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Baseline Study of Computer-Based Examination and Biometric Technologies in Nigeria

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Abstract
Educational administrators have incorporated the Computer-Based Examination (CBE) system for assessment as a remedy to the mirage of challenges confronting the traditional paper and pencil method in Nigeria. The system is being utilized to promote effective, efficient, and reliable assessment of courses with hundreds or thousands of student enrolments across hundreds of higher institutions. It is being used by different private and public agencies for recruitment, professional, scholarship, bursary, and career assessments. This paper presents findings on the baseline study of the association between CBE and biometric technologies in Nigeria. The study included succinct discussions on computer-based examination, biometric technologies and results from an online survey involving 22010 randomly selected individuals across Nigeria via a questionnaire that centred on the CBE and biometric technologies. The questionnaire featured indices on familiarity with CBE, CBE and biometric technologies, general concerns for CBE, requirements for effective CBE monitoring and supervision and feedback on multi-modal biometric models for supervision of CBE. Statistical analyses of data from the survey established some of the challenges militating against the smooth conduct of CBE in Nigeria,and the measures to address them as well as steps for achieving high-performing biometric technologies-supported CBE systems.

Keywords: *Examination, invigilation, remote monitoring, educational technology, electronic proctoring*

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I. Introduction

At present, the number of applicants to post-secondary institutions in Nigeria stands at one million, nine hundred and forty thousand (1,940,000). This number is expected to increase steadily, although the capacity of all institutions for admission is approximately five hundred thousand (Abubakar & Adebayo, 2014). The extremely fierce competition among candidates is largely attributed to the institutions' low admission rates and capacities.Some desperate applicants have turned to various sorts of examination-related violence and dubious tacticsto further their causes. Educational administrators have embraced the adoption of the Computer Based Examination (CBE) model for testing,and evaluation as a remedy to these challenges. In Nigeria, the CBE platform is being utilized to promote effective, efficient, and reliable assessment on courses with hundreds or thousands of student enrolments across hundreds of higher institutions. This is in addition to post-secondary admission recruitment examinations as well as job placements (Iwasokun*et al.*, 2018). Although CBE introduced flexibility, timeliness, reliability, and impartiality in educational and other types of assessment, there are still cases of excesses and violations on the parts of the test takers and the invigilators. To attain academic honesty and integrity through good identity management, the prevention of impersonation, and a decrease in violence, the Joint Admission and Matriculation Board (JAMB) has been saddled with the task of overseeing the nationwide pre-admission examination in Nigeria. The Agency has acknowledged the significance and encouraging impact of the CBE in addressing some of the aforementioned challenges as well as the attendant problems of CBE (Assaf, et al., 2007; Chi-Chien, 2004; Kikelomo et al., 2010; Iwasokun and Akinyokun, 2016). Cheating and other human invigilation-related vices have persisted in tarnishing the credibility, acceptability, and integrity of CBEs around the world (Ricketts et al., 2003). Additionally, the current methods of candidate validation and system integrity checking using passwords, Personal Identification Numbers (PIN), Identification (ID) cards, examination slips, and tokens are vulnerable to theft, imitation, transfer, loss, or forgetfulness, as the case may be. It has been proven that using these possessive approaches to deter applicants from engaging in unethical behaviours including pimping, script exchange, peeping into other candidates' screens, and external sourcing, among others, is ineffective (Wales and Baraniuk, 2008; Goswami andBau, 1991). The ever-increasing number of students and teachers dealing with millions of courses has further heightened the concern over protection against misuse in the form of cheating or unauthorized help during

computer-based examinations. Although several scientists presently concentrate efforts on proposing solutions to this concern through methods that demand an examinee intrusively provide an authentication sample such as a password, Identity Card, and Radio Frequency Identification(RFID), there is still the issue ofachieving the mandatory level of safety or reliability (Ketab, 2016).

Efforts are now been geared at using one or more biometric features of the examineeto achieve safety, integrity and reliability during computer-based assessments. The biometric features presently enjoying dominanceinclude face, voice, fingerprint, palm print, iris, keystroke analysis and mouse dynamic (Iwasokun et al., 2022). User acceptance satisfaction has also been pursued as an essential factor, hence, transparency and continuous authentication are being utilized to attain a proven scale. According to Colonna (2021), in a bid to prevent postponing or stalling examinations in the wake of the COVID-19pandemic, establishments such as universities opted forvirtual proctoring technologies, using multifacetedproblemson ascertaining the reliabilityand transparency of online assessments without disregardingethical and legal constraints, specificallyconcerning students' majorprivilegesvis-a-visconfidentiality, data safety and non-apathy. Schools have also been adoptingbiometric systems for registration and confirmation of the identity of studentsto achieve cashless catering systems, automated registration of students' arrival in school and school library automation (Bryce et al, 2010). Attentions are also being shifted to using fingerprints, iris prints, voice prints and facial recognition systemsfor enhanced control, monitoring and administration in non-educational and educational settings. It is also noted that smart and intelligent operational environments now constitute the major application areas of pervasive computing, hence personal authentication approach based on unimodal or multi-modal biometrics now features in the establishment of a secured verification method for real-time monitoring (Mohsin, 2018). Biometrics is also being adopted for the psychometric remote monitoring of patients associated with major adverse cardiac events (MACE) risk biomarkers.It is also being used for remote monitoring of access, clinical trials, research and attendance tracking in healthcare facilities to achieve accurate identification, and streamlined administrations, among others (Shufeit*et al.,* 2020). Biometrics is equally being used in law enforcement through a series of Automated Biometric Identification Systems (ABIS) which create and store biometric information that matches biometric templates for the face, finger, iris and/orother biometric technology.There are face-based surveillance or recognition systems for real-time or post-event monitoring with much interest and acceptance in cities, airports, borders, or other sensitive places such as stadiums and worshipcentres.

The specific objective of the study was to perform a baseline study of computer-based examination (CBE) and its association with biometric technologies in Nigeria. This objective was based on the hypothesis that the Nigerian computer-based educational assessment systems are issues-based, poorly financed, underperforming, and with less integration of biometric technologies. The research questions centred on familiarity with computer-based examinations, computer-based examinations and biometric technologies, concerns for biometric technologies, requirements for effective supervision of computer-based examinations and feedback on adopting multi-modal biometric technologies for the control and monitoring of computer-based examinations. The study is significant for assessing the impact of computer-based examination, its current challenges and the gains and issues of the adoption of biometric technologies for the control and monitoring of computer-based examinations in Nigeria.

II. Baseline Study Of Computer-Based Examination And Biometric Technologies In Nigeria

A baseline study of the Nigerian computer-based assessmentswas carried out to establishthe strengths, challenges and prospects. The study was based on the hypothesis that the Nigerian educational assessment systems are issues-based, poorly financed and under-performing. This hypothesis formed the basis of a questionnaire (https://docs.google.com/forms/d/e/1FAIpQLSdHKZyycOhye5nKIqfg5uvb5o_VDifM8Xxg_FgZlM0Xj32BLQ/viewform?edit_requested=true&usp=embed_facebook) which served as the research instrument. The questionnaire leveraged some research questions on some areas of the Nigerian's educational assessment including familiarity with conventional and computer-based methods, requirements for effective computer-based assessments, and feedback on assessmentmethods. It was administered for the assessment of the impact of the formulated questions on the current state of examinations at all levels of education. Another reason for the administration is to know whether biometric technologies have roles to play in attaining a more transparent and acceptable educational assessment monitoring procedure. The first section of the questionnaire asked the respondent questions on familiarity with CBE, types of CBE taken, frequency of participation in CBE, level of comfortability with CBE, challenges faced during CBEs, perceived advantages of CBE, awareness of biometric authentication, and previously used biometric authentication mode. There were also questions on the frequency of use of biometric authentication, perceived security, concern with biometric authentication, trust in biometric systems, willingness to use the biometric systems, general concerns regarding remote supervision of CBE, privacy issues with remote supervision, confidence level on integrity and fairness of CBE compared to physical

examination. Section two presented questions on the requirements for effective computer-based examinations while section three presented questions on feedback on the multi-modal biometrics model.The research instrument was hosted on *Google Forms* for easy access and nationwide responses. Respondents were alerted through email contacts for the online assessment between February 01, 2024, and July 31, 2024. A total of 22,010 responses were received.

III. Results

The research adopted statistical techniques for data analysis. The primary purpose of the techniques was to describe the nature of the surveyed data, explore the relation of the data to the underlying population, create and validate the prototype for summarizing an understanding of the relationship among the data as well as establish predictive analytics for establishing scenarios for making future decisions. The distributions of the Respondents across the six geopolitical regions of Nigeria are presented in Table 1. It is established from the Table that on a regional basis, the highest number of Respondents from the South West participated in the survey. In contrast, the least number of Respondents from the North West participated in the survey.

Table 1: Distributions of Respondents across the six geopolitical zones of Nigeria

Region	Frequency	Percentage
North Central	4,908	22.3
North East	3,368	15.3
North West	2,223	10.1
South East	2,575	11.7
South South	3,720	16.9
South West	5,216	23.7

IV. Familiarity With Computer-Based Examination

Theanalysis of the surveyed data on the level of Respondents' familiarity with CBEshowed that 15759 (71.6%)of the Respondents were very familiar with CBE while 20139(91.5%) of them had taken CBE before. Table2 presents the distributions of the types of CBEs taken by the Respondents. It is revealed that the greatest number of Respondents had participated in academic-related CBEs while the least number of Respondents had written CBE for other types of assessment that were not captured in the Research Instrument.

Table 2: Distribution of different CBEs taken by the Respondents

CBE	Frequency	Percentage
Academic	13140	59.7
Professional	8320	37.8
Job Recruitment	7219	32.8
Career promotion	6251	28.4
Scholarship	5921	26.9
Bursary	3830	17.4
Others	2641	12.0

The analysis also revealed that 7792 (35.4%) of the Respondents had written CBE not more than once every year, 7109 (32.3%) of them had written CBE two to five times yearly and 7109 (32.3%) of them had also written CBE more than five times in the previous years. Table 3 presents the distributions of the Respondents' level of comfort with CBE. It is revealed that 15,869 (72.1%) of the Respondents had comfortable experiences while writing CBEs. Table 4 also established that some Respondents experienced multiple challenges with CBE while the most encountered challenges were technical issues such as network, connectivity, server, software and hardware failures.

Table 3: Respondents Level of Comfort with CBE

Level	Frequency	Percentage
Very Uncomfortable	220	1
Uncomfortable	220	1
Neutral	5701	25.9
Comfortable	11159	50.7
Very Comfortable	4710	21.4

Table 4: Respondents reports on Challenges with CBE

Challenge	Frequency	Percentage
Technical Issues	16640	75.6
Time Wastefulness	6801	30.9
User Interface/navigation Difficulties	8210	37.3
Security Issues	6251	28.4

Others	1321	06.0

Figure 1 presents the distributions of the perceived advantages of CBE to the Respondents. It is revealed that the highest percentage (80.6%) of the Respondents believed CBE promotes timely release of results and post-examination feedback while the least number of Respondents believed environmental friendliness is an advantage from the adoption of CBE for assessment at different levels.

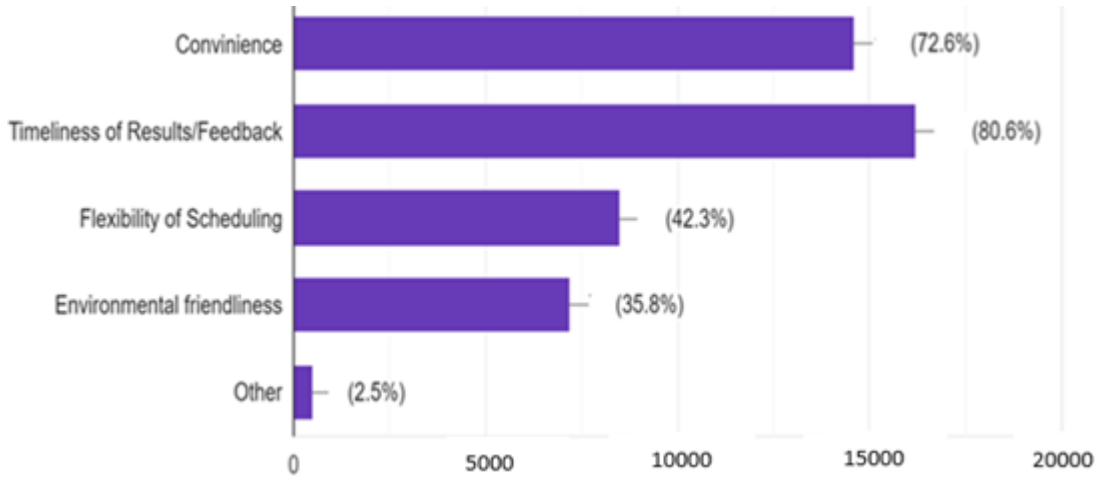

Figure 1: Chart of the distribution of the perceived advantages of CBE to the Respondents.

CBE And Biometric Technologies

Analysis of the survey data on the frequency of use of biometric authentication showed that 5810 (26.4%) of the Respondents had used biometric authentication not more than once in the previous years while 6999 (31.8%) of the Respondentshad used biometric technology 2-5 times in the previous years. 9200 (41.8%) of the Respondents submitted that they had experienced biometric authentication more than 5 times yearly. Figure 2 presents the distributions of the respondents' levels of awareness of biometrics-based technologies for CBE candidates' authentication. 54.2% of the Respondents claimed to be very familiar while 40.8% claimed to be somewhat familiar and 5.0% claimed not to be familiar with biometric-based technologies for CBE candidates' authentication.The familiarity of the highest number of Respondents with biometric authentication is premised on the prevalence of biometrics-based technologies in most places where CBE is practised across the country. Figure 3 presents the distributions of previously used biometrics authentication modes by the Respondents. It is revealed that the highest percentage (90.5%) of the Respondents had used fingerprint authentication before. 78.6%, 28.4% and 10.9% of the Respondents were previously authenticated with facial, voice and iris recognition respectively. The dominance of fingerprint authentication is premised on its wide application in banks, schools, recreation and hospitality centres, and other private or public establishments.

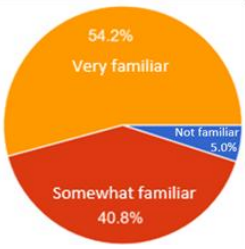

Figure 2: Distributions Of Respondents Familiarity With Biometrics-Based Technologies For CBE Candidates' Authentication

Somewhat familiar

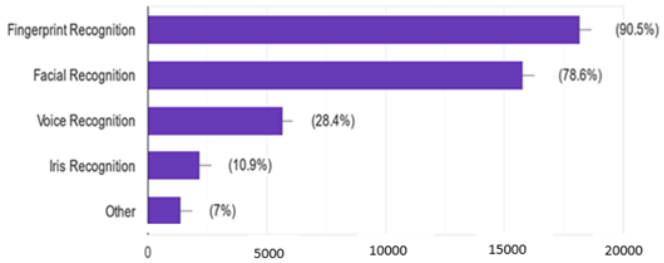

Figure 3: Distributions Of Previously Used Biometrics Authentication Modes By The Respondents

Table 5 presents the distributions of the Respondents' perceived levels of security of biometric technologies. It is revealed from the Table that 17,961(81.6%) of the Respondents agreed that biometric technology is suitablysecured. Table 6 also presents the distributions of the concerns of the Respondents for biometric authentication. It is revealed from the Table that most Respondents (13800) expressed concern about privacy, 11819 Respondents expressed concern about the potential for data breach and 14240 Respondents expressed concern for accuracy and reliability. 2421 of the Respondents expressed concern fornone of the issues.

Table 5: Distributions of Respondents perceived level of security of biometrics authentication

Level	Frequency	Percentage
Much more secure	6,471	29.4
More secure	11,490	52.2
Indifference	2,949	13.4
Less secure	990	04.5
Much less secure	110	00.5

Table 6: Distributions of Respondents concern for biometrics authentication

Issue	Frequency	Percentage
Privacy	13,800	62.7
Potential for data breach	11,819	53.7
Accuracy and Reliability	14,240	64.7
Others	2421	11.0

Analysis of the responses on trust for biometric technologiesrevealed that 29.9% of the Respondents expressed 'full trust' in biometrics technologies for authentication of candidates during CBE, 52.7% of them expressed 'trust' in biometric technologies with some very little reservations, 15.9% of them maintained 'neutrality' while 1.5% of them expressed 'distrust' in biometric technologies for authentication of candidates during CBE. On willingness to use biometric technologies, analysis of responses revealed that 37.3% of the Respondents were 'very willing' to use biometric systems, 52.7% of them were 'willing' to use biometric systems, 9.5% of them were 'neither willing nor unwilling' while 0.5% stated their 'unwillingness' to use biometric technologies.

V. Concerns For Computer-Based Examination

Table 7 presents the distributions of the general concerns of the Respondents about CBE. The highest number of Respondents expressed concern about technical difficulties that often mar their experiences with the technology. This established that several of the Respondents had experienced hardware or software challenges while writing CBE. 55.7% of the Respondents expressed concern about privacyissues which could be blamed on the fact that most privacy rights are often forfeited while writing CBE. 51.7% of the Respondents expressed concern about the fairness and integrity ofthe invigilation of CBE which could be connected to their private encounters with the administrators and public perceptions. It is also revealed that 46.8% of the Respondents showed concern about the security of the examination data which could be premised on their levels of trust and personal security experiences with data and information. 53.2% of the Respondents also expressed concern on the reliability of supervision which speaks of their degree of reservation for the thoroughness and functionality of the invigilation process.

Table 7: Distributions of Respondents general concern on remote invigilation of CBE

	Frequency	Percentage
Privacy issues	12260	55.7
Technical difficulties	16199	73.6
Fairness and integrity of examination	11379	51.7
Security of the examination data	10301	46.8

Reliability of supervision	11709	53.2
Others	550	2.5

Analysis of the data on the concern for privacy issues of the supervision of CBE is presented in Table 8.It is established from the Table that an overwhelming number of Respondents expressed concern aboutthe privacy of candidates during CBE. This is justified by the fact that most CBE Centers are open spaces with well-organized strategies for the monitoring and control of the candidates' on-the-spot activities. Table 9 also presents the distributions on the level of confidence in the integrity and fairness of CBE compared to physical examinations.A look at the distribution revealed that almost all the Respondents believe in the integrity and fairness of CBE compared to the conventional or physical method. This is strongly connected to the fact that CBE is more objective and less susceptible to human judgment, emotion and biases.

Table 8: Distributions of Respondents' concern with privacy in remote invigilation of CBE

Degree	Frequency	Percentage
Not concerned	1849	8.5
Slightly concerned	1321	6.0
Moderately concerned	4270	19.4
Concerned	9640	43.8
Very concerned	4930	22.4

Table 9: Distributions of Respondents' level of confidence in the integrity and fairness of CBE compared to physical examinations

Degree	Frequency	Percentage
Not confident	308	1.4
Slightly confident	1321	6.0
Moderately confident	4270	19.4
Confident	10300	46.8
Very confident	5811	26.4

Further analysis of the responses also revealed that 27.4% of the Respondents were 'very concerned' with the security of personal and examination data during CBE. It was also revealed that 44.8% of them were 'concerned', 16.9% of them were 'moderately concerned', 7.0% of them were 'slightly concerned' and 4.0% of them were'not concerned'. These figures established that almost all the Respondentswere mindful of the need to preserve the sanctity and integrity of personal and examination data during CBE.Analysis of data on reliability of the supervision of CBE showed that 16.9% of the Respondents agreed that the supervision is 'very reliable' while 34.3% of them agreed that the supervision is 'reliable'. 42.8% of them remained 'neutral' on the assessment of the reliability of supervision of CBE while 6.0% opined that the supervision of CBE in its present form is 'unreliable'.The high number of respondents showing apathy for the reliability of the supervision of CBE points to the fact that more needed to be done on the supervision of CBE in the country.

Figure 4 presents the Respondents' views on the strategies that could mitigate the general and specific concerns for CBE. It is established from the Figure that all the Respondents agreed that one measure or the other is needed to mitigate the general and precise challenges confronting CBE. However, the highest percentage of the Respondents (84.1%) suggested serious improvement in technical support during CBE while the lowest percentage (64.7%) suggested comprehensive training for users as a panacea for the challenges confronting candidates of CBE.

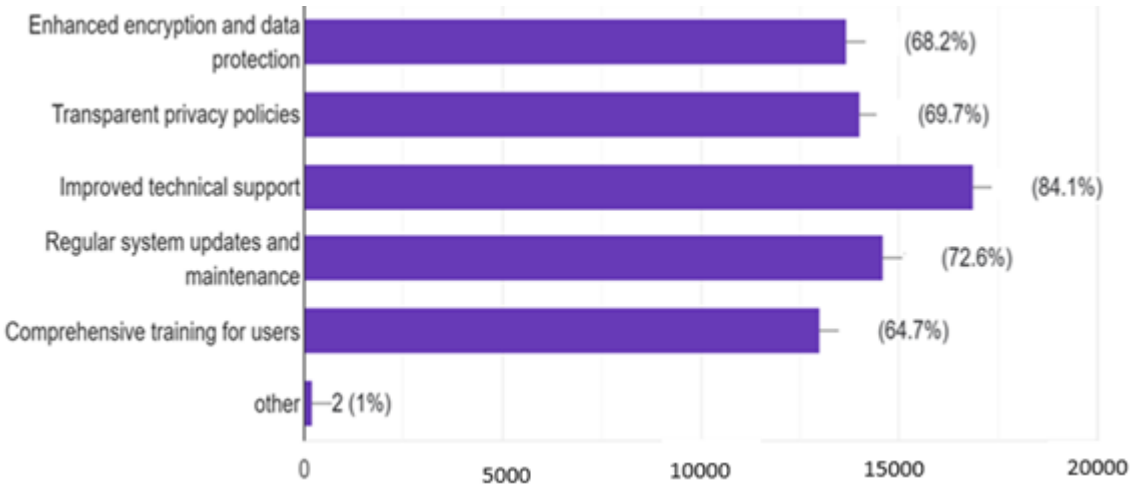

Figure 4: Distributions of Respondents views on the strategies that could mitigate the general and specific concerns for CBE

Requirement For Effective Supervision Of CBE

Figure 5 presents the distributions of the responses on what the Respondents considered asthe most important actions needed for a more effective supervision of CBE. It is established from the distribution that all the Respondents agreed that some immediate actions are required for more effective supervision of CBE. Notably, the highest percentage of the Respondents (79.1%) suggested robust identity verification while the lowest percentage of Respondents (53.7%) suggested the introduction of a more user-friendly interface for CBE.

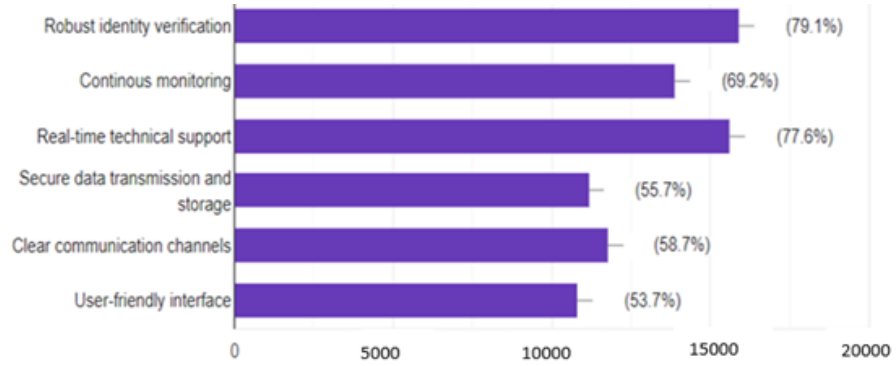

Figure 5: Distributions of Respondents views on most important actions for effective supervision of CBE

Table 10 presents the distributions of Respondents' rating of confidentiality (A), integrity (B), authentication (C), availability (D), technical support and training (E), usability and user-friendliness (F), real-time monitoring (G), and information gathering and feedback (H) to effective and reliable conduct of CBE. The Table confirmed that an enormously high number of Respondents posited the importance of all the attributes for effective and reliable conduct of CBE. Confidentiality is required for integrity, authentication promotes transparency and safety, availability guarantees a good level of satisfaction and technical support and training of personnel are necessary for promoting candidates' satisfaction and personnel display of a high level of competence. While high usability and user-friendliness experience of the users guarantees wide acceptance, real-time monitoring of the CBE proceedings helps to achieve transparency and curb infractions. Reliable information gathering and feedback on the conduct of the CBE are useful for effective planning and future projection. Table 11 also presents the distribution of responses on the technical requirements for the supervision of CBE. It is shown from the Table that almost all the Respondents agreed that high-speed connections, reliable and compatible hardware, a secured software platform and regular backup and sound recovery systems are required for effective and efficient CBE. Notably, the strong connection between software and the hardware apparatus for successful, transparent, fool-proof and reliable conduct of CBE is buttressed by these responses.

Table 10: Distributions of Respondents' rating of indices on effective and reliable conduct of CBE.

Assessment	Number of Respondents

	A	B	C	D	E	F	G	H
Not important	110	66	66	66	0	66	220	0
Slightly important	990	330	770	440	220	220	770	0
Moderately important	4380	1981	1871	2729	1981	1651	2619	2619
Important	6669	5591	5150	6669	5150	5480	6669	6779
Very important	9860	14042	14152	12106	14659	14593	11731	12612

Table 11: Distributions of responses on technical requirements for supervision of CBE

Degree	Frequency	Percentage
High-speed connection	19171	87.1
Reliable and compatible hardware	19281	87.6
Secure software platform	18620	84.6
Backup and recovery systems	16199	73.6

VI. Feedback On The Multi-Modal Biometrics Model For Cbe Supervision

The analysis of responses on awareness and understanding of multi-modal biometrics showed that 46.3% of the Respondents claimed 'advanced' awareness and understanding, 44.8% of them claimed 'moderate' awareness and understanding while 9% claimed 'limited' awareness and understanding. On perceived effectiveness of the adoption of multi-modal biometrics authentication for CBE, 19.4%, 57.2%, 20.4%, 2.5% and 0.5% of the Respondents agreed that multi-modal biometric authentication is 'very effective', 'effective, 'moderately effective', 'slightly effective' and 'not effective' respectively. These ratings justify the belief by the majority of the Respondents on the effectiveness and acceptance of multi-modal biometric authentications in several places, including CBE centres.On willingness to accept and trust the deployment of multi-modal biometrics technologies for authentication and supervision of CBE candidates, 28.9% of the Respondents were 'very willing' while 59.2% of them were 'willing'. 10% of them preferred to be 'neutral and 2.0% of them were 'unwilling' to accept and trust the deployment of multi-modal biometrics technologies for CBE authentication and supervision.Table 12 presents the distributions of the responses on the choice of trainings considered important for examiners and examinees to effectively utilize multi-modal biometric models for the control and supervision of CBE.The figures in the Table show clearly that a very great number of the Respondents saw the importance of regularly undergoing the listed trainings by the examiners and the examinees as one of the ways of supporting and promoting CBEs. Figure 6 shows the distributions of the responses on the suggested modes of training for the CBE examiners and examinees. It is revealed that the majority of the Respondents believe that each of the training is very essential for the free flow of CBE and smooth experiences of examiners and examinees.

Table 12: Distributions of responses on training considered important for effective utilization of multi-modal models for supervision of CBE

Training	Frequency	Percentage
Biometric authentication technology	16750	76.1
Biometric enrolment process	14681	66.7
Operating biometric devices/software	16640	75.6
Interpretation of biometric authentication results	14901	67.7
Recognizing and addressing potential biometrics authentication issues	14130	64.2
Data privacy and security protocols	12039	54.7

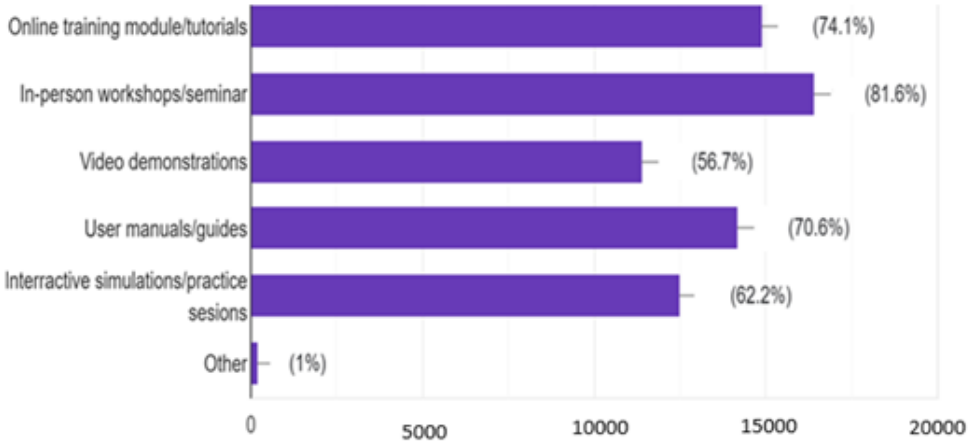

Figure 6: Distributions of responses on the suggested modes of training for CBE

On the frequency of training sessions for examiners and examinees, 38.3% of the examiners opted for training 'as needed', 36.8% of them opted for training on an 'annual' basis, 7.5% of them opted for training on a 'semi-annual' basis, 14.4% of them opted for training on 'quarterly' basis while 3.0% of them opted for training on 'one-time' basis. The distribution of responses on the choice of channels or avenues for supporting the users of multi-modal biometric systems is presented in Figure 7. It is revealed from the Figure that the greatest number of Respondents favoured'Live Chat' as a choice for user support followed by 'phone', 'dedicated personnel', 'email' and 'online fora/community support' in that order.

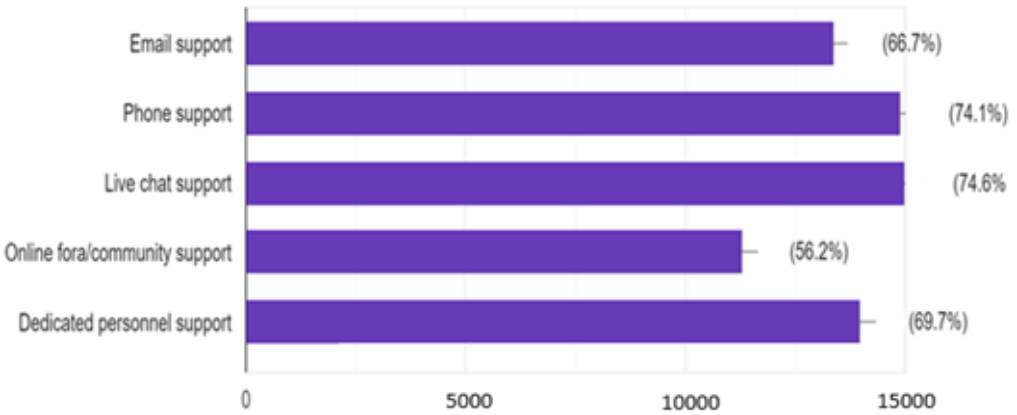

Figure 7: Distribution of responses on the choice of channels or avenues for supporting the users of multi-modal biometric systems

On the acceptable response time for resolving issues or queries relating to the use of biometrics technologies for the authentication and supervision of computer-based examination, 66.2% of the Respondents opined that all issues should be resolved within 1 hour, 29.9% of them suggested that resolution of all issues should be within 24 hours, 2.5% of them favoured 48 hoursas the maximum time for resolving all issues and 1.5% of them opined that all issues should be resolved within 1 week. These responses highlighted the fact that the majority of the Respondents favoured quick, timely and non-delayed resolution of all issues that are connected with the use of multi-modal biometrics for CBE authentication and control. Further to these, 83.7% of the Respondents favoured the use of 'integrated features' within the CBE system as a means of providing feedback on issues with the multi-modal biometrics. 81.6%, 73.6%, 68.2% and 57.25% of the Respondents supported the adoption of 'dedicated feedback', 'online feedback forms', 'email' and 'periodic survey' respectively, as means of providing feedback by the CBE candidates and examiners. On the importance of having mechanisms in place for continuous training in respect of multi-modal biometrics authentication and supervision of CBE, 14086 (64%) of the Respondents opined having such a mechanism in place is 'very important' while 5943 (27%) of them said it is 'important'. 1651 (7.5%) of the Respondents remained 'neural' and 330 (1.5%) of them opined that having such a mechanism is 'not important'. These distributions affirmed that almost all the Respondents saw the necessity of training on multi-modal biometrics authentication and supervision of CBE on a regular and continuous basis. Table 13 presents the distributions of the responses on the likelihood of future widespread adoption of multi-modal biometrics for remote invigilation of CBE. It is

revealed from the Table that 18589 (89%) of the Respondents clearly expressed their belief that future implementation and deployment of CBE will leverage multi-modal biometrics technologies for its control and invigilation tasks.

Table 13: Distributions of the responses on the likelihood of future widespread adoption of multi-modal biometrics for remote invigilation of CBE

Assessment	Frequency	Percentage
Very unlikely	440	2
Unlikely	220	1
Neutral	1761	8
Likely	8320	37.8
Very likely	11269	51.2

VII. Discussion

The perspectives of 22010 Respondents who participated in a baseline study of CBE and its relationship with biometric technologies have been presented. The baseline study established that the adoption of CBE is rising in Nigeria for academic, professional, job recruitment, career promotion, scholarship, and bursary assessments.A significant number of the Respondents had participated in CBE which corroborated the claim by Azor and Ogwu (2019) that CBE has had its way into different aspects of human society including education and other areas where qualification or suitability level is being investigated. Aderogba (2020) also stated that many of the examinations and tests in Nigeria are being taken oncomputers instead of writing on paper.The highly comfortable experience expressed by most respondents justified the claim by Shobayo et al. (2021) who posited that students' perceived experience with the computer-based test was positive and useful. Telia and Bashorun (2012) also indicated positive experiencesand preferences of candidates toward CBT over traditional paper and pen examinations among candidates. The report by some Respondents of some challenges experienced during CBE also confirmed the impact that issues like inadequate ICT infrastructure and IT skills, unstable power supply, examination managers'lack of integrity, and software and hardware compatibility factors, among others, continued to bear negatively on the conduct of CBEs in Nigeria. Okah-Tim (2023) wrote on the prevalence of these issues in most CBE Centres and counselled on the need for adequate measures to curb them. Findings on the perceived advantages of CBE to Respondents also revealed the technology has greatly and positively impacted examinations and testing in Nigeria. There are claims that CBE has promoted timely release of results, convenience, flexibility of schedule, and environmental friendliness. These submissions align with the views of Okah-Tim (2023); Shobayo et al. (2021) andWalker and Delius (2004) who identified speed of delivery, administration and scoring efficiency, improved test security, consistency and reliability, faster response rate among others as benefits of CBE over traditional paper-and-pencil method. Meijer et al. (2015) also opined that CBE is cost-effective, and the availability of powerful computersin educational contexts makes computer-based testdelivery feasible and attractive. Daniels andGierl (2017) also identified that CBE provides interactions or communicationopportunities and immediate feedback ineducational contexts.

Findings from the study confirmed most of the Respondents had experienced fingerprint, facial, voice and iris authentication. However, there isaprevalence of fingerprint authentication in most CBE centers. This is based on its combination of accuracy, convenience, security, speed, and versatilitymaking it an invaluable tool for ensuring secured access to digital services and protecting sensitive information. Iwasokun (2021) posited that fingerprint is the most popular for its high degree of individuality (no two individuals with identical prints) and constancy or consistency (it does not change in relative appearance, though changes may be noticed in scale). It is also endowed with high availability (it is fixed on all individuals by nature) and universality (possessed by every individual regardless of gender, age, skin colour, or race) (Barde, 2013; Jain *et al*., 1999; Roberts, 2007; Michael and Imwinkelried, 2006; Palmiotto, 1994; Salter, 2006). In addition, the fingerprint is not forge-able, stole-able, misplace-able, or forgettable. During cases of damage, it reproduces in short intervals of time (Iwasokun, 2012; Iwasokun*et al*., 2012).Most of the Respondents agreed that biometric technologies are suitably secured and appropriate for CBE candidates' authentication. This agreement explains why biometric technologies are highly used in various industries and establishments for identity management.Iwasokunet al. (2021)had buttressed the significantcontributions of biometric technologies to flawless human identity verification and management, detection, and prevention of fraudulent activities as well as preventing the risk of unauthorized access, creation of fake accounts, and account takeovers by fraudsters.Respondents hadexpressed concern about biometric technologies in areas of privacy as well as data breach, accuracy, and reliability. This justified the view of Ebelogu et al. (2019) and Labati et al. (2012) who stated that data breach, measurement inaccuracy, and reliability failure remain some of the notable challenges against the implementation of biometric technologies.Trust is the readiness to be contingent on technology in a given condition in which negative consequences are likely.The high level of trust in the adoption of biometric technologies for CBE

candidates' authentication expressed by the Respondents agreed with the position of Jain et al. (2019) and Semnani-Azad et al. (2019), that because of high performance, reliability and accuracy levels, biometric technologies presently enjoy a high level of trust among the populace in several places of their implementation or adoption. The high level of trust also justifies the very high number of Respondents that signalled their willingness to use biometric technologies as may be required. A substantial number of the Respondents expressed familiarity with multi-modal biometrics, belief in its effectiveness and willingness to accept and trust its deployment for CBE candidates' authentication and monitoring.Several of them also supported regular training of major stakeholders towards boosting the contributions of multi-modal biometric technologies to CBE. Suggested trainingincludes biometric authentication technology, biometric enrolment process, operating biometric devices and software, interpretation of biometric authentication results, data privacy and security protocols, among others. Suggested modes of training also include online, modules or tutorials, in-person workshops, video demonstrations, user manuals, and interactive simulations. Regular training has been established as one of the ways of achieving strong and functional multi-modal biometric technologies and a part of the requirements for up-to-the-task CBE platforms. This position aligns with Wolf et al. (2017) who stated that regular training on the adoption and operations of biometric technologies remains one of the surest ways of achieving set goals for any of its domainsor areas of application.

Technical difficulties, lack of openness and fairness, and poor security have been established as some of the issues or challenges facing the integrity of CBE. This agrees with the submission in Danladi and Dodo (2019) that the introduction of CBE is apt and capable of driving the desired objectives, but it is being inhibited by some factors including human inconsistencies and manipulations, technical hitches, power supply, poor internet services, and issues around cybersecurity.The expression of concern about the privacy of candidates during CBE by the overwhelming number of Respondents is premised on the fact that most CBE Centres are open spaces with measures for overseeing the candidates' on-the-spot activities. Notably, privacy is not preserved in CBE as candidates' personal information may be used for providing news about the examinations, considering and processing applications for qualifications and communication, carrying out necessary checks to verify identity, and dealing with complaints and appeals, among others.A high levelof dissatisfaction has been expressed with the current levels of supervision of the CBE. Some likely reasons for this are the inability to prevent some cases of cheating and other occurrences in which innocent candidates were incorrectly accused, which have further heightened the need for invigilation software amongst large educational institutes. Robust identity verification, continuous monitoring, real-time technical support, secured data transmission and storage, clear communication channels and user-friendly interfaces have been identified as some of the major ways of improving CBE takers' satisfaction with the supervision. High-speed connections, reliable and compatible hardware, secured software platforms, regular backup, and sound recovery systems have also been identified as some major strategies. Invigilation softwareor e-proctoring will promote reliable supervision and academic integrity in online assessments. According to Gill (2021), remote proctoring technology will carefully flag behaviours that indicate potential cheating and perceived errors can be disregarded or discarded.It was also established that regulartechnical training and support for stakeholders in addition to up-to-time system updates and maintenance are needed to mitigate the challenges confronting CBE. This corroborates the opinion of Suryadi and Rahmawati (2018) that quick measures for addressing the challenges and improving the acceptability and credibility of computer-based examinations are necessary and should be well-designed and articulated.

A premium had also been placed on confidentiality, integrity, authentication, availability, technical support and training, usability and user interface, real-time monitoring and information gathering and feedback in the quest for effective and reliable conduct of CBE. Confidentiality is required for veracity, authentication endears transparency and safety, availability assures a good level of approval and technical support and personnel training is needed for achieving examination takers' endorsement and personnel exhibition of a tall level of expertise. The high usability and user-friendliness of the CBE platform will promote widespread endorsement and remote invigilation will support transparency and curb infractions. Reliable information gathering and feedback on the conduct of the CBE are requisites for effective planning and future projections.The Respondents have also stretched the need for timely responses to queries on technical hitches during CBE. This position is based on the need for quick resolution of issues and crises that may arise during CBE so that candidates are not put at the receiving end. This also aligns with the view presented by Iwasokunet al. (2019) that timely resolution of all technical and operational issues during CBE and other related activities is critical for operational transparency and integrity of results. Conclusively, a good number of the Respondents agreed that the deployment of remote invigilation and supervision technologies that are based on multi-modal biometric technologies will rule future CBE platforms which had been expressed in (Suryadi and Rahmawati, 2018; Evwiekpaefe and Eyinla, 2021).

VIII. Conclusion

This paper presented thereport of a study on the general concepts of CBE vis-à-vis its operations, scope, challenges, strengths and prospects as well as its synergy with biometric technology. The study was based on a survey of 22010 randomly selectedindividuals (Respondents) across Nigeria and findings from analysis of obtained data revealed that a substantial fraction of the Respondents had participated in CBE for academic, professional, job recruitment, career promotion and/or scholarship purposes with some degree of satisfaction and conveniences. The Respondents however expressed concerns about lack of technical support, insecurity of data, and lack of privacy and confidentiality and some measures for addressing them. It was established that the adoption of robust identity verification strategies, continuous monitoring process, real-time technical support, secured data transmission system, clear communication channels and implementation of user-friendly interfaces could guarantee effective administration and control of CBE. High-speed connection, reliable and compatible hardware, secured software solution and good backup and recovery system were also identified as the most notable technical requirements for the seamless conduct of CBE.

Several of the Respondents expressed familiarity with the adoption of biometric technologies for CBE candidates' authentication and monitoring and other purposes and acknowledged their high level of security and reliability. The effectiveness of biometric technology for candidates' authentication was affirmed by the Respondents and their willingness to accept and support its deployment at CBE centres. However, for attaining hitch-free operation of biometric technologies such as fingerprint, iris, voice and face recognition systems, the importance of some routine training for the examiners and the examinees was emphasized. Suggestedtrainingincludes biometric authentication technology, biometric enrolment process, interpretation of biometric measurements, data privacy and security protocols, which could be an online forum, in-person workshop, video demonstrations, user manuals, interactive simulation or practice modules. It was also established that future implementation and deployment of CBE platforms will ride on multi-modal biometric technologies for candidates' authentication and monitoring.

Availability Of Data
Not Applicable

Competing Interests
The authors declare that there are no conflicts of interests

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