

Implementation of “Bit and Seeds” Game-Based Project-Based Learning to Illustrate Abstract Concepts in Object-Oriented Programming

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Abstract

This study is motivated by the difficulty faced by students in understanding abstract concepts in Object-Oriented Programming (OOP). This study aims to develop a game-based learning media using the Project-Based Learning (PjBL) approach and to measure the improvement of students' conceptual understanding. The method used is Research and Development (R&D) adopting the ADDIE model, which consists of analysis, design, development, implementation, and evaluation stages. The instruments include a conceptual understanding test (pre-test and post-test) and a questionnaire to measure user acceptance. The results indicate an improvement in students' understanding of OOP concepts, as shown by higher post-test scores compared to pre-test scores. In addition, user acceptance of the developed media is categorized as very good, with an average score of 9.43. These findings suggest that integrating PjBL with game development is effective in facilitating the understanding of abstract OOP concepts. The novelty of this study lies in positioning game development not only as a learning medium but also as the core learning process.

Keywords: *project-based learning; object-oriented programming; game development; black box testing; bit and seeds.*

Introduction

1.1. Background of the Issue

Information technology education today faces the phenomenon of “abstraction failure” in Object-Oriented Programming (OOP) instruction. Students are often able to memorize code syntax but fail to construct a mental model of how objects interact in computer memory. A study by Iqbal et al. (2022) confirms that without a concrete visual context, crucial concepts such as polymorphism and encapsulation become merely theoretical jargon with no practical meaning for students. Information technology education today faces the phenomenon of “abstraction failure” in Object-Oriented Programming (OOP) instruction. Students are often able to memorize code syntax but fail to construct a mental model of how objects interact in computer memory. A study by Iqbal et al. (2022) confirms that without a concrete visual context, crucial concepts such as polymorphism and encapsulation become merely theoretical jargon with no practical meaning for students.

Within the Multimedia Education Program, conventional teacher-centered teaching methods have proven inadequate for bridging this competency gap. Students tend to write “fragile code” that functions externally but is structurally chaotic internally because they do not properly apply PBO principles.

As a pedagogical intervention, the Project-Based Learning (PjBL) approach integrated with game development offers a potential solution. Véggh and Czakóová (2023) found that the game development environment forces students to “concretize” abstract concepts; a Class is no longer merely code, but rather a blueprint for a character that can move. Based on this argument, this study examines the implementation of PjBL through a case study of the game “Bit and Seeds.” The urgency of this research lies in validating the effectiveness of PjBL not only as a method of software production but as a cognitive tool for deeply understanding PBO material.

1.2. Research Question

- 1) How was the Project-Based Learning (PjBL) model implemented in the development of the “Bit and Seeds” game to facilitate understanding of object-oriented programming concepts?
- 2) What is the level of user acceptance of the “Bit and Seeds” game as a course outcome, in terms of interface, gameplay, and system stability?

1.3. Research Objectives

Based on the research questions established, the objectives of this study are:

- (1) To describe the implementation of the Project-Based Learning (PjBL) method in the Object-Oriented Programming course through a case study of the “Bit and Seeds” game development, from the design phase to the completion of the product.
- (2) Analyze the level of user acceptance of the “Bit and Seeds” game as a learning outcome, examined from the aspects of user experience and technical quality based on respondent feedback.
- (3) This study uses two types of instruments: a user satisfaction questionnaire and an Object-Oriented Programming (OOP) concept comprehension test. The concept comprehension test instrument is used to measure respondents’ level of understanding of basic OBP concepts before and after using the learning media.

1.4 Research Benefits

1.4.1. Theoretical Benefits

- (1) Contribution to the Literature: This study is expected to contribute to the body of literature on technology education, particularly regarding the effectiveness of the Project-Based Learning (PjBL) model in teaching programming courses with a high level of abstraction, such as Object-Oriented Programming (OOP).
- (2) Method Validation: To provide empirical evidence regarding the integration of game development as a constructivist learning medium capable of bridging the gap between programming theory and software engineering practice.

1.4.2. Practical Benefits

- (1) For Students: This research provides hands-on experience in the software development cycle, helps visualize OOP concepts (such as inheritance and polymorphism) in a tangible, visual form, and results in an industry-ready product portfolio.
- (2) For Faculty and Educators: The results of this research can serve as a reference for alternative learning strategies to shift the OOP teaching paradigm from conventional, passive methods to more participatory and product-output-oriented approaches.
- (3) For Future Product Development: User feedback data regarding the “Bit and Seeds” game generated in this study can serve as a foundation for evaluating the development of advanced features (such as additional levels, more complex farming mechanisms, and map expansions) in the future.

Research Methodology

This study employs a Research and Development (R&D) approach to produce a product in the form of an agricultural simulation game titled “Bit and Seeds.” The software development design is integrated with the Project-Based Learning (PjBL) model, which aims to visualize abstract concepts of Object-Oriented Programming (such as Class, Object, and Inheritance) into concrete game mechanics.

The research subjects included 46 respondents comprising internal students, external students, and the general public. Sampling was conducted using Accidental Sampling during product dissemination events or showcases. Before user testing, the product’s functionality was validated using Black Box Testing to ensure features operated according to specifications without requiring an in-depth analysis of the internal code structure.

Primary data collection was conducted using a questionnaire instrument. This study employed the Research and Development (R&D) method by adapting the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The ADDIE model was selected for its systematic and flexible nature in the development of technology-based learning media. Post-pilot digital evaluation. The measured variables include user satisfaction (User Satisfaction) using a numerical rating scale (range 1–10) and user experience (User Experience) through open-ended questions. Data analysis employed a mixed-methods approach. Quantitative data were analyzed using simple descriptive statistics to determine the mean value of product feasibility, while textual feedback was analyzed using Content Analysis techniques through the stages of data reduction, issue categorization (such as bug reports or feature requests), and data presentation

This study employs a Research and Development (R&D) approach with a development model adapted from the ADDIE model, which comprises five stages: Analysis, Design, Development, Implementation, and Evaluation.

Research Findings and Discussion

3.1 Product Implementation Results (Game Development)

This study successfully developed a software product in the form of an agricultural simulation game titled “Bit and Seeds.” As an outcome of the Project-Based Learning (PjBL) method, the development of this game focused not only on entertainment but also on the application of object-oriented programming (OOP) structures.

Technically, the PBO concept is implemented in the game architecture as follows:

- 1) Class & Object: Applied to the creation of game entities. For example, Plant is created as a parent class, while Corn and Tomato are objects or specific instances of that class.
- 2) Inheritance: This mechanism is evident in the Item system. The Tool class inherits basic attributes from the Item class but has additional methods, such as use, for digging the ground—a capability not found in ordinary items.

3.2 User Evaluation Results

After the development phase, the game was tested at an exhibition involving 46 participants (a mix of UPI students, students from other universities, and members of the general public). Based on the questionnaire distributed, the following quantitative data was obtained:

Table 1. Table of quantitative data analysis

Rating Score	Number of Respondents	Percentage
10	28	60,9%

9	10	21,7%
8	8	17,4%
< 8	0	0%
Total	46	100%

Based on the table above, it can be seen that 100% of respondents gave a positive rating (a score of 8 or higher). The mean user satisfaction score was calculated as:

$$\text{Mean} = 9.43$$

Based on the interpretation criteria (Chapter 3), a score of 9.43 falls into the “Very Good” category. This indicates that, in terms of functionality and user experience, the game “Bit and Seeds” is highly commendable and has been well-received by its target audience.

3.3 Discussion

The results of the study indicate that the use of the “Bit and Seeds” game in the learning process can improve students’ understanding of Object-Oriented Programming (OOP) concepts, particularly regarding classes, objects, and inheritance. This improvement suggests that game-based learning tools can help students make abstract concepts more concrete and easier to understand.

Theoretically, these findings align with the constructivist theory in education, which emphasizes that knowledge is actively constructed through learning experiences. The Project-Based Learning (PjBL) approach provides students with the opportunity to engage directly in the product development process, thereby fostering more meaningful learning.

Furthermore, the findings of this study are supported by research conducted by John W. Thomas, which indicates that PjBL is effective in enhancing conceptual understanding through students’ active engagement in real-world projects. This is further reinforced by research conducted by R. Fadhilah, which demonstrates that PjBL has a positive impact on learning outcomes.

In terms of game usage, these findings align with S. Adipat’s research, which states that game-based learning can enhance student engagement and motivation. Additionally, J. Cárdenas-Cobo’s research also indicates that game development can significantly improve students’ programming competencies.

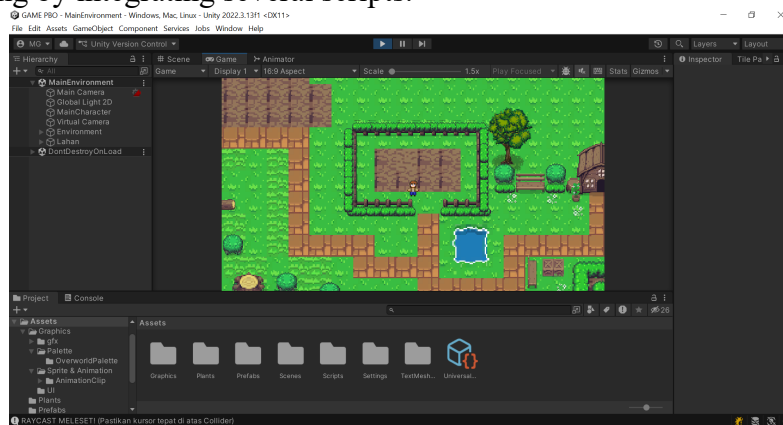
Thus, this study not only supports previous theories and research but also offers a new contribution in the form of integrating PjBL with the development of the “Bit and Seeds” game as a medium to concretize the abstract concept of PBO.

3.3.1 Game Production Process

The production process begins with preparing the necessary design assets, including both characters and environments. We obtain these design assets from opengameart.org, a website that provides art and sprites for game development, most of which are free for personal use.



Next, we set up the folder structure in Unity and immediately imported the assets we had obtained. At this stage, we also began testing basic mechanics, such as character animations and character controls using keyboard input. After that, we began implementing the game's core mechanic gardening by integrating several scripts.



Gambar 4. Prototype View

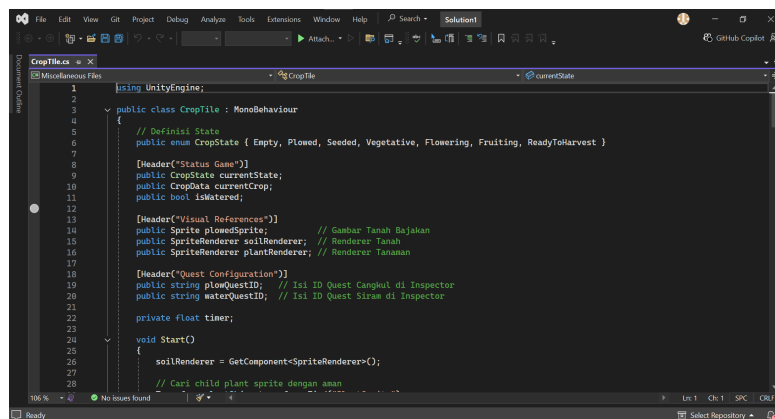


Figure 5. Script for land

Once all the game mechanics were running smoothly, we moved on to debugging fixing all the bugs that arose when the game was run. At this stage, we also added a minimap and HUD to make navigation easier while playing the game.

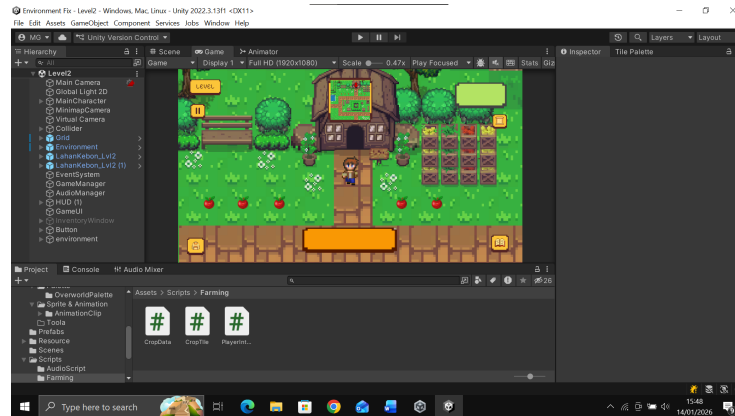


Figure 6. Final display and HUD



Discussed the overall results of these evaluations in section 3.2.

At this stage, the game is complete and ready to be tested at the Growday 2025 exhibition, organized by fifth-semester multimedia education students on December 17, 2025, at the Ahmad Sanusi Building of the Indonesia University of Education. Every visitor to our booth will be able to try out and test the game firsthand, as well as provide feedback or evaluations regarding it; we have already.

3.3.2 The Effectiveness of PjBL in Mastering PBO Content

The findings of this study confirm the hypothesis that game-based PjBL is effective in overcoming the barriers to abstraction in PBO. The high user satisfaction score (9.43) is not only an indicator of entertainment value but also an indicator of technical stability. A game cannot run smoothly without a solid object structure.

Unlike conventional methods, in which students work only on code snippets, the “Bit and Seeds” approach forces students to think systemically. In line with the findings of Végh & Czakoová (2023), the visual debugging process (e.g., watching characters traverse a tree) provides students with instant feedback to refine the encapsulation logic and collision detection in their code. Thus, the game serves as a “living laboratory” where the validity of PBO theory is tested in real-time.

3.3.3 User Feedback Analysis

In addition to numerical ratings, qualitative data from the “Impressions” and “Suggestions” columns provide in-depth insights into product quality. Based on content analysis, respondents' feedback can be grouped into three main themes:

- 1) Visual and Atmospheric Appreciation (Positive Reinforcement) The majority of respondents praised the game’s graphics and atmosphere. Comments such as “The pixels are crisp,” “The game has a fun vibe,” and “It’s similar to Stardew Valley” appeared

repeatedly. This confirms the findings of Adipat et al. (2021) that visual elements in games significantly enhance user engagement.

- 2) Requests for Additional Features (Feature Wishlist) Since this game was developed as part of a college assignment (with limited time), it is understandable that the content is not yet extensive. The data shows consistent requests for features, including:
 - a. New Mechanics: “Ability to fish and cook” (Tiara, UPI).
 - b. Content Expansion: “More seed options,” “Add farms,” and “Expanded map.”This indicates that users are enjoying the game and want more playtime.
- 3) Technical Report (Bug Reporting) Although the system ran smoothly, observant respondents identified minor technical issues. One specific piece of feedback was, “The tree shouldn’t be transparent” (Khumaira, UPI Cibiru). From a PBO perspective, this indicates that the Collision Detection property on the Tree object has not been enabled or that the inheritance of the Solid Object property was overlooked. This feedback is invaluable as material for code evaluation and debugging by the students.

Conclusions and Recommendations

This study concludes that the implementation of the Project-Based Learning (PjBL) method through the development of the “Bit and Seeds” game has proven effective in bridging the abstraction gap in Object-Oriented Programming education, as students successfully transformed complex theoretical concepts into concrete and functional software products. This output received an excellent level of acceptance from users, particularly regarding the visual aspects and gameplay experience, indicating the game’s success as both a learning medium and a viable entertainment product. Based on these findings, this study recommends the development of advanced features such as the addition of activity mechanics and the expansion of the game area, as well as technical improvements to the collision detection system to enhance realism. Additionally, it is recommended that educators integrate a more rigorous software testing module into the project curriculum to ensure a balance between the creativity of features and the stability of the code structure produced by students.

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