Working Memory Capacity as a Predictor of Academic Achievement in Computer Studies among Secondary School Students in Onitsha Education Zone

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Abstract
The study determined working memory capacity as a predictor of academic achievement in Computer studies among secondary school students in Onitsha Education Zone. Two research questions and two null hypotheses guided the study. The study adopted the Predictive correlational research design. The population of the study comprised 5, 455 senior secondary year two (SS2) students offering computer studies out of which a sample of 1,000 students drawn using random and purposive sampling techniques were used. The instruments for data collection were Figural Intersection Test (FIT), Reading Span Test (RST) validated by experts. The reliability of The reliability of FIT is as established with the Cronbach Alpha reliability coefficient ranging from 0.84-0.93 while that of the RST was 0.88. The students' achievement scores in Computer studies for two terms were obtained and the average scores were used as the students' achievement in Computer studies. The data obtained were analyzed using simple and multiple linear regressions. The findings of the study revealed among others that 0.4% of the variance in achievement in Computer studies was predicted by working memory capacity. Also, achievement scores in computer studies was significantly predicted by students' working memory capacity. It was recommended that learning instruction should be organised into learning bits, units or modules and taught sequentially proceeding to the known to the unknown.

Keyword: *Working-Memory, Achievement, Computer, Predictor, Regression*

Introduction

Computer studies was introduced into secondary school level of education in 2014 to advance students' level of study of computation, automation and information. The study of the computer studies is devoted to using and programming computers. It spans through theoretical knowledge such as algorithms to practical skills such as designs and use of hardware and software.

The National Educational Research Development Council (NERDC) to aid the learning of computer studies developed a three-book series aimed at building knowledge and skills starting from junior secondary schools. Attention was focused on new trends in computer science, programming, computer application and the use and development of Information and Communication Technology (ICT). The objective is to stimulate further interest in the study of computer science and computer related studies/career that will enable a learner take up career in computer science at higher levels, thus addressing the challenges of the digital divide and the dearth of computer programmers.

The government of Anambra state, according to Premium times (2013) in the bid to forestall any shortage of computer resources needed for the proper implementation of the computer studies curriculum in secondary school donated 22, 500 laptops and I, 400 printers worth 2.65 billion to secondary schools in the state. The then governor, Mr. Peter Obi who expressed his commitment on ICT in secondary schools further noted that, the government of the state had also procured 520 transformers for distribution to schools in the 177 communities in the state. A consortium of five partners had worked together to achieve the laudable objectives for the connectivity and educational packages.

Despite the importance of the computer studies and effort to ensure proper implementation of the computer studies curriculum, students' achievement in the subject have not improved as expected. The WAEC Chief examiner in 2017 reported that students' poor achievement was evident in drawing of logic gates, used application packages wrongly, poor navigation and selection of windows and general poor usage of the computer system. In 2018, although the Chief Examiner reported that students' achievement was slightly better compared to 2017, he noted that students also showed poor achievement in questions relating to programming and lacked the knowledge of the functions of registers and use of footer. The Chief examiner further noted in 2019 that students' achievement compared favourably to 2018 but that students performed poorly on file structure and organization and had general poor computer practical skills. The Chief examiner reported that major cause of students' unsatisfactory achievement is the lack of continuous computer practical classes among others.

Literature on factors affecting students' achievement in computer studies revealed that, although the government and the teachers have done a lot to ameliorate the challenges of learning computer studies, little is known about how much of the computer contents the students working memory capacity can process during class. Nothing was also known about how students' cognitive style and mobility fixity influence their understanding of the computer studies concepts and whether these factors account for any variance in computer studies achievement.

Working memory capacity according to Coasta and Faria (2018) is identified as the ability to focus attention on a given task while at the same time avoiding distraction from task-irrelevant information. Working memory, as Diamond (2013) noted, is a system responsible for the active maintenance of goal-relevant information in the face of concurrent processing and/or interference. According to Ferbinteanu (2018), it is a hypothetical cognitive system responsible for providing access to information required for ongoing cognitive processes. Thus, working-memory capacity (WMC) refers to an individual differences construct reflecting the limited capacity of a person's working memory. WMC does not refer to a total amount of mental capacity or a speed of information processing per se, rather, WMC refers to an ability to maintain a task goal in the face of salient interference.

WMC is measured most often through a test that requires people to commit a short list of items to memory while performing some other task (Niaz, De-Nunez and De-Pineda, 2021). It is also measured using the Figural Intersection Test (FIT) developed by Pascual-Leone in 1975 to measure mental capacity and attention. In the present study, WMC will be measured using FIT and reading span test as a confirmatory test. Working memory capacity plays a vital role in allowing learners to actively combine concepts and ideas and connecting novel information with activated, old long-term memory information.

According to Sweller's (1994) cognitive load theory, working memory capacity limits the amount of information one can process in each cognitive activity. If the cognitive load of the situation exceeds working memory capacity, learning processes will be affected. Sweller outlined two types of cognitive load: the external load (how materials are presented, that is, with potential distractions) and the internal cognitive load (the materials' complexity; the amount of interactivity among elements in the materials). Relatedly, Halford, Wilson, and Phillip (1998) theory illustrates working memory's important role in long-term learning when they noted that processing limits occur according to the number of elements that have to be associated to form an idea. The same idea was held by George Miller Armitage's (1956) information processing theory which suggests that if working memory is too limited, it can be insufficient to grasp a complex concept. There are barely any studies in computer studies among secondary school students in Onitsha Education zone that investigated the predictive power of WMC on students' academic achievement in Computer studies. The need therefore arises for an in-depth study on the predictive influence of WMC on students' academic achievement in computer studies.

Purpose of the Study

The purpose of the study was to determine working memory capacity as a predictor of secondary school students' academic achievement in computer studies in Onitsha Education Zone. Specifically, the study determined the:

1. Predictive power of working memory capacity (WMC) on students' achievement in Computer studies.
2. Contribution of the individual dimensions of WMC (visuospatic and verbal) in the prediction of students' achievement in Computer studies.

Research Questions

The following research questions guided the study:

1. What is the predictive power of working memory capacity (WMC) on students' achievement scores in computer studies?
2. What is the contribution of the individual dimensions of WMC (visuospatic and verbal) in the prediction of students' achievement scores in computer studies?

Hypotheses

The following null hypotheses were tested at 0.05 level of significance:

1. Students' working memory capacity scores is not a significant predictor of academic achievement in computer studies.
2. The contribution of the individual dimension of working memory capacity (visuospatic and verbal) in the prediction of students' achievement scores in computer studies is not significant.

Method

The design of the study was predictive correlational survey. According to Nworgu (2015), correlational studies are those in which the researcher seeks to establish the relationship existing between two or more variables that are of interest in the study. The design was therefore chosen because the study sought not just to establish the simple relationship between the variables but the predictive association showing the variance in the outcome variable that is explained by the predictor variables. The area of the study is Onitsha Education Zone of Anambra state. The population of the study is 5, 455 senior secondary year two (SS2) students offering Computer studies in 2022/2023 academic session. The population is composed of 3, 671 females and 1, 780 male students offering Computer studies. The sample for the study was

1100 SS2 students offering Computer studies in Onitsha Education Zone obtained from the population using purposive and random sampling techniques.

The instruments for data collection are Figural Intersection Test (FIT) and Reading Span Test (RST). FIT is a group administered paper and pencil test designed by Pascual-Leone to measure working memory capacity. Detailed descriptions of the test, its administration and scoring procedures, and its theoretical derivation are provided by Parkinson (1975b), Goodman (1979) and Johnson (1982b). The following summary description as well as the procedures followed in the present study are adapted from Goodman (1979). The task consisted of a booklet of items in which each item consists of two sets of figures, one 'presentation set' on the right side of the page, and one 'intersecting set' on the left. In the presentation set a number of geometric figures are arranged discretely. In the intersecting set, the same figures are presented in an overlapping way such that there is one area of common intersection. The figures in the presentation and intersecting sets correspond with respect to shape but not necessarily size or orientation. The subject's task is to find area of intersection and mark it with a dot. The instrument is copy-righted and the researcher had written Prof. Pascual-Leone to obtain the instrument. The original copy of the instrument is attached as Appendix A on page 98.

In the present study, a test of working memory capacity was also done using verbal span and visual span test. A commonly used measure is a dual-task paradigm (involving verbal and visual), combining a memory span measure with a concurrent processing task, sometimes referred to as "complex span". Daneman and Carpenter invented the first version of this kind of task, the "reading span", in 1980. Student read a number of sentences (usually between two and six) and tried to remember the last word of each sentence and the words in their order as well as the number of digits in the order it was flashed on the screen. At the end of the list of sentences, they repeated back the words in their correct order. The computerized version of the test was used in this study. The score inventory of the students for two terms was obtained and the average determined and used as students' achievement in Computer studies. The validity of Group Embeeded Figure Test (GEFT) was according to Witkin, Oltman, Raskin and Karp (1971) who tested the items against other measure of cognitive style. The reliability of FIT is as established by Pascual-Leone who found the split half reliability estimate to range from 0.86-0.91 with the Cronbach Alpha reliability coefficient ranging from 0.84-0.93. The reliability of RST was established by Daneman and Carpenter (1980) was 0.88.

The instruments were administered to the students with the aid of four research assistants. They were briefed on the data collection process and the norms for administering the FIT and CST as well as the RST. Thereafter, they meet with the school authorities to seek permission for the conduct of the study and on approval, they met with the school computer studies teachers. After having acquainted the computer studies teachers on the purpose of the study and it objects, as well as the need data collection procedures, they collected the students' computer studies score for two terms and wrote the serial numbers against their names on the instruments. This was to ensure that each student's score in the test is matched against their academic achievement in computer studies. The instruments were administered and collected the same day to ensure that it is the students who answered to them and to reduce sample mortality. The instruments were scores and the scores in each dimension was summed to get the students' score. After, collection, they were scored and the data collated for analysis.

Data generated from the study were analyzed using simple linear and multiple regressions. The coefficient of determination was used to explain the variation in the outcome variable that was attributed to the predictor variables. The null hypotheses were tested at 0.05 level of significance using simple and multiple linear regression. The decision rule was that whenever Pvalue is less than or equals 0.05 ($P \leq 0.05$) the null hypothesis was rejected and was not rejected whenever Pvalue is greater than 0.05 ($P > 0.05$).

Results

Research Question 1: What is the predictive power of working memory capacity (WMC) on students' achievement scores in computer studies?

Table 1: Prediction of Students' Achievement in Computer Studies by Working Memory Capacity

Model	R	R^2	Adjusted R^2	Unstandardized coefficients (B)	Std. Error
Constant WMC	.067[a]	.004	.004	67.304 .792	14.747

a. Predictors: (Constant), WMC

Table 1 shows that a low positive relationship (R = 0.067) exists between students' working memory capacity and their achievement in computer studies. The R-Square value of 0.004 indicates that 0.4percent of the variance in computer studies scores is predicted by working memory capacity. The unstandardized coefficient B of 0.792 shows that a unit rise in working memory capacity increases academic achievement in computer studies by 0.792.

Research Question 2: What is the contribution of the individual dimensions of WMC (visuospatic and verbal) in the prediction of students' achievement scores in computer studies?

Table 2: Contributions of the Individual Dimensions of Working Memory Capacity to Academic Achievement Scores in Computer studies

	Model	Unstandardized Coefficients		Standardized Coefficients	t	Pvalue
		B	Std. Error	βeta		
1	(Constant)	68.978	1.218		56.643	.000
	Visuo-spatic WMC	.159	.798	.013	.200	.550
	Verbal WMC	.046	.783	.004	.059	.750

a. Dependent Variable: Computer studies Achievement

Table 2 shows the standardized beta coefficient which indicates correlation between variables. The unstandardized B coefficient shows the prediction powers of each dimension of working memory capacity which indicates their relative contribution to achievement in computer studies. Table 2 shows that visuo-spatic WMC has a low positive predictive relationship (R = 0.013) with students' achievement in computer studies while verbal WMC has a low positive relationship (R = 0.004) with achievement in computer studies. Table 2 also reveals that a unit increase in visuo-spatic WMC contributed 0.159 to achievement in computer studies and whenever a students' verbal WMC increased by 1 unit, academic achievement in computer studies increases by 0.046. The order of relative contribution to achievement in computer studies from the highest to lowest by each dimension of WMC; visuo-spatic (0.159), followed by verbal WMC (0.046).

Hypothesis 1: Students' working memory capacity scores is not significant predictor of their academic achievement in computer studies.

Table 3: Significance of Prediction of Achievement in Computer studies by Students' Working Memory Capacity

Model		Sum of Squares	df	Mean Square	F	Pvalue
	Regression	1076.383	1	1076.383	4.949	.026[b]
1	Residual	238794.803	1098	217.482		
	Total	239871.185	1099			

a. Dependent Variable: Computer studies Achievement
b. Predictors: (Constant), Working Memory Capacity

Table 3 shows that working memory capacity is a significant predictor of achievement scores in computer studies, F (1, 1098) = 4.949, p < .05. The null hypothesis was therefore rejected implying that students' working memory capacity scores is a significant predictor of their academic achievement in computer studies. Since working memory capacity is a significant predictor of achievement scores in computer studies, the regression model (Y= a + bX) for the prediction of achievement score in computer studies as derived from Table 1, where constant = 67.304 and b value = 0.792 is:

CSA = 67.304 + 0.792(WMC)

Where, CSA = Computer studies Achievement score and WMC = Working Memory Capacity Score

Hypothesis 2: The contribution of the individual dimension of working memory capacity (visuospatic and verbal) in the prediction of students' achievement scores in computer studies is not significant.

Table 4: Significance of Prediction of Students' Achievement in Computer studies by the Dimensions of Cognitive Style

Model		Sum of Squares	df	Mean Square	F	Pvalue
	Regression	67.231	2	33.616	.154	.288[b]
1	Residual	239803.954	1097	218.600		
	Total	239871.185	1099			

a. Dependent Variable: Achievement
b. Predictors: (Constant), Verbal WMC, Visuo-spatic WMC

Table 4 shows that the dimensions of WMC are not significant predictor of achievement scores in computer studies, F (1, 1097) = 0.154, p > 0.05. The null hypothesis was therefore rejected implying that the contributions of the individual dimension of working memory capacity (visuospatic and verbal) in the prediction of students' achievement scores in computer studies are not significant.

Table 2 shows that visuospatic WMC is not significant predictor of achievement scores in computer studies, t(1, 1097) = 0.200, p > 0.05 and verbal WMC is also a significant predictor of achievement scores in computer studies, t(1, 1097) = 0.059, p > 0.05.

Discussion

The findings of the study showed that working memory capacity significantly predicted 0.4percent of academic achievement scores in computer studies and increases academic achievement by 0.792 when increased by a unit. The study's results are contingent upon the observation that improving working memory overload, whether through increasing capacity or decreasing demands, enhances learning. The robust predictive correlation between working memory capacity and academic achievement is consistently observed across cognitive processes, alongside intelligence quotient, suggesting that working memory capacity possesses a significance beyond being a mere surrogate for intelligence. In contrast, children who experience challenges with working memory frequently exhibit suboptimal academic performance due to being overwhelmed by the demands of the classroom or learning environment. This is evidenced by their tendency to forget essential task-related information, struggle to adhere to instructions, and exhibit incomplete engagement with various tasks. Consequently, the process of learning is significantly hindered.

In the past, there was a prevailing belief that working memory capacity exhibited a high degree of heritability and was regarded to be a fixed trait. Nevertheless, current understanding suggests that there is potential for improvement in working memory through the utilization of adaptive training activities that promote sustained engagement at an individual's specific working memory capacity. Individuals who exhibit deficits in working memory frequently experience difficulties in remembering and retaining information while engaged in cognitive tasks. As an illustration, individuals may possess comprehension of a three-step directive they were recently provided with, yet experience difficulty in retaining the second and third stages when executing the initial step. It is imperative for children to effectively retain, retrieve, and analyse the information they have acquired in order to apply it accurately.

Enhancing working memory capacity has the potential to improve performance in overall problem-solving aptitude and enhance fluid intelligence. Fluid intelligence refers to the cognitive capacity to effectively solve novel issues, apply logical reasoning in unfamiliar contexts, and discern underlying patterns. On the other hand, crystallized intelligence refers to the capacity to apply acquired knowledge and past experiences. The existing body of literature indicates that children who demonstrate underachievement in academic settings may be more likely to possess deficiencies in working memory rather than exhibiting low levels of intellect. Teachers frequently fail to recognise poor working memory ability in students, typically attributing their difficulties to inattentiveness or weaker intellectual abilities. Insufficient intervention in children with limited working memory capacity can have a lasting impact on their academic achievements throughout their adult lives, impeding their ability to reach their full potential. Enhancing working memory is crucial for addressing learning difficulties.

To effectively address mathematical and computer science problems, it is important for students to possess the cognitive ability to retain numerical and abstract knowledge, manipulate said information, and maintain awareness of intermediate solutions. The utilisation of visuospatial working memory may be observed in the context of doing calculations or creating computer algorithms, particularly when tactics entail the use of spatial representations to depict sequential processes and numerical values, such as a number line. In the context of computer research, calculations may exhibit a greater dependence on verbal working memory when procedures entail the generation, modification, or repetition of verbal information, such as a counting procedure. Similarly, for the purpose of reading and comprehending a written text, it is necessary for children to retain recently encountered propositions, merge them with adjacent segments of text, and draw upon their prior knowledge to construct a cohesive comprehension of the text. The relationship between verbal working memory and reading comprehension may be stronger than that of visuo-spatial working memory. However, visuo-spatial working memory may still play a role in reading comprehension by facilitating visual imagery. It is worth noting that the processing of verbally conveyed spatial information can potentially hinder the processing of visuo-spatial items.

The findings of the study is related to the findings of Blamkenship, O'Neill, Ross and Bell (2016) that that working memory was associated with each assessed measure of academic achievement. The findings of the study also collaborate with the findings of Ahami, Mammad, Azzaoui, Boulbaroud, Rouim and Rusinek (2017) that there is a significant correlation between forward memory span and activated schema, and significant negative correlations are registered between backward memory span and activated schema. The findings of the study is in line with the findings of Bos and Weijer-Bergsma (2019) that classroom obtained verbal working memory scores were the strong predictors of academic achievement. The findings of Quilez-Robres, Moyano and Cortes-Pascual (2021) that task monitoring and working memory had a greater relationship with general and specific achievement, support the findings of the present study.

Conclusion

The conclusion drawn from the findings of the study is that working memory capacity is a significant predictor of academic achievement in computer studies. Students' achievement in computer studies is significantly influence by working memory capacity.

Recommendations

The following recommendations are made based on the findings of the study:

1. Learning instruction should be organized into learning bits, units or modules and taught sequentially proceeding to the known to the unknown.
2. Computer studies classes should be focused on the goals and objectives of instruction so as to reduce the cognitive loads that may be beyond the students working memory capacities.

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