

Design and Development of a Customized Computer Assisted Instruction (CAI) Model for Teaching Science Subjects in Nigerian Senior Secondary Schools

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ABSTRACT

This research work focused on the Design and Development of Customized Computer Assisted Instruction (CAI) Model for Teaching Science Subjects in Nigerian Senior Secondary Schools. As science education is yet to achieve its target objective of achieving sustainable science education for industrialization, there is need to find out the causes of the problem and proffer solution to it. Survey method was used to find out the current scenario in the teaching and learning of science subjects in Nigeria secondary schools. Three hundred copies of questionnaire were used to collect data from a sample of 20 secondary schools across the six geo-political zones of the country. Three research questions and two hypotheses were formulated that guided the study. Data collected were analyzed using mean and standard deviation. Chi-square was used to test the hypothesis. The major finding, among others showed that all the schools in the six geo-political zones still lacked science teachers, particularly in physics subject. This finding therefore justified the need to find an alternative solution to the teaching of science subjects in our schools. The researchers therefore, designed and developed a customized CAI for teaching science subjects at the senior secondary school level using physics as case study. The methodology adopted for the design of the CAI software was top down, and the structured systems analysis and design methodology. Visual Studio 2015 and Microsoft SQL server 2013 were also used to develop the model CAI. Experimentation of the software by students offering physics recorded huge success, thus raising the hope that full utilization of the software will go a long way in addressing the lack of science teachers, and as well aid students' understanding of the subject for improved academic performance.

Keywords: Sustainable, CAI, Chi-Square, ICT, Science Education.

INTRODUCTION

There is no gainsaying the fact that for any nation to attain sustainable development, there is need to give science education the priority it deserves. Science education is the bedrock upon which any nation can be built. It has been recognized worldwide as a pre-requisite for technological development.

Science education is very important to the development of any nation. This is why every nation must take it very seriously in all institutions of learning [1].

According to [2], citing [3], for any nation, including Nigeria to attain sustainable development, there is need to recognize science education as a priority area of education for her citizens. Science, according to [3] is the bedrock upon which any nation can be built. This means that no country can be recognized globally without talking about its scientific advancement or progress.

According to [4], science education is a process of teaching or training especially, in school to improve one's knowledge about environment and to develop one's skill of systematic inquiry as well as natural attitudinal characteristics.

[5], observed that science education identifies natural phenomena appropriate to child interest and skills. It equips teachers, learners and the society with knowledge, skills, equipment and freedom to perform noble task useful for improving socio-economic standard. He also noted that science education courses are designed to produce capable scientists who would contribute meaningfully to the academic excellence of the society to raise the economic level of nations.

Despite the importance of science education to national development, Nigeria's science education is not without its shortcomings. [6], contended that science education has failed to produce skilled human resources needed for transformation into national prosperity. This shows that most Nigeria's development in the direction of modernization has been haphazard leading to acquisition of obsolete technology. Science teachers are collectively a key factor to be considered when talking about the development of science education in any nation. The bane of Nigeria's science education is shortage of science teachers. [7], observed that the status of competency in secondary school science education in Nigeria appears very low. He went further to say that majority of teachers who are already in the system seemed to lack initiatives and skills that are imperative to make science education standard to meet the global education challenges. [8], agreed that a good percentage of teachers (science teachers) lacked competency for imparting science education skills.

[9], observed that poor performance in Physics might be due to shortage of science instructors in quantity and quality. He also observed that other problems such as insufficient laboratory equipment and facilities, poor motivating methods and shortage of appropriate Physics book affect student performance in Physics. [10], stated that students trained by qualified and experienced instructors performed much better than students trained by unqualified and unskilled instructors. Other factors militating against science education in Nigeria as expressed by [11], include, insufficient facilities and poor teaching method. [12], observed in their study, a steady increase in the enrollment of students who sat for May/June WASSCE in Biology, Physics, Chemistry, Mathematics and English from 2008 - 2012 in Nigeria without a steady increase in the students' academic performance.

The above finding is consistent with [13], who reported student poor academic performance in all the geo-political zones in Nigeria. This also corroborated [14], who observed that candidates' performance in Senior School Certificate Examination (SSCE) have been consistently poor with biology having the highest enrolment and the poorest result. Insufficient qualified and devoted instructors have been recognized as a factor affecting students' performance in science subjects. Suffice it to say that despite steady increase in the number of universities and other tertiary institutions in Nigeria, our secondary schools still lack sufficient science teachers. It should be noted that science facilities that are not available in schools can be provided in a short period of time if money is provided. But that is not the case with human resources. Training of skilled manpower is not usually provided overnight. It takes time. It is against this background that the researchers tend to proffer ICT solution to the problem of shortage of science teachers, using Physics as a case study.

STATEMENT OF THE PROBLEM

For many years now, there have been complaints about inadequate science teachers in Mathematics, Physics, Chemistry and Geography. In Anambra State, for instance, the government tries to solve this problem by engaging the services of not fully employed young graduates called P.T.A Teachers who earn between ten to twenty thousand naira a month. Some of these teachers are not graduates (specialists) in the subjects they teach. It is common to come across a graduate of Mathematics or Chemistry teaching Physics. Few graduate specialists in science education are not employed due to lack of fund to pay them by the government. Some state governments placed embargo on employment to avoid this necessary expenditure. In view of the above, there is the need to find alternative solution to the issue of shortage of science teachers. The researchers, therefore, tend to explore IT solution to the problem.

RESEARCH AIMS AND OBJECTIVES

The main aim of this research work is to develop a Customized Computer Assisted Instruction Model for teaching science subjects in Nigerian Secondary Schools.

The specific objectives include:

- (a) To investigate the current scenario as regards availability of adequate science teachers in Physics.
- (b) To develop web-based interactive software that can achieve the following:
 - Present course material to a student.
 - Give the student time to go through the material.
 - Give the student test at interval.
 - Grade the student and determine whether the student has done well or not so as to move to a new topic or to repeat the topic.

- (c) To test the effectiveness of the software (CCAI model) developed for teaching and learning.

RESEARCH QUESTIONS

The following research questions were formulated to guide this study:

- (i) What is the current situation as regards the problem facing the teaching and learning of Physics in Nigerian Secondary Schools?
- (ii) To what extent do inadequate Physics teachers result to poor academic performance in Physics?
- (iii) What are the challenges facing the use of existing CAI in teaching and learning of Physics?

RESEARCH HYPOTHESIS

1. Ho: The problem of shortage of Physics teachers in our schools does not exist.
2. Ho: There is no significant effect of inadequate Physics teachers on academic performance of students in Physics.

MATERIALS AND METHODS

Survey Methodology: This methodology was used for data collection as regards the problems facing the teaching and learning of science so as to justify the Information and Communication Technology (ICT) solution to the problem of shortage of teachers in science subjects.

Data was collected from the six Geo-Political zones of the country. Data collected were analyzed using mean and standard deviation. Mean and standard deviation were used to answer the research questions, while chi-square (χ^2) statistics was employed to test the hypothesis.

The cut off mean was 2.5. Any value of 2.5 and above was accepted, but any mean below 2.5 was rejected.

TEST OF HYPOTHESIS ONE:

TABLE 1: SUMMARY OF RESULT OF CHI-SQUARE (χ^2) CALCULATION

Calculated/Critical	Value
χ^2 calculated	176.28
χ^2 critical (value)	32.67

From the table above

$$\begin{aligned} \chi^2 \text{ calculated value} &= 176.28 \\ \chi^2 \text{ critical value} &= 32.67 \\ &\text{(value from chi-square table)} \end{aligned}$$

Degree of freedom = 21
 Level of confidence = 5%

Since χ^2 calculated value exceeds χ^2 critical value ($176.67 > 32.67$), we reject the null hypothesis and accept the alternative hypothesis which implies that there is a problem of inadequate Physics teachers in the senior secondary schools in Nigeria.

TEST OF HYPOTHESIS TWO

TABLE 2: SUMMARY OF THE RESULT OF CHI-SQUARE (χ^2) COMPUTATION

Calculated/Critical	Value
χ^2 calculated	182.23
χ^2 critical (value)	32.67

From the table above:

χ^2 calculated = 182.23
 χ^2 critical value = 32.67
 Degree of freedom = 21
 Level of confidence = 5%

Since chi-square (χ^2) calculated value exceeds χ^2 critical value i.e. $182.23 > 32.67$, we reject the null hypothesis and accept the alternative hypothesis which implies that there is significant effect of inadequate Physics teachers on the academic performance of students in Physics.

FINDINGS

The result of our investigation from the six geo-political zones of the country showed that shortage of science teachers still exists. The percentage of respondents who either strongly agreed or agreed on the question as to whether inadequate qualified teachers is a major problem in teaching and learning of Physics was 76.3%, while those who disagreed and strongly disagreed was 23.7% .

Then the question as to whether inadequate Physics teachers (science teachers) has effect on academic performance of the students yielded the following responses. Seventy six percent (76%) of the respondents agreed that inadequate Physics teachers is the main cause of poor performance of students in exams, while twenty four percent (24%) of the students disagreed with the above claim.

The result of test of first hypothesis showed that there was a problem of inadequate Physics teachers in our schools. The second hypothesis implied that inadequate Physics teachers has led to poor performance of students in Physics exams. The above scenario, by inference, applies to other science subjects, especially chemistry and mathematics.

The above findings have justified the need for our research and the development of customized CAI for teaching and learning of science subjects in our senior secondary schools.

SYSTEMS ANALYSIS OF THE PRESENT SYSTEM

Generally speaking, systems analysis is the study of the existing system so as to determine the problems or shortcomings of the system and proffer solutions to the problems. The researchers adopted this approach and discovered the weaknesses of the existing system as follows:

The present system is fraught with the following problems/shortcomings:

- (i) The fixed time for the lessons may not be suitable for the teacher or the students. This results in absenteeism by either the teacher or students.
- (ii) The current system is affected by emotional and situational factors. A teacher who is sad or tired may not be able to deliver.
- (iii) Congested classrooms coupled with insufficient basic facilities can seriously affect the quality of teaching and learning.
- (iv) Time constraint may not allow all the students to interact with the teacher by way of asking questions.
- (v) The present system, which applies collective lesson method, does not give room for a student to learn at his own pace as every learner is pushed along with others.
- (vi) The present system is disrupted by incessant industrial action.
- (vii) Human factors may introduce elements of bias in assessment of the students.

The implications of the above are:

- (i) Decline in the number of students offering science subjects.
- (ii) Poor performance of students in science subjects.

Software Design Methodology: This is a set of procedure that one can follow to accomplish software development process from the beginning to the completion of the software product.

Software development methodologies are many and varied. But in this research, we have adopted a hybrid methodology - comprising two methodologies, Top-down Design and Structured Systems Analysis and Design Methodology (SSADM). This choice was made because of the advantages and supplemental nature of the two methodologies.

Model of the Design: The model for this design is modified Mappalotteng model of 2014. The modified model consists of the following design steps:

- i. Preliminary study of client needs

- ii. Material design
- iii. Programming aspect
- iv. The display aspect
- v. The learning aspect and
- vi. Evaluation

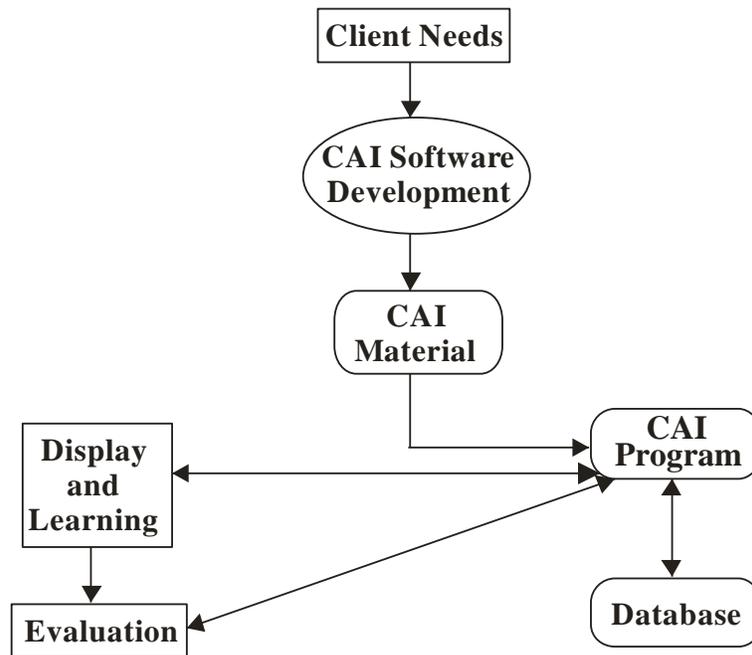


Fig 1: CAI Model (adapted from [15])

Analysis of the New System: The New system uses computer for teaching and learning of science subjects as different from human method. Here, students are taught and examined using Customized Computer Assisted Instruction (CCAI) software. In this case computer acts as a patient teacher, making the materials for studies available to the students, tests the students, determine whether they have performed well or not and determine, based on the students' performance, to move the student forward to another topic or allow the student to re-learn the previous topic and re-examine the student again.

The Main Modules

The new system is made up of 3 modules, Basic Electricity, Static/Current Electricity and Resistance/Electric Power.

Sub Modules

Module 1: Basic Electricity: It consists of the following sub modules – Lessons 1-4, Questions, Scores, Pass or Fail. In this case, pass takes the learner to the next module, but fail takes the learner back to the current module under study.

Module 2: Static and Current Electricity – It is made up of the following modules Lessons 1 – 4, Questions, Scores, Pass/Fail. The last sub module (fail/pass) determines next line of action as describe in module 1 above.

Module 3: Resistance and Electric Power – It has the same sub modules as in 1 and 2.

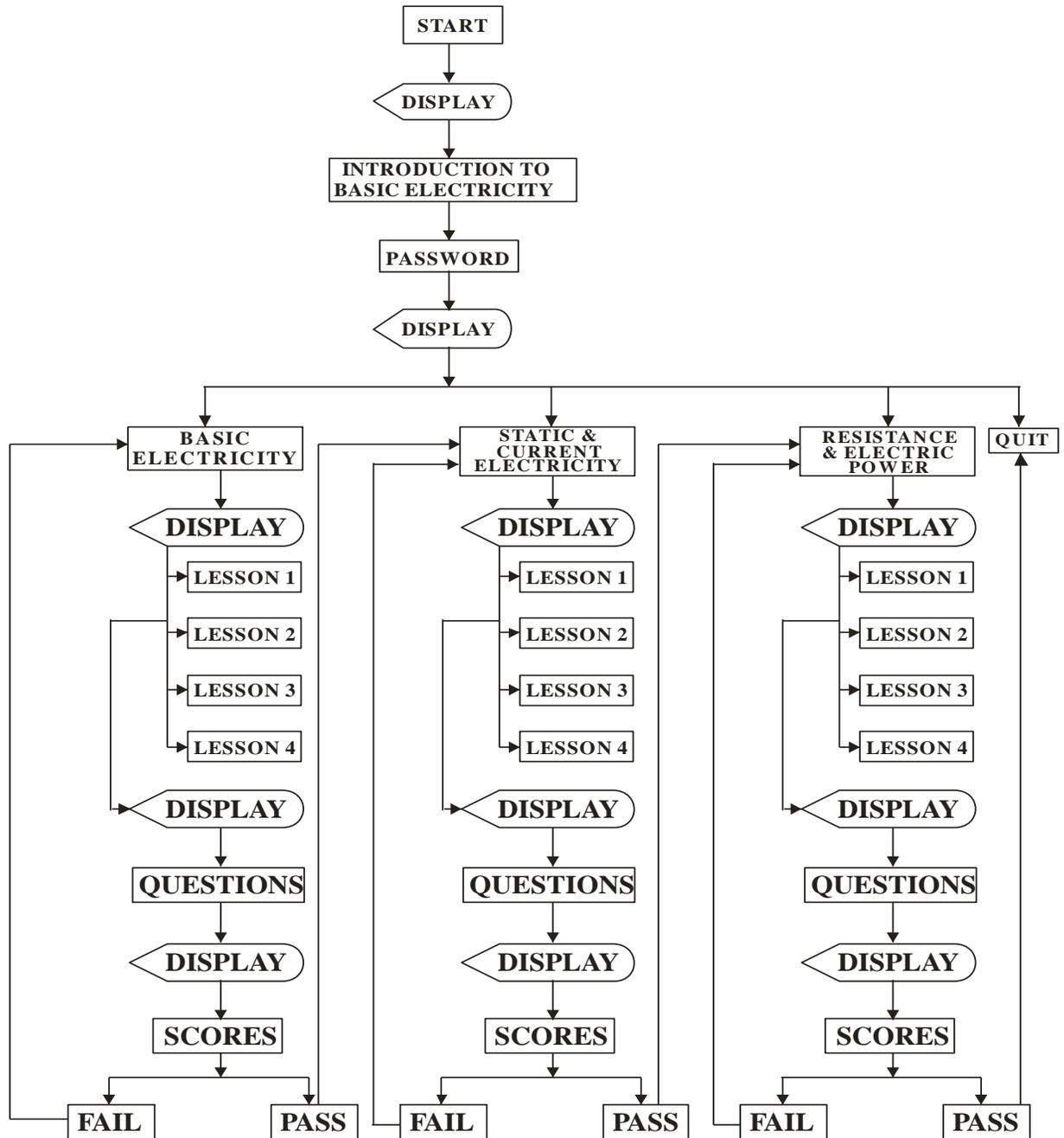


Fig 2: High Level Model of the New System

Advantages of the New System

The new system has a lot of advantages over the existing system.

- (i) The new system would allow the students to learn at their own pace. Better talented students are not inhibited and the slower ones are not rushed.
- (ii) The new system can be available for twenty-four hours, all things being equal, a feat no human being can accomplish.
- (iii) The new system would enable the students study on their own during industrial action (strike).
- (iv) The new system can reduce pressure on over-crowded classrooms, thereby creating conducive learning environment.
- (v) The privacy nature of computer assisted instruction helps the shy and slow learners to increase their speed of learning.
- (vi) The multimedia approach of the new system helps the learners to understand difficult concepts through multi-sensory approach.
- (vii) With the new system, learning is no longer confined in the conventional classrooms as learning can take place anywhere.
- (viii) The new system is a self-learning technique which may not need the assistance of human teacher. This helps to solve the problem of shortage of science teachers in our schools.
- (ix) The new system is impartial in its assessment of the students.

RESULTS AND DISCUSSION

At the onset of the research work, we stated our specific objectives. We, therefore, summarize the achievements recorded at the end of the research as follows:

- All the sample schools used in the six geo political zones of Nigeria still experience shortage of science teachers, the increase in the number of universities and other tertiary institution notwithstanding.
- Eighty percent of the schools do not have CAI software in their laboratories.
- We have successfully developed a customized Computer Assisted Instruction (CAI) that can do the following, using multi-media approach.
- Present course material to a student and give the student time to listen and go through the material.
- Give the student test at intervals and determine whether the student has done well or not so as to move forward to the next topic or to make him repeat the previous lesson.
- Students taught with customized CAI performed better than those taught with the old manual system.

The new customized CAI software developed would meet the curricular needs of the students at senior school certificate level, as the course materials were taken from school certificate syllabus - hence customized.

The new software when stored in the school network server can be accessed by all the students in the school. The software can also be uploaded to the Net for global use.

The CAI software can serve as a useful teaching tool. This would no doubt remove the monotonous chalk and talk method of the existing system

CONCLUSION

The new system developed would obviously take care of the weaknesses of the existing system. Recall that the existing system is affected by emotional and situational factors. There are also problems of congested classroom and other inherent problems found in the existing system. The new system is devoid of these problems. It allows the students to learn at their own pace. The multimedia approach of the new system helps learners to understand difficult concepts through multi-sensory organs of the body.

Therefore, it is the belief of the researchers that electronic approach to the issue of shortage of science teachers in our schools would go a long way towards resolving the problem which has been age long.

RECOMMENDATION

In view of the problems of the existing system and the obvious advantages of the new system, the researchers recommend as follows:

- Government should sponsor the production of Customized CAI software for teaching science subjects in commercial quantity.
- All the schools in Nigeria should have customized CAI in their laboratories for teaching of science subjects such as Physics, Chemistry, Mathematics and Biology.
- More research should be carried out to improve on this work.

REFERENCES

1. Aina, J.K. (2013). Importance of Science Education to National Development and Problems Militating against its Development. American Journal of Education research, 225-229.
2. Okoli, S.O., Obiajulu, A.N. and Ella, F.A. (2013). Science Education for Sustainable Development in Nigeria, Academic Journal of Interdisciplinary Studies, 2 (6).
3. Onah, A.O. (2003). Science Education and Poverty Eradication in Nigeria, Eha-Amufu School of Education Journal 3 (1).
4. Pember, S.T. and Humbe, T.T. (2009). Science Education and National Development. Being a Paper Presented at the ASUTIBS Maiden National Conference CEO Katsina.
5. Lewi, A. (1985). Science Teaching in Africa. London: Heinemann Educational book Ltd.
6. Momeke, C.O. (2007). Effects of the Learning Cycle and Expository Instructional Approaches on Students' Learning Outcome in Secondary Biology. An Unpublished

- Ph.D Thesis Submitted to the School of Post Graduate Studies, University of Benin, Benin city.
7. Nada, T. (2008). The reality of innovation in government: <http://www.innovationpeer-reviewreality>.
 8. Gardner, D.P. (2005). A Nation at Risk: Imperative for Education Reform. The National Commission on Excellence in Education, U.S. Education Department, Washington D.C.
 9. Akanbi, A.O. (2003). Trends in Physics Education in Schools in Kwara Condition. Lafiagi Journal of Science Education 5 (1 and 2), 69 - 75.
 10. Apata, S.F. (2007). Influence of Instructors Academic Qualification and Experience on Students' Performance in Senior School Physics in Kwara Condition, Unpublished M.SC Thesis.
 11. Ojo, M.O. (2001). Problems Training Science and Mathematics Teachers in Nigeria, A Paper Presented in the Train - the Trainers Workshop for Science and Mathematics Instructors in Schools of Education in Six Geo-Political Zones of Nigeria.
 12. Sakiyo, J. and Badau, K.M. (2015). Assessment of the trend of secondary school students' academic performance in the sciences, Mathematics and English: implications for the Attainment of Millennium Development Goals in Nigeria, Advances in Social Sciences Research Journal, vol. 2, No. 2, 31 - 38.
 13. Alaka, A.A. and Obadara, O.E. (2013). Scholastic Performance of Students at West African Senior Secondary Certificate Examination in Nigeria: Journal of Education and Social Research 3 (1).
 14. Ibe, B.O. and Maduabum, M.A. (2001). Teachers Qualification an Experience as Correlates of Secondary School Students' Achievements in Biology. Journal of Education Thought, 1 (2) 176 - 183
 15. Mappalotteng, A.M. (2014). Developing a Computer Assisted Instruction Model for Vocational High Schools, Research Inventory: International Journal of Engineering and Science vol. 4, Issue 10 p. 31-42.