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| RESEARCH ARTICLE

COMPUTATIONAL THINKING SKILLS NEED OF COMPUTING STUDENTS IN PROGRAMMING ENVIRONMENT IN FEDERAL UNIVERSITIES IN SOUTH SOUTH, NIGERIA

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| ABSTRACT

This study determined the computational thinking skills need for computing students in programming environment in Federal Universities, South-South Nigeria. Two specific objectives, two research questions and two research hypotheses were formulated to guide the study. The study adopted descriptive survey design. A simple random sampling technique was used to select a sample size of two hundred and thirty (230) respondents comprising one hundred and eighty-three (183) final year Computer Science students and forty-seven (47) lecturers were drawn from the population of five hundred and eighty (580) in the eight Federal Universities in south-south, Nigeria using Taro Yamane formula. The researcher developed an instrument for the study titled "Computational Thinking Skills Need for Computing Students in Programming Environment Questionnaire (COTSNCSPEQ)" which was used for data collection. The instrument was subjected to face validation by three experts, a reliability of 0.83 was obtained using Cronbach Alpha method. The instrument was administered with the help of research assistants. The data were analyzed using SPSS statistical package. Mean was used to answer research questions while independent t-test was used to test the null hypotheses at 0.05 level of significance. The findings of the study revealed that computing students need problem formulation skill and recursive skills for computational thinking. Based on the result of the findings, the researcher concluded that computing students should be trained in order to improve their skills in problem formulation and recursive towards computational thinking in programming environment. The researcher recommended among others that university lecturers and computing students should be encouraged to put more effort in improving their skills in problem formulation and recursive skills for effective computational thinking in computing environment.

| KEYWORDS

Computational thinking skills, computer programming, programming environment, problem formulation

| INTRODUCTION

The rapid advancement of technology has significantly influenced the educational landscape, particularly in the field of computing. As Federal Universities in South-South Nigeria continue to produce graduates to meet the demands of the global job market, it has become increasingly important to equip students with essential computational thinking skills required for effective performance in programming environments. Computational thinking, a fundamental skill in computing, involves problem-solving methods that can be applied across various disciplines, particularly in programming.

Computing in the programming environment encompasses the overall performance

of students in programming tasks, which is directly influenced by their proficiency in the aforementioned computational thinking skills. In other words, the ability of students to succeed in a programming environment is contingent upon their mastery of problem formulation skills and recursive skills

(Belmar, 2022). Recent observations within the academic setting indicate that many computing students struggle with problem formulation and recursive skills, key components of computational thinking. For instance, lecturers and industry practitioners have consistently reported that students often find it challenging to break down complex problems into manageable parts, a crucial skill for effective programming (Treve, 2021). This difficulty is not only observed in classroom settings but also in real-world applications where graduates are expected to apply their knowledge to solve industry-specific problems.

Problem formulation skill refers to the ability to define a problem clearly and understand its requirements, a crucial first step in programming (Rahman 2019). Problem formulation skill is a critical component of computational thinking and is foundational in the programming environment. This skill involves the ability to define and understand a problem comprehensively before attempting to solve it. Theoretical perspectives on problem formulation offer various definitions that emphasize different aspects of the skill, particularly its role in breaking down complex tasks and guiding the problem-solving process. Problem formulation skill is the ability to break down a complex issue into specific, manageable parts that can be addressed through programming. It is the first step in the problem-solving process, where the programmer defines what the problem is, what the solution should accomplish, and what constraints must be considered. This skill is crucial because a poorly formulated problem can lead to ineffective solutions or, worse, no solution at all. For example, when a programmer is tasked with developing software to manage student records, problem formulation would involve clearly defining what "managing student records" entails. This could include identifying the specific functions the software should perform, such as storing, updating, and retrieving records, as well as understanding any constraints, such as data privacy regulations and system compatibility requirements. Without this clear definition, the programmer might miss critical aspects of the problem, leading to incomplete or flawed software.

Recursive skill involves the capability to recognize patterns and apply repetitive processes in problem-solving, which is fundamental in many programming tasks (Pirolli and Anderson, 2016). Recursive skill is an essential aspect of computational thinking, particularly in programming. It involves the ability to recognize patterns and apply repetitive processes or functions to solve problems. Recursion is a method where the solution to a problem depends on solutions to smaller instances of the same problem. This skill is crucial for solving complex problems that can be broken down into simpler, more manageable sub-problems. Recursion is defined by Rinderknecht (2014) as a process where a function calls itself in order to solve a problem. In this context, recursive skill refers to the ability to understand and implement such self-referential processes in programming. Rinderknecht highlights that recursion is a powerful tool for solving problems that have a repetitive structure, such as navigating through data structures like trees and graphs. Ian and Tamarisk (2013) defined recursive skill as the ability to conceptualize and design solutions that involve repetitive procedures, where a problem is solved by breaking it down into smaller instances of the same problem until a base case is reached. Ian and Tamarisk emphasized that this skill is not only about recognizing when

recursion is appropriate but also about understanding the underlying principles that make recursive solutions effective. This includes grasping the importance of a base case, which prevents infinite recursion and ensures that the problem is eventually solved.

Ukwa (2018) conducted a research on problem formulation skills need of computer students for effective web design in Akwa Ibom State, Nigeria. The purpose was to determine the influence of problem formulation skill in programming on computer science effectiveness in web designing. The study was guided by four specific objectives, four research questions and four null hypotheses which were tested at .05 level of significance. Comparative research design was adopted for the study. The population consisted 85 Computer Science students of both part-time and regular programmes in University of Uyo. A total of 80 respondents constituted the sample size for the study. A 20 item questionnaire developed by the researcher tagged Problem formulation skills need for programming (PFSNP) was validated by three experts. The reliability coefficient stood at 0.78. The finding of the study indicated that there was significant influence of problem formulation skill on programming for effective web design. Based on the findings, it was concluded that there was significant influence. It was also recommended among others that students should be encouraged to take problem formulation course in mathematics seriously in order to acquire problem formulation skill for effective web design. The study conducted by Ukwa (2018) relates to the present study in that both studies investigated problem formulation skill acquisition by computer students. Furthermore, the two studies investigated Computer Science Education student's skill in problem formulation on programming which is major skills in Computing. However, the two differ in that while former investigated problem formulation skill of students in University of Uyo, the later looked for problem formulation skill in Federal Universities in South-South, Nigeria.

Hamouda *et al*. (2018) conducted a study on the recursive skill development needs of computer students for effective web design in Nigeria. The research aimed to determine the influence of recursive problem-solving skills in programming on the effectiveness of computer science students in web design. The study was guided by four objectives, four research questions, and four null hypotheses, tested at a 0.05 level of significance. A comparative research design was adopted, involving a population of 85 Computer Science students enrolled in both part-time and regular programs at the University The sample size comprised 80 respondents. A 20-item questionnaire, titled Recursive Skill Development Needs for Programming (RSDNP) was developed by the researcher and validated by three experts, yielding a reliability coefficient of 0.78. The findings revealed that recursive skills significantly influenced programming effectiveness, which in turn enhanced web design. Based on these findings, the study concluded that recursive skills are critical for programming success and effective web design. It was recommended that students focus on recursive problem-solving techniques in mathematics and programming courses to strengthen their skills for web design. The study is related to the current research in its investigation of recursive skill acquisition among computer students. Both studies emphasize the importance of recursive problem-solving as a core skill in programming and computing. However, the two studies differ in their scope: while the research focused on students at the University, the present study extends its analysis to students in Federal Universities within the South-South region of Nigeria. Lacking these skills, not only hampers students' academic performance but also limits their career prospects in the highly competitive field of computing. It is against this backdrop that the researcher is seeks to determine the

computational thinking skills needed for computing students in programming environments in federal universities in South-South Nigeria.

| Statement of the Problem

Information and Communication Technology is a creation from Computer Programming. Softwares are measured in terms of reliability, useability, flexibility and general acceptable standard for deployment by industries and organizations. Computer Programming depends on logical thinking ability on how problems could be solved using computer system or any automated devices. Computational thinking is a fundamental skill that needs to be mastered by computing students in order to effectively solve problems in the world of digital technology. Ogunode *et al.* (2021) observed that software developed in Nigeria are not easily deployed by organizations and institutions. The author queried the level of proficiency ability among computer science students in software development. The researcher observed that to excel in today's workspace, strong computational thinking skill is crucial and practical experiences where students apply their knowledge in real-world setting are vital for career readiness. The researcher also observed that computing students in Federal universities in South-South, Nigeria seems not to be good in programming, the rise of technologies like Artificial intelligence, Blockchain or Internet of things (Iot) is impacting the computational thinking skills in the workforce. It is against this background that the researcher aims at examining the computational skill needed for computing students in programming environments in Federal Universities, South-south, Nigeria.

| Purpose of the Study

The main purpose of this study is to determine the computational thinking skills need for computing students in programming environment in Federal Universities in South-South Nigeria. Specifically, the study seeks to determine:

i. The problem formulation skills need of computing students in programming environment in Federal Universities in South-South, Nigeria
ii. The recursive skills need of computing students in programming environment in Federal Universities in South-South, Nigeria.

| Research Questions

i. What is the problem formulation skills need of computing students in programming environment in Federal Universities in South-South, Nigeria?
ii. What is the recursive skills need of computing students in programming environment in Federal Universities in South-South, Nigeria?

| Research Hypotheses

The following research hypotheses was raise to guide the study:

Ho_1. There is no significant difference in the mean responses of lecturers and students on the problem formulation skills need of computing students in programming environment in Federal Universities in South-South, Nigeria.

Ho_2. There is no significant difference in the mean responses of lecturers and students on the recursive skills need of computing students in programming environment in Federal Universities in South-South, Nigeria.

| Research Method

A descriptive survey design was adopted for this study. The study was conducted in Federal Universities in South-South, Nigeria. A simple random technique was used to select a sample size of two hundred and thirty (230) respondents comprising one hundred and eighty-three (183) final year Computer Science students and forty-seven (47) lecturers were drawn from the population of five hundred and eighty (580) in the eight Federal Universities in south-south, Nigeria

using Taro Yamane formula. The researcher developed twenty (20) items research instrument titled: "Computational Thinking Skills Need for Computing Students in Programming Environment Questionnaires" (COTSNCSPEQ) for data collection. The instrument was subjected to face validation. The internal consistency of the instrument was determined using Cronbach Alpha reliability test. The questionnaire was administered on the respondents by the researcher together with 8 research assistants. Mean was used to answer the three research questions while the independent sample t-Test was used to test null hypotheses at 0.5 level of significant. Real limit was used as decision rule for the research questions is indicate as follows: Very Lowly Possessed/Needed = 1; Lowly Possessed/Needed =2; Highly Possessed/Needed =3 and Very Highly Possessed/Needed = 4. In order to test the null hypotheses, if the p-value is less or equal to 0.05 ($p \leq 0.05$), the null hypothesis was rejected. Notwithstanding, where p-value is greater than 0.05 ($p > 0.05$), then the null hypothesis was retained.

Findings and Discussions

What is the problem formulation skills need of computing students in programming environment in Federal Universities in South-South, Nigeria?

Table 1: Summary of Performance Gap Analysis of mean responses in problem formulation skills need for computing students in programming environment

n = 230

S/N	Items	$\overline{XN}$	XP	PG=$\overline{XN}$-$\overline{XP}$	Remark
1	Clearly define programming problems given in a programming environment.	3.75	2.37	1.37	Skill Needed
2	Able to articulate the constraints of a programming task before starting to code.	3.75	2.00	1.75	Skill Needed
3	Able to break down complex programming problems into simpler manageable sub-problems.	3.50	2.06	1.43	Skill Needed
4	Able to determine the inputs/expected outputs for a programming problem effectively.	3.75	2.12	1.62	Skill Needed
5	Knowledge of specifying the requirements of a programming problem.	3.50	2.18	31	Skill Needed
6	Able to reframe or redefine programming problems when initial solutions are not feasible.	3.75	2.37	1.37	Skill Needed
7	Ability to use examples to illustrate the problem I am trying to solve in programming.	3.75	2.18	1.56	Skill Needed
8	Proficient in using problem statements to guide my coding process.	3.50	1.56	1.93	Skill Needed
9	Ability to distinguish between the essential and non-essential components of a problem.	3.75	1.75	2.00	Skill Needed
10	Ability to communicate the problem formulation process clearly to others.	3.50	1.93	1.56	Skill Needed
	Cluster Mean	3.65	2.12	1.59	

Source: Researcher 2024

The data presented in Table 1 indicated that all the identified items on problem formulation skills have their mean difference to be positive values (1.31 to 2.00), indicating that student's skill level is below what is needed. The result implies that computing students need skills on all the identified problem formulation skills in programming environment.

Research Question 2

What is the recursive skills need of computing students in programming environment in Federal Universities in South-South, Nigeria?

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Table 2: Summary of Performance Gap Analysis of mean responses in recursive skills need for computing students in programming environment

n = 230

S/N	Items	$\overline{XN}$	$\overline{XP}$	PG=$\overline{XN}$-$\overline{XP}$	Remark
1	Ability to understand the concept of recursion.	3.50	2.25	1.25	Skill Needed
2	Ability to accept recursion in coding task	3.50	1.87	1.62	Skill Needed
3	Ability to identify situations where recursion is a suitable approach for solving a problem.	3.75	1.93	1.81	Skill Needed
4	Proficient in tracing recursive function calls/their outcomes.	3.50	2.00	1.50	Skill Needed
5	Ability to debug recursive functions effectively when it does not produce the expected results.	3.50	2.06	1.43	Skill Needed
6	Optimization of recursive solutions to improve their efficiency.	3.50	2.25	1.25	Skill Needed
7	Familiarity with the base case recursion.	3.25	2.06	1.18	Skill Needed
8	Understanding recursive case in recursion	3.75	1.43	2.31	Skill Needed
9	Capability to convert iterative solutions into recursive solutions when needed.	3.75	1.62	2.12	Skill Needed
10	I can use recursion to solve problems involving tree and graph structures.	3.75	1.81	1.93	Skill Needed
	Cluster Mean	3.58	1.92	1.64	

Source: Researcher 2024

The data presented in Table 2 indicated that all the identified items on recursive skills have their mean difference to be positive values (1.18 to 2.31), indicating that student's skill level is below what is needed. The result implies that computing students need skills on all the identified recursive skills in programming environment.

Research Hypothesis 1

There is no significant difference in the mean responses of lecturers and students on the problem formulation skills need for computing students in programming environment in Federal Universities in South-South, Nigeria.

Table 3: Summary of t-test analysis on the difference in mean responses of lecturers and students on problem formulation skills need for computing students in programming environment

df = 228

S/N	Items	Groups	N	Mean	SD	t-value	p-value	Decision
1	Clearly define programming problems given in a programming environment.	Lecturers	47	3.75	0.50			
						4.91	.001	Significant
		Students	183	2.37	0.50			
2	Able to articulate the constraints of a programming task before starting to code.	Lecturers	47	3.75	0.50			
						4.49	.001	Significant
		Students	183	2.00	0.73			
3	Able to break down complex programming problems into simpler manageable sub-problems.	Lecturers	47	3.50	0.57			

						3.46	.003	Significant
		Students	183	2.06	0.77			
4	Able to determine the inputs/expected outputs for a programming problem effectively.	Lecturers	47	3.75	0.50			
						3.80	.001	Significant
		Students	183	2.12	0.80			
5	Knowledge of specifying the requirements of a programming problem.	Lecturers	47	3.50	1.00			
						2.71	.014	Significant
		Students	183	2.18	0.83			
6	Able to reframe or redefine programming problems when initial solutions are not feasible.	Lecturers	47	3.75	0.50			
						4.09	.001	Significant
		Students	183	2.37	0.61			
7	Ability to use examples to illustrate the problem I am trying to solve in programming.	Lecturers	47	3.75	0.50			
						3.54	.002	Significant
		Students	183	2.18	0.83			
8	Proficient in using problem statements to guide my coding process.	Lecturers	47	3.50	0.57			
						6.61	.001	Significant
		Students	183	1.56	0.51			
9	Ability to distinguish between the essential and non-essential components of a problem.	Lecturers	47	3.75	0.50			
						7.83	.001	Significant
		Students	183	1.75	0.44			
10	Ability to communicate the problem formulation process clearly to others.	Lecturers	47	3.50	0.57			
						3.43	.003	Significant
		Students	183	1.93	0.85			

Source: Researcher (2024)

Table 3 gives the summary of the t-test analysis comparing the difference in the mean responses of Computing Lecturers and Students on the problem formulation skills need for computing students in programming environment in Federal Universities in South-South, Nigeria. The result reveals that the difference in the responses of the two groups were statistically significant in all the items on problem formulation skills with t-values ranging from 2.717 to 7.838 and p-values ranging from 0.001 to 0.014 Since all the p-values are less than 0.05 level of significance, it implies that there is a significant difference between the mean of the respondents. Hence, the null hypothesis one which states that there is no significant difference in the mean responses of lecturers and students on the problem formulation skills need for computing students in programming environment in Federal Universities in South-South, Nigeria was rejected.

Ho2. There is no significant difference in the mean responses of lecturers and students on the recursive skills need for computing students in programming environment in Federal Universities in South-South, Nigeria.

Table 4: Summary of t-test analysis on the difference in mean responses of lecturers and students on recursive skills need for computing students in programming environment

df = 228

S/N	Items	Groups	N	Mean	SD	t-value	p-value	Decision

1	Ability to understand the concept of recursion.	Lecturers	47	3.50	0.57	3.35	.004	Significant
		Students	183	2.25	0.68			
2	Ability to accept recursion in coding task	Lecturers	47	3.50	1.00	3.45	.003	Significant
		Students	183	1.87	0.80			
3	Ability to identify situations where recursion is a suitable approach for solving a problem.	Lecturers	47	3.75	0.50	4.02	.001	Significant
		Students	183	1.93	0.85			
4	Proficient in tracing recursive function calls/their outcomes.	Lecturers	47	3.50	1.00	2.93	.009	Significant
		Students	183	2.00	0.89			
5	Ability to debug recursive functions effectively when it does not produce the expected results.	Lecturers	47	3.50	0.57	2.92	.009	Significant
		Students	183	2.06	0.92			
6	Optimization of recursive solutions to improve their efficiency.	Lecturers	47	3.50	1.00	2.73	.013	Significant
		Students	183	2.25	0.77			
7	Familiarity with the base case recursion.	Lecturers	47	3.25	1.50	2.03	.047	Significant
		Students	183	2.06	0.92			
8	Understanding recursive case in recursion	Lecturers	47	3.75	0.50	8.10	.001	Significant
		Students	183	1.43	0.51			
9	Capability to convert iterative solutions into recursive solutions when needed.	Lecturers	47	3.75	0.50	7.60	.001	Significant
		Students	183	1.62	0.50			
10	I can use recursion to solve problems involving tree and graph structures.	Lecturers	47	3.75	0.50	4.04	.001	Significant
		Students	183	1.81	0.91			

Source: Researcher (2024)

Table 4 gives the summary of the t-test analysis comparing the difference in the mean responses of Computing Lecturers and Students on the recursive skills need for computing students in programming environment in Federal Universities in South-South, Nigeria. The result reveals that the difference in the responses of the two groups were statistically significant in all the items on recursive skills with t-values ranging from 2.031 to 8.106 and p-values ranging from 0.001 to 0.047 Since all the p-values are less than 0.05 level of significance, it implies that there is a significant difference between the mean of the respondents. Hence, the null hypothesis two which states that there is no significant difference in the mean responses of lecturers and students on the recursive skills need for computing students in programming environment in Federal Universities in South-South, Nigeria was rejected.

Discussion of Findings

The findings revealed that all the identified items on problem formulation skills have their mean difference to be positive values (1.31 to 2.00), indicating that student's skill level is below

what is needed. The result implies that computing students need skills on all the identified problem formulation skills in programming environment.

The result reveals that the difference in the responses of the two groups were statistically significant in all the items on problem formulation skills with t-values ranging from 2.717 to 7.838 and p-values ranging from 0.001 to 0.014 Since all the p-values are less than 0.05 level of significance, it implies that there is a significant difference between the mean of the respondents. Hence, the null hypothesis one which states that there is no significant difference in the mean responses of lecturers and students on the problem formulation skills need for computing students in programming environment in Federal Universities in South-South, Nigeria was rejected.

| Conclusion

Based on the findings of the study, it is concluded that students' skill level is below what is required. The result implies that computing students need skills in all the identified problem formulation skills and identified recursive skills in programming environment. The study concludes that since students' skill level is below what is required, students need skills in all programming environment.

| Recommendations

Based on the findings of the study, the following recommendations are made

1. NUC should sponsor lecturers on trainings and seminars to be able to impart more knowledge to students on computational thinking
2. Curriculum planners should be able to provide teaching strategies for both students and lecturers in computers science and other related disciplines.

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