Development and Evaluation of a Computer-Aided Learning (CAL) Package on C++ Programming Language

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Abstract

The increasing rate at which access is being provided to education worldwide is due to the growth in computer technology and its application in education. Technology has created a great potential for borderless education. The potential for growth is tremendous particularly in higher education even in developing countries like Nigeria. This trend has caused educators to have a re-think of the very nature of teaching, learning and quality of education. Against this background, this paper was aimed at teaching students the fundamentals of C++ programming language in higher institutions in Nigeria using Computer Aided Learning software system (CAL) developed for C++, which is a course being taught at the 2nd year, 3rd year and 4th year to students of Engineering and Computer Science in the universities and HND 1 in the polytechnics. Quantitative feedback was collected from students and teaching staff using paper-based questionnaires. Student examination marks were compared for 2007/2008 and 2008/2009 sessions, allowing a comparison of student performance before and after the replacement of the traditional lecture with the CAL package. Ethical approval for the study was granted by the institution's ethics committee. The CAL package on C++ programming was well received by teaching staff and students. Students' performance in examination improved after the introduction of CAL program, suggesting that it provides a suitable alternative to didactic teaching. The creation and distribution of the CAL package on CDROM and its availability via the Internet are intended to contribute to the general learning of programming languages. The package sets a precedent for the development of more Internet-based, student-authored CAL packages in the future, thus roviding additional resources for independent learning.

Keywords: Computer Aided Learning (CAL), C++, programming, learning, teaching, education

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Introduction

The programming knowledge requirements for engineering, science and technology students have been debated for many years, and concerns have been expressed about this, especially in the higher education sector. This paper considers a programming course, C++, specifically designed to address some of these issues of the introduction of CAL packages. Traditionally, at the Federal University of Technology Owerri (FUTO), the 3rd year Computer Science students attended a single 1-hour didactic lecture on C++ programming language within the programming courses. The lecture covered the fundamentals of programming, basic declarations, expressions in C++ and control structures. The main learning objectives were for students to have a full understanding of the basics of programming and how to relate these to understanding C++ programming language which is a scientific programming language that must be taught and passed by all Computer Science students and some other engineering-based students during the same course. Computer Aided Learning (CAL) represents an alternative, independent method of instruction. CAL has been available to students in different fields of endeavour [1]. A previous evaluation study at Glasgow demonstrated that CAL is a suitable replacement for didactic lectures on the subject of diagnostic imaging [2]. To create an alternative to the traditional didactic lecture described above, an interactive CAL package on C++ programming language was created during the 1st semester of 2007/2008 and refined throughout the session, with evaluation extending into the following academic session.

Computer Aided Learning (CAL) can be defined as a way of individualizing instructions by making use of the computer as assistance for teaching, reading and learning. Computer Aided Learning (CAI), is a diverse and rapidly expanding spectrum of computer technologies that aide the teaching and learning process. Examples of CAL applications include guided drill and practice exercises, computer visualization of complex objects, and computer-facilitated communication between students and teachers. The number of computers in American schools has risen from one for every 125 students in 1981 to one for every nine students in 1996. While the United States leads the world in the number of computers per school student, Western European and Japanese schools are also highly computerized [3]. In CAL lesson, the user and the computer are usually involved in a dialogue process. The dialogue can be via the screen and keyboard (which is mostly common) or by using speech input etc. the major advantages they have are that the pupils are captivated by the terminals, they learn at a fast rate with a high level of retention and finish each session of the subject with a sense of accomplishment.

In the CAL package, a form of interaction between the user and the computer is made possible in such a way that necessary action can be carried out to a response made by a user. CAL packages are designed with an anticipation of making the learning process less tedious and much more interesting to the user. Figure 1 depicts integrated components which make up CAL. The developed software package - Computer Aided Learning of C PLUS PLUS (CALCPPLUS) - is classed under the CAL (Computer Aided learning) packages. The package has the facility which allows the teacher to store questions on his own, using a database which is part of this software. It also has the facility which allows the students retrieve the question which appears in graphics mode to make the student more interested in it. Many educators agree that the most pressing problem affecting the use of computer aided learning or computer aided instruction as a classroom tool today is the need for high quality software [4, 5]. There are varieties of software tools that are used in the design and development of CAL packages. Some of these are: Visual Basic programming, ASP.Net, C++, etc. Besides, some web-designing programming software such as Hypertext Mark-up Language (HTML), Microsoft PowerPoint, Microsoft FrontPage, Macromedia Dreamweaver, etc. could also be utilized to some degree. Each of them has a distinct advantages and disadvantages of one form or the other.

Impact of Technological Education

The advancement in technological education has left a distinct gap between developed and the developing world. One of the several reasons why the United States became a technological leader in the 20th century was its development of an advanced system of technical education. Mechanical arts schools began in Philadelphia in the 18th century, and by the end of the 19th century they had spread to every major American city. In the 20th century, a state-based system of vocational education provided training in basic technical skills. Between 1862 and 1890, engineering and agricultural colleges in every state were funded by a federal programme known as the Morrill Land Grant [6]. Many technological innovations of the 20th century promised breakthrough in the methods and effectiveness of teaching for the 21st century. Some of the most promising innovations included access to Internet and programmed instruction (instruction delivered in a graded sequence of steps, usually by means of a computer or other device). The revolution in computer and communications technology holds out hope that all students will connect with more information and more people than ever before, and that learning might become more individualized [7].

Universities and Colleges are institutions of higher education that offer programmes beyond the high school level. Universities and Colleges provide necessary training for individuals wishing to enter professional careers. They also strive to develop students' creativity, insight, and analytical skills. By acquainting students with complex ideas in an intellectually stimulating environment, colleges and universities can provide unique opportunities for personal enrichment while also preparing students for future careers [6]. Such diverse

professions as engineering, teaching, medicine, and information science all require a higher education. These citadels of learning strive to inform students of established principles of knowledge as well as of the most recent developments in academic research. Instruction takes place in classrooms, lecture halls, laboratories, and other settings. When students enrol in a course, professors provide them with a syllabus, or outline, of the course. The syllabus describes how the course will be taught. It includes a list of the required books and articles students are to read; the schedules and descriptions of course examinations, papers, and other assignments; and an explanation of methods used to evaluate or grade student performance. Methods of instruction may be a lecture, lecture-discussion, discussion, laboratory, seminar, internship, clinical experience, community service, distance education, or a combination of these and other formats [8].

The development of new technologies and the globalization of the world economy have created high demand for workers with computer, communications, and other occupational skills that can be acquired at colleges or universities. For example, computers and other new technologies have eliminated many low-skilled jobs in a variety of fields, but these same technologies have created widespread job opportunities for those who have the proper training. In addition, employers increasingly seek out college graduates who have gained the critical thinking and problem-solving skills necessary to adapt to changing economic conditions [9].

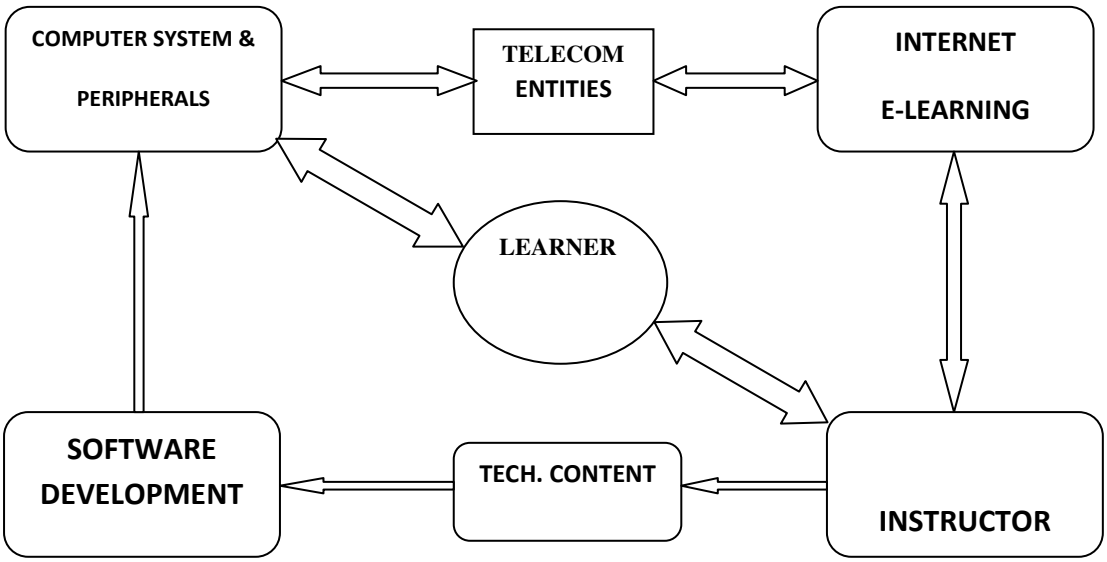

Figure 1: A **Block Representation of CAL for Science and Engineering Education**

Problems Facing Deployment of E-Learning

The journey to the information superhighway through e-learning is real but it is unfortunate that this important issue is not being given the much needed attention it deserves by the academic communities in Nigeria. Some of the problems facing the deployment of e-learning systems in Nigerian tertiary institutions include:

a) **Student Attrition**: This is caused by lack of face-to-face contact with the lecturer, which makes the model impersonal. This constraint can now be virtually eliminated through videoconferencing technology, which is a telecommunications technology that makes it possible for teacher-student interaction. This technology allows groups to have conferences in one connection combining video and audio transmission. If this is employed in our academic communities, then student attrition would be eliminated.

b) **State of Information Technology (IT) in Academic Communities in Nigeria**: Since the industrial revolution is quite a distant ahead of us in this part of the globe, the academic communities in Nigeria are far away from e-learning age. These academic communities form a block of technological desert. IT development in Nigerian tertiary institutions is at lower ebb and as such, they are cut off from their counterparts and researchers at the global terrain. This has made the journey of the nation's academic communities into the e-educational superhighway to be somehow retarded.

c) **Management Attitudes**: Funding is one of the areas where the support of the management is highly needed. Provision of adequate facilities and other equipment are supposed to be done by the management. However, this is not so in our tertiary institutions. Various management's assistance towards the development of the e-learning is rather slow in some institutions and in some others, no aid or assistance are given by the management.

d) **Lack of Personnel**: Knowing full well that the world has gone computer and educational development depends on computer, it is important to improve the level and acceptance of computer literacy and usage in the society. But the main problem is either that the people are resisting change or too lazy to learn. Most institutions even lack enough experts to support computer usage while some have none.

e) Economic Constraint: Capital is the backbone of any good educational resource but the fact is that the educational sector is poorly funded, little or no facilities/infrastructure to aid teaching-learning are available and the little available funds are being mismanaged. The cost of installing good and up-to-date computer equipment in a country like Nigeria with battered economy is enormous. This factor seriously militates against the noble adoption of e-learning in Nigerian institutions of higher learning.

f) Technological Constraints: A major setback towards the pragmatic adoption of e-learning in Nigerian institutions is the near-absence of the required information technology infrastructure necessary for its deployment. Less than 20% of Nigerian teachers own computers or have access to them. The energy authority, Power Holding Company of Nigeria (PHCN), is not living up to expectation as power is supplied for less than an average of 4 hours a day in most towns. Electricity is totally absent in most remote communities in Nigeria and other sources of generating power are more expensive options and are not affordable by an average income earner in Nigeria. This particular factor is seriously hindering the growth of information technology and as such, causing serious setback to adoption of e-learning in Nigeria.

As a matter of fact, individuals in their house or in their academic communities that want to achieve their objectives can use the e-learning developed in this study. It may not be necessary to be in an academic community before it is used. Hence, the problems listed above may not adversely affect the individual who opt for this system as a means of learning the C++ programming language so far as the individual can afford to overcome the inhibiting factors discussed above.

Aims And Objectives

The project required the students to:

- Visit the computer laboratory and see how the CAL package is installed and how it can be loaded.
- Create an alternative resource to teaching the 300/400 level students about the basics of computer programming, and to present the subject matter in a more interactive and engaging way than the traditional didactic lecture
- Provide flexible access to current information for technologists and the laboratory assistants
- Educate staff, tutorial staff and the computer laboratory staff at the laboratories about the functionality of the software by providing them with a copy of the finished resource on CDROM
- Make the resource freely available on the campus intranet to wider community to promote education on the learning of C++ programming

- Carry out a summative evaluation of the resource as a lecture replacement tool for Computer Science and Engineering students.

Time Line

The CAL package was planned, developed and evaluated over a 3-month period, through the following stages:

- ***Preliminary needs analysis***: questionnaire to on-site undergraduates asking them about their experiences of the didactic lecture on C++ programming and the attitudes to support lecture with CAL
- ***Early formative assessment***: questionnaire to recent graduates, technologists, laboratory assistants, computer analysts, software developers and computer science students to gather feedback on the "look and feel" of the CAL interface at an early stage of development.
- ***Formative evaluation***: questionnaire on the complete first module to all 300 level computer science students
- ***Summative evaluation***: questionnaire on all the four modules to Computer Science teaching staff with expert knowledge on computer programming and software development.

Discussion of Results

Preliminary needs analysis

Prior to the development of the CAL package, a questionnaire was circulated by e-mail to students of Computer Science and Electrical Engineering in years 4 and 5 to gauge their opinions on the lecture they had attended in year 3 on the subject of scientific programming using C++; to gather suggestions on how the CAL package should be designed; and to assess students' views on CAL as a lecture replacement in general. It has been argued that questionnaire can be used to gather large amounts of information, at a relatively low cost, in a short time [10]. In this case, only 24 of the 400 4th and 5th year of Computer Science and Electrical Engineering students responded (6%), because the survey was conducted during the ASUU (Academic Staff Union of Universities) strike, and via e-mail. It must also be acknowledged that students' feedback was retrospective. In terms of preliminary needs analysis, however, the resulting data provided a useful starting point for the system design and development. Results are shown in Table 1

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Table 1: Results of the preliminary needs evaluation (N=24, 6%)*

Question	Quartile 1	Median	Quartile 3
How helpful were the lectures on C++ programming language? (1 = Not at all helpful, 5 = Very helpful)	2	2	2
How interesting did you find the lectures? (1 = Not at all interesting, 5 = Very interesting)	2	2	3
How useful do you find CAL packages generally? (1 = Not at all useful, 5 = Very useful)	2	3	3
How useful do you think a CAL package on C++ would be? (1 = Not at all helpful, 5 = Very helpful)	2	3	4
How happy would you be for the C++ lectures to be replaced with a CAL package? (1 = Not at all happy, 5 = Very happy)	3	4	5
How important do you think it is for the C++ CAL package to be available online? (1 = Not at all important, 5 = Very important)	3	4	5

* The first and third quartiles are included to show the inter-quartile range of responses

The qualitative responses to this preliminary needs analysis suggested that the package should be:

- Well illustrated with numerous and colourful pictures to maintain user interest and aid memory retention
- Highly interactive
- Kept concise, excluding unnecessary detail

In addition, the following features were requested:

- Optional links to more detailed information
- Navigable contents index
- Printable version of the contents
- Optional quiz

A CAL package was subsequently developed that included the following modules:

1. Topics in C++
2. Students Activity
3. Teacher Activity
4. Report Generation

Early Formative Assessment

At an early stage of development, a formative questionnaire was circulated by hand to teaching staff and students on campus (selected using convenience sampling), asking to review the "look and feel" of the prototype CAL. This took place during the ASUU strike hence, the number of participants was small: two computer science scholars (recently graduated), two computer technologists, two computer laboratory assistants, five computer science students and three electrical engineering students. Participants were also asked to comment on features they liked, disliked or would like added.

As Table 2 shows, responses to all questions were favourable. Several suggestions were made for refinement of the package, such as including more references to detailed information, slightly more difficult quiz questions, and rollover explanations of images. The first module was modified to include respondents' feedback.

Table 2: Results of early formative evaluation of Module 1 (N=14)

Question	Quartile 1	Median	Quartile 3
How easy to use was the package? (1 = Very difficult, 5 = Very easy)	5	5	5
How well was the information presented? (1 = Very badly, 5 = Very well)	4	5	5
How interesting was the package? (1 = Very dull, 5 = Very interesting)	4		4
How useful was the information in the package? (1 = Useless, 5 = Very useful)	4	4	4
How much information was in the package? (1 = Not enough, 5 = Too much)*	3	3	3
What did you think of the integrated quiz? (1 = Very bad idea, 5 = Very good idea)	4	4	5

* A response of 3 was considered the ideal response to this question, whereas for other questions a rating of 5 was considered optimal

Evaluation Methodology

Formative Evaluation Questionnaire

*A*fter the development of the first module, student opinion was sought via a questionnaire containing seven lickert-scale items and a number of open-ended questions. The questions asked are shown in Table 3. All the 3rd year students were asked to work through the first module of the package in a mandatory laboratory practical class. The CAL package was considered sufficiently detailed and self-explanatory that the staff supervision was not required, although staff operated on open-door policy to support individual students seeking assistance.

Summative Evaluation Questionnaire

Once the four modules were complete, the subsequent cohort of three-year students was asked to use the cal package, again in a time-tabled, unsupervised class. students were assigned to one of the two computer centres, where they were expected to work at their own pace.

The questionnaire, like the CAL package, has been refined – in particular, related items were grouped under appropriate themes to facilitate participant engagement with the questionnaire, a policy advocated by [11].

Table 3: Results of formative evaluation questionnaire completed by Computer Science students (N=55)

Question	Quartile 1	Median	Quartile 3
How easy to use was the package? (1 = Very difficult, 5 = Very easy)	5	5	5
How well was the information presented? (1 = Very badly, 5 = Very well)	4	5	5
How interesting was the package? (1 = Very dull, 5 = Very interesting)	3	4	4
How useful was the information in the package? (1 = Useless, 5 = Very useful)	4	4	4
How much information was in the package? (1 = Not enough, 5 = Too much)*	3	3	3
What did you think of the integrated quiz? (1 = Very bad idea, 5 = Very good idea)	4	4	4
How happy would you be for the C++ lecture to be replaced by CAL? (1 = Not all happy, 5 = Very happy)	4	4	5

* A response of 3 was considered the ideal response to this question, whereas for the other questions a rating of 5 was considered optimal

The questionnaire included nine statements associated with a five-point Likert scale ranging from “strongly disagree” to “strongly agree”, a higher rating representing a more positive response. The statements are listed in Table 4. Students were also encouraged to rate each module on a scale ranging from “very poor” to “very good”. For each item, a value of 3 represented a neutral response. A space for qualitative comments about each questionnaire item was also available, and students were invited to provide additional comments about the resource in general.

The questionnaire was distributed to a purposive sample of teaching staff knowledgeable about the subject of C++ programming. These included eight graduate assistants with some teaching responsibility, three programming lecturers, and one technologist involved in teaching the course.

Focus Groups

Discussion with several students about the CAL package was facilitated through broader discussions, within two of five focus groups, on the application of educational methods and technologies in the science and engineering curriculum as part of the researcher’s contiguous research studies.

Analysis of Examination Results

The third-year class examinations held in March 2008 and March 2009 included questions on the topic of C++ programming, allowing for

a comparison of student performance before and after the introduction of CAL as a lecture support tool. Individual student marks were obtained for these examination questions, and an independent samples t-test was carried out to compare performance between the two separate student cohorts (student sitting in the March 2008 examination had been lectured to, while students sitting in March 2009 examination had received the CAL package). The 2009 examination question was based on the content of CALCPPLUS Module 1. The results from the 2009 examination were not included in the analysis, as the examination format has changed from essay questions to multiple-choice questions.

RESULTS

Formative Evaluation Questionnaire

Fifty-five forms were returned from the class of 113 students in 2007/2008 session (48.7%). The results, shown in Table 3 indicate that the first module was well received by students.

Table 4: Results of summative evaluation questionnaire completed by Computer Science students (n=51, 43.6%) and by teaching staff (N=12)

Questionnaire Item*	Role	Quartile 1	Median	Quartile 3
Layout and design				
The CAL program is easy to use.	Students	4	4	5
	Staff	4	4.5	5
The information is well presented.	Students	4	4	4
	Staff	4	4	5
The CAL program is interesting and fun to use.	Students	3.5	4	4
	Staff	3	4	4
Content				
The CAL program included just the right amount of information	Students	3	4	4
	Staff	3	4	4
The integrated quiz is useful in allowing users to review their understanding	Students	4	4	5
	Staff	4	4	5
The information in the program is useful to students' learning	Students	4	4	5
	Staff	4	4	4
CAL as an alternative to lectures				
The CAL program adequately replaces lectures on this topic	Students	2	3	4
	Staff	2	3	4
There is scope for more didactic lectures to be replaced with CAL programs	Students	3	3	4
	Staff	2.75	3	4
Rating of Individual modules				
Fundamental concepts of C++	Students	4	4	4
	Staff	4	4	4
Basic Declarations & Expressions	Students	4	4	4
	Staff	3.75	4	4
Control Structures in C++	Students	4	4	4
	Staff	3.75	4	4

* For each item, a rating of 5 was considered the optimal response

Summative Evaluation Questionnaire

Fifty-one forms were returned from the class of 117 third-year students in 2007/2008 session (43.6%), and 12 forms were collected from members of the teaching staff with expert knowledge on programming.

Summative results are reported in Table 4. They indicate that all four modules were well received by staff and students and that staff responses were closely aligned with those of the students.

Focus Groups

Third-year students cited CAL as an appropriate medium through which to teach the principles of C++ programming:

- *It was targeting a subject-area that does not need to be taught in lectures*
- *Yes, the subject lends itself better than say, programming. (dialogue among third-year students about CAL).*

This sentiment was also expressed by third-year students in a separate focus-group discussion:

- *I don't think it's a topic that really needs a lecture or there's anything that needs explaining … Knowing how big C++ programming has to be, there's no need for a lecture on that.*
- *I don't think lectures should be eliminated from Scientific programming*
- *I wouldn't say that either, but the little quizzes in CAL are really useful. (dialogue among third-year students about CAL)*

These statements also served to highlight the importance of self-assessment of students, as well as their reluctance to see lectures replaced by CAL in general.

Analysis of Examination Results

The mean value of the 2008 examination scores was 19.4 of a possible 33, while that for 2009 was 21.4/33. At $p = 0.0005$, this difference is statistically significant, suggesting that the students who learned from CAL package performed better than the previous cohort, who had been lectured via traditional teachning method.

Summary Of Findings

The preliminary needs analysis indicate that students did not consider the traditional lecture on the topic on C++ programming to have been particularly helpful or interesting, although it did fulfil the learning objectives described in the introductory part of this paper. The respondents were supportive of the idea of replacing the lecture with CAL, particularly if the learning package were made available on the campus intranet.

The subsequent formative evaluations indicated that the CAL package:

- Was very easy to use
- Contained an appropriate amount of well-presented information
- Was interesting and fun to use
- The integrated quiz was thought to promote the student learning, and
- The majority of students were satisfied with the package as a lecture replacement

The findings from the summative evaluation reiterate previous positive findings on the layout and design of the package and its content. The overall consensus on the ability of CAL to replace lectures was neutral, however, with some respondents for and others against lecture replacement, as indicated by the inter-quartile range in ratings. This range of opinion is further demonstrated by responses to open-ended questionnaire items:

- Would be a good support rather than replacement (Student)
- Certain more difficult classes may not be well suited as CAL programs in place of lectures, but may be to augment lectures (Student)
- Doing CAL package with lecturer in room to explain/amplify would work. (Lecturer)

Students and staff also felt that replacing lectures with CAL was appropriate only for certain subjects:

- Depends on the content of the lecture (Student)

CAL has been shown to be effective alternative to lectures in human physiology [12] and orthodontics [13], although its use does not need to be fully integrated into the curriculum to ensure uptake by students [14]. Reluctance on

the part of students to part with the traditional lecture has been cited in relation to veterinary pathology and clinical sonography [15]; it has been suggested that students are caught between different learning and teaching paradigms [16].

In terms of finding evidence that students' learning is supported equally well by CAL and by lectures, the significant increase in students' examination scores in this study is encouraging. However, the problem with comparing two educational methods using examination marks is that the comparison does not take into account either the revision or further study carried out by the students between the teaching treatment and the examination [17] or any inequity in the level of difficulty of question between the periods.

One of the benefits of face-to-face teaching is the ability to ask questions to check understanding. Active participation in large-group teaching activities can be promoted through the use of questions with feedback [18]. The focus-group comment made by the third-year student would suggest that CAL quizzes serve the same function in CAL as a lecture replacement.

The triangulated evidence from the questionnaires, focus groups and examination results suggest that CAL is an acceptable replacement for a lecture on this particular topic.

Recommendations

The most important challenge of the arrival of CALCPPLUS and other modes of dispensing e-learning is now at the door steps of our various educational researchers, management, planning and training institutions. Therefore, the following recommendations are made:

1. That, our present and future educators are not only made to be IT literate, but put through the requisites for their ultimate admission into modern day classroom via the e-learning.
2. That, there is a dire need to restructure the training curricula of our future educators in the light of the present and future envisaged IT.
3. That, both educators and learners should be aided and properly oriented, not only to be informed, but effective and efficient users and producers of the IT tools so as to utilize the CALCPPLUS system effectively.

Conclusion

Information technology will continue to play a vital role in all aspects of human endeavour especially in educational sector since the world is going through information revolution that will drastically change the way we think, the way we live, and the environment in which we live. It is appalling that Nigeria Universities have not been able to benefit much from the said information revolution. The technology and funds are not necessarily the inhibiting factors, but the will and awareness does not seem to be present nor penetrating the psyche in our academic communities.

The researchers strongly believe that the deployment of CALCPPLUS will definitely leapfrog the educational chasm in Nigeria and provide the desired impetus for technological and socioeconomic emancipation of Nigeria. An important warning, however is that the federal and state governments, rich multinational firms and individuals need to show adequate commitment and political will necessary to remove the IT infrastructural constraints that inhibit the attainability of the positive benefits of e-learning.

The brief conclusion is to appeal to all IT learned personalities and others looking forward to a progressive future life in our society to see and accept the e-learning as an evolving need of the modern civilization, and the automate solution to some of the current prevailing social embarrassment (particularly in our educational sectors) militating against our collective drive to chart a new conducive social order.

Finally, the researchers strongly believe that we all own the present and future generations of our society the important duty of bringing e-learning within the reach of eligible Nigerian students, especially the undergraduates.

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