ADOPTION OF COMPUTERIZED ADAPTIVE TESTING IN ASSESSMENT OF STUDENTS IN MATHEMATICS

.
IHENDINIHU, U.E.
Department of Science Education, Michael Okpara University of Agriculture, Umudike.
ihendinihu.uchechi@gmail.com

Abstract
The global lockdown of activities occasioned by recent outbreak of the corona virus pandemic made online individualized teaching and learning more popular and created the need to refocus on individualized assessment. This study explored the perception of teachers on the possibility of adopting Computerized Adaptive Testing (CAT) in assessing the achievement of Secondary School Students in Mathematics using a descriptive survey research design. Four research question and two hypotheses guided the study. A researcher constructed questionnaire validated by four experts and found to have a reliability index of 0.81 using Cronbach Alpha was used to collect data from a sample of 100 teachers purposively selected from Abia State. Data analyses were done using mean and Chi–square test statistics. Results indicated that both male and female teachers independently agreed developing, analyzing, selecting and scoring items are feasible and available for implementing the CAT process. However, all the factors relating to availability of sever / web / browser and platforms for implementing the CAT were perceived as inadequate for adopting CAT in secondary schools. Furthermore, teachers agreed to the fact that Low computer literacy of students and teachers, non-availability of adequate computers, inadequate power supply, poor internet accessibility, non-availability of skilled workforce to drive the program, insecurity of item bank and possibility of impersonation are perceived challenges of adopting CAT in secondary schools. The researcher concludes that the pace of adoption of CAT in Abia state will likely be slow due to these constraints and calls for government and other stake holders' intervention to tackle the challenges before advocating for the adoption of CAT in secondary schools.

Key words: Computerized Adaptive Testing, Assessment, Adoption, Achievement, Mathematics

Introduction

The role of assessment in teaching and learning, guidance, certification, placement and determination of skills and competences of individuals call for care and diligence in the assessment of learners. Hence, assessment is central to teaching and learning. In line with this, the National policy on education on assessments stipulates that assessment shall encompass the broad areas of assessment for learning (formative) and assessment of learning (summative). Furthermore, the policy stipulates that the goals of assessment shall be to: accurately measure the abilities of

students; enhance the global competitiveness of the products of the Nigerian educational system; improve the credibility of examinations conducted in Nigeria; eliminate the untraceable problems associated with the traditional paper pencil test (PPT); and improve learning (FRN, 2014). In pursuance of the above goals, the government advocates for migration from PPT to CBT (Computer Based Test) at all levels of education in Nigeria. Also, assessment bodies involved in conducing large-scale public examinations are encouraged to migrate to electronic testing as soon as possible.

According to Osuji (2012), electronic assessment is seen as the end to end assessment process where Information and Communication Technology (ICT) is used to present assessment activities, and record responses. It means that all the aspects of assessment, from the planning, setting of the questions, marking, recording and statistical analyses are done electronically. This practice has become necessary in the secondary school system because entrance examinations into tertiary institutions and most job interview examinations are computer based. Also, job environments require the use of computer for their operations. This makes it imperative that students nowadays be exposed to online learning and assessment early. Globally, educational processes including teaching and learning have moved and have continued to move from the usual classroom face to face interaction between teachers and the learners to learning which is not restricted to the four walls of an institution. This type of learning which has been accepted the world over in the form of open and distance learning (ODL) is driven by electronic learning is adopted in some tertiary education and certification courses. It is expected that e–learning will sooner or later be adopted in secondary schools.

The emergence of Covid–19 made advocated online teaching and learning more popular. Many secondary schools and state governments organized online teaching and learning activities during the lockdown period occasioned by the corona virus pandemic. These teaching and learning activities took the form of radio classrooms, google classes, zoom classes, and so on, using the curriculum of the various classes in various subjects including mathematics. The gradual migration from physical classroom learning to virtual or online teaching and learning makes the adoption of adaptive pedagogic practices imperative, going by the critical need for quality and sustainable ICT driven education in the world of today. E-learning makes the adoption of acclaimed individualized or adaptive teaching and learning possible (Osuji, 2012).

Adaptive teaching–learning is a pedagogic instructional method that uses computers as interactive teaching devices in order to adapt educational materials according to students' learning needs (Eluwa & Uko, 2020). It uses computer algorithms to orchestrate the interactions with the learner and deliver customized resources and learning activities to address the unique needs of each learner (Edward, 2014. Ikwumelu et al, 2015). This calls for the introduction of Computerized Adaptive Testing (CAT), a computer-based test that adapts to the examinees ability level. In other words, it is a form of computer – administered test in which the next item or set

of items depends on the correctness of the test taker's responses to the most recent items administered. CAT successively selects questions for the purpose of maximizing the precision of the examination based on what is known about the examinee's perspective. The difficulty of the examination seems to tailor itself to their level of ability (Moosbrygger & Kelava. 2012).

The basic computer–adaptive testing method is an iterative algorithm with the following steps:

- The pool of available items is searched for the optimal item, based on the current estimate of the examinee's ability. Nothing is known about the examinee prior to the administration of the first item, so the algorithm is generally started by selecting an item of medium or medium – easy, difficulty as the first item.
- The chosen item is presented to the examinee, who then answers it correctly or incorrectly.
- The ability estimate is updated, based upon all prior answers.
- These steps are repeated until a termination criterion is met.

As a result of adaptive administration, different examinees receive quit different test items.

The CAT process can be summarized as follows:

- Adjusting to an examinee's skill level through dynamically selecting appropriate items (Moosbrugger & Kelava, 2012).
- Determining the appropriate difficulty index of items.
- Building calibrated item pool.
- Defining item selection algorithm.
- Segmenting item pools into intervals to which items are assigned according to their determined difficulty parameter.
- Defining the termination criteria.
- Adopting the scoring procedure.

Several researchers have highlighted the challenges facing the adoption of information and communication technology in the teaching and learning as well as assessment in our school system. Some of the factors implicated include: lack of computers/ICT laboratories (Eze & Akabugwo, 2016): low level of ICT accessibility (Nwosu & Kamaruddin, 2018). Low computer literacy of students and teachers (Ogwo, Maiden & Onwe, 2015), cost of acquiring a computer, poor technical infrastructural development and impersonation (Osuji, 2012). A review of literature on adoption of computer–based assessment has been organized by some researchers. Furthermore, researchers have developed an adaptive assessment system for adoption and adaption by educational systems. For instance, Osuji (2012) discussed the general overview of e–assessment as a global change in assessment, its benefits, the responsibilities in the e–assessment process, and requirements of e–assessment in the Nigerian higher education system.

Shute and Rahimi (2016) presented a review of literature on Computer–based assessment for learning in elementary and secondary education as a viable way to merge instruction and assessment of Students' developing

proficiencies. The researchers examined relevant literature reviews that covered topics related to assessment for learning (formative) and assessment of learning (summative) in the digital age, effectiveness of feedback in computer–based assessment, environments and psychometric analysis of the performance data of simulation–based assessments. The review covered a range of educational levels. Examples of research studies per category were provided. Findings show that using Computer based Assessment for Learning (CBAFL) in the classroom, via the internet, or embedded in a game, generally enhances learning and other outcomes across a range of content areas. An overview of the reviews shows that a wide range of computer-based assessment are available and adopted in elementary and secondary schools outside Nigeria.

Rushton (2014) investigated the impact of Computer–Adaptive Benchmark Data and Assessment Literacy on students Achievement in Mathematics in Suburban communities in Northern Utah. The researcher analyzed unit post test scores and results from the Instructional Materials Motivation Survey (IMMS) for seventh and eighth grade mathematics for control and treatment groups using Analysis of Covariance (ANCOVA). Results indicated that summative scores for seventh and eighth grade students who received instruction for the unit along with the SMI benchmarks and assessment Literacy training were not statistically different from students in the control groups. Also, the result showed that the Student Mathematical Motivation overall mean scores were not statistically significant. Choi and McClenen (2020) developed adaptive formative assessment system, called Computerized Formative Adaptive Testing (CAFT) by using artificial intelligence methods based on computerized adaptive testing (CAT) and Bayesia networks as learning analytics. The result of the efficiency, validity and reliability test on the CAFT showed that, through CAFT, learners adaptively take items and tests to receive personalized diagnostic feedback about their learning progression. Consequently, the study highlights that a learning management system which integrates CAT as an artificially intelligent component is an efficient educational evaluation tool for a remote personalized learning service. Also UOC (2017) introduced a flexible online platform for computerized adaptive testing. The software architecture enables the development of fully customizable CAT tools with respect to domain – specific item design and visualization as well as deployed CAT algorithms. A prototypical implementation of the architecture and a set of domains – specific item types were presented to demonstrate the feasibility of the proposed approach and outline of future directions of development and research were given.

The review of related literature indicates that CAT is being introduced in assessing mathematics achievement of elementary and secondary school students in countries like Kenya. Besides many systems or software for such assessment have been developed by scholars. In summary, computer and internet supported teaching, learning and assessment are incorporating themselves more and more into the daily routine of the educational system, especially in the higher institutions of learning. Considering the important role of mathematics in accelerating the social, economical

and technological growth of a nation; its nature as an abstract subject and the need to individualize teaching, learning and assessment of the subject, it becomes necessary to survey the opinion of teachers on the adoptability of computerized adaptive testing in Mathematics. Hence, the purpose of the study is to assess the perception of teachers on the feasibility of adopting CAT in secondary schools particularly in mathematics.

Specifically, the study seeks to:

1. Assess the opinion of teachers on the possibility of adopting the CAT process.
2. Determine the perceived challenges of adopting CAT in secondary schools.
3. Determine whether the opinion expressed by teachers on the adoption of CAT in secondary schools is independent of their gender.
4. Determine whether teachers' opinions on the challenges of adopting CAT in secondary schools are independent of their gender.

Research Questions

1. What are the teachers' perceptions of the feasibility of adopting the CAT process in secondary schools?
2. What are the scores of male and female teachers for adopting the CAT process in secondary schools?
3. What are the likely challenges of adopting CAT in secondary schools?
4. What are the scores of male and female teachers on the perceived challenges of adopting CAT in secondary schools?

Research Hypotheses

Ho1. The perception of teachers on the adoption of CAT in secondary schools is independent of their gender.

Ho2. The perception of teachers on the challenges of adopting CAT in secondary schools is independent of their gender.

Methodology

The study adopted a descriptive survey research design to assess the perception of teachers on the feasibility of adopting computerized Adaptive Testing in secondary schools with a focus on mathematics. Also, opinion of teachers on the possible challenges of adopting CAT were determined. Using purposive sampling, the researcher selected 100 teachers (40 males and 60 females). The sample include 60 mathematics teachers, 25 computer studies teachers and 15 principals. The reason for selecting these teachers' classes is that Mathematics teachers will be conversant with constructing, selecting and analyzing the item pool. The computer studies teachers are expected to be familiar with the server requirements and software for implementing CAT. At the same time, the principals will be more knowledgeable in the modalities for providing ICT facilities is schools for CAT. The instrument for data collection was the researcher's developed structured questionnaire of the 4 – point scale Likert format of Strongly Agree (SA) = 4 points, Agree (A) = 3 points, Disagree

(D) = 2 points and Strongly Disagree (SD) = 1 point. The instrument, "Adoption of Computerized Adaptive Testing" was validated by two Lecturers in Measurement and Evaluation, one lecturer from Computer Science Education and one lecturer from Mathematics education. The reliability index was 0.81 obtained using Cronbach Alpha. The instrument has two sections A and B. Section A sought information on demographic variables (subject area and gender) while section B sought information on CAT. Two sub sections of section B are the CAT adoption process and challenges of adopting CAT in secondary schools. The research questions were answered using mean (that is comparing the mean response on each item by the mean of the scale: 2.5) while the hypotheses were tested using Chi–Square.

Results

Results of data analysis are presented in tables according to research questions and hypotheses that guided the study.

Research Question One: What are the teachers' perceptions of the feasibility of adopting CAT process in secondary schools

Table 1: Scores of teachers on the adoption of the CAT process.

S/N	Item	SA	A	D	SD	Mean	Remarks
1	The server/Web/ browser required to run CAT are available.	6	10	34	50	1.72	Disagree
2	Examinees' skill level can be adjusted through dynamically selecting appropriate testing items.	39	24	20	17	2.85	Agree
3	The appropriate difficulty index of question items can be determined.	40	23	21	16	.87	Agree
4	Calibrated question it em pool (question bank) in different domains or topics can be built.	50	34	12	4	3.34	Agree
5	A platform that can be able to operate with arbitrary testing strategies can be provided	6	10	36	48	1.74	Disagree
6	A platform for defining item selection algorithm can be provided.	8	11	35	46	1.81	Disagree
7	A platform for defining the termination criteria can be provided	7	12	32	49	1.77	Disagree
8	A platform that can allow for flexible specification under which constraints the test is executed can be created.	40	25	22	13	2.92	Agree
9	There is the possibility of technical integration with learning platforms on different layers.	8	10	35	47	1.79	Disagree

Table 1 shows that items 2, 3, 4, 8, 10, 11, and 12 had mean score greater than 2.5 which is the mean value of the four-point scale. The implication is that teachers are agreed to the fact that: Calibrated question bank in different domains of the topics can be built and evaluated using scoring procedures and the difficulty index of the questions can be determined; Examinee's skill level can be adjusted through dynamically selecting appropriate testing items as processes of CAT. These results show that all the factors which pertains to constructing and evaluating calibrated question bank from different topics in mathematics, determination of appropriate difficulty index of the question, adjusting examinees' skill through dynamically selecting appropriate testing items are perceived by teachers to be feasible to make available for adoption of CAT. These factors depends largely on availability of qualified mathematics teachers. Furthermore, results in table 1 show that items 1, 5, 6, 7, 9 had mean score less than 2.5. This implies that the teachers opine that the server required to run CAT is not adequately available in secondary schools in Abia state for adopting the CAT; the platform that can define item selection algorithm, allow for flexible specification of constraints under which test is executed, integrate learning and testing on different layers, define termination criteria and operate with arbitrary testing strategies are not adequately available in secondary schools. These results show that teachers perceive all the factors relating to availability of server/web/browser and platforms for implementing CAT process as inadequate for the purpose.

Research Question Two: what are the scores of male and female teachers for adoption of CAT process in secondary schools?

S/N	Item	Male		Female	
		Mean	Remarks	Mean	Remarks
1	The server/Web/ or browser required to run CAT is available.	1.73	Disagree	1.72	Disagree
2	Examinees' skill level can be adjusted through dynamically selecting a ppropriate testing items.	2.70	Agree	2.95	Agree
3	The appropriate difficulty index of question items can be determined.	3.00	Agree	2.78	Agree
4	Calibrated question item pool (question bank) in different domains or topics can be built.	3.0	Agree	3.23	Agree
5	A platform that can be able to operate with arbitrary testing strategies can be provided	1.70	Disagree	1.77	Disagree
6	A platform for defining item selection algorithm can be provided.	1.80	Disagree	1.82	Disagree
7	A platform for defining the termination criteria can be provided	1.68	Disagree	1.83	Disagree
8	A platform that can allow for flexible specification under which constraints the test is executed can be created.	2.98	Agree	2.88	Agree
9	There is the possibility of technical integration with learning platforms on different layers.	1.80	Disagree	1.78	Disagree
10	Items stemming from arbitrary domains can	3.15	Agree	3.23	Agree

Table 2; scores of male and female teachers on the adoption of CAT.

Hypothesis One: The perception of teachers on the adoption of CAT in secondary schools is independent of their gender.

Table 3: Chi – Square test of independence of opinion of male and female teachers on adoption of CAT process.

Gender	No	SA	A	D	SD	Total
Male	40	134 (132.8)	94 (97.2)	121 (119.6)	131 (130.4)	480
Female	60	198 (199.2)	149 (145.8)	178 (179.4)	195 (195.6)	720
Total	100	332	243	229	326	1200

$X^2 = \sum \frac{(O_i - E_i)^2}{E_i}$, where O_i is observed frequency and E_i is expected frequency. The values outside the brackets under SA, A, D, and SD are the observed frequencies whereas the values inside the bracket are the corresponding expected frequencies.

$X^2_{cal} = 0.1713$

$X^2_{cal} = X^2_{3,0.05} = 7.82$

Decision: since $X^2_{cal} < X^2_{tab}$, we do not reject H_o

This indicates that the opinion expressed by teachers on the adoption of CAT in secondary schools is not dependent on their gender.

Research Question 3: what are the likely challenges of adopting CAT in secondary schools?

Table 4: Challenges of adopting CAT

S/N	Item	SA	A	D	SD	Mean	Remarks
1	Low Computer Literacy of Students	50	34	10	6	3.28	Agree
2	Low Computer Literacy of teachers	45	39	11	5	3.24	Agree
3	Non availability of adequate personal computers	46	37	9	8	3.21	Agree
4	Unreliable and Inadequate power supply	40	50	10	-	3.30	Agree
5	Poor Internet Accessibility	48	36	10	6	3.26	Agree
6	Lack of Provision of funding by government	50	32	12	6	3.26	Agree
7	Non availability of skilled manpower to drive the program	42	48	10	-	3.32	Agree
8	Difficulty in building adequate item bank	8	11	35	46	1.81	Disagree
9	Insecurity of Item bank	30	44	20	6	2.98	Agree
10	Impersonation	49	35	16	-	3.33	Agree
11	Non availability of software for CAT	49	36	15	-	3.34	Agree

Results in table 4 indicates that teachers perceive all the items indicated (except item 8) as likely challenges of adopting CAT in secondary school mathematics assessment. The mean response of teachers on each of these items is greater than 2.50. Hence low Computer Literacy Level of teachers and students, non-availability of adequate personal computers, power supply, skilled manpower and software for CAT; poor internet accessibility; insecurity of item bank, the problem of impersonation and inadequate funding by the government are all factors perceived by teachers as challenges of adopting CAT. However, the teachers did not consider difficulty in building adequate valid item bank as a challenge of adopting CAT in secondary school in Abia state. The mean response of teachers on this item (1.81) is less than 2.50.

Research Question Four: what are the scores of male and female teachers for the perceived challenges of adopting CAT in secondary schools?

Table 5: Score of male and female teachers on challenges of adopting CAT

S/N	Item	Male		Female	
S/N	Item	Male	Remarks	Female	Remarks
1	Computer Literacy of Students	3.33	Agree	3.25	Agree
2	Computer Literacy of teachers	3.18	Agree	3.28	Agree
3	Non availability of adequate personal computers	3.15	Agree	3.25	Agree
4	Unreliable and Inadequate power supply	3.30	Agree	3.30	Agree
5	Poor Internet Accessibility	3.28	Agree	3.37	Agree
6	Lack of Provision of funding by government	3.23	Agree	3.28	Agree
7	Non availability of skilled manpower to drive the program	3.33	Agree	3.32	Agree
8	Difficulty in building adequate item bank	1.80	Disagree	1.82	Disagree
9	Insecurity of Item bank	3.00	Agree	2.97	Agree
10	Impersonation	3.23	Agree	3.30	Agree
11	Non availability of software for CAT	3.40	Agree	3.28	Agree

Hypothesis Two: The perception of teachers on the challenges of adopting CAT in secondary schools is independent of their gender.

Table 6: Chi – Square test of independence of opinion of male and female teachers on challenges of adopting CAT process.

Gender	No	SA	A	D	SD	Total
Male	40	186 (182.8)	157 (160.4)	62 (63.6)	35 (33.2)	440
Female	60	271 (274.2)	244 (240.6)	97 (95.4)	48 (49.8)	660
Total		457	401	159	83	1100

Note: The values outside the brackets are observed frequencies whereas the values inside brackets are the expected frequencies. The formula for Chi square is

$X^2 = \sum \frac{(O-e)^2}{e}$ where o is the observed frequency and e is the expected frequency.

$X^2_{cal} = 0.475$ and $X^2_{3,0.5} = 7.82$

X^2_{cal} (0.475) is less than $X^2_{3,0.5}$ (7.82).

The null hypothesis is not rejected. Hence, the opinion of male and female teachers on the challenges of adopting CAT in secondary schools is not dependent on their gender.

Discussion of Findings

The result of analyses of the perception of teachers on adopting the CAT process in secondary schools in Abia state as shown in tables 1 indicate that all the factors relating to developing, analyzing, selecting and scoring items are significant for implementing the CAT process. Hence the teachers agree to the fact that calibrated question item pool (question bank) in different domains of topics can be built for adoption of CAT. Also teachers perceived that the appropriate difficulty index of the question items can be determined. Similarly, teachers perceived that the examinees skill level can be adjusted through dynamically selecting appropriate testing items for each level from the calibrated question. Teachers also agreed that a platform that can allow for flexible specification under which constraints the test is executed can be created. The result shown in tables 2 and 3 show that the opinion of teachers on the adoption of CAT process is independent of their gender. This result is in line with a prior expectation. The fact that there are available qualified, experienced and competent mathematics teachers suggests that item construction, analysis and selection will not pose a challenge to the adoption of CAT in secondary schools.

Furthermore, results shown in tables 4, indicate the following as perceived challenges that could face the adoption of CAT in secondary schools: low computer literacy level of teachers and students; non availability of adequate personal computers; unreliable power supply, poor internet accessibility, poor funding by government, inadequate skilled computer technologists and teachers to drive the program, insecurity of item banks, non-availability of software for CAT and

possibility of impersonation. Hence teachers perceived all the factors relating to availability of sever / web / browser and platforms for implementing CAT process as inadequately available for that purpose. Results in tables 5 and 6 show that this result is independent of gender.

This outcome of the study is in line with a prior expectation. The fact that there have always been constant fluctuations in network and server services and platforms in the state attest to the opinion of the teachers that such related factors will likely not make for smooth adoption of CAT in secondary schools. More so, given the fact that some of the secondary schools in the state are located in remote areas where internet services are not available, makes the adoption of CAT in such areas impossible. Most teachers in secondary schools are not ICT complaint. There are not enough Computer Studies teachers / technologists to develop or adopt and adapt developed CAT soft wares in the secondary schools and also to enhance Computer Literacy of the students to be able to participate in CAT. The non-availability of the facilities for adopting CAT Stems from poor funding of the educational system by the government.

The findings of the present study are supported by the report of the following researchers: Anene, Ikerionwu, Danladi, (2013), who reported that majority of the undergraduate student–teachers are not computer literate and that computers were not available in schools; Nwosu and Kamaruddin (2018) who noted low level of ICT accessibility and use due to lack of access to ICT, insufficient ICT competency among teachers; Ogwo, Maidoh and Onwe (2015),who found that computer literacy level of the students was low while that of the teachers was slightly higher than that of the students, and Eze and Akubugwo (2016) who reported lack of computer / ICT laboratory, incompetent teachers that resulted to poor teaching and learning method.

Furthermore, the outcome of this study accords with the result of the study by Mutisya (2020) who reported that there is significant relationship between ICT infrastructure and adoption of CAT, but differed with another aspect of the study which reported negligible relationship between teachers and students' level of computer Literacy and adoption of CAT.

Conclusion

From the study's findings, the researcher concludes that all the factors which pertains to constructing and evaluating calibrated question bank from different topics in mathematics, determination of appropriate difficulty index of the question, adjusting examinees' skill through dynamically selecting appropriate testing items are perceived by teachers to be feasible to make available for adoption of CAT. Also the study concludes that teachers perceive all the factors relating to availability of server/web/browser and platforms for implementing CAT process as inadequate for adoption of CAT. The implication of this is that the pace of adoption of CAT in secondary school assessment in Abia State is likely to be slow due to the identified constraints.

Recommendations

Based on the study's findings, the research recommends the following for effective implementation of CAT in secondary schools.

1. The government at all levels should join efforts to provide adequate computer systems to all schools.
2. The school authorities in collaboration with the host communities, parent teachers' association could arrange for government support to provide efficient source of power and internet connectivity in their areas.
3. The government should recruit qualified computer studies teachers and technologists who can use CAT software packages and device a system of controlling impersonation.
4. The head of the examination unit of the ministry of education should work out modalities on how to ensure the safety of Item banks.
5. The ministry of education can organize computer training programs for teachers and students.
6. This study calls for the intervention of government and other stake holders in education to tackle the perceived challenges before advocating for the adoption of CAT in secondary schools.

References:

Anene, J. N., Ikerionwu, J. C. & Danladi, E. N. (2013). Student–teachers knowledge and acquisition of Computer in Sandwich programme of university of Abuja, Nigeria. *International Journal for cross – Disciplinary subjects in Education* 4(4) 1332 – 1340

Choi, Y. & McClenen, C. (2020). Development of Adaptive Formative Assessment System Using Computerized Adaptive Testing and Dynamic Bayesian Networks. *Journal of Applied Science* 10 (8196) doi:10.3390/app10228196 www.mdpi.com/journal/app/sci

Edward, L. (2014). *A study of Adaptive Learning for Educational Game Design.* ProQuest UMI, ISBN 971321049602.

Eluwa, I. O. & Uko, M. P (2020). Adaptive Pedagogic Practices for Sustainable Mathematics and Statistics Education in Tertiary institutions. *International Journal of Gender and Development Issues* 1(9): 62 – 71.

Eze, R. O. & Akubugwo, I. G (2016) Evaluation of the Integration of Computer / ICT Education by Teachers in Junior Secondary Schools in Nigeria: A case study of Abia State. *Information and Knowledge Management* 6 (7): 14 – 21 www.iiste.og.

Federal Republic of Nigeria (2014). National Policy on Education. Lagos: NERDC.

Hoogland, K. & Tout, D. (2018). Computer–based assessment of Mathematics into twenty – first century pressures and tensions. *International Journal on Mathematics Education.* DOI:10.1007/s11858-018-0944-2.

Ikwumelu, N. Ogene, A. O. & Oketa, E. C. (2015). Adaptive Teaching: An invaluable pedagogic practice in social studies Education. *Journal of Education and Practice,* 6 (33), 140 – 144. Retrieved from www.iiste.org ISSN 2222-1735 (paper) ISSN 2222-288x (online).

Mutisya, T. M. (2020). *Adoption of Computer Adaptive Testing in Educational Assessment in Kenya*. MED research project submitted to the Department of psychology, school of Education, University of Nairobi.

Nwosu, Daniel, S. M. & Kamaruddin, N. S (2018) Teachers' use of ICT in Teaching and learning in Secondary Schools. *IOSR Journal of Humanities and Social sciences* (IOSR – JHSS) 23(4): 30 – 40 DOI:10.9790/0837-2304073040

Ogwo, E; Maidoh, N. E. & Onwe, C. E. (2015). Computer studies and its impact in secondary schools in Abia State of Nigeria. *Modern Education and Computer Science* (6) 16 – 23. DOI:10.5815/ijmecs.2015.06.03

Osuji, U. S. A. (2012). The use of e–Assessments in the Nigerian Higher Education System. *Journal of psychological Studies* 1 (1). 48 – 59.

Rushton, S. J. (2014). *The impact of Computer–Adaptive Benchmark Data and Assessment Literacy on Student Achievement and Motivation in Mathematics* All Graduate Thesis and Dissertations 2177 https://digitalcommons.usu.edu/etd/2177.

Shute, V. J. & Rahimi, Seyedahmad (2016). Review of Computer–based assessment

for Learning in elementary and secondary education. Journal of Computer Assisted Learning DOI:101111/cat.12172 Pg 1 – 112.

Stone, E. & Tim, D. (2011). *Computer–Adaptive Testing for students with Disabilities: A review of the Literature.* Research Report ETSRR – 11 – 32: Princeton, New Jersey.