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Multi-Factored Linear Models for Predicting Learning Outcomes of Computer Science Students in Private and Public Universities in Nigeria

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Abstract: The apparent disparity in the academic learning outcomes of Computer Science (CS) students in private and public universities in Nigeria is currently a big concern. In this study, two multi-factored evaluation models are developed to investigate and predict learning outcomes of CS students in a privately-owned Caleb University (CU), Imota and a government-owned University of Lagos (UNILAG), Akoka-Yaba, both situated in Lagos State Nigeria. The two universities were chosen for this study using convenience sampling. The data used in this study was collected from 267 CS student volunteers (200-500 level) in UNILAG and 139 CS student volunteers (200-400 level) in CU who were enrolled between 2012/2013-2017/2018 academic sessions via. a developed closed-ended questionnaire tagged "Multifactor Student Performance Evaluation Instrument for Nigerian Universities (MSPEINU)" with a r eliability coefficient of 0.86. 18 factors were investigated with their associated 65 independent variables that largely affect performance of students. Regression and correlation are the descriptive statistics used to analyze and examine the cause-and-effect impact of the factors as well as the degree of that impact on the student learning outcomes. The findings from this study show that the actual factors affecting performance of computer science students in UNILAG are student's attitud e to learning, student attendance, student background knowledge, lecturer attitude, lecturer teaching style, class population, family income and parent education while student attendance, student opinion, proper guidance, parent education, family income, lecture time, student background knowledge, electricity, student health, lecturer teaching style and lecturer attitude are the factors affecting the computer science students in CU. The predictive models developed in this study present potential cost and performance improvement benefits as it guides the university administrators, the lecturers, the students and other relevant university stakeholders towards sound decision making. They are also robust and exhaustive enough to be generalized to other similar universities in Nigeria.

Key words: Private university, public university, student learning outcome, multifactored predictive model, computer science

INTRODUCTION

The great contributions of educational institutions to the growth and development of a nation cannot be overemphasized. A major goal of educational institutions is to contribute to the development of human assets by improving the quality of education. However, universities in Nigeria are consistently, engaged with the struggle to surmount pressure of major proportions which threatens their survivability and capacity to meet the demands of the 21st century educational services standard and also impede their ability to fulfill their roles of producing skilled manpower for national growth and development (Matthew *et al.* 2018). The problems presently being faced by public universities in Nigeria include but are not limited to inadequate infrastructure, insurgency, dilapidated equipment and structures, incessant strike actions, obsolete educational system and curricula, poor quality tertiary education, examination malpractices, brain drain and poor funding (Ahmad *et al*., 2016). For example, more often than not, students do not have access to sufficient educational resources and conducive learning environment that can enhance their creativity and improve their learning outcomes (Akomolafe and Adesua, 2019). On the other hand, the attitude and commitment of some students to learning and achieving excellence are also very poor in most cases (Kolo *et al*., 2015). In most private universities, challenges include quality assurance as

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they concentrate more on profit-making, cost of accessing educational service and dearth of qualified academic members of staff (Adetunji *et al*., 2016). These challenges in turn defeat the purpose of education, especially, to learn, understand and apply acquired knowledge to solve societal problems as graduates being turned out are most times un employable and tagged "half-baked". No holistic approach can be employed to address these challenges wholly because each of these challenges is peculiar and requires thorough analysis and mitigation plan (Elbadrawy *et al*., 2015). Therefore, this research aims at investigating the hidden factors affecting the performance of students enrolled for a bachelor's degree programme in computer science of private and public universities in Nigeria. Furthermore, it strives to identify the common challenges of the students in these universities and those that are peculiar to each of the universities. Existential evidence of the aforementioned challenges (interchangeably used as factors henceforth) in a privately-managed university and a government-owned University in Nigeria was investigated. Furthermore, predictive models were developed to explicitly establish the linear cause-and-effect relationship between each of these factors and learning outcomes of students. The results of this research can help to support student's learning process and planning, upsurge student's academic performance in computer science, help the institutions in the study area as well as others that share similar academic programme structure and general peculiarities, to understand the causes of student's failure in computer science courses and make sound and sustainable decisions on mitigation strategies to eliminate the negative impact of these factors on student's learning outcomes and curb future incessant re-occurrence of massive poor performance in computer science courses.

MATERIALS AND METHODS

In this study, the research design, study area, population and sample size, data collection instrument and factor coding, reliability of the data collection instruments and data analysis using regression and correlation for student performance predictive model development.

Research design: Correlation and multi-regression analyses are the technical tools employed in this study to model and predict student learning outcomes.

Study area: The study was conducted at Caleb University (CU), a privately-owned institution and University of Lagos (UNILAG), a federal government-managed institution. UNILAG is located Akoka-Yaba road, Lagos State at a latitude and longitude of 6°31'59.99"N and 3°23'5.99"E , respectively. In the same vein, CU is situated along Itoikin-Ijebu-Ode Road, Imota Lagos State at a latitude and longitude of 6.6194°N and 3.5105s°E, respectively. However, the two universities are located in Lagos State in the South-Western part of Nigeria.

Population and sample size: A sample of two universities, one private and one public were chosen using convenience sampling. 300 students between 200 level and 500 level from UNILAG and 200 students between 200 level and 400 level from CU were randomly selected, respectively. The choice of the number of randomly-chosen respondents was informed by the total number of students studying computer science in both universities. 267 copies of the duly-filled questionnaire was returned from UNILAG while 139 copies were retrieved from CU.

Data collection instrument and factor definition: The key data used in this study was gathered using a well-structured self-administered questionnaire as presented in the Appendix 1. The developed close-ended questionnaire tagged "Multifactor Student Performance Evaluation Instrument for Nigerian Universities (MSPEINU)" was made available in hard-copy. The questionnaire was made up of 65 variables in total and was divided into seven sections. The sections are carefully prepared to capture even the slightest potential contributory circumstance defined as variables. General classes of factors investigated include student's perception, commitment and drive, family contribution, university infrastructures and environment and the lecturer's knowledge and teaching styles. The variables in the questionnaire were statements quantified with varying Likert scale points as presented in Table 1-4. The respondents (students) were obligated to respond to the questionnaire based on their experiences as a computer science student in the respective universities.

Table 1: Likert scale for the student CGPA of the questionnaire (6-points)

Studies (CGPA)	Points
<1.5	1
1.5-2.5	2
2.5-3.5	3
3.5-4.0	4
4.0-4.5	5
4.5-5.0	6

Table 2: Likert scale for section 2-5 of the questionnaire (5-points)

Likert scale	Points
Strongly agree	13-15
Agree	10-12
Undecided	7-9
Disagree	4-6
Strongly disagree	1-3

Table 3: Likert scale for section 6 of the questionnaire

Likert scale	Points
Very often	13-15
Often	10-12
Moderately	7-9
Rarely	4-6
Never	1-3

Table 4: Likert scale for section 7 of the questionnaire

Likert scale	Points
Yes	1
No	0

Definition of associated student performance variables: There were 18 factors investigated by the questionnaire with a total of 63 variables as originally defined in the research of (Temitayo and Ibrahim, 2018). Each factor was coded based on the number of variables designated to investigate it. These various factors and their respective coding is shown below where f1, f2, ... , f63 are the variables.

Student Study Pattern (SSP): This is the aggregate of the student's effective study in computer science relative to the regularity of revising and practice. It was investigated by two variables, "the studying is often a wa sted effort" and "I study before the next class" represented by f6 and f48, respectively.

Student Attendance (SATD): This is the level of effort, seriousness and devotion of students towards their academics and their classes as a computer science undergraduate. Investigated by three variables, "How often do you go to class late?", "How often do you miss classes" and "I am very serious with classes" represented by f7, f49 and f50, respectively.

Student Attitude (SATT): This is the level of responsiveness of a student relative to their interest, behavior and seriousness to computer science courses and characterized by student's participation in class activities, tutorials, assignment, willingness to learn and motivation from friends, colleagues and lecturers. This was investigated by "I participate and ask question in class", "blending in after missing a class is very easy ", "group discussion helped me understand my courses explicitly" " I understood every topic before lecturer leaves?" "how often do you do your assignments yourself?", "do you attend tutorials? "having a personal computer aided my practice in computer science" and "how often do you attend tutorials?" which are represented by f4, f5, f8, f47, f51, f52, f53 and f61, respectively.

Student Opinion (SOP): This is the student's view point of computer science. A positive view point implies a reduction in fear factor of the student. This was investigated by the variable terms "computer science is fun to me", "computer science is scary" "com puter science is confusing and cause headache", "do have interest in computer science" and "do you fear computer science courses" which are represented by f1, f2, f3, f60 and f62, respectively.

Lecturer Attitude (LATT): This is the lecturer's assertiveness, dedication to duty, elaboration on subject matter in classes, delivery of course content in a less ambiguous manner, relation with students to improve their interest in their courses and the ability to motivate students to understand what is taught. The variable terms used for investigation include "lecturers come to class fully prepared", "lecturers are very clear and explicit enough", "lecturers are partial with their dealing with students", "lecturers don't miss classes" "lack of motivation of lecturers discourages commitment to learn" which are represented by f9, f11, f13, f15 and f19.

Lecturer Teaching Style (LTS): This is the pattern of teaching adopted by computer science lecturers. It involves the level of creativity at which the class is taught to have a deep knowledge and grasp the concept of a course. This was investigated by variable terms: "lecturers enforce discipline in class", "lecturers are friendly during class", "lecturers waste time on matters with less relevance in class", "lecturers spend extra time to explain things during class", "lecturers help me develop interest in their courses" and "lecturers allow student to ask questions and take time to explain" which are represented by f10, f17, f18, f22 and f23 and f24.

Communication Skills (LCS): This is the ability of the lecturer to use appropriate communication approaches to deliver teaching in a less ambiguous manner and to the understanding of the students. This entails the clarity and explicitness of the lecturer. This was investigated by variables, "lecturers are always clear, precise and communicate understandably", "most lectures always seem unreal and magical" and "lecturers do not deliver course content well to understan ding" which are represented by f16, f20 and f35, respectively.

Lecturer Availability (LA): This has to do with the presence and accessibility of the lecturers to pass instructions, guide and teach as their responsibilities are defined. This factor was investigated by the variables; "lecturers attend to me whenever I have difficulty with their courses", "lecturers are always available and accessible" and "lecturers usually come early to class" which are represented by f_{21}, f_{14} and f_{12}, respectively.

Student Health (SH): This is the influence of medical condition on student's performance in computer courses. This factor was investigated by the variables, "how often

do you use drugs", "prolong usage of computer causes headache", "how often do you visit the health center", "I take few compulsory medications frequently" and "I fall sick quite often" which are represented by f26, f32, f54, f55 and f56, respectively.

Electricity (E): This is the irregularity of power supply as it affects the student's practice using computers and also other laboratory works. This factor was investigated by the variables "It is difficult t o charge my computer even within the campus" and "Irregular power supply reduced the effectiveness of my practice " which are represented by f25 and f27, respectively.

Background Knowledge (SBK): This is the academic strength of the student in other courses that are elementarily related or needed in Computer Science (Mathematics and Physics). This factor was investigated by the variables; "I have a good background in physics", "I would love to offer mathematics courses" and "I have a good background in Mathematics" which are represented by f28, f29 and f30, respectively.

University Learning Environment and Facilities (ULF): This is the availability of appropriate learning environment and facilities (computer laboratory) within the university environment. This factor was investigated by the variables; "lack of required facilities disrupts clear understanding of the courses I am taking", "the environment where we have our lectures is not conducive" and "the school library is equipped with materials relevant for learning" which are represented by f33, f37 and f38, respectively.

University Class Population (UCP): This has to do with the student total population ratio during the computer science classes. This factor was investigated by the variable: "large class population disrupt concentration in class" and represented by f36.

University Lecture Time (ULT): This is the conduciveness of the lecture schedule. This factor was investigated by the variable "lectures are scheduled to non-conducive times" are represented by f34.

Family Income (FI): Family income has to do with the robustness of the family income of the student. As it influence the ability of the student to afford textbook materials, print handout or even own a personal computer for effective study. This factor was investigated by the variables; "expensive cost of living affected my performance in school ", "I can afford to buy enough textbooks " and "did you sponsor your academic pursuit and maintenance" represented by f42, f46 and f63.

Table 5: Reliability statistics table of the variables

Variables	Values
Cronbach's alpha	0.863
Cronbach's alpha based on standardized items	0.858
No. of items	64

Family Issues (FIS): This is the degree of disturbance from home. An unsettled home creates a paranoid atmosphere which seemly affects student performance. This factor was investigated by the variables; "quarrel between family members is normal", "I had to travel to settle quarrels within my family", "how often do you go home", "how often do you quarrel with your family", "how often do you communicate your family" and "quarrel between my family members escalates a times" which are represented by f43, f44, f45, f57, f58 and f59.

Parent Education (FPE): This is the degree of education of the student's parent. A poor motivation from home might destabilize the student cognitive sense, hence, influencing the student's performance in computer science. This factor was investigated by the variables: "my parents support modern education" and "my parents are illiterates" are represented by f39 and f40.

Proper Guidance (FPG): This is the student 's family guidance and support to study computer science. A student from a family of computer scientist is possible to get huge support and guidance from home. This factor was investigated by the variable "I received advices from family members often" and represented by f_{41}.

Reliability of the data collection instrument: Reliability test was conducted using Cronbach's alpha to ascertain the validity of variables and factors contained in the questionnaire. The coefficient of reliability obtained was 0.86 as presented in Table 5, a value indicating that the data collection instrument used in this study and the contents are good.

Data analysis: Microsoft Excel was used to capture and analyze the data gathered from the questionnaire in separate worksheets for both universities. Then, correlation and regression analyses were carried out on data that emanated from both universities, respectively.

Correlation: This analysis was conducted to identify the variables and factors that correlate with the respondent's performance. Correlation between each variables and student performance was determined at statistically significant $p>0.05$. A dataset of correlates was then generated from each of the two datasets on which the correlation analysis was performed. The newly generated dataset of significant variables and factors that correlated with the student performance were regressed to develop the predictive model.

Regression: This analysis was conducted to measure the average relationship between student performance (CGPA) and the predictors of student performance. Precisely, multiple linear regression in Microsoft Excel 2013 was used to quantify and generate the degree of influence of the predictor variables on student performance variable. Four multi-linear regression models were developed with the aim of examining the effects of predictors that were intrinsic to the students who studied computer science, their lecturers, university environment, family and all other associable factors on student performance. Hence, two sets of models were designed to predict Student's Performance (SP). These are categorized as controlled and uncontrolled student performance models. The student controlled performance model is developed to predict student performance relative to factors that can be directly controlled or motivated by the students themselves. The proposed model, hence, considers performance with respect to the study habit, perception and the rate of fear, attendance, attitude and tutorials of the student with the assumption that all the factors are significant. On the other hand, the student uncontrolled performance model was modelled to predict student performance with regards to factors that cannot be controlled (influenced) directly by the student. This includes factors that are intrinsic to the lecturers, university and environment, family and other factors which might have an effect on student performance.

RESULTS AND DISCUSSION

The correlation analysis was carried out with Microsoft Excel (survey). A factor or variable is significant to student performance and for future performance prediction, if it satisfies the significant correlation coefficient of greater than or equal to ±0.25 and regression $p<0.05$.

Correlation analysis: Nine out of the eighteen factors being investigated on the student performance in Caleb University was found significant, satisfying the significant correlation coefficient value, r, of • ±0.25. The significant factors are FPE, FI, UCP, SBK, LTS, SSP, SATD, SATT and LATT as presented in Table 6. In UNILAG, twelve out of the eighteen factors investigated was found significant. The significant factors are SATD, SOP, LATT, LTS, LA, SH, E, SBK, ULT, FI, FPE and FPG as shown from their r values presented in Table 7. In Table 8 and 9, the correlation table of the student performance variables for CU and UNILAG are presented.

Table 6: Correlation table of the student performance factors for Caleb University

Variables	CGPA	SSP	SATD	SATT	SOP	LATT	LTS
CGPA	1						
SSP	0.4412	1					
SATD	-0.2766	0.014861	1				
SATT	0.2592	-0.39692	-0.52769	1			
SOP	0.00907	-0.02225	0.264084	-0.03801	1		
LATT	0.06538	-0.08016	-0.00462	-0.00521	-0.18442	1	
LTS	0.25539	0.065526	0.23458	-0.1942	0.175078	-0.02692	1
LCS	0.008338	0.091471	0.109869	-0.02128	0.221967	-0.0724	0.131534
LA	-0.00854	0.025377	-0.04289	0.019643	-0.12733	0.181273	0.066247
SH	-0.0166	0.023957	0.004175	0.047232	0.182491	0.155564	0.180852
E	0.006723	0.14396	0.017694	-0.05435	-0.04784	0.053365	0.141984
SBK	-0.3862	-0.16235	0.115873	-0.09483	-0.03069	0.067755	-0.01519
ULF	-0.00633	0.155377	0.221757	-0.1491	0.027418	-0.04774	-0.02311
UCP	0.2743	-0.18678	-0.20636	0.200954	-0.06798	0.103519	-0.09342
ULT	0.007787	-0.05366	0.098991	-0.0912	-0.02336	-0.16511	-0.01288
FI	-0.1830	-0.16763	0.111329	-0.22056	-0.03992	-0.12412	0.086061
FIS	0.005918	0.066799	-0.17286	0.067929	-0.04265	0.167608	-0.24321
FPE	-0.01489	-0.07888	-0.11988	0.139859	0.026819	0.103668	0.075045
FPG	0.008383	0.014448	0.120117	-0.02003	0.215941	-0.08419	0.162218

Table 7: Correlation table of the factors from UNILAG

Variables	CGPA	SSP	SATD	SATT	SOP	LATT	LTS
CGPA	1						
SSP	0.003377	1					
SATD	0.29459	0.218232	1				
SATT	0.007093	0.086979	0.0846	1			
SOP	0.29250	0.248324	0.137299	0.154647	1		
LATT	-0.46240	0.1558	0.308544	0.092376	0.194737	1	
LTS	0.3169	-0.00849	0.122636	0.049816	-0.00756	0.112911	1
LCS	-0.00529	0.00021	0.187101	0.08118	0.109623	0.034203	0.042177
LA	-0.30210	0.28728	0.093369	0.026114	0.117125	0.22107	0.036724

Table 7: Continue

Variables	CGPA	SSP	SATD	SATT	SOP	LATT	LTS
SH	-0.26398	-0.24554	0.01288	-0.02634	0.007101	0.029897	-0.01524
E	-0.26120	0.237634	0.048185	-0.02209	0.151604	0.141344	0.036595
SBK	0.27258	0.247419	0.158932	0.078822	0.056	0.09629	0.023175
ULF	-0.03072	0.016778	0.135465	-0.02053	0.193735	0.178519	-0.06269
UCP	0.019241	0.074053	-0.05376	0.067587	0.061435	-0.09856	-0.09651
ULT	0.27119	0.210318	0.0708	0.031578	0.029732	0.073379	0.106208
FI	0.273433	0.266905	0.1131	0.114583	0.056724	0.155211	0.041254
FIS	-0.01034	0.128007	0.010449	0.090013	0.088471	0.006308	-0.09656
FPE	-0.28864	0.246962	0.106555	0.105106	0.072209	0.026724	-0.04173
FPG	0.28103	0.21903	0.061402	-0.03519	-0.00945	0.027217	0.072632

Table 8: Correlation table of some of the student performance variables for Caleb University

Variables	CGPA	f1	f2	f3	f4	f5	f6
CGPA	1						
f1	-0.53482	1					
f2	-0.27904	0.247875	1				
f3	0.392231	-0.19965	-0.43689	1			
f4	-0.08627	0.189091	-0.15901	0.430728	1		
f5	-0.29139	0.06669	0.392141	-0.77646	-0.57501	1	
f6	-0.17552	0.163152	0.362734	-0.35001	-0.33238	0.259077	1
f7	0.276871	0.215237	-0.40741	0.370942	0.240257	-0.40679	-0.54436
f8	0.110313	-0.22141	-0.0377	0.078988	0.191052	-0.09007	-0.09326
f9	0.012099	-0.00797	0.379331	-0.16281	-0.30319	0.072299	0.590914
f10	-0.09433	-0.19854	-0.11193	0.002835	0.173266	-0.01171	-0.0962
f11	-0.09282	0.046474	-0.0019	0.034538	0.091389	0.101594	-0.0608
f12	-0.04868	0.149648	0.307274	-0.04762	-0.18195	-0.00679	0.256602
f13	0.101182	-0.09973	-0.20648	0.083913	-0.0457	-0.13561	-0.06199
f14	0.028272	0.061162	-0.14864	0.120688	-0.02977	-0.07949	0.016163
f15	0.277142	0.055076	0.201501	-0.10898	0.056727	0.110926	0.031725
f16	0.014594	-0.01587	0.023407	0.103322	-0.0508	-0.11917	0.07779
f17	-0.09777	-0.10569	0.001162	-0.04311	0.118658	-0.01294	-0.28638
f18	0.041264	-0.06661	-0.10507	-0.03085	0.096582	0.0796	-0.01034
f19	-0.10933	0.128373	0.083158	0.114008	-0.07792	-0.08342	0.298104
f20	0.255791	-0.09474	0.09836	-0.01698	-0.1221	-0.05243	0.108301
f21	0.074053	0.017522	0.011916	0.164809	-0.00513	-0.15343	0.242657
f22	-0.01972	0.076851	0.059498	-0.02066	-0.05279	0.122088	0.045581

Table 9: Correlation table of some of the variables for University of Lagos

Variables	CGPA	f1	f2	f3	f4	f5	f6
CGPA	1						
f1	-0.07592	1					
f2	0.120366	0.097524	1				
f3	0.132173	0.017511	-0.17856	1			
f4	0.145735	0.12569	0.044786	0.128817	1		
f5	-0.14415	0.087863	0.069382	-0.07638	-0.13702	1	
f6	0.258688	0.049849	-0.21718	0.309837	0.099346	-0.08745	1
f7	0.236547	0.084987	0.061643	-0.04218	0.15787	0.14511	0.070574
f8	0.18887	-0.05189	-0.08709	0.126061	0.158427	-0.05422	0.144183
f9	0.00210	0.033957	0.105209	0.145719	0.130781	0.102482	-0.05346
f10	-0.02044	0.0771	0.067295	0.029719	0.040139	-0.04488	0.022753
f11	0.11546	-0.02843	-0.02152	0.19792	0.199557	-0.02572	0.154158
f12	0.27499	0.104038	0.008503	0.074934	0.124611	0.128335	0.02314
f13	0.27592	-0.00441	0.11011	-0.02778	-0.01791	0.10021	-0.00321
f14	-0.01445	0.085928	-0.00052	0.100851	0.15758	0.01669	0.055163
f15	0.30232	-0.05198	0.063742	0.018386	0.098799	0.003276	-0.04476
f16	0.11689	0.018134	-0.08286	0.154204	0.050558	-0.14918	0.068931
f17	0.25902	-0.03812	0.020426	0.119003	0.064438	-0.05538	0.019565
f18	-0.03658	-0.00242	0.008544	0.024029	-0.06822	-0.05094	-0.00932
f19	-0.29339	-0.02433	0.015802	-0.06565	-0.00423	0.047967	0.033129
f20	0.24354	-0.03433	0.041186	-0.02932	0.091929	-0.02946	-0.02115
f21	0.24761	0.059117	0.095905	0.042952	-0.06833	0.038265	-0.07453
f22	0.29827	-0.25999	-0.03657	0.016691	0.042565	-0.03229	0.034834

Regression analysis: Regression analysis was used to obtain a linear expression of the relationship that exists between the factors and student learning outcome (grade). The regression analysis was carried out with SPSS 20.0. A factor or variable is significant for student performance modeling and prediction, if it satisfies the correlation coefficient value, r, greater than or equal to ±0.25 and regression significant $p<0.05$.

Table 10: Controllable model regression analysis table for Caleb University

	Unstandardized coefficients		Standardized coefficients		
Models	B	SE	Beta	t-values	Sig.
(Constant)	2.853	1.555		1.835	0.044
SSP	0.107	0.162	0.064	0.660	0.009
SATD	-0.005	0.211	-0.003	-0.025	0.008
SATT	0.139	0.320	0.050	0.435	0.006

Model summary; R = 0.849a; R^2 = 0.722; Adjusted R^2 = 0.882; SE of the estimate = 0.726

Table 11: Controllable model regression analysis table for UNILAG

	Unstandardized coefficients		Standardized coefficients		
Models	B	SE	Beta	t-values	Sig.
(Constant)	3.549	0.559		6.347	0.000
SATD	0.037	0.166	0.014	0.226	0.028
SOP	-0.138	0.235	-0.036	-0.590	0.045

Model summary; R = 0.083; R^2 = 0.681a; Adjusted R^2 = 0.663; SE of the estimate = 0.64736

Student Controllable Performance Model (SCPM): The factors for the development of the controlled performance model are SSP, SATD, SATT and SOP. Although, only the factors that satisfies the correlation and regression significant value were selected for the regression model development.

Controllable Performance Model for Caleb University: Three out of the four influential factors being investigated on the student performance of the computer science students in Caleb University was found significant by satisfying the significant correlation value greater than or equal to ±0.25. The non-significant factor is SOP while the significant factors which are SSP, SATD and SATT were used for regression analysis. The linear relationship of the significant factors for the controlled student's performance model is presented in Eq. 1 based on the $p<0.05$, of the regression analysis shown in Table 10. The standard error value of 0.726 indicates that the potential accuracy of the model predictions is 72.6%. The R^2 value of 0.722 also indicates that the model reduces the residual variance by 72.2% Eq. 1:

$$SP = 2.853+0.107SSP-0.005SATD+0.139SATT \quad (1)$$

Controllable performance model for University of Lagos: Two out of the four controlled performance factors affecting the performance of computer science students in UNILAG was found significant by satisfying a correlation coefficient value • 0.25 and a regression $p<0.05$. The non-significant factors are SSP and SATT while the significant factors are SATD and SOP. The linear relationship of the factors in UNILAG for the controlled student's performance model is presented in Eq. 2 based on p-values of the regression analysis shown in Table 11. The standard error value of 0.647 indicates that the potential accuracy of the model predictions is 64.7%. The R-squared value of 0.681 also indicates that the model reduces the residual variance by 68.1% Eq. 2:

$$SP = 3.549+0.037SATD-0.138SOP \quad (2)$$

Student Uncontrollable Performance Models (SUPM): The factors for the development of the uncontrolled performance model are LATT, LTS, LA, E, SBK, ULF, UCP, ULT, FI, LCS, SH, FIS, FPE and FPG. But only the factors that satisfy the correlation coefficient and regression p-value were selected for the model development.

Uncontrollable performance model for Caleb University: Six out of the fourteen uncontrolled performance factors being investigated on the performance of the computer science students in Caleb University was found significant by satisfying the correlation coefficient value • 0.25 and the regression value <0.05. The non-significant factors are LA, E, ULF, ULT, LCS, SH, FIS and FPG while the significant factors are FPE, FI, UCP, LTS, LATT and SBK. In Eq. 3, the linear model of the relationship among the significant factors affecting the performance of computer science students in UNILAG is presented based on p-values of the regression analysis shown in Table 12 Eq. 3:

$$SP = 3.511-0.20FPE-0.25FI+0.30UCP+ 0.80LTS+0.23LATT-0.92SBK \quad (3)$$

The standard error value of 0.65 indicates that the potential accuracy of the model predictions is 65%. The R^2 0.703 also indicates that the model reduces the residual variance by 70.3%.

Student uncontrollable performance model for University of Lagos: Ten out of the fourteen uncontrolled performance factors being investigated on the student performance of the computer science students in the University of Lagos was found significant. The non-significant factors are ULF, FISLCS, UCP while the significant factors are LA, E, ULT, SH, FPG, FPE, FI, LTS, LATT and SBK as shown in Table 13 and Eq. 4:

Table 12: Uncontrolled model regression analysis table for Caleb University

	Unstandardized coefficients		Standardized coefficients		
Models	B	SE	•	t-values	Sig.
(Constant)	3.511	1.461		2.403	0.018
FPE	0.020	0.159	0.012	0.128	0.006
FI	0.025	0.219	0.010	0.113	0.046
UCP	-0.030	0.097	-0.028	-0.306	0.044
LTS	0.080	0.280	0.025	0.286	0.032
LATT	0.023	0.302	0.007	0.076	0.049
SBK	0.092	0.227	0.036	0.404	0.038

Model summary; R = 0.084a; R^2 = 0.703; Adjusted R^2 = 0.042; SE of the estimate = 0.65057

Table 13: Student uncontrollable performance factor regression analysis table for UNILAG

	Unstandardized coefficients		Standardized coefficients		
Models	B	SE	•	t-values	Sig.
(Constant)	3.500	1.095		3.195	0.0020
LATT	-0.042	0.197	-0.014	-0.214	0.0430
LTS	0.111	0.229	0.032	0.485	0.0428
LA	0.042	0.162	0.016	0.258	0.0397
SH	0.070	0.185	0.026	0.376	0.0307
E	-0.015	0.140	-0.007	-0.109	0.2130
SBK	0.047	0.166	0.018	0.282	0.1780
ULT	0.010	0.099	0.007	0.104	0.4180
FI	0.032	0.201	0.011	0.160	0.2730
FPE	0.073	0.138	0.034	0.533	0.2950
FPG	0.072	0.097	0.049	0.742	0.3590

Model summary; R = 0.072a; R^2 = 0.005; Adjusted R^2 = 0.064; SE of the estimate = 0.67554

Table 14: Uncontrolled student performance regression analysis table for UNILAG

Linear models	Sample validation size	Maximum error (predicted versus actual)	Degree of accuracy (%)
SCPM (CU)	100	±0.18	93
SCPM (UNILAG)	200	±0.09	96
SUPM (CU)	100	±0.21	90
SUPM (UNILAG)	200	±0.14	96

$$SP = 3.500-0.042LATT+0.111LTS-0.042LA-0.070SH-0.015E+0.047SBK+0.010ULT-0.032FI-0.073FPE+0.072FPG \quad (4)$$

Model validation and prediction: The four linear regression models developed to predict the performance of computer science students in the universities were validated to ascertain their accuracies using considerable randomly selected respondent data. For a randomly selected student from the collected data, having values of CGPA, LATT, LTS, SH, LA, E, SBK, ULT, FI, FPE, FPG, SATD and SOP at 3.60, 3.20, 2.50, 1, 3, 3, 4.3, 4, 2, 3, 3, 3 and 1.40, respectively, a sample process for the validation of the models is illustrated using the SUPM (Eq. 4) as follows:

$$SP = 3.500-0.042LATT+0.111LTS-0.042LA-0.070SH-0.015E+0.047SBK+0.010ULT-0.032FI-0.073FPE\ 0.072FPG$$

By substituting the values of the independent factors in Eq. 4:

$$SP = 3.500-0.042(3.20)+0.111(2.50)-0.042(3)-0.070(1)-0.015(3)+0.047(4.3)+0.010(4)-0.032(3)-0.073(2)+0.072(3)$$

SP = 4.2356-0.6584 = 3.5772. The predicted value is approximately 3.58 while the actual SP (CGPA) is 3.60 with an actual error of 0.0028. 100 random samples of student's performance records from CU and 200 random samples from UNILAG were selected for validation. The validation results of the samples of student performance data validated using the developed models is summarized and presented in Table 14. The low maximum error achieved indicate that the student performance models are reliable and near-accurate.

Peculiar factors affecting students studying computer science: The analyses conducted in this study and the corresponding results obtained indicate that University Class Population (UCP), Student Study Pattern (SSP) and Student Attitude (SATT) are the peculiar factors affecting the performance of majority of the computer science students in Caleb University. The increasing demand for University education as corroborated by Ubogu and Veronica (2018) and the damaging impact of the incessant

Table 15: Peculiar factors affecting performance of computer science students

Universities	Peculiar factors
Caleb University	UCP, SSP, SATT
UNILAG	SOP, LA, SH, E, ULT, FPG
Both universities	FPE, FI, SBK, LTS, SATD, LATT

industrial strike actions routinely embarked upon by academic staff members in public universities (UNILAG inclusive) as confirmed by Albar and Onye (2016) could account for this uprising number of student's population in private universities including CU to avoid being a victim of public university strikes. As presented in Table 15, Student's Opinion (SOP), Lecturer Availability (LA), Student's Health (SH), Electricity (E), University Lecture Time (ULT) and Family Proper Guidance (FPG) are the significant factors influencing student's performance in UNILAG. These corroborate with the results of Fagbola stating that a positive impression by the student about computer science, the availability of the academic mentors and teachers, a stable state of student's health, constant supply of electricity, a favorable and appropriate lecture time as well as getting desired attention from the family and friends cumulatively would contribute immensely to computer science student's success in public universities. Similarly, the parent's education and financial strength, the student's rudimentary knowledge of computer science or related subjects, the lecturer's teaching style ensuring clarity of thoughts and expressions with effective communication, student's attendance in class and lecturer's motivating attitudes as corroborated by Madukwe *et al*. (2019) are the recipes for success common to both the Caleb University and UNILAG.

CONCLUSION

In this study, multi-factored linear models for predicting Learning outcomes of computer science students in private and public universities in Nigeria were developed with Caleb University and University of Lagos, Nigeria as study areas. This attempt was in a bid to determine, build a sustainable ecosystem of improved and acceptable student learning outcomes above low grade index in computer science programmes from developing economies. The cause-and-effect relationships of individual determinant factor which could potentially influence student learning progress and the final learning outcome of the student were investigated. In order to understand and evaluate the effects of controllable and uncontrollable factors affecting computer science student's performance relating to study background, lecturers, university environment and family, four multi-linear predictive models of student learning outcomes were developed in this study. Eighteen factors that could student performance was exhaustively explored but twelve was found significant in UNILAG while nine was found significant in Caleb university. Based on the results obtained, it is evident that the performance of computer science students in Nigerian Universities are influenced by the income level and educational background of the parents and/or guardian can improve significantly with more frequent class attendance, general background knowledge of related subjects, improved teaching style and attitude of lecturers and unreserved support by parents, especially, morally, emotionally and financially. Furthermore, the results obtained indicate that provisioning of a more conducive teaching and learning environment and recruitment of dedicated lecturers will strongly assist in improving the quality of learning outcomes of computer science students, especially, in public universities. In future works, more public and private Universities could be integrated into similar research for analysis.

Appendix:

Questionnaire: Multifactor student performance evaluation instrument for Nigerian universities

Questionnaire: Multifactor Student Performance Evaluation Instrument for Nigerian Universities

SECTION 1 (Personal Information)

What department are you: _____

Name of Institution: _____

Level of study: _____

f_{64} What is your CGPA: Less than 1.5 ☐ 1.5-2.5 ☐ 2.5-3.5 ☐ 3.5-4.0 ☐ 4.0- 4.5 ☐ 4.5-5.0 ☐

SECTION 2 (Students' background and ability)

Kindly check the closest option that to your experience concerning these questions.

Strongly Agree 5	Agree 4	Undecided 3	Disagree 2	Strongly Disagree 1

S/N	Expressions	5	4	3	2	1
f_1	Computer Science is fun to me					
f_2	Computer Science is scary					
f_3	Computer Science are confusing and causes headache					

f_4	Having a personal computer aided my practice in Computer Science					
f_5	Group discussion helped me to understand my courses explicitly					
f_6	Studying is often a wasted effort					
f_7	I am very serious with my classes					
f_8	Blending in after missing a class is very easy					

SECTION 3 (lecturer factors)

Strongly Agree 5	Agree 4	Undecided 3	Disagree 2	Strongly Disagree 1

S/N	Expressions	5	4	3	2	1
f_9	Lecturers come to class fully prepared					
f_{10}	Lecturers allow student to ask questions and take time to explain					
f_{11}	Lecturers are very clear and explicit enough					
f_{12}	Lecturers usually come early to class					
f_{13}	Lack of motivation of lecturers discourages commitment to learn programming					
f_{14}	Lecturers are always available and accessible					
f_{15}	Lecturers don't miss classes					
f_{16}	Lecturers are always clear, precise and communicates understandably					
f_{17}	Lecturers are friendly during class					
f_{18}	Lecturers waste time on matters with less relevance in class					
f_{19}	Lecturers are partial in their dealing with students					
f_{20}	Lecturers do not deliver course content well and to understanding					
f_{21}	Lecturers attend to me whenever I have difficulty with their course(s)					
f_{22}	Lecturers help me develop interest in their course					
f_{23}	Lecturers spend extra time to explain things during class					
f_{24}	Lecturers enforce discipline during their class					

SECTION 4 (Facilities and the University environment)

Strongly Agree 5	Agree 4	Undecided 3	Disagree 2	Strongly Disagree 1

S/N	Expressions	5	4	3	2	1
f_{25}	Irregular power supply reduces the effectiveness of my practice					
f_{26}	I take a few compulsory medications frequently					
f_{27}	It is difficult to charge my computer even within the campus					
f_{28}	I have a good background in mathematics					
f_{29}	I have a good background in physics					
f_{30}	I would love to offer mathematics courses					
f_{31}	I fall sick quite often					
f_{32}	Prolong usage of computer causes headache					
f_{33}	The environment where we have our lectures is not conducive					
f_{34}	Lectures are scheduled to non-conducive times					
f_{35}	Most lectures always seems magical and unreal					
f_{36}	Large class population disrupts concentration in class					
f_{37}	Lack of required facilities disrupts clear understanding of the courses I am taking					
f_{38}	The school library is equipped with materials relevant for learning					

SECTION 5 (family)

Strongly Agree 5	Agree 4	Undecided 3	Disagree 2	Strongly Disagree 1

S/N	Expressions	5	4	3	2	1
f_{39}	My parents support modern education					
f_{40}	My parents are illiterates					
f_{41}	I receive advices from family members often					
f_{42}	Expensive cost of living affects my performance in school					
f_{43}	Quarrel between family members is normal					
f_{44}	Quarrel between my family members escalates a times					
f_{45}	I have to travel to settle quarrels within my family					
f_{46}	I can afford to buy enough textbooks					

Appendix 1: Continue

SECTION 6 (Students' commitment)

Very Often 5	Often 4	Moderately 3	Rarely 2	Never 1

S/N	Expressions	5	4	3	2	1
f_{47}	I participate and ask questions in class					
f_{48}	I study before the next class					
f_{49}	How often did you miss class?					
f_{50}	How often did you go late to class?					
f_{51}	I understood each topic before the lecturer leaves					
f_{52}	How often do you do your assignments yourself?					
f_{53}	How often do you attend tutorials?					
f_{54}	How often do you use drugs?					
f_{55}	How often do you fall sick?					
f_{56}	How often do you visit the health center?					
f_{57}	How often do you travel back home?					
f_{58}	How often do you quarrel with your family?					
f_{59}	How often do you communicate with your family?					

SECTION 7 Self Drive

S/N	Questions	Yes	No
f_{60}	Do you have interest in Computer Science?		
f_{61}	Do you attend tutorials?		
f_{62}	Do you fear computer science courses?		

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