Witherby and Carpenter [3]. found that students with stronger prior knowledge generally achieve better learning outcomes because they are more capable of integrating new information effectively. Collectively, these findings support the results of the present study, indicating that implementing apperception supported by the OOPify visual block programming media may provide students with opportunities to connect previously understood concepts with new knowledge, thereby making the learning process more meaningful.

From the perspective of instructional media, the findings of this study are consistent with previous research demonstrating that visual block programming may support students in understanding programming concepts, particularly during the early stages of learning. The use of OOPify may enable students to focus on the relationships among classes, objects, attributes, and methods without being burdened by the complexity of programming syntax. These findings are consistent with the meta-analysis conducted by Hu et al.[32], which reported that block-based visual programming has a positive effect on programming learning outcomes across various educational levels, with its effectiveness influenced by learner characteristics, the type of instructional media, and instructional design. Furthermore, Dan Sun et al. found that block-based programming enhances students' computational thinking skills, programming behaviors[54], and positive attitudes because learners are able to concentrate more on problem-solving logic rather than syntax writing. Similarly, Batni et al.[55], through a systematic review, concluded that the use of Scratch and other visual block programming environments consistently improves students' understanding of fundamental programming concepts, creativity, learning motivation, problem-solving skills, and self-efficacy. In addition, Sonjaya and Munir [56] reported that visual block programming positively influences programming learning outcomes by helping students understand algorithmic logic through more concrete visual representations. These findings are further supported by the systematic review conducted by Strong et al.[57], which concluded that block-based programming environments function as instructional scaffolding, facilitating students' transition to text-based programming through the visualization of relationships among program components. Therefore, the findings of the present study suggest that integrating the Activating Prior Knowledge strategy with OOPify not only may help students connect their prior knowledge with newly learned concepts but also provides visual representations that support a gradual understanding of Object-Oriented Programming concepts. Taken together with the statistically significant difference observed in the Wilcoxon Signed-Rank Test and the positive responses from students, the findings suggest that OOPify has considerable potential as an instructional medium for facilitating knowledge construction and supporting students' conceptual understanding of Object-Oriented Programming.

This study has several limitations that should be considered when interpreting the findings. First, the sample consisted of only 33 students from a single class, limiting the generalizability of the results to a broader population. Second, the relatively short implementation period and the use of a one-group Pre-Test–Post-Test design without a control group may have prevented the full implementation of the Activating Prior Knowledge strategy supported by OOPify from being comprehensively evaluated. Therefore, the observed differences in learning outcomes cannot be attributed solely to the implementation of OOPify and the Activating Prior Knowledge strategy, as other factors such as maturation, repeated testing, teacher influence, and classroom experiences may also have contributed to the observed outcomes. Another limitation concerns the Pre-Test and Post-Test instruments, which consisted of two non-identical 25-item forms. Although both forms were developed based on the same seven conceptual indicators, the number of items representing each indicator was not identical between the two forms (e.g., the Method indicator contained six items in the Pre-Test and seven in the Post-Test, while the Encapsulation indicator contained seven and eight items, respectively).

Consequently, part of the observed score change may be attributable to differences in item distribution and difficulty between the two forms rather than solely to the instructional intervention. Furthermore, the OOPify media and the research instruments were developed based on relevant literature and reviewed internally by the researcher and supervising lecturers, but they did not undergo a formal expert-validation process involving independent media and material experts. As a result, the extent to which the media and instruments meet formal validity standards prior to implementation cannot be fully ascertained. Furthermore, the subgroup analysis based on students' initial proficiency should be interpreted cautiously because grouping participants according to their Pre-Test scores may introduce regression-to-the-mean effects. In addition, this study focused primarily on cognitive learning outcomes and did not evaluate its effects on computational thinking, problem-solving skills, or students' cognitive load. Therefore, future research is recommended to involve a larger sample size, employ an experimental design with a control group, extend the duration of the instructional intervention, establish parallel-form equivalence between Pre-Test and Post-Test instruments through item-difficulty and discrimination analysis, conduct formal expert validation of the instructional media and instruments prior to implementation, and incorporate assessments of computational thinking, problem-solving, and cognitive load, as recommended by Qi et al. [21], Huda et al. [44], Vinueza-Morales et al. [27], and Talan et al. [34]. Such improvements would enable a more comprehensive evaluation of the implementation and potential of the Activating Prior Knowledge strategy supported by visual block programming across different educational contexts.

CONCLUSION

This study successfully developed and implemented an Activating Prior Knowledge strategy supported by the OOPify visual block programming media for teaching Object-Oriented Programming (OOP). The instructional implementation integrated the KWL (Know–Want to Know–Learned) strategy, brainstorming activities, and the use of OOPify to support students in connecting their prior knowledge with new concepts in a more structured manner. The usability evaluation indicated positive student perceptions of OOPify, particularly in the satisfaction aspect, suggesting that students perceived the developed media as engaging, easy to use, and supportive of learning Object-Oriented Programming concepts. Based on the learning outcome analysis, the findings provide preliminary evidence that the implementation of the Activating Prior Knowledge strategy supported by OOPify was associated with statistically significant differences between the Pre-Test and Post-Test scores, as indicated by the Wilcoxon Signed-Rank Test. Furthermore, the N-Gain analysis showed that students with lower prior knowledge exhibited the highest average learning gains within the moderate category. However, because this study employed a one-group Pre-Test–Post-Test design and the subgroup analysis was based on Pre-Test score classifications, these findings should be interpreted as observed patterns rather than evidence of differential causal effects across ability groups. Future research is therefore recommended to involve a larger sample size, extend the duration of the instructional intervention, and employ an experimental design with a control group to provide stronger evidence regarding the implementation and educational potential of the proposed instructional strategy and learning media.

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AUTHOR CONTRIBUTION STATEMENT

AS Conceptualization, methodology, software development, investigation, data collection, formal analysis, visualization, and writing-original draft preparation. JK Investigation, data collection, software development support, and writing-review and editing. MV Methodology support, formal analysis, visualization, and writing-review and editing. LR Supervision, methodology review, and writing-review and editing. All authors have read and approved the final version of the manuscript**.**

AI DISCLOSURE STATEMENT

The author used ChatGPT (OpenAI) during the preparation of this work for language editing and translation purposes. After using the tool, the author thoroughly reviewed and edited the content as needed and takes full responsibility for the content of the publication.

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