Construction and Validation of Virtual Assessment Standard Indicator Scale for Universities

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Abstract

Virtual teaching and learning in Nigeria gained momentum at all levels of education since the global pandemic of 2020 which compelled the adoption of remote teaching. The resultant shift from traditional to virtual classroom by teachers and lecturers during the pandemic created a problem as most teachers and students lacked the skills needed for the conduct of online examinations, hence the need for the Virtual Assessment Standard Indicator Scale to guide the conduct of virtual assessment using a variance-based structural equation modelling. A total of 1,724 undergraduates studying science, social science and art courses in federal, state and private universities in the South-South geo-political zone of Nigeria were sampled. The estimated reliability indices which were between 0.93 and 0.98 for all the ten (10) latent constructs, the acceptable values of 0.5 or higher of AVEs, and the estimated HTMT values of less than 0.9, established the adequacy of Virtual Assessment Standard Indicators Scale as an essential tool for assessing the academic development of students in virtual classrooms. The scale validation procedures used can be adopted by test developers and researchers within the scope of the findings of this study.

Keywords: variance-based structural equation modeling, virtual assessment standard indicator scale, virtual assessment

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Introduction

Classroom instruction and assessment at all levels of education in Nigeria was through physical presence particularly in most public schools before COVID '19 pandemic. Learners were not allowed to use the telephone or any electronic gadgets during teaching to avoid distractions and examination misconduct. This trend changed with the lockdown during the pandemic when face- to-face teaching and the conduct of physical examinations became impossible due to social distancing measures enforced to curb the spread of the virus. As a result, teachers made spirited efforts to engage students in virtual teaching although it was not easy to transit from physical conduct of examinations to online assessment. Consequently, most schools engaged in only teaching and postponed examinations till after the pandemic. This approach was defective as examination is known to play a significant role in the teaching and learning process because without it, teachers will neither be able to identify the extent to which instructional goals have been qualitatively achieved (Kifordu & Igweh, 2021) nor determine the effectiveness of their teaching and how much students have learnt (Panizzon, 2019). It is, therefore, important to create avenues through which the conduct of virtual assessment could be made seamless in Nigeria.

Classroom assessment can be classified into two: formative and summative. Formative assessment provides information as feedback for ongoing teaching and learning. Summative assessment on the other hand, provides information at the end of instruction to determine if teaching has been well done. Since assessment is a critical aspect of the teaching-learning process, it must be valid and reliable to guide the lecturer before, during, and after online teaching. An examination is considered valid if the questions reflect the instructional objectives of teaching and are based on the contents of instruction. It must measure the intended purpose, skills or knowledge of the learners and be related to the learning objectives of the course. In addition, items must be clearly written and well-structured to prevent confusion that can hinder the true performance of students (Ray et al., 2018). Virtual assessments should reflect course curriculum and objectives of teaching to ensure quality assurance of the test. Quality is also engendered if the test environment is well secured through good monitoring and supervision in compliance with examination rules and regulations (Kifordu & Igweh, 2021). Students should be aware of these rules and the sanctions for breaking any. It is important that proctors are trained to monitor or invigilate online examinations to secure virtual examination environment as it is done with physical examinations. This guarantees that grades obtained reflect the true ability of students (Joint Admissions and Matriculation Board [JAMB], 2023).

According to the United State Family Educational Rights and Privacy Act of 1974 (FERPA), students should have the right to access, inspect and review examination scripts in order to reflect on their performance. There should be opportunity for feedback and remediation. The invention of information technology in education, especially the Internet, is one of the most appropriate solutions to educational concerns (Pakdaman et al., 2019). However, it has to be cost effective. The inability of many Nigerian schools, particularly tertiary institutions, to conduct examinations remotely during the lockdown, stem from the fact that most public tertiary institutions in Nigeria lack the needed ICT facilities. As a result, many of the lecturers lack the technical knowhow for online examinations. Against this background, the researcher proposed and validated a PLS structural model with ten (10) identified standard indicators as a Virtual Assessment Standard Scale which could be deployed for conducting valid and reliable online examinations in Nigeria and other climes.

Literature Review

Assessment is an essential part of teaching and learning. It is the process used to measure the level of achievement of learners. In education, assessment has a wide variety of methods and tools for measuring and keeping record of learning progress, academic readiness and educational needs of learners (Handley & Williams, 2011). However, it is necessary in both virtual learning and in the traditional classroom, its methods are different in the virtual learning programme and in the traditional classroom. Westhuizen (2016) submitted that integrating virtual assessment into the virtual teaching and learning process is in a progressive state in developing countries, Nigeria inclusive. Virtual assessment, otherwise called e-assessment or online examination, is an electronic process which presents test activities and records learners' responses with the use of information technology. It is the transfer of scientifically sound assessment into digital space (Aon, 2025) where learners can take examinations, do quizzes or assessments using devices connected to the internet (Teachfloor, 2024). These imply that electronic devices and reliable internet are needed for virtual assessment. The literature further suggests that online examinations can be safely taken from anywhere in the world as opposed to traditional face-to-face examinations.

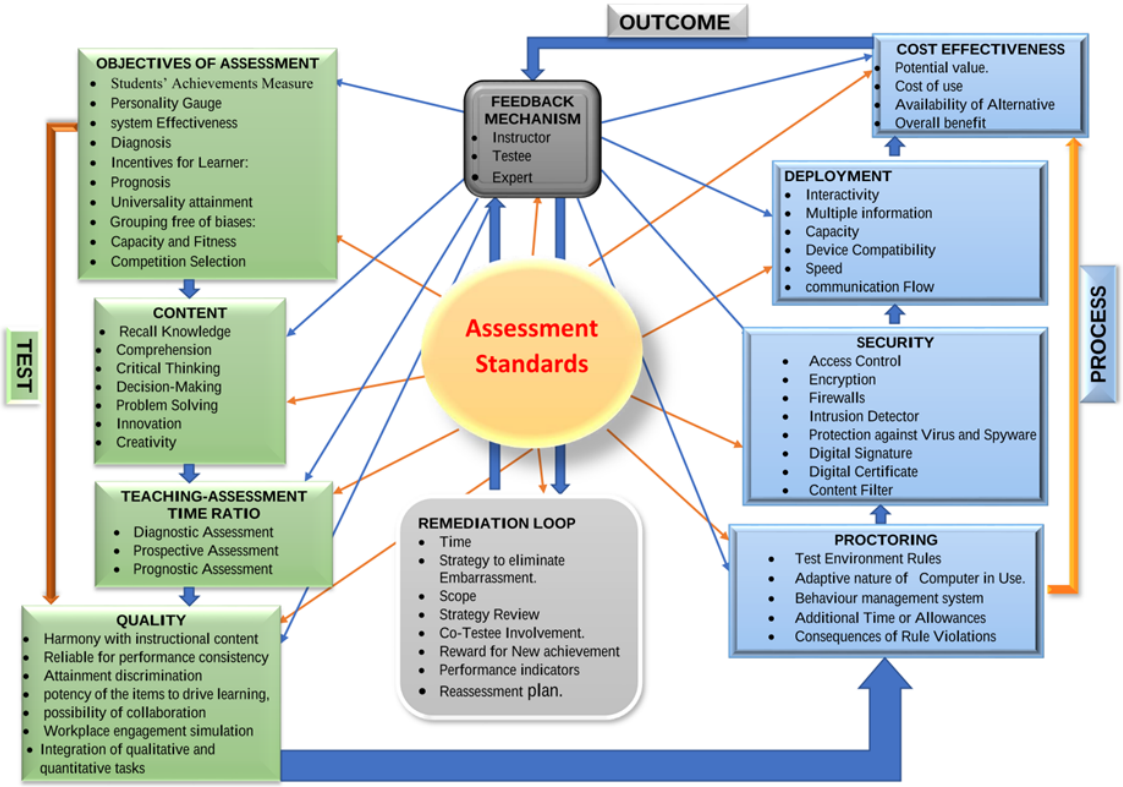
The origin of virtual assessment could be traced to the University of Cambridge Local Examinations Syndicate which conducted its first major test of e-marking in November 2000. By 2012, over 150 countries had adopted the method of marking of paper and pencil examinations electronically (Ofqual, 2017) which metamorphosed into virtual assessment (Benton, 2015). Akinsanmi et al. (2010), who developed an e-assessment platform for Nigerian universities, asserted that 'no attempt has been made to design an online test engine in Nigeria.' At the end of their project, they reported that their newly-developed tool demonstrated a possible solution to the problem of carrying out course assessment for large class sizes. If e-assessment web applications run in our schools and colleges nationwide, it will substantially reduce stress on both students and examiners, and make Nigerian students more conversant with fundamental contemporary concepts of ICT.

Though most Nigerian universities and higher education colleges resorted to virtual learning and assessment during the Covid-19 pandemic (Olatunde-Aiyedun et al., 2021), the country's educational institutions have not been able to develop a standardized virtual assessment tool as is the case in face-to-face assessment standards. The need for this standardized virtual assessment tool underscores the purpose of this study.

Conceptual Framework

The conceptual framework in Figure 1 shows the links and interrelationships between the ten (10) proposed virtual assessment standard indicators. It gives an insight into the standards that designate a reliable virtual assessment tool.

Figure 1
Conceptual Framework



The major purpose of assessment is for students to demonstrate their achievements in a course for formative feedback, or grading (Boud, 2010). As a result, virtual assessment can and should have the same academic rigour as face-to-face assessment to merit credibility. The formulation of objective is followed by a selection of contents that will meet the needs of learners. It should have the components of recall of knowledge, comprehension, critical thinking, decision-making, problem solving, innovation and creativity. The contents of an assessment must be sequenced to find the right balance between time allotted to teaching, assessment and continuity of the selected content. The estimate of the instructional time that will be devoted to assessment should be spelt out at the planning stage as a matter of priority. The quality of the virtual assessment is premised on the assessment being in harmony with instructional contents, being reliable and able to capture differences in the levels of students' understanding, thereby giving interpretive information about learners' understanding.

In this study, the process of conducting virtual assessment must ensure that there are test environment rules that are adequately enforced through proper monitoring to guarantee test standards and reflect students' learning outcome accurately. Martin (2015) reveals that virtual assessment environment may create additional opportunities for students to use prohibited resources. Process also demands that the access and contents of the virtual assessment platform be well secured. To achieve this, there must be access control, encryption of content, firewalls, intrusion detector, protection against virus and spyware, digital signature, digital certificate, and content filter. The framework stresses the use of the device and system of virtual assessment as a medium of transmission. As reported by Lei and Gupta (2010) and

Rolim and Isaias (2018), students and instructors appreciate the accessibility and flexibility of virtual assessments since it makes them self-directed and self-motivated during assessment. The medium of transmission of virtual assessment must have multiple information when the virtual assessment is on, to provide instructional guide at intervals and enable interaction between the system and the test takers. This makes it user friendly. The virtual assessment device or system must not be too expensive for ease of adoption.

Assessment requires that students reflect on their learning processes and take ownership of it to help teachers maintain students' engagement in a virtual learning environment (Nordegren, 2020). Prompt feedback on assessment is therefore required as remediation to loop back to the assessment objectives, content, teaching assessment time ratio, quality, proctoring, security, medium of transmission, cost effectiveness and feedback mechanism. This explains why the remediation in the framework is conceptualized as a loop.

Statement of the Problem

COVID-19 pandemic has redefined most secular roles and duties, with many countries forging ahead by leveraging virtual approaches in the engagement of the various duties that must be accomplished. Teaching in Nigerian universities is not exempted from this paradigm shift. When students are engaged with virtual teaching, corresponding assessment components capable of promoting real learning should also be integrated. Verified criteria guiding design and development of effective quality online assessment tasks include the use of quantitative and qualitative methods, open-ended tasks that simulate workplace engagements, interaction between learners and others through appropriate communication technologies, peer feedback and tutoring, varieties of internet resources, and learners' responsibility within the assessment task. It is uncertain if any online assessment device or system in Nigeria and in other climes has met the totality of the above-stated criteria. Due to the need to fill this identified gap and have a standard online assessment opened to policy uptake, this study developed and validated the Virtual Assessment Standard Indicator Scale for universities.

Research Questions

1) What relationship exists between the ten (10) virtual assessment standard indicators (objective of assessment, content, teaching-assessment time ratio, quality, proctoring, deployment, cost effectiveness, security, feedback mechanism and remediation loop) and the items attached to each?
2) How independent are the ten (10) virtual assessment standard indicators (objective of assessment, content, teaching-assessment time ratio, quality, proctoring, deployment, cost effectiveness, security, feedback mechanism and remediation loop) identified through literature search?

Methodology

The study adopted a survey design, involving the collection and analysis of quantitative data.

Sampling and Sample

The study adopted the existing stratification of Nigeria into geo-political zones and employed purposive sampling to select one state with federal, state and private universities from three

out of the six (6) zones. A pilot study was conducted in one of the selected states with 183 students who shared similar attributes with the main sample. Simple random sampling was then used to select 300 students (150 male and 150 female) each from two faculties (science and humanities) in each sampled university except in private universities where the number of students available was not sufficient. In total, 1724 students from six (6) universities (two each from federal, state and private] formed the sample for the study.

Instrumentation

The researchers developed a scale with two sections called Virtual Assessment Standard Indicators (VASI). Section A provides the demographic characteristics of respondents. Section B elicited information from students on their lecturers' conduct of virtual assessment with reference to the courses registered for in the semester. It has five (5) subscales (awareness, relevance, skill of usage, previous usage and aspiration for future usage) in each of the ten (10) hypothesized virtual assessment standard indicators. The 59 items of the draft version of the scale were reduced to 58 (objective of assessment [10 items]; content [7 items]; teaching-assessment-time ratio [3]; quality [6]; proctoring [5]; security [7]; deployment [6]; cost effectiveness [4]; feedback mechanism [3] and remediation loop [7]) by experts. Two items on security subscale were merged because they measured the same attribute. Respondents rated on a five-point Likert scale with 0=None, 1= very poor, 3=average; 4=good and 5= outstanding. The sample for the study responded to the items on the instrument virtually with the Online Data Kit (ODK). Content validity of the scale was established using Lawshe Content Validity Ratio (CVR). Table 1 presents the estimated CVRs on the responses of the sample to the 58 items on the proposed virtual assessment standard indicators.

Table 1
Estimated Content Validity Ratios and Index

Item	VASI	Essential_ Student	CVR	Item	VASI	Essential_ Student	CVR
1	**Objective of**	160.00	0.73	32	**Security**	166.00	0.79
2	**Assessment**	171.00	0.85	33	(Secu)	177.00	0.91
3	(Obj Ass)	177.00	0.91	34		168.00	0.82
4		176.00	0.90	35		171.00	0.85
5		173.00	0.87	36		170.00	0.84
6		173.00	0.87	37		173.00	0.87
7		178.00	0.92	38		169.00	0.83
8		174.00	0.88	39	**Deployment**	171.00	0.85
9		174.00	0.88	40	(Depl)	170.00	0.84
10		174.00	0.88	41		168.00	0.82
11	**Content**	175.00	0.89	42		170.00	0.84
12	(Cont)	175.00	0.89	43		166.00	0.79
13		176.00	0.90	44		172.00	0.86
14		171.00	0.85	45	**Cost**	166.00	0.79
15		176.00	0.90	46	**Effectiveness**	169.00	0.83
16		171.00	0.85	47	(Cost Eff)	172.00	0.86
17		174.00	0.88	48		172.00	0.86
18	**Teaching**	173.00	0.87	49	**Feedback**	170.00	0.84
19	**Assessment**	159.00	0.72	50	**Mechanism**	172.00	0.86
20	**Time Ratio**			51	Feedmech		
	TATRATIO	164.00	0.77			172.00	0.86
21	**Quality**	173.00	0.87	52	**Remediation**	174.00	0.88

22	(Qual)	174.00	0.88	53	**Loop**	176.00	0.90
23		170.00	0.84	54	(Rem loop)	172.00	0.86
24		176.00	0.90	55		175.00	0.89
25		175.00	0.89	56		173.00	0.87
26		172.00	0.86	57		174.00	0.88
27	**Proctoring**	175.00	0.89	58		173.00	0.87
28	(Proct)	175.00	0.89				
29		173.00	0.87				
30		174.00	0.88				
31		170.00	0.84				

Table 1 reveals that the ratio of all the items for the ten indicators ranged between 0.72 and 0.91, suggesting the fact that all the items are valid enough to measure the proposed virtual assessment standard indicators since they are above 0.5. The Content Validity Index (CVI) for the entire scale was estimated to be 0.86 >0.5; thereby establishing the content validity of the entire scale, and Cronbach Alpha reliability index was estimated to be 0.993.

Data Analysis

The study adopted a reflective measurement model in Partial Least Square Structural Equation Modelling (PLS-SEM) for the analysis of data gathered from respondents. A PLS-SEM measurement model shows the relationships between a construct and its indicators (items linked to each construct).

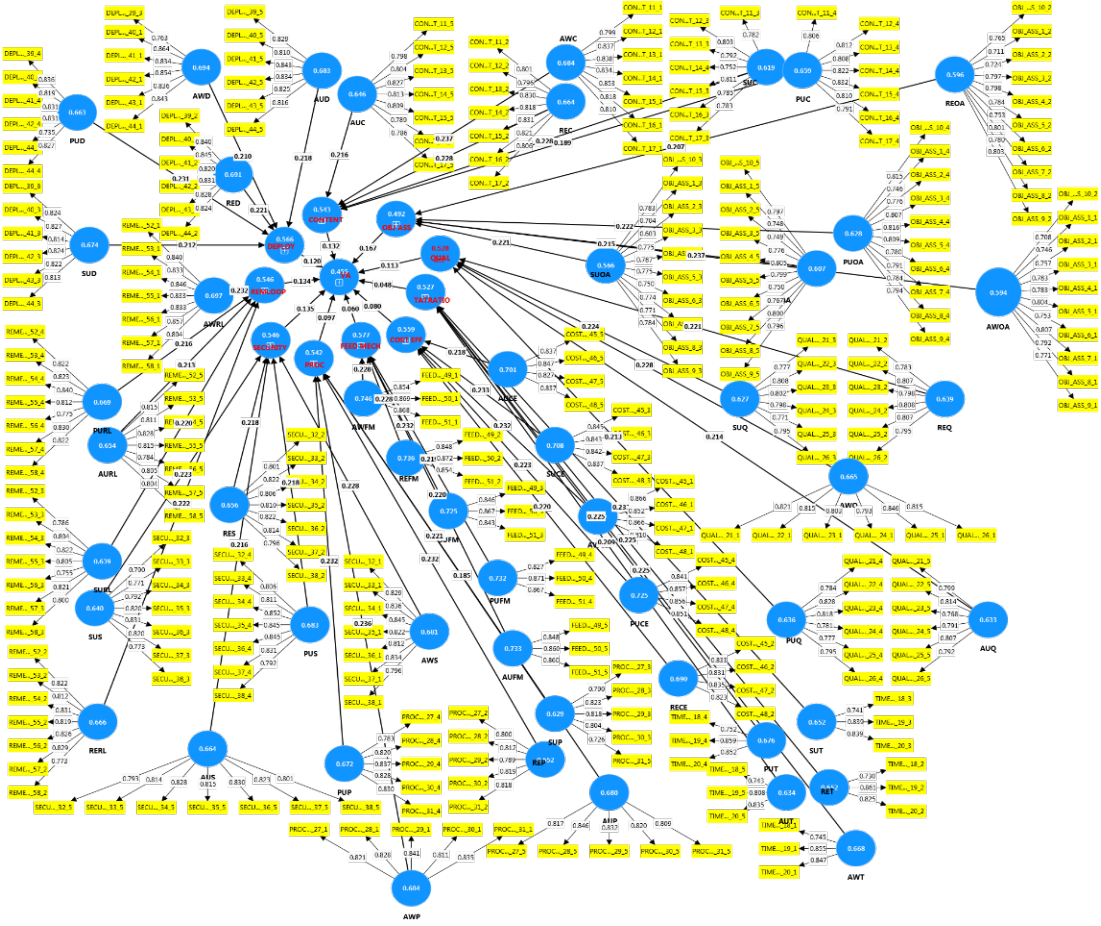
Results

1) What relationship exists between the ten (10) virtual assessment standard indicators and the items attached to each?

The reflective measurement model was estimated for reliability and validity to establish the relationship between each virtual assessment standard indicator and the items linked to them**.** Cronbach Alpha and Composite reliability are reported as estimates of reliability of a reflective PLS measurement model**.** Figure 2 presents the measurement model for virtual assessment standard indicators.

Figure 2

Measurement Model for Virtual Assessment Standard Indicators



The measurement model has ten (10) constructs (i.e blue circles with red ink labels). They (obj ass, content, tatratio, qual, proc, security, deploy, cost eff, feed mech, and rem loop) are referred to in this write up as virtual assessment standard indicators. The five (5) circles (with white labels) linked to each construct are the subscales of the virtual assessment virtual indicators. The sub-scales are awareness, relevance, skill of usage, previous usage and aspiration for future usage. Table 2 shows the results of the estimates of reliabilities and validities of the factors of VASI and those of the subscales. For example, the subscales are OBJ ASS (AWOA, awareness of OBJ ASS}; REOA (relevance of OBJ ASS); SUOA (skill of usage of OBJ ASS); PUOA (previous usage of OBJ ASS), and AUOA (aspiration for usage of OBJ ASS).

Table 2
Estimated Reliability (Cronbach & Composite) and Average Variance Extracted (AVE) Indices

	Cron. alpha	Com. reliab.	AVE		Cron. alpha	Com. reliab.	AVE
OBJ ASS	**0.979**	**0.98**	**0.492**	**DEPL**	**0.973**	**0.975**	**0.566**
AWOA	0.924	0.936	0.594	AWD	0.911	0.931	0.694
REOA	0.924	0.936	0.596	RED	0.911	0.931	0.691
SUOA	0.914	0.929	0.566	SUD	0.903	0.925	0.674
PUOA	0.934	0.944	0.628	PUD	0.898	0.922	0.663
AUOA	0.928	0.939	0.607	AUD	0.907	0.928	0.683
CONT	**0.975**	**0.976**	**0.543**	**COST EFF**	**0.958**	**0.962**	**0.559**
AWC	0.923	0.938	0.684	AWCE	0.87	0.912	0.72
REC	0.916	0.933	0.664	RECE	0.85	0.899	0.69
SUC	0.897	0.919	0.619	SUCE	0.863	0.907	0.708
PUC	0.914	0.931	0.659	PUCE	0.874	0.913	0.725
AUC	0.909	0.927	0.646	AUCE	0.858	0.904	0.701
QUAL	**0.969**	**0.971**	**0.528**	**FEED MECH**	**0.948**	**0.953**	**0.577**
AWQ	0.899	0.923	0.665	AWFM	0.829	0.898	0.746
REQ	0.887	0.914	0.639	REFM	0.821	0.893	0.736
SUQ	0.881	0.91	0.627	SUFM	0.811	0.888	0.725
PUQ	0.885	0.913	0.636	PUFM	0.816	0.891	0.732
AUQ	0.884	0.912	0.633	AUFM	0.818	0.892	0.733
TATRATIO	**0.935**	**0.943**	**0.526**	**SECURITY**	**0.975**	**0.977**	**0.546**
AWT	0.751	0.857	0.668	AWS	0.922	0.937	0.681
RET	0.731	0.848	0.652	RES	0.913	0.93	0.656
SUT	0.732	0.849	0.652	SUS	0.906	0.926	0.64
PUT	0.760	0.862	0.676	PUS	0.922	0.938	0.683
AUT	0.733	0.850	0.655	AUS	0.916	0.933	0.664
PROC	**0.965**	**0.967**	**0.542**	**REMLOOP**	**0.975**	**0.977**	**0.546**
AWP	0.885	0.916	0.684	AWRL	0.928	0.942	0.697
REP	0.867	0.904	0.652	RERL	0.916	0.933	0.666
SUP	0.852	0.894	0.629	SURL	0.906	0.925	0.639
PUP	0.878	0.911	0.672	PURL	0.917	0.934	0.669
AUP	0.882	0.914	0.680	AURL	0.912	0.93	0.654
VA**SI**	**0.996**	**0.996**	**0.455**				

In PLS-SEM, Cronbach Alpha and Composite estimates of reliabilities are reported because of the general belief that Cronbach underestimates reliability while Composite overestimates the index. As a result, the assumption in PLS-SEM is that the true reliability of a construct lies between the two, with Cronbach as the floor and composite as the ceiling (Hair et al., 2017). The estimates of reliability in Table 2 reveal acceptable reliability ranging from 0.731 to 0.98 for all the virtual assessment standards and their sub-scales; since the indices of reliabilities are all above 0.7 bench mark. This is an indication that all the ten (10) constructs (virtual assessment standard indicators) and the sub-scales have internal consistency (Hair et al., 2017), confirming their stability.

Convergent validity was established with the estimations of factor loadings and the Average Variance Extracted (AVE). A factor loading of 0.7 and above means that the indicators (items linked to each construct) and the construct share a lot in common; that is, there is a very strong and positive relationship between them while an AVE of 0.5 and above; shows that the indicators of a construct explain more than 50% of the variance in the construct. Table 3 shows the factor loading for all the items.

Table 3

Factor Loadings of Items and AVEs of Virtual Assessment Standard Indicators

Construct		**Subscales**				
Virtual Assessment Standard Indicator (AVE)	**Items/ Indicators**	**Factor Loading**	**Factor Loading**	**Factor Loading**	**Factor Loading**	**Factor Loading**
Objective of Assessment (0.492)		**Awareness (AWOA)**	**Relevance (REOA)**	**Skill of usage (SUOA)**	**Previous usage (PUOA)**	**Aspiration for future usage AUOA)**
	Obj Ass 1	0.746	0.711	0.704	0.746	0.748
	Obj Ass 2	0.757	0.724	0.603	0.776	0.749
	Obj Ass 3	0.783	0.797	0.775	0.807	0.776
	Obj Ass 4	0.783	0.798	0.787	0.816	0.805
	Obj Ass 5	0.804	0.784	0.775	0.809	0.799
	Obj Ass 6	0.753	0.753	0.750	0.780	0.750
	Obj Ass 7	0.807	0.801	0.774	0.791	0.767
	Obj Ass 8	0.792	0.780	0.771	0.784	0.800
	Obj Ass 9	0.771	0.803	0.784	0.794	0.796
	Obj Ass 10	0.708	0.765	0.783	0.815	0.797
Content (0.543)		**Awareness (AWC)**	**Relevance (REOA)**	**Skill of usage (SUC)**	**Previous usage (PUC)**	**Aspiration for future usage (AUC)**
	Cont-11	0.799	0.801	0.782	0.806	0.798
	Cont-12	0.837	0.796	0.803	0.812	0.804
	Cont-13	0.838	0.830	0.792	0.808	0.827
	Cont-14	0.834	0.818	0.752	0.822	0.813
	Cont-15	0.853	0.831	0.811	0.832	0.809
	Cont-16	0.818	0.821	0.785	0.810	0.789
	Cont-17	0.810	0.806	0.783	0.791	0.786
Teaching Assessment Time Ratio (0.526)		**Awareness (AWT)**	**Relevance (REOA)**	**Skill of usage (SUT)**	**Previous usage (PUT)**	**Aspiration for future usage (AUT)**
	Time-18	0.745	0.730	0.741	0.752	0.743
	Time-19	0.855	0.861	0.839	0.859	0.808
	Time-20	0.847	0.875	0.839	0.852	0.835
Quality (0.528)		**Awareness (AWQ)**	**Relevance (REOA)**	**Skill of usage (SUQ)**	**Previous usage (PUQ)**	**Aspiration for future usage (AUQ)**
	Qual-21	0.821	0.783	0.777	0.784	0.799
	Qual-22	0.815	0.807	0.808	0.828	0.814
	Qual-23	0.803	0.798	0.802	0.818	0.768
	Qual-24	0.793	0.808	0.798	0.781	0.791
	Qual-25	0.846	0.807	0.771	0.777	0.807
	Qual-26	0.815	0.795	0.795	0.795	0.792

Proctoring (0.542)		**Awareness (AWP)**	**Relevance (REOA)**	**Skill of usage (SUP)**	**Previous usage (PUP)**	**Aspiration for future usage (AUP)**
	Proc-27	0.821	0.800	0.790	0.763	0.817
	Proc-28	0.828	0.812	0.823	0.820	0.846
	Proc-29	0.841	0.789	0.818	0.837	0.832
	Proc-30	0.811	0.819	0.804	0.828	0.820
	Proc-31	0.835	0.818	0.726	0.830	0.809
Security (0.546)		**Awareness (AWS)**	**Relevance (REOA)**	**Skill of usage (SUS)**	**Previous usage (PUS)**	**Aspiration for future usage (AUS)**
	Secu-32	0.829	0.801	0.790	0.806	0.793
	Secu-33	0.836	0.822	0.771	0.811	0.814
	Secu-34	0.845	0.806	0.792	0.852	0.828
	Secu-35	0.822	0.810	0.820	0.845	0.815
	Secu-36	0.812	0.822	0.831	0.845	0.830
	Secu-37	0.834	0.814	0.820	0.831	0.823
	Secu-38	0.796	0.796	0.773	0.792	0.801
Deployment (0.566)		**Awareness (AWD)**	**Relevance (REOA)**	**Skill of usage (SUD)**	**Previous usage (PUD)**	**Aspiration for future usage (AUD)**
	Depl-39	0.763	0.840	0.824	0.836	0.829
	Depl-40	0.864	0.845	0.827	0.819	0.810
	Depl-41	0.834	0.820	0.814	0.831	0.843
	Depl-42	0.854	0.831	0.824	0.831	0.834
	Depl-43	0.836	0.828	0.822	0.735	0.825
	Depl-44	0.843	0.824	0.813	0.824	0.816
Cost Effectiveness (0.559)		**Awareness (AWCE)**	**Relevance (REOA)**	**Skill of usage (SUCE)**	**Previous usage (PUCE)**	**Aspiration for future usage (AUCE)**
	Cost-45	0.866	0.833	0.845	0.841	0.837
	Cost-46	0.852	0.831	0.843	0.857	0.847
	Cost-47	0.866	0.835	0.842	0.856	0.827
	Cost-48	0.810	0.823	0.837	0.851	0.837
Feedback Mechanism (0.577)		**Awareness (AWFM)**	**Relevance (REOA)**	**Skill of usage (SUFM)**	**Previous usage (PUFM)**	**Aspiration for future usage (AUFM)**
	Feed-49	0.854	0.848	0.846	0.827	0.848
	Feed-50	0.869	0.872	0.867	0.871	0.860
	Feed-51	0.868	0.854	0.843	0.867	0.860
Remediation Loop (0.546)		**Awareness (AWRL)**	**Relevance (REOA)**	**Skill of usage (SURL)**	**Previous usage (PURL)**	**Aspiration for future usage (AURL)**
	Reme-52	0.840	0.822	0.786	0.822	0.815
	Reme-53	0.833	0.812	0.804	0.823	0.811
	Reme-54	0.846	0.831	0.822	0.840	0.828
	Reme-55	0.833	0.819	0.805	0.812	0.815
	Reme-56	0.833	0.826	0.755	0.775	0.784
	Reme-57	0.857	0.829	0.821	0.830	0.805
	Reme-58	0.804	0.773	0.800	0.822	0.804

Results in Table 3 reveal that the factor loadings of all the indicators (items linked to each construct) are between 0.704 (OBJ ASS-1-3) and 0.875 (TIME-20-2) which are all greater than or equal to 0.7 cut off except 0.603 (OBJ ASS-2-3) that is below. However, the item was

retained for relevance since OBJ ASS-2-1, OBJ ASS-2-2, OBJ ASS-2-4 & OBJ ASS-2-5 have loadings above 0.7. Values in the first column of Table 2 show the AVEs of all the factors (indicators) and the sub factors which are all above the cut off of 0.5 (0.492 to 0.577), implying that the indicators (items linked to each construct) represent the construct. In other words, they share a lot in common (Hair et al., 2017). Acceptable AVEs with factor loadings of 0.7 and above establish the convergent validities of the ten (10) constructs.

2) How independent are the ten (10) virtual assessment standard indicators identified through literature search?

The independence of each of the ten (10) virtual assessment standard indicators was determined by estimating the discriminant validity of the ten (10) constructs using Hetro-Trait-Mono-Trait (HTMT) ratio proposed by Henseler et al. (2015). The HTMT results are presented on Table 4.

Table 4

Hetro-Trait-Mono-Trait (HTMT) Ratio of Pairs of Constructs in the Model

	Cont Ent	Cost Eff	Deploy	Feed Mech	Obj Ass	Proc	Qual	Reme Loop	Secu
Content									
Cost Eff	0.81								
Deploy	0.822	0.937							
Feed Mech	0.796	0.926	0.899						
Obj Ass	0.91	0.813	0.817	0.788					
Proc	0.842	0.887	0.896	0.865	0.835				
Qual	0.905	0.864	0.864	0.843	0.866	0.91			
Remloop	0.804	0.919	0.887	0.939	0.8	0.873	0.857		
Security	0.817	0.898	0.929	0.878	0.817	0.918	0.876	0.883	
Tatratio	0.816	0.772	0.755	0.76	0.786	0.809	0.853	0.765	0.773

It can be observed from Table 4 that the HTMT ratios of every pair of constructs in the model are less than or (approximately) equal to 0.9. They are between 0.755 (smallest) and 0.939 (highest); the highest is (approximately) equal to 0.9. This proves the discriminant validity of the constructs in the model.

The result of the assessment of the measurement model for this study shows that the ten (10) indicators in the model are valid, reliable and distinct. It signifies that all the indicators (constructs) of virtual assessment standards (objective of assessment, content, quality, proctoring, feedback mechanism, deployment, cost effectiveness, security, remediation loop and teaching assessment time ratio) identified through literature search and opinion poll can be used as standards for the conduct of virtual examinations.

Discussion

Since assessment is central to the teaching-learning process, there is need to know the assessment standards to guide lecturers before, during and after online teaching (Olatunde-Aiyedun et al., 2021). It is important to develop a scale to assess the quality of a Nigerian home grown assessment standard for online teaching (Akinsanmi et al., 2010). The result of the analysis reveals that the ten factors (objective of assessment, contents, quality, proctoring,

feedback mechanism, deployment, cost effectiveness, security, remediation loop and teaching assessment time ratio) of virtual assessment standard indicators all have internal consistency. This suggests that the responses of participants to the items of all the factors of virtual assessment standard are consistent (Frost, 2022; Hoffmann & Birnbrich, 2012) as the reliability indices are all greater than 0.7. This makes the scale reliable.

Results of the loadings serve to affirm the strong positive relationships between the indicators (items linked to each construct) and their respective constructs. In like manner, the AVEs of all the sub factors of virtual assessment standards are a pointer to the fact that the explained variance exceeds the unexplained (Bagozzi & Yi, 1988; Hair et al., 2017). In other words, each sub scale of VASI explains more than 50% of the variance of its indicators and less variance in the errors of the indicators. It means that each factor is measuring what it is intended to measure. OBJ ASS-2-3 was retained in the model for its importance since it has acceptable loading on the sub-scales of OBJ ASS (OBJ ASS-2-1, OBJ ASS-2-2, OBJ ASS-2-4 & OBJ ASS-2-5). Ping (2009) pointed out that indicators with low factor loadings may be retained if they are important to the study, especially first time studies. The HTMT ratios of less than or equal to 0.9 (Henseler et al., 2015) for every pair of constructs in the model confirm that the ten (10) constructs of the model are different. These results establish the adequacy of Virtual Assessment Standard Indicators as a tool for assessing the academic development of students in the virtual classroom.

Conclusion

Virtual assessment has many dimensions that must be considered to make it a credible and worthwhile exercise. Results of analysis of this study authenticate the virtual assessment standards indicators identified through literature search and opinion poll conducted at the onset of the study. The virtual assessment indicators (objective of assessment, content, quality, proctoring, feedback mechanism, deployment, cost effectiveness, security, remediation loop and teaching assessment time ratio) should be carefully integrated into online examinations.

A Nigerian home-grown virtual assessment standard indicator will be a good guide for the conduct of credible virtual assessment at all levels of education. It can be adopted by university administrators for the conduct of online assessment and adapted for use at other levels of education in Nigeria and in other climes.

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