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Adoption of Metacognitive Approach to Teaching and Learning of Programming Language Concepts to Undergraduate and Graduate University Students

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Abstract: Mastering programming language concepts is critical for students in computer science and related fields. However, traditional teaching methods often fall short of fostering deep understanding and problem-solving skills. This paper explores the adoption of a metacognitive approach to teaching and learning programming language concepts among undergraduate and graduate university students. The study finds a significant change in students' programming problems using a metacognitive intervention designed to increase students' confidence in solving programming challenges. It also shows how the intervention (Metacognitive Approach) significantly impacted students' gender differences. Finally, seek the significant influence of the intervention (Metacognitive Approach) on students' mode of entry into the University. The study employed a descriptive approach using the Lagos State University of Education (LASUED) of Lagos State as a case study. The population is composed of 52 computer science and computer science education students. The study consisted of 34 male students and 18 females selected using a purposive sampling technique. The study reveals that metacognition, which involves awareness and regulation of cognitive processes, can enhance students' ability to learn complex subjects independently and adaptively. The research shows that students who engage in metacognitive practices demonstrate significant improvements in understanding and retention of programming knowledge, likewise greater confidence and autonomy in tackling programming challenges. The study also discusses practical implementations of metacognitive strategies in the classroom, suggesting that this approach can transform the teaching and learning of programming languages. In conclusion, adopting a metacognitive approach to teaching programming languages holds promise for improving educational outcomes. It encourages students to become active participants in their learning journey, equipped with the skills to navigate and master complex programming concepts. This approach benefits students academically and prepares them for lifelong learning and professional success in the ever-evolving technology field.

Keywords: Coding, equations, metacognition, problem solving, sciences.

Introduction

Learning programming is complex, and university dropout rates are frequently high. The transition from novice to expert takes around ten years. Researchers have pinpointed the characteristics of beginners and how they learn. Specialists possess superior semantic and schematic understanding, whereas beginners face syntactic comprehension and problem-solving difficulties. Experts break down issues into more minor, more manageable ones and consider more than one solution than novices do (Nurulain Mohd Rum & Zolkepli, 2018). One possible solution to this issue is the widespread use of metacognitive tactics in schools to teach pupils how to complete academic activities and advance their knowledge levels gradually. These teaching techniques support students' cognitive development and aid in acquiring specialised knowledge. Piaget asserts that these techniques are essential to students' lives. Teaching techniques known as metacognitive tactics assist students in comprehending and developing various skills within the classroom. Studies have demonstrated that metacognition is one of the best strategies for raising academic achievement and assisting individuals in realising their potential (Wilson & Conyers, 2013). Using these techniques, students can develop their ability to think strategically, which affects how their brains solve problems. Metacognitive methods fall into two categories: knowledge and regulation. Knowledge is understanding one's own thought processes, while regulation is the management of one's thought processes. "Working smarter, not harder" is how Lucero and Morrell (n.d.) define the metacognitive approach. It promotes introspection by encouraging students to consider what aspects of learning new content they found successful and unsuccessful. Metacognition strategies significantly impact young children; thus, it's essential to modify them so that learning strategies match how the mind naturally works. The results of metacognition techniques differ depending on the discipline, and scientific students frequently struggle to comprehend and conceptualise learning challenges (ALshammari, 2015).

The general education literature has spent decades debating and studying metacognition and self-regulation—two critical abilities for effective learning. In computing education, there has recently been an increase in interest in learning how metacognitive and self-regulatory skills contribute to student achievement (Dastyni et al., 2022). Metacognitive strategies help students better comprehend how they learn and how to do so. Zimmerman (2002) describes a successful self-regulated learner as someone who is proactive in their learning efforts, aware of their strengths and limitations, and guided by personally set goals and task-related strategies. These learners also monitor their behaviour about their goals and reflect on their growing effectiveness. This raises their self-worth and inspires them to keep refining their teaching strategies. A great deal of work has gone into developing creative methods for teaching programming. While metacognition is recognised as helpful in the learning process, there is still a dearth of research showing the impact of metacognitive tactics in programming classes (Çakiroğlu & Er, 2020).

It has been observed that teaching and learning programming is a ubiquitous difficulty in computer science education. This is because practical aptitude is now more in demand than just theoretical. Research has shown that students with metacognitive management abilities outperform pupils who do not in programming (Nurulain Mohd Rum & Zolkepli, 2018). The more complex the programming task, the more metacognitive control abilities the programmer must possess. A rookie programmer must acquire metacognitive skills due to the cognitive processes of learning computer programming (Nurulain Mohd Rum & Zolkepli, 2018).

Research Problem

Teaching advanced programming language concepts to undergraduate and graduate students in the quickly developing fields of computer science and programming education presents formidable obstacles. Students' different cognitive needs are frequently unmet by traditional instructional approaches, leading to a range of comprehension and retention levels. Even though learning programming languages is essential for academic achievement and professional preparedness, many students find it challenging to comprehend abstract ideas, apply theoretical knowledge in real-world situations, and solve problems. Metacognitive methods can potentially improve learning outcomes in various academic fields since they entail being aware of and in control of one's learning processes. Nonetheless, there is still a lack of widespread acceptance of metacognitive strategies designed especially for programming education. Investigating the best ways to incorporate these tactics into the curriculum is crucial to enhance student's educational experiences and results. Thus, this study aims to ascertain if teaching and learning programming language principles to undergraduate and graduate students through a metacognitive approach is successful. It seeks to pinpoint the possible advantages, difficulties, and best practices for using metacognitive methods in programming instruction. By filling this knowledge vacuum, the study hopes to offer perceptions that may result in better instructional strategies, improving students' understanding, recall, and application of programming skills.

Research Focus

The focus of this study is to determine how best to incorporate metacognitive techniques into teaching and learning programming languages. It also shows how encouraging students to reflect on their thought processes might improve their comprehension, problem-solving abilities, and general programming competency. The study will compare regular teaching approaches with those that integrate metacognitive practices to investigate the effects of metacognitive strategies on graduate and undergraduate students. The development of self-regulation abilities, the capacity to observe and modify learning tactics, and the impact of these methods on students' academic performance and recall of programming concepts are important areas of attention

Research Aim and Questions

The study, therefore, addresses the following research questions:

- Is there any significant change in students' solving programming problems following students' involvement in a metacognitive intervention designed to increase students' confidence in solving programming challenges?
- Does the intervention (Metacognitive Approach) significantly impact students' gender differences?
- Does the intervention (Metacognitive Approach) significantly influence the students' mode of entry into the University?

Literature Review

Metacognitive and Programming

The main challenges faced by Nigerian students in learning computer programming are analytical thinking and problem-solving abilities. These abilities are essential for the growth of metacognition, the process of reflecting on cognition, which has a favourable correlation with academic success. In the classroom, metacognitive techniques like selecting, assessing, rewriting, monitoring, and checking are crucial for fostering self-regulated learning models.

Students with these abilities do better in programming, and metacognitive management techniques and skills are critical for programmers. The greater the difficulty of the problem, the greater the need for constructive criticism, metacognitive control, and deliberate contemplation.

After assembling a sizable corpus of research on metacognition and self-regulation in programming education, Dastyni et al. (2022) used backwards snowballing to offer a more thorough analysis of fundamental theories from fields other than computing education, some of which have been studied in programming education and others of which are unknown. They also suggested how metacognition and self-regulation could assist in shaping programming education in the future and made fresh observations about how the computing education community applied those ideas. They specifically talked about research that offered their metacognitive theories in the context of programming education and studies that exemplified the use of pre-existing theories to support their design and discussion of outcomes. Metacognition and self-regulation are popular areas of interest in education research, as they are linked with successful learning. Although extensively researched in other disciplines for decades, the application of metacognition and self-regulation in computing education contexts is newer and less understood despite increased attention in recent years. Researchers in computing education should investigate how previous studies on metacognition and self-regulation in other domains might be applied to computer programming in particular, as it is a distinct activity. The general education literature has spent decades debating and studying metacognition and self-regulation—two critical abilities for effective learning. In computing education, there has been an increasing amount of attention lately on learning how metacognitive and self-regulatory skills contribute to student achievement (Azevedo, 2020; Loksa et al., 2022). Türkmen et al. (2024) noted that metacognition and self-regulation are popular areas of interest in programming education, and they have been extensively researched outside of computing. While computing education researchers should draw upon this prior work, programming education is unique enough that we should explore the extent to which previous work applies to our context (Olop et al., 2024).

Metacognition comprises the ability to be aware of one's cognitive processes (metacognitive knowledge) and regulate them (metacognitive control). Research in educational sciences has amassed a large body of evidence on the importance of metacognition in learning and academic achievement (Fleur et al., 2021; Meher et al., 2021). Metacognition, the ability to think about one's thinking, has been a subject of philosophical inquiry since ancient times, yet is only more recently coined as a term and investigated empirically (Keestra, 2024).

Since good learning is associated with metacognition and self-regulation, these concepts interest education researchers in general. The application of self-regulation and metacognition in computing education contexts is relatively new. While it has received more attention recently, it is still little understood despite decades of substantial research in other areas. Because computer programming is so distinct from other activities, researchers studying computing education should investigate how previous findings on metacognition and self-regulation in different domains may be adapted for this setting (Dastyni et al., 2022).

The impact of the techniques on students' performance in programming courses was investigated by Çakiroğlu and Er (2020). The participants' programming performances were ascertained, and their experiences with the role of the strategies were explained through qualitative methodologies. The findings showed that while about half of the students' programming performances fell into the pre-structural and unistructural categories of the Solo taxonomy, the other half did not. Cognitive understanding and cognitive regulation mechanisms were discovered to be significantly influenced by the calibre of the programming challenges. Additionally, it was found that the students' problem-solving techniques and mental capacities were beneficial to their metacognitive development.

Using the MAI instrument, Nurulain Mohd Rum and Zolkepli (2018) conducted an exploratory study to determine the degree of metacognition awareness of inexperienced programmers. Interviews with knowledgeable lecturers were also held to determine the pedagogical and metacognitive approaches used in the teaching and learning activities. Through the interview sessions, the learning behaviours of novices were also identified. It was determined that an individual's metacognitive awareness and academic success were correlated.

The impact of metacognitive methods on academic performance and the inclination towards social studies among intermediate school students in Hafer Al Batin City, Saudi Arabia, was studied by ALshammari (2015). To accomplish its goals, the study employed a sample of forty male children in the first grade from "Tahfiidh al Quran School," chosen by deliberate sampling. The study's sample was split into two groups: the experimental group, which included 20 students, studied utilising the conventional approach. The study's findings demonstrated statistically significant variations in academic performance and inclination for social studies. Based on the research findings, the study suggested activities that stakeholders in Hafer Al Batin City should implement to attain optimal results in their educational system.

Self-Regulatory Learning

There are three key elements of self-regulated learning that educators must understand in order to support their students' growth as successful learners.

Cognition: The mental process of knowing, comprehending, and learning is known as cognition. When we refer to cognitive strategies, we're talking about abilities like memorising ways or topic-specific tactics like using various brush strokes or methods to solve scientific equations. This is the cornerstone of effective teaching; learning activities and knowledge acquisition depend on cognitive processes.

Metacognition: How students keep track of and intentionally guide their learning is known as metacognition. For instance, after determining that a specific cognitive memorising strategy is likely to be effective, a student then keeps track of its effectiveness and consciously modifies (or does not) their memorisation technique in light of that information. Metacognitive strategies are those that we employ to keep an eye on or regulate our cognitive processes. Examples include verifying our memorisation approach's accuracy and choosing the best mental strategy for the task (Cullen, 1985).

Motivation: Our willingness to use our cognitive and metacognitive abilities in the context of learning is what motivates us. One of the motivational techniques will be persuading oneself to tackle a problematic revision job today, which will impact our current well-being and improve our future well-being in the test tomorrow. Throughout the learning process, there are intricate interactions between motivation, metacognition, and cognition. She used cognitive tactics for Freya, such as practising self-testing at home and employing mnemonic devices. She planned her spelling drills using metacognitive techniques, understanding why a mnemonic was the best tool for the job and keeping an eye on her struggles with exam time constraints. Finally, Freya summoned the motivational techniques to practice repeatedly and endure under duress. Motivation is crucial to students' performance (Uka & Prendi, 2021). Motivation is one factor that drives students to gain knowledge and learn new things (Motevalli et al., 2020). Motivation and learning behaviour are essential factors in determining students' learning achievement. Motivation is an abstract thing that makes it difficult to measure the willingness of students to learn. Motivating the learner to learn is pertinent to curriculum implementation (Filgona et al., 2020). That is why motivation is an influential factor in the teaching-learning situations. The success of learning depends on whether or not the learners are motivated. Motivation drives learners to reach learning goals. Recognising that motivating learning is a central element of good teaching is essential.

Self-regulated learners can drive themselves to participate in and advance their learning because they are conscious of their advantages and disadvantages. Metacognition is crucial to this. The phrase is becoming more and more common in education. However, teachers sometimes struggle to define it beyond the basic idea of "thinking about thinking" in the classroom context. Comprehending our meaning is the first step toward assisting educators in enhancing students' metacognition. We enter every learning opportunity or task with some metacognitive information about this specific sort of activity (knowledge of the task), our skills and dispositions (knowledge of ourselves as learners), and what strategies are accessible and effective (knowledge of strategies).

Self-regulation in learners is the skills and confidence to take control of their learning. Students set goals, monitor their progress, and reach for success (Reinders et al., 2023). Self-regulated learning is the capacity to monitor and regulate your learning activities. It is vital in an increasingly complex and digitalised world with unlimited information at your fingertips (Kubik et al., 2021). Self-regulated learning is a critical skill at all levels of education, which can be promoted through structured training programs, various uses of feedback, and addressing misconceptions about self-regulated learning from (pre-service) teachers. According to Mahajan (2024), education plays a central role in sustainable development, providing individuals with the knowledge, skills, and attitudes necessary to create a sustainable future. A key aspect of this educational process is self-regulated learning (SRL), the self-directed process through which learners transform their intellectual and academic skills. Self-regulation of learning involves developing metacognitive awareness (planning, monitoring, and evaluating (Bakhtiar & Hadwin, 2022).

Metacognitive Cycle

We begin with this knowledge before applying and adapting it to a learning assignment. Metacognitive regulation is this. It involves organising how to approach a task and working on it while keeping an eye on the plan to assess progress and the task's overall success. The metacognitive regulation cycle is depicted in the schematic opposite (see Figure 1).

This is a continuous cycle rather than a one-time event with distinct steps. You update both your topic knowledge and abilities and your metacognitive knowledge (about yourself, methods, and tasks) as you work through the job of applying your cognitive and metacognitive skills. Throughout this guide, the themes of planning, monitoring, and evaluating are repeated, as are the many facets of metacognitive knowledge (task, learner, and techniques). Teachers should consider these when assigning assignments and helping students finish them. These processes are automatic and unconscious in an expert learner. However, it can be helpful to make them explicit for inexperienced learners. Providing clear guidance on metacognitive management techniques, in particular, is crucial.

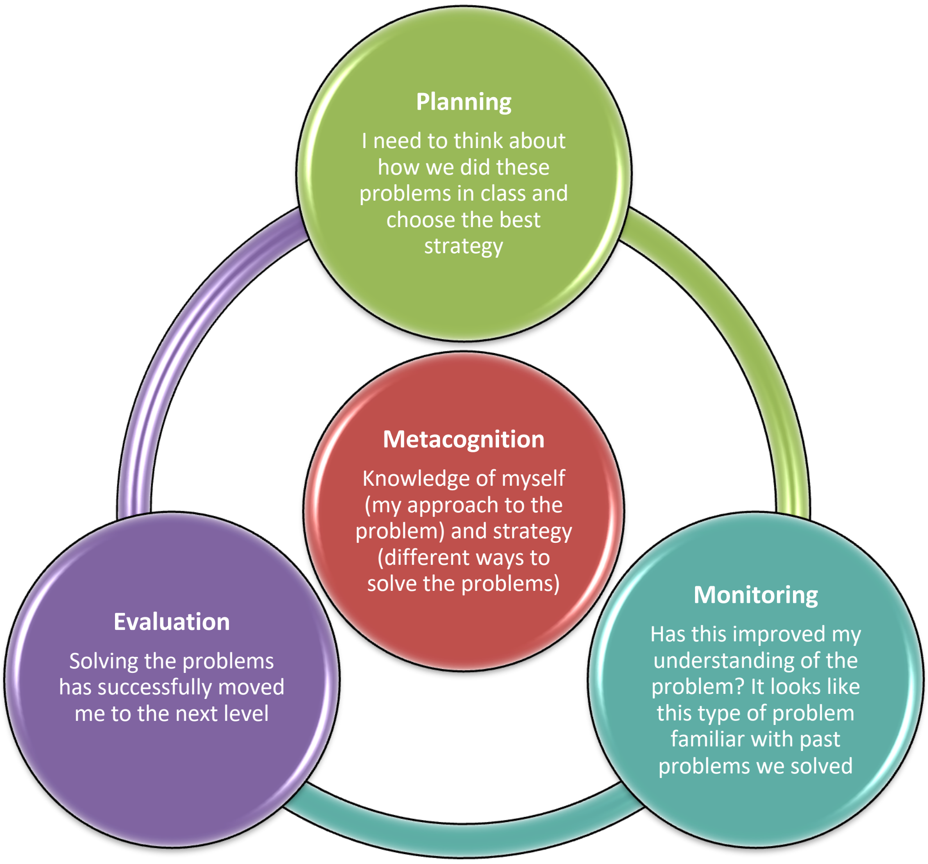
Planning: encouraging students to reflect on the learning objective (as determined by the instructor or by themselves) and to plan their approach to the task; this includes making sure they comprehend the purpose, draw on pertinent prior knowledge, choose suitable methods, and plan how to divide their effort;

Monitoring: stressing the necessity for students to evaluate their progress while working on the learning task, including the self-testing and self-questioning exercises that are essential to manage learning and adjust their selected tactics and

Evaluation is the process of determining how well their plan and its execution worked.

Figure 1

Metacognitive Cycle



Research Methodology

General Background

A quantitative data collection and analysis procedure was carried out. The study was conducted at the Lagos State University of Education (LASUED). The population was composed of 52 computer science and computer science education students. The composition of the selected students included gender differences, department, and mode of entry into the university.

Sample

The sample group of the study used consisted of 34 male students and 18 female counterparts enrolled in the computer science department of Lagos State University of Education. The sample was drawn from over 1500 students enrolled for the study but came to lectures regularly using a purposive sampling technique for the selection. This implies that the selected students participated from beginning to end.

Instrument and Procedures

An achievement test of pretest and post-test data was used to determine the role of metacognition in programming performances. A small sample of 52 was chosen for the study. All of the participants had received introductory programming courses the previous year. The participants were first exposed to the pretest before moving through the metacognitive approaches. Thereafter, they were exposed to posttest; the two results were subjected to statistical analysis (SPSS 23.0). The metacognitive activities in programming learning include:

i. Deciphering the meaning of the problem to solve.

ii. An algorithm or flow chart can be used to deconstruct it into identifiable parts.

iii. Identify the keywords and their uses.

iv. Follow the rules (syntax) and arrangement of the codes to give meaning (semantic).

v. Writing the correct codes.

vi. Thinking beyond the given, making inferences, making corrections or drawing conclusions from known information.

vii. Maturing the correct ways to solve any given problem.

Data Analysis

Table 1

Students' Gender Difference

	Frequency	Per cent	Cumulative Percent
Female	18	34.6	34.6
Male	34	65.4	100.0
Total	52	100.0	

Table 1 depicts the gender difference of the students who participated in this study. As reflected in Table 1, 18(34.6%) students are female while 34(65.4%) students are male. This implies that more male students participated than their female counterparts.

Table 2

Students' Department

	Frequency	Percent	Cumulative Percent
Computer Science	17	32.7	32.7
Computer Science Education	22	42.3	75.0
Mathematics	13	25.0	100.0
Total	52	100.0	

Table 2 reveals the department to which the students belong. As indicated in Table 2, more of the participating students came from computer science education with 22(42.3%), next are students from computer science core with 17(32.7), while those from the mathematics department are only 13(25%) respectively.

Table 3

Students' Mode of Entry

	Frequency	Per cent	Cumulative Percent
Direct Entry	6	11.5	11.5
Regular	46	88.5	100.0
Total	52	100.0	

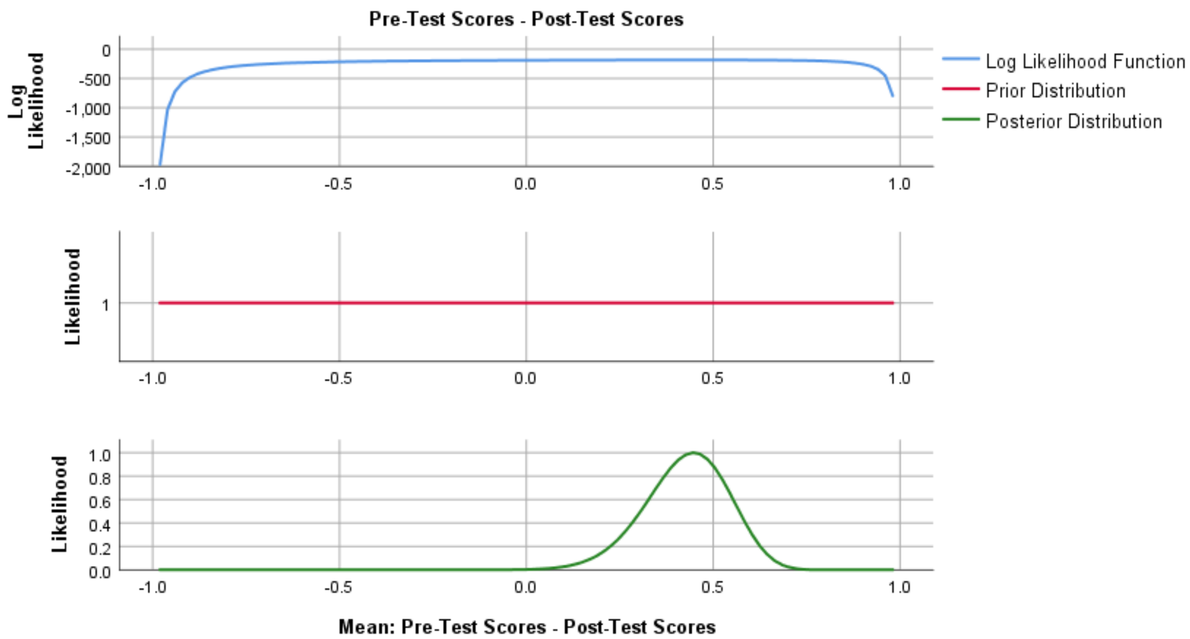
Table 3 shows the mode of entry of students into the university. From Table 3, those students entered through regular means are 46(88.5%) while those with direct entry means just 6(11.5%). This means that those with regular means outweigh direct-entry students.

Results

Testing of Research Questions

Figure 2

Prior, Posterior and Log Likelihood Function of Pretest and Posttest Scores



According to Van De Schoot et al. (2021), Bayesian statistics is an approach to data analysis based on Bayes' theorem, where available knowledge about parameters in a statistical model is updated with the information in observed data. The background knowledge is expressed as a prior distribution and combined with observational data as a likelihood function to determine the posterior distribution. The posterior can predict future events (Mallik, 2021; Peter Rosenfeld & Olson, 2021). Naïve Bayes (NB) is a well-known probabilistic classification algorithm. It is a simple but efficient algorithm with various real-world applications (Wickramasinghe & Kalutarage, 2021). Bayesian approaches are now an integral part of the toolkit for most statisticians and data scientists (Bon et al., 2023; Hu, 2019).

In Bayesian analysis (Figure 2), the prior distribution represents our prior belief about the value of an unknown parameter. After observing data, it is combined with the posterior distribution to update our belief.

Prior Distribution represents the initial beliefs about the parameters before observing any data. The result here indicates that the students had no background information on learning programming concepts. Likelihood Function represents the probability of the observed data given the parameters. Students are expected to perform well after going through the stages of the metacognitive strategy. At last, Posterior Distribution, which is the updated belief about the parameters after observing the data, shows that employing a metacognitive approach to solving programming problems yielded a significant result.

RQ1: Is there any significant change in students' solving programming problems following their involvement in a metacognitive intervention designed to increase their confidence in solving programming challenges?

Table 4

Paired Samples Statistics

		Mean	**N**	**Std. Deviation**	**Std. Error Mean**
Pair 1	Pre-Test Scores	2.9615	52	1.58376	.21963
	Post-Test Scores	6.6731	52	1.46490	.20314

Table 5

Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper	t	df	Sig. (2-tailed)
Pair 1	Pre-Test Scores - Post-Test Scores	-3.7115	1.6007	.2210	-4.1572	-3.2659	-16.72	51	.000

A paired-sample t-test was conducted to evaluate the impact of the intervention on students' scores in the programming course. There was a statistically significant increase in score from Pre-Test ($M=2.9615$, $SD=1.58376$) to Post-Test [$M=6.6731$, $SD=1.46490$, $t(51)= -16.720$, $p <0.0001$, the eta squared statistic (.848) indicate a large effect size (see Table 4 and 5)

RQ2: Does the intervention (Metacognitive Approach) significantly impact students' gender differences?

Table 6

Summary Data for Research Question Two

	N	Mean	Std. Deviation	Std. Error Mean
Female	18.000	4.806	.825	.194
Male	34.000	4.824	1.502	.258

Table 7

Independent Samples Test for Research Question Two

	Mean Difference	Std. Error Difference	t	df	Sig. (2-tailed)
Equal variances assumed	-.018	.382	-.047	50.000	.963
Equal variances not assumed	-.018	.323	-.055	49.882	.956

Note. Hartley test for equal variance: F = 3.315, Sig. = 0.0045.

An independent-sample t-test was conducted to compare the male and female gain scores for the pre-test (before an intervention) and post-test (after an intervention - metacognitive strategy) regarding the programming learning course. There was no significant difference between the female (M=4.806, SD=.825) and the male [M=4.824, SD=1.502; t(49)= -.055, p=.956].

RQ3: Does the intervention (Metacognitive Approach) significantly influence the students' mode of entry into the University?

Table 8

Summary Data for Research Question Three

	N	Mean	Std. Deviation	Std. Error Mean
Direct Entry	6.000	5.000	1.000	.408
Regular	46.000	4.794	1.340	.198

Table 9

Independent Samples Test for Research Question Three

	Mean Difference	Std. Error Difference	t	df	Sig. (2-tailed)
Equal variances assumed	.207	.569	.363	50.000	.718
Equal variances not assumed	.207	.454	.455	7.570	.662
Hartley test for equal variance: F = 1.795, Sig. = 0.2380					

Note. Hartley test for equal variance: F = 1.795, Sig. = 0.2380.

An independent-sample t-test was conducted to compare the students' mode of entry into university (Direct entry and regular) using gain scores about programming learning courses. There was no significant difference between the Direct entry students (M=5.000, SD=1.000) and the Regular students [M=4.794, SD=1.340; t(7)= .455, p=.662].

Discussion

It was observed that (The Bayesian analysis) result indicates that the students did not have any background information on the concepts of programming to learn. So, from the analysis, it is shown that students perform well after being taken through the stages of metacognitive strategy. At last, Posterior Distribution, which is the updated belief about the parameters after observing the data, shows that employing a metacognitive approach to solving programming problems yielded a significant result.

In the same vein, a paired-sample t-test was conducted to evaluate the impact of the intervention on students' scores in the programming course. The results revealed that there was a statistically significant increase in score from Pre-Test ($M=2.9615$, $SD=1.58376$) to Post-Test [$M=6.6731$, $SD=1.46490$, $t(51)= -16.720$, $p <0.0001$. The eta squares statistical test also complemented the results that there was a significant effect of an intervention on the student's performance with .85. The study corroborates with Campbell and Atagana (2022), who suggested that employing intervention (Scratch in higher education) can be engaging and valuable, especially for students with no prior programming experience. Also, Munda et al. (2024) agree that students with learning difficulties benefit from intervention programs. Similarly, Muhammad et al. (2020) confirm that using the intervention is a way for students to retain learning with long-term retention and avoid learning wrong concepts.

Higher Education institutions strive to improve students' academic performance. Early intervention for at-risk students and a reasonable curriculum are vital for student's success (Cheng, 2022). Hu (2023) opined that as interest in programming education grows, more educators are incorporating programming into classrooms. Evidence shows that programming can help develop essential skills for future societal advancement. Predicting students' programming performance helps teachers realise their teaching effect and students' learning status in time to support students (Shen et al., 2023).

On the contrary, an independent-sample t-test was conducted to compare the male and female gain scores for the pre-test (before an intervention) and post-test (after an intervention - metacognitive strategy) concerning the programming learning performance of the students. The results indicated no significant difference between the female ($M=4.806$, $SD=.825$) and the male [$M=4.824$, $SD=1.502$; $t(49)= -.055$, $p=.956$]. This is against the work of Gao et al. (2022), in which several results show that gender or significance has a specific difference in programming learning. Similarly, Carter and Jenkins (1999) presented the results of investigations carried out at the Universities of Kent and Leeds into how gender influences students' learning approach in programming. The research of Gunasekara (2021) supports that although both male and female students believe programming is essential for future careers, there is a strong gender effect on their perception of curricula and their ability to program. The male students outperformed female students in understanding the concepts, working in the programming development environment, and fixing bugs. Lishinski et al. (2016) reported significant gender differences in the relationships between SRL constructs and learning outcomes; they also found that females' self-efficacy had a different connection to programming performance than their male peers.

Similarly, an independent-sample t-test was conducted to compare the students' mode of entry into university (Direct entry and regular) using gain scores about programming learning courses. There was no significant difference between the Direct entry students ($M=5.000$, $SD=1.000$) and the Regular students [$M=4.794$, $SD=1.340$; $t(7)= .455$, $p=.662$]. In this, Saliu and Musa (2017) affirm that the impact of the University Mode of Entry on the Academic Performance of Architecture Students is statistically significant in Ahmadu Bello University Zaria. Emaikwu's (2012) results indicated no statistically significant difference in the mean academic achievement of students admitted into the university through a unified tertiary matriculation examination, remedial programme and direct entry admissions. Aciro et al. (2021) undertook a study to collate the literature on the relationships between the students' entry grades and their university academic performance to validate earlier assertions and identify opportunities for further research in this field. They found a mode of entry a significant consideration.

Limitations of the Study

The following limitations were faced in the study:

Sample size limitations: The study's sample size is small because only one institution was used, so it is a bit difficult to generalise the results of this study.

Data collection methods: During the intervention's implementation, some students withdrew unexpectedly, which affected the study's outcome and posed a problem with its final generalisation.

Potential biases or confounding factors that could have affected the results: Some students started well and came to lectures regularly, but they could not partake in the last pot test because of their health challenges.

Conclusions and Implications

Metacognitive students know how their cognitive systems function, check their performance (self-monitoring) and assist in developing self-learners who organise their coursework to enhance learning opportunities and sharpen problem-solving abilities. Employing the metacognitive method also aids students in assessing their development, offering direction and improving their educational experiences. The application of this technique needs to be done carefully since metacognition can have a detrimental effect on students' self-esteem because it can impede healthy self-esteem development. Because metacognitive methods necessitate a knowledge of task instructions, they are inappropriate for kids with appropriate reading and comprehension skills or high self-esteem.

Recommendation

1. The undergraduate students use a metacognitive strategy to learn with a high degree of self-regulation. Creating engaging classroom and school activities that support self-regulated learning of computer programming is advised to maintain these abilities in students and their classmates.

2. Despite the respondents' extremely high degree of programming proficiency in learning, many students struggle to understand the ideas. It is, therefore, advised to create and implement intervention programs that specifically meet these pupils' learning requirements, especially during trying times.

3. Considering all the indicators of the metacognitive approach to learning on programming performance, it is advised to use self-regulation techniques, such as a metacognitive strategy, to improve lecture room activities.

4. More investigation into the effects of metacognitive techniques on programming and learning would be beneficial. Future studies should also incorporate additional non-cognitive variables to gain a more thorough understanding of the elements influencing computer programming performance.

Suggestions for Future Research

Therefore, it is recommended that further research be done critically in areas like examining how students' metacognitive skills evolve as they learn programming languages. This can entail following a group of students from the time they learn programming to the advanced stages and comparing the efficacy of conventional instruction with metacognitive approaches in teaching programming. Think about various programming languages and difficulty levels. Examine how metacognitive techniques affect students from a variety of backgrounds, including non-traditional students, learning-disabled kids, and students who have never programmed before. Examine the creation and incorporation of technological tools that assist metacognitive techniques in programming education, such as AI-driven teaching systems, applications, or metacognitive prompts in IDEs. Examine the effects of metacognitive learning sessions led by peers.

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Conflicts of Interest

None.

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