Journal of Engineering Education Transformations ,
Volume 38, No. 4 , April 2025 , ISSN 2349-2473, eISSN 2394-1707

10.16920/jeet/2024/v38i4/25096

Case Study: Enhancing Learning in C Programming Through Gibbs Reflective Cycle

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Abstract — This study focuses on the importance of mastering basic coding concepts, particularly in C programming, as a foundational step in learning high-level languages. It highlights the effectiveness of using the Gibbs reflection cycle as a method to teach programming fundamentals, emphasizing reflective learning to engage students in the teaching process. Rather than solely focusing on coding concepts like recursion, functions, and loops, the study utilizes the Gibbs reflection cycle to guide problem-solving activities. Students analyze their thoughts, emotions, experiences, assessments, analyses, conclusions, and action plans, particularly in the context of computing factorials using various techniques such as algorithms, recursive functions, and iterative loops. The analysis of students' reflections yields multiple solutions to the same problem, encouraging collaborative learning and drawing on past experiences to find the most effective solution. Through the administration of multiple-choice question tests before and after applying the Gibbs reflection cycle, the effectiveness of this strategy in enhancing problem-solving skills and conceptual understanding is evaluated. The study underscores the strengths of using the Gibbs reflection cycle to explore different factorial computation methods in C programming, leading to the discovery of eight different solutions for the same problem. It emphasizes the importance of reflective learning in improving student satisfaction, comprehension, and performance. Overall, integrating the Gibbs reflection cycle positively impacts learning experiences, resulting in improved performance, scores, and reduced variability. Research suggests that reflective approaches can effectively enhance problem-solving abilities and broaden conceptual knowledge in C programming.

Keywords—Gibbs reflective cycle, problem solving, C programming, Factorial, Functions, Recursion

1. Introduction

In order to promote reflective thinking and experience-based learning, Gibbs' Reflective Cycle is a systematic framework. Created by Graham Gibbs, this model provides a methodical way for people to look at and evaluate their experiences, behaviors, and feelings in a structured way.

The six phases of the cycle are the following: Action Plan, Conclusion, Analysis, Evaluation,

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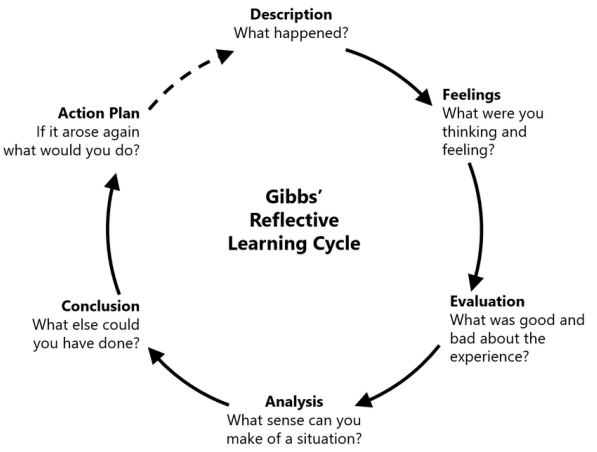

Fig 1 : Gibbs Reflection Cycle

Feelings, and Description (Adeani et al., 2020). Fig. 01 shows the Gibbs Reflection Cycle .With every step, people are prompted to investigate various aspects of an event, which promotes a better comprehension of their ideas, actions, and responses. Explaining what happened and the circumstances surrounding the experience or event in question is the description process. Sensations prompt people to communicate their feelings, identifying and appreciating their feelings in the process. Assessing the experience critically, determining what went well and what did not, and thinking through the consequences are all part of the evaluation process. In-depth investigation of the experience's causes for particular results, actions, or difficulties faced is called analysis. At this point, the experience's contributing factors are examined in greater detail. The conclusion summarizes the key learning from the analysis, provides broad conclusions, and considers potential areas for improvement. In an action plan, particular recommendations for future enhancements are outlined in light of the findings from the reflective process (Paterson & Chapman, 2013). Gibbs' Reflective Cycle is widely used to promote critical thinking, self-awareness, and continual improvement in a variety of fields, including professional development, healthcare, and education. People can learn from their experiences, spot trends, and create plans for both professional and personal development by being led through an organized reflection process. For those looking to increase their comprehension of experiences, sharpen their decision-making abilities, and promote a proactive attitude toward learning and growth, this model is an invaluable resource. Because of its flexibility, it is frameworks that can be applied in a variety of settings and helps people improve their learning process and practices.

2. Literature Review

The study's findings demonstrated that by utilizing Gibbs Reflective Cycle as a helpful framework, students can write perceptive comments on the literary works they are studying(Adeani et al., 2020). The well-structured framework for writing reflection helped the students delve deeply into the text because the reflective cycle includes important elements that they might study from the literary work. This study concludes that, due to its well-structured model that aids students in producing more insightful comments on literary works, the most recent model developed by Kolb, Johnson, and Gibbs is considered to be the most suitable to be used in literary classrooms. Supervision is a crucial aspect of management that aids the company in achieving its goals. The infection prevention and control link nurse (IPCLN) kept an eye on 94 healthcare workers' adherence to hand hygiene protocols through direct supervision methods(Fandizal & Handiyani, 2020). The "Gibbs Reflective Cycle" was created as a method of supervisory reflection to assess nurses' adherence to hand hygiene practices because direct supervision is ineffective. The method used is the Pilot Study, which includes both external and internal reform agents. Using purposeful sampling, a sample of up to thirty respondents including doctors, nurses, and caregivers was chosen. When it came to hand hygiene, 72.33% of police officers followed the study's protocol, according to its implementation. It is expected of student nurses to engage in reflective learning from the outset of their nursing education, as reflection is a critical skill in the modern nursing setting(Wilding, 2008). This article provides an example of how implementing critical reflection on practice resulted in significant learning outcomes. Gibbs' (1988) cycle helped the author, a first-year student nurse, illustrate how to apply this cyclical framework practically. After the analysis highlighted gender-related concerns in nursing and professional behavior, those issues were logically looked into. At the end of the article, the benefits of using Gibbs' (1988) cycle in various personal contexts are discussed, along with the cycle's superiority as a teaching tool for student nurses worldwide. The teaching staff was given the chance to look at challenging situations from multiple perspectives. In order to think about their feelings, thoughts, and actions in relation to challenging situations, teachers discovered that Gibbs' reflective cycle was a helpful tool(Markkanen et al., 2020). The participants tried to understand the situations from the students' point of view and saw the challenging

circumstances as opportunities to reflect on their professional practice. Conclusions: Teachers have to navigate challenging situations involving their students and continually adjust to their varied needs in their day-to-day work. The thoughts of teaching staff regarding these circumstances are detailed in this small-scale study. Based on this study, it may be possible to focus reflective learning from challenging situations by utilizing frameworks such as Gibbs' reflective cycle.The purpose of the study is to investigate how nurses' critical thinking skills relate to an implementation case reflection discussion (CRD) based on the Graham Gibbs Cycle(Ardian et al., 2019). This study used the cluster sampling technique and had a sample size of 85 nurses to assess the implementation of CRD. Method: To analyze the data, paired t-tests were employed. In summary, case reflection discussions (CRD) based on the Graham Gibbs Cycle improved nurses' critical thinking skills. This study highlights several key points, including the need for higher education for nurses, evidence-based nursing, study guides, theoretical development, and nursing management supervision and assessment. Lots of researchers found Gibbs Reflection cycle as key tool to train students in their respective field. Hence I decided to use this method to teach C programming to first year engineering students. Reflective writing assignments have gained prominence in various educational contexts as effective tools for promoting critical thinking and deepening learning experiences. Ezezika & Johnston discuss the development and implementation of a reflective writing assignment for undergraduate students in a public health biology course(Ezezika & Johnston, 2023). Their study underscores the value of reflective writing in enhancing students' engagement and understanding of course content. Pitts offers a reflective analysis on the introductory evaluation course, pinpointing areas to initiate the learning process. This study highlights the role of reflective practices in guiding students' self-assessment and facilitating their transition into evaluative thinking(Pitts, 2021). Nurlatifah explore the implementation of reflective assessment using Gibbs' reflective cycle to evaluate students' writing skills(Nurlatifah et al., 2023). Their findings emphasize the effectiveness of this approach in promoting self-awareness and improving writing proficiency among students. MindTools reflect on their experiences transitioning from senior nurses to novice nurse academics. Their study highlights the importance of reflective practices in professional development and the cultivation of teaching expertise(MindTools, 2019). Zhan investigate the experiences of master of nursing specialists during internships through written reflections(Zhan et al., 2023). Their qualitative research underscores the role of reflective writing in fostering self-reflection and professional growth among nursing practitioners. This underscores the widespread recognition of Gibbs' reflective cycle as a valuable tool for promoting reflective learning practices. In summary, the literature highlights the growing importance of reflective writing assignments and Gibbs' reflective cycle in various educational and professional contexts. These studies collectively underscore the significance of reflective practices in fostering critical thinking, self-awareness, and professional development among learners.

3. Methodology

It is required of first-year engineering students to learn C programming in order to solve problems. The following case study illustrates how to use C programming to find the factorial of a given number.

Fig. 02 shows the detailed Methodology of implementation of Gibbs Reflection cycle for problem of finding factorial of a given number.

Gibbs reflection cycle methodology and the standard teaching approach were used in an experiment. Students were asked to rate their learning and experience using feedback. To evaluate the effects of reflection learning, two assessments were administered. In addition to applying various reasoning, identifying multiple solutions for a given problem, and optimizing the answer, students are expected to locate and eliminate flaws in the code.

A. Description

It is essential to comprehend the factorial concept before beginning the programming task. A factorial shows the sum of all positive integers up to a specified value. To illustrate, the factorial of 5 (represented as 5!) can be computed as follows: $5 \times 4 \times 3 \times 2 \times 1 = 120$. Explain to the students what they need to do: "Develop a C program that computes the factorial of a user-inputted number."

B. Feelings

Encourage students to express their initial feelings regarding the programming task. This might include

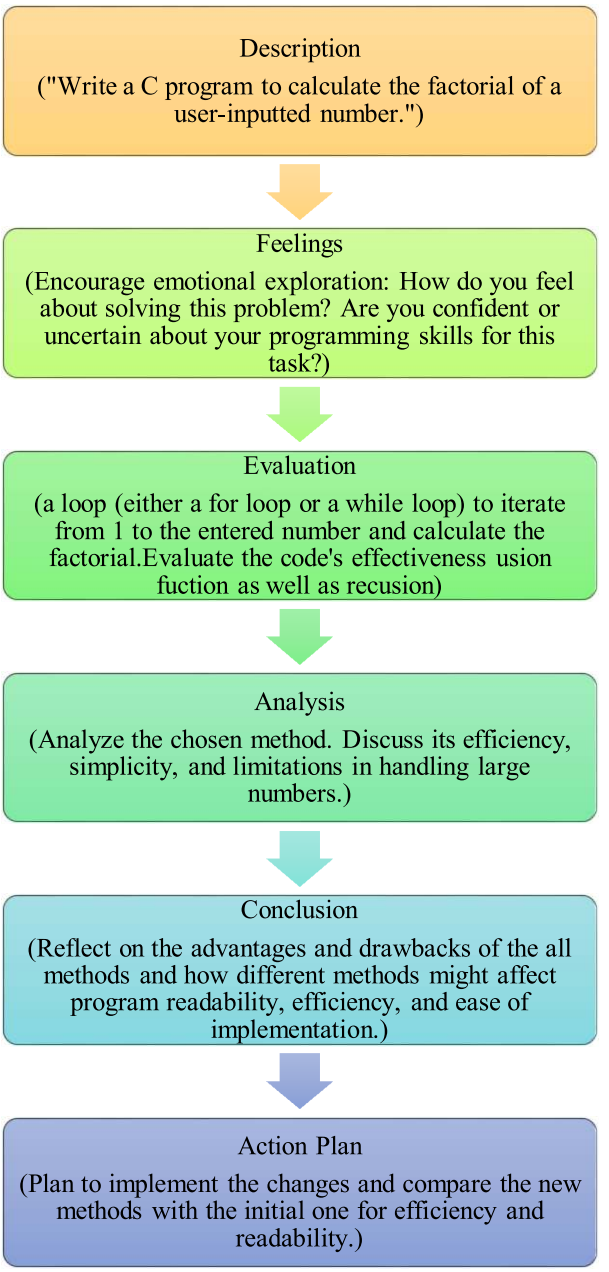

Fig. 2 : Gibbs Cycle Methodology

emotions like confidence, curiosity, uncertainty, or even apprehension about tackling the problem. Acknowledging these feelings helps in fostering self-awareness and can influence the learning process positively.

C. Evaluation

Start coding by initializing variables. Take user input for the number whose factorial needs to be calculated. Implement a loop (e.g., a for loop) starting from 1 up to the entered number to compute the factorial. Evaluate the code for potential issues, such

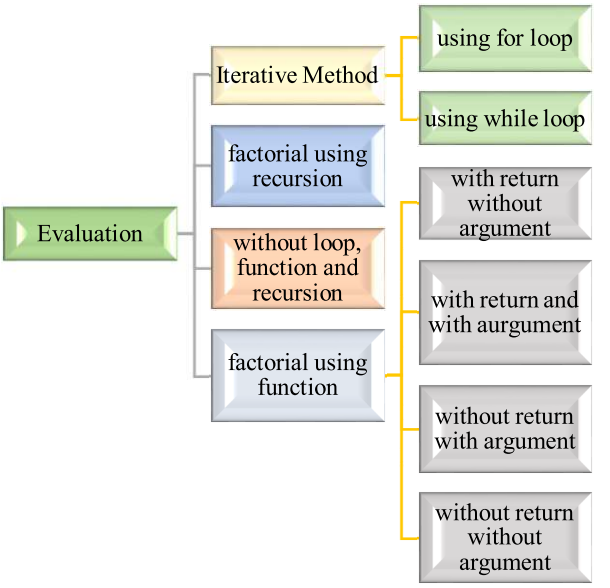

Fig. 3 : Evaluation methods

as handling zero, negative numbers, or very large inputs. Assess whether the program correctly addresses these scenarios and provides accurate factorial calculations. Fig. 03 shows the all possible 8 solutions rather method to calculate factorial of user defined number.

D. Analysis

Analyze the chosen method (in this case, an iterative approach) for factorial calculation. Discuss its efficiency in terms of time complexity and memory usage. Evaluate its simplicity for understanding and maintaining the code. Explore limitations like integer overflow for larger values and how the program responds to negative input or zero.

E. Conclusion

Summarize the outcomes from the analysis stage. Reflect on the advantages of the chosen method for factorial calculation, highlighting its simplicity and ease of implementation. Similarly, identify its limitations, emphasizing where improvements or alternative approaches could be beneficial.

F. Action Plan

Based on the conclusions drawn, outline steps for further exploration or improvement. For instance, if the iterative method was used, consider enhancing it to handle larger numbers by employing data types with larger storage or exploring alternative methods

like recursive functions. Plan to implement these enhancements and compare their efficiency and readability with the initial method. This detailed methodology, incorporating Gibbs' Reflective Cycle, enables students to approach the factorial problem systematically in C programming. It encourages critical thinking, thorough evaluation of code, reflection on chosen approaches, and iterative improvements, fostering a deeper understanding of programming concepts.

4. Results And Discussion

The factorial calculation methods were implemented and evaluated using various approaches, including iterative loops, recursion, and mathematical approximations. The findings and comparisons among these methods are detailed below:

A. Iterative Methods (for loop, while loop)

The iterative approaches using for and while loops exhibited straightforward implementations and were effective in computing factorials for moderately small numbers. However, these methods encountered limitations when handling larger inputs due to potential integer overflow issues, affecting the accuracy of results.

B. Recursive Method

The recursive approach provided an elegant solution for calculating factorials. It offered clear code structure and readability. However, it faced challenges with stack overflow for significantly large input values, affecting its practicality for very large numbers.

C. Mathematical Approximation (Stirling's Approximation)

Stirling's Approximation demonstrated an alternative approach, providing a non-iterative and non-recursive method. It approximates the factorial using mathematical formulas. However, this method relies on floating-point operations and may encounter precision limitations for very large numbers, resulting in approximation errors.

D. Accuracy and Precision

The iterative and recursive methods maintain accuracy for smaller inputs but face limitations with large numbers due to memory constraints or integer overflow. Stirling's Approximation, while offering a non-iterative solution, may lack precision for extremely large factorials due to inherent approximations.

Performance and Efficiency: Iterative methods are efficient for smaller inputs but might exhibit slower performance with larger values due to multiple iterations. Recursive methods, despite their elegance, suffer from stack overflow issues for very large inputs. Stirling's Approximation showcases a non-iterative nature but might not provide accurate results for extremely large factorials.

E. Trade-offs

Each method presents trade-offs in terms of readability, performance, and accuracy. While iterative methods offer simplicity, they face limitations with larger inputs. Recursion introduces elegance but encounters stack overflow issues. Mathematical approximations trade accuracy for non-iterative solutions but may lack precision for very large factorials.

In conclusion, each method for calculating factorials in C programming has its advantages and limitations. Depending on the context, developers should choose an appropriate method considering factors such as input size, accuracy requirements, and computational efficiency.

F. Feedback testing

To check the impact of the reflection learning the feedback of the students was taken to check the satisfaction and understanding of the topic on Google form. Students were asked to rate the reflection

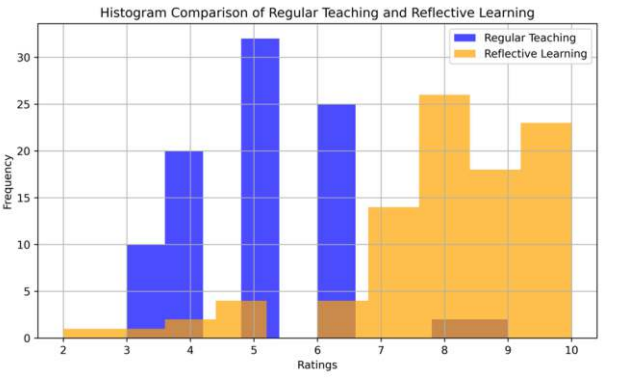

Fig. 4 : Feedback Testing using Histogram

learning on scale of 1 to 10 (low to high) as per their understanding of topic. Average satisfaction percentage is calculated. Fig.04 shows the Feedback Testing using Histogram.

Percentage of Feedback of Regular Teaching ratings >=7 is 4.40%

Percentage of Feedback of Reflective Learning ratings > =7 is 87.10%

The response from students indicates that the reflective learning style has greater impact. Students are happy with 70% or higher of the understanding, according to 87.10%.

G. Performance Testing

Two Multiple Choice Question (MCQ) examinations were administered to assess conceptual understanding. Before employing the Gibbs Reflection cycle for coding, there was one 10-mark multiple-choice exam and another 10-mark multiple-choice examination. In order to assess a thorough grasp of topics such as recursion, functions, and loops in C programming, the second test's question difficulty level was maintained high. Fig. 05 shows the Comparison of Test 1 and Test 2 Marks.

It is clearly visible that student's performance has been improved in test 2 after using Gibbs reflective cycle. Fig, 05 shows the boxplot of the distribution of the marks of the students. Average marks obtained are increased in test 2. Table 01 shows the Test Marks Statistics.

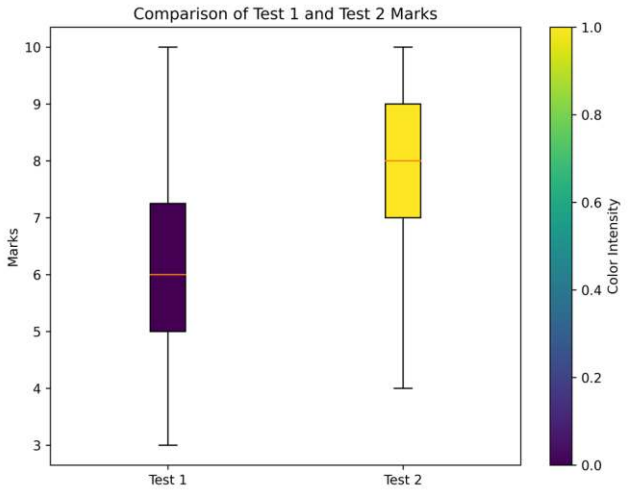

Fig. 5 : Comparison of Test 1 and Test 2 Marks

Table 1 :
Test Marks Statistics

Sr. No.	Parameter	Test 1 before Gibbs Reflection Learning	Test 2 after Gibbs Reflection Learning
1	**Total Number of Students**	95.00	95.00
2	**Mean**	5.93	7.89
3	**Standard Deviation**	1.67	1.44
4	**Minimum value**	3	4
5	**25%**	5	7
6	**50%**	5	8
7	**75%**	7	9
8	**Maximum Value**	10	10

Total Number of Students: Both tests were conducted with the same number of students (95), ensuring a fair comparison between the groups. Fig. 06 shows the Performance Testing Statistics. Fig. 07 shows the Disribution of Test 1 and Test2 Marks.

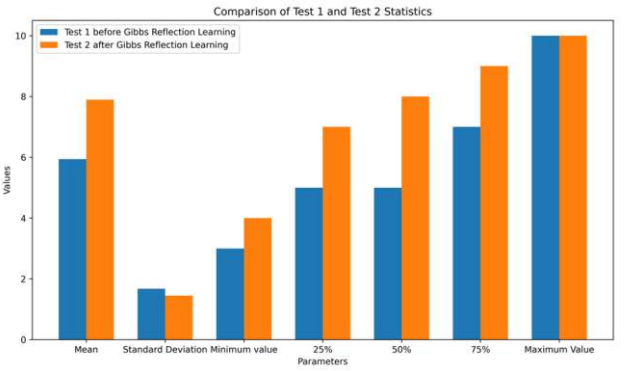

Fig. 6 : Performance Testing Statistics

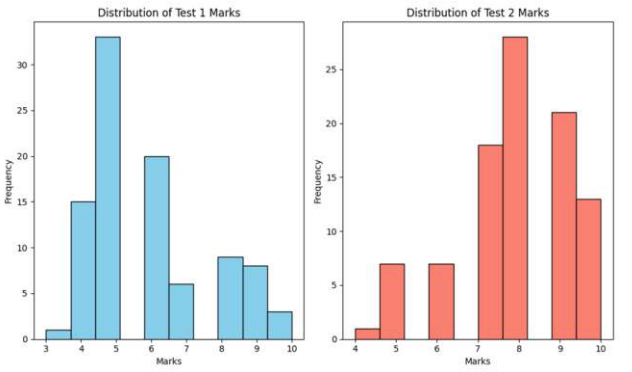

Fig. 7 : Distribution of Test 1 and Test2 Marks

H. Mean Scores

The mean score for "Test 2 after Gibbs Reflection Learning" (7.89) is notably higher compared to "Test

1 before Gibbs Reflection Learning" (5.94). This substantial increase in the mean score suggests an overall improvement in students' performance after the implementation of Gibbs Reflection Learning.

I. Standard Deviation

The standard deviation for "Test 2 after Gibbs Reflection Learning" (1.45) is lower than that of "Test 1 before Gibbs Reflection Learning" (1.67). This indicates that the scores in "Test 2" are less dispersed or more clustered around the mean compared to "Test 1," suggesting increased consistency or less variability in the scores after the reflective learning approach.

J. Minimum and Maximum Values

The minimum score for "Test 2 after Gibbs Reflection Learning" (4) is higher than that of "Test 1 before Gibbs Reflection Learning" (3), indicating an improvement in the lowest attained scores. Both tests have the same maximum score (10), demonstrating that the highest achievable score remained constant across both assessments.

K. Quartiles

The quartiles (25th, 50th, and 75th percentiles) for "Test 2 after Gibbs Reflection Learning" show an upward shift compared to "Test 1 before Gibbs Reflection Learning." This indicates improvements in the overall distribution of scores, with higher median and higher quartile scores in the post-reflection test.

Conclusion

This study highlights the strengths Gibbs reflection cycle to calculate factorial of the given number by using different methods in C programming. Students come up with 8 different solutions for the same problem with this strategy. It emphasizes the significance of reflective learning in enhancing student satisfaction, comprehension, and performance. Integrating Gibbs' Reflective Cycle positively impacted learning experiences, leading to improved performance, scores and reduced variability. In general, research suggests using reflective approaches to improve problem-solving abilities and expand conceptual knowledge in C programming. While the Gibbs reflection cycle enhances C programming learning, it has limitations. It relies on subjective student experiences, demanding significant time and may not cover all topics comprehensively. It's less effective for complex concepts, presents assessment challenges, and requires resources. Addressing these ensures sustainable effectiveness. Future research in enhancing learning in C programming through the Gibbs reflection cycle could focus on several key areas. These include investigating the long-term impact of reflective learning on students' programming skills, comparing its effectiveness with other teaching methods, exploring technology integration for facilitating reflective processes, examining instructor training and support needs, developing tailored assessment methods, and investigating strategies to enhance student engagement and motivation.

Acknowledgment

I am grateful to Dr. Preeti Bhamare, Mrs. Seema Gondhalekar and Mr. Vishal Galande for their unwavering support and direction during this study.

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