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Validity and reliability of a questionnaire developed to explore quality assurance components for teaching and learning in vocational and technical education

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Most vocational and technical education (VTE) educational systems invest in quality assurance for teaching and learning to improve the skills of the workforce that would contribute to socio-economic development. Quality assurance provides confidence in educational services to meet the quality desires of teaching and learning settings. Yet it has been reported that there are challenges in teaching and learning effectiveness due to a lack of technological breakthroughs among students, resulting in an insufficiently skilled workforce. The primary aim of this study is to develop and validate a questionnaire for quality assurance for teaching and learning in vocational and technical education. The questionnaire was developed based on the data obtained by item generation through an interview with quality managers, administrators, and lecturers and a literature review. The content validity of the quality assurance for teaching and learning (QATL) questionnaire was validated using expert judgment. The principal component analysis (PCA) and orthogonal varimax techniques examined the structures and validity of the quality components. After exploratory factor analysis on the quality components under input, process, and output domains, the input quality factors explained 78.81% of the cumulative variance, the process quality factors explained 72.679% of the cumulative variance, and the output quality factors explained 75.027% of the cumulative variance. The analysis used Cronbach's alpha to test the internal consistency reliability, and the alpha values ranged from 0.835 to 0.963, indicating very high reliability. Present findings suggest that the QATL is a valid and reliable instrument for assessing quality components of quality assurance for teaching and learning in vocational and technical education. These quality components enable optimal VTE objective achievement if implemented in teaching and learning.

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Introduction

As far back as decades ago, the vital role of quality assurance (QA) practices for teaching and learning in vocational and technical education (VTE) was to produce high-quality graduates who could contribute significantly to socio-economic development. The United Nations Economic, Scientific, and Cultural Organizations (UNESCO) are concerned about quality assurance in vocational and technical education (VTE) to improve the skilled workforce and work productivity in societies (UNESCO-UNEVOC, 2017). Bateman and Coles (2017) describe VTE as an occupation-specific program that provides skills, knowledge, and competencies to boost workforce participation and social engagement. Quality VTE has become an optimum desire for all nations. Nations give attention to the quality mechanisms for their promotion. According to Mohammad Gasmelseed (2021), quality assurance best practices in teaching and learning can promote effective and efficient VTE systems that can contribute significantly to the socio-economic development of a nation (Mohammad Gasmelseed, 2021). Oviawe (2018) affirmed that in most technologically successful countries, quality assurance needs to be provided in the VTE to ensure diverse technical know-how and skills that can curb the technological challenges. Most developing countries, particularly Nigeria, have challenges associated with quality assurance in vocational and technical education. Some of these challenges include hindrance to progress in strengthening students' linkages to the world of work, improving recognition of formal VTE qualifications, and providing opportunities for employment and self-employment for graduates (Okoye and Arimonu, 2016; Onwusa, 2021). There are challenges in teaching and learning effectiveness due to a lack of technological breakthroughs among VTE students, resulting in an insufficiently skilled workforce. This lack of a skilled workforce amongst developing nations, especially Africans, particularly Nigeria, to address technological development requires new ways to improve teaching and learning processes (Onwusa, 2021). To reduce the unconditional challenges in quality teaching and learning and to improve the teaching process, there must be adequate input, process, and output quality materials for effective teaching (Karam et al., 2021). Quality teaching is an outcome-driven means of achieving desired learning assets (Karam et al., 2021). Therefore, quality assurance in teaching and learning processes serves as an instrument for monitoring, supervising, and evaluating the educational input, process, and output to maintain standards for the achievement of the VTE objectives (Okorafor & Nnajiifo, 2017; Moodley, 2019; Karam et al., 2021). Hence, quality assurance ensures the educational development of learners, the credibility and integrity of VTE education systems, and quality improvement practices in teaching and learning for quality up-skilling and reskilling of learners (Okeke, 2019; Garira, 2020; Karam et al., 2021).

Thus, in most developing nations, QA best practices in teaching and learning are needed to achieve VTE objectives (Oviawe, 2020). Best practices in teaching and learning are required to meet the demands of 21st-century technology for a labor market that can interact with society's readiness to embrace economic, social, and technological changes. Quality assurance practices encourage continuous learning to update students' competencies in meeting the ever-increasing demand for skills and knowledge (UNESCO-UNEVOC, 2017). Quality assurance for teaching and learning in VTE is linked to student performance conditions to target the VTE objectives (Said, 2018; Okeke, 2019). The importance of QA practices implies activities that emphasize relationships between input, process, and output for quality teaching and learning (Oviawe, 2018; Garira, 2020). Therefore, to improve quality teaching and to learn VTE

effectively, there has to be the right mix of input-process materials to produce a competent workforce (Oviawe, 2018; Garira, 2020; Karam et al., 2021). As a result, quality VTE requires input-process quality components for teaching and learning (Van der Scheer et al., 2019; Oviawe, 2020). So, to ensure quality teaching in VTE, it is necessary to identify quality components that inhibit it (Wulandari et al., 2020). Moreover, sustaining quality teaching to foster rigorous learning in VTE programs strengthens effectiveness and productivity and maintains the viability of the VTE objectives. Thus, developing a comprehensive, generalizable, and valid instrument in QA for teaching and learning in VTE will influence the delivery of skills, knowledge, and competencies required (Wulandari et al., 2020).

However, many studies have been conducted on quality teaching and learning determinants across many fields without a particular emphasis on VTE programs. Among the studies that focus on the literature on quality education includes: Van der Scheer et al. (2019) developed a tool to investigate quality teaching in three dimensions, which include providing a positive and inclusive classroom climate; classroom management quality; and a transparent activating instructional approach (adaptive instruction, teaching-learning strategies, and goal orientation). Nogueira & Fernandez (2018) developed an instrument to investigate quality teaching as subject matter knowledge, instructional representation and plans, instructional objectives and context, and knowledge of students' understanding. However, the scale is mainly concerned with teacher knowledge. Mohammad Gasmelseed (2021) established general quality assurance practices in teaching and learning in Sudan. When utilized effectively, the study recommended that input materials such as facilities, machinery, and consumables can influence quality teaching and learning in TVET.

Furthermore, the instrument did not examine quality measures such as process and output to improve TVET teaching and learning quality. However, to date, there is no evidence of a tool that has emerged to identify quality components of QA for quality teaching and learning in VTE. As a result, this study aims to develop and test a set of questionnaires that assess QA practices in education and learning in VTE programs.

Literature review

Over the last two or three decades, the philosophy and guiding principles of quality assurance expressed by the leading quality gurus like Deming, Juran, and Crosby on the importance of ensuring quality standards in an organization for optimum production (Yang, 2017). As a result, recent scholars and experts in education settings have stressed the quality of teaching by using tools to tackle classroom problems and improve students' learning outcomes (Darling-Hammond et al., 2020). This study underpins total quality management theory (TQM) because it can influence the entire VTE educational system in all activities, staff, and environment to meet the changing demands of the labor market, which is becoming a problematic task in developing countries. Applying this theory helps to determine the operational level of inputs and processing materials for professional learning opportunities (Rahman et al., 2021). These opportunities should be practical, encouraging procedures, processes, good practice guides, and forms linked to teaching, learning, and using technology (Ghavifekr & Rosdy, 2015; Rahman et al., 2021). Therefore, VTE providers must consistently control the quality of the inputs and processes to guarantee work without defects. The management has to perform its executive function to support the changing process by implementing TQM that can strive for quality and support the consequent process for quality assurance

in teaching and learning. Thus, in any educational system, ensuring quality standards has the potential to achieve quality content and results. Therefore, the most significant impairment in VTE is the ability to provide quality services. Ayeni (2017), quality services result from the available input materials when processed. As such, the best practice of quality assurance for teaching and learning is the commitment of the stakeholders to ensure quality components in classroom settings (Akareem & Hossain, 2016; Matorera, 2018). Subsequently, different scholars perceive quality assurance aspects differently (Randahn & Niedermeier, 2017). According to the OECD (2019), to ensure quality achievement, emphasis must be placed on the effectiveness of teaching, learning, and curriculum implementation, the availability of necessary facilities and equipment, and maintenance. According to Netshifhefe et al. (2017) and Choiriyah, Kumaidi (2018), quality assurance in teaching and learning is a means of checking the process and outcomes to ensure quality benchmarks.

Choiriyah, Kumaidi (2018), and Aryal (2020) opine that quality in VTE is the level of excellence in performance based on the quality of the content, input, processing transaction, and output. As such, output quality does not come by chance but requires adequate planning and deliberate effort. Awodun and Boris (2020) stated that quality assurance is the management of goods, services, and activities from the input stage through processes to the output stage of production. Garira (2020) affirmed that quality assurance for teaching and learning reflects on the input, process, and output resources for optimal educational standards. Therefore, quality assurance is a holistic process concerned with ensuring the integrity of outcomes. Thus, the study aims to develop and validate an instrument of QA for teaching and learning in VTE to provide a quality workforce. Moreover as a result, producing skillful and knowledgeable students with the competency to contribute to nation-building.

Methodology

A mixed-method design was adapted, combining qualitative and quantitative research techniques. The researchers developed the instrument of QA for teaching and learning (QATL) in two phases. Phase one is for item generation and development of the questionnaire through interviewing quality managers, VTE administrators, and VTE lecturers. Step two tests the quality components, such as construct validity and internal consistency reliability. The college of education's research committees sought permission to conduct the study. The qualitative and quantitative participants received written explanations of the study's objectives and methodology, with the option to withdraw at any time. The researchers assured the participants that their data would remain confidential.

Phase 1 Qualitative/development of the QATL instrument. The qualitative approach phase includes two stages: the development of an item pool and item reduction and the development of the QATL.

The development of an Item Pool

Technique and participants. A qualitative study using in-depth face-to-face semi-structured interviews were used, which aimed to explore the quality managers', VTE administrators', and VTE lecturers' perspectives on the quality components of QA practices for teaching and learning. Moreover eighteen participants, comprising six quality managers, six administrators, and six lecturers, completed the semi-structured interviews between February 2021 and July 2021. They were from six out of twelve colleges of education offering VTE in the North-East of Nigeria. The

following questions guided the interview: 1. Considering your experience, what are the quality components of quality assurance practices for teaching and learning? 2. Considering your experience as a quality manager, administrator, and lecturer, could you identify the quality components of QA practices for teaching and learning in VTE based on input, process, and output domains? Qualitative data were analyzed using thematic analysis (Braun & Clarke, 2006). The qualitative findings paved the way for creating a practical assessment tool to identify the quality components of QA for teaching and learning in VTE. The themes that emerged from the qualitative data build the related constructs, which provided the basis for developing scale items. The interview data generated a draft of an indicators pool based on a critical review of existing literature and related assessment tools of quality assurance practices for teaching and learning. Okoro et al. (2019) and Knekta et al. (2019), the development of instruments should include clear, unambiguous, and understandable statements to the respondents in both negative and positive directions. Twelve themes emerged from the qualitative data analysis: curriculum content, governance and management; teaching resources; student admission; quality of instruction; classroom management; monitoring and supervision; assessment and evaluation; teaching climate; innovation; creativity; and graduate employability. We developed an item pool with 99 items based on our qualitative results and literature review.

Item reduction and development of the QATL

Technique and participants. Three professionals with expertise in quality control and teaching VTE validated the 99-item pool. The expert uses factors to determine which items to retain and which to remove, including face validity, wording clarity, and the measured constructs' appropriateness (Zelt et al., 2018). The items that remained after reduction and modification were used for the initial QATL and then sent to the experts for face and content validity. These experts included two experienced quality managers with a Ph.D qualification in management, two experienced lecturers with a Ph.D qualification in the area of TVET, and two experienced administrators with a master's degree qualification in human resource management. The experts made recommendations and comments on whether certain items should be removed, modified, or added. The study retained 78 items based on the experts' comments and suggestions, and each item's relevance was determined by how well it fits its corresponding construct.

Phase 2 Quantitative/psychometric properties of the QATL questionnaire. This phase includes the pilot study and the QATL questionnaire validation.

Pilot study. In the first version of the QATL questionnaire, 78 items were administered to a sample of 100 people to evaluate the items' clarity and estimate the reliability of the constructs. The responses of quality managers, administrators, and lecturers led to the conclusion that the items are trustworthy. The internal consistency yielded the following Cronbach's alpha values for each construct: teaching resources 0.964, curriculum content 0.924, governance and management 0.885, student admission 0.879, monitoring and supervision 0.942, quality of instruction 0.897, classroom management 0.881, assessment and evaluation 0.881, teaching climate 0.845, creativity 0.957, innovation 0.835, and graduate employability 0.928, indicating sufficient internal consistency (Taber, 2018). The instrument appeared to have good reliability and permitted further development.

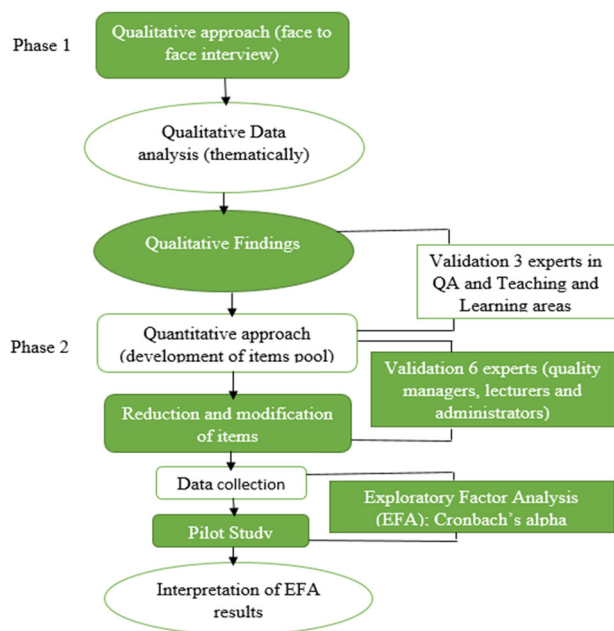


Fig. 1 Flowchart of the methodological approach.

Validation of the QATL questionnaire instrument. Furthermore, the appropriateness of the constructs based on input, process, and output quality measures was determined using the exploratory factor analysis (EFA) approach. Therefore, based on the EFA results, ten items were removed out of 78 items, leaving 68 items used for the main study. Figure 1 below presents the flowchart of the methodological approaches.

Research sample. The participants for the study were selected through a purposive sample because only colleges of education offering vocational-technical education (VTE) were included. Because of different population subgroups, a stratified sampling approach was used, including the administrators, quality managers, and lecturers. Out of 272 questionnaires distributed, 259 were returned and used for the study. The return rate was 95.22%. 23.17% were administrators, 2.31% were quality managers, and 74.52% were lecturers. The total number of males was 66.79% (173), and females were 33.21% (86).

Research instrument. A closed-ended questionnaire tailored to the context of this research was to evaluate appropriate measures of QA practices for teaching and learning in VTE at six colleges of education in North-East Nigeria. The questionnaire contained 68 items presented on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). This study identifies quality components for developing a reliable instrument for teaching and learning in VTE. Based on the three domains of quality assurance, Table 11 shows the twelve quality components of teaching and learning.

Input quality primarily measures the use of resources to facilitate learning. The input domain reveals the planned material and human resources available to deliver the arranged quantities at all levels of the VTE educational system. The input domain comprises all the quality components the VTE programs need to successfully provide high-quality VTE in teaching and learning to achieve the VTE goals.

- The curriculum content is measured using five items that cover the appropriateness of the curriculum implementation. The VTE curriculum needs to align with its goals: to

give young men and women the skills, knowledge, and abilities they need to have productive jobs that can help the economy grow.

- Students are admitted based on two criteria: (1) to make sure that admission into VTE programs is fair and appropriate; and (2) to make sure that admitted students meet both general and program-specific entry requirements.
- Teaching resources: are measured by ten items. VTE must ensure that teaching and learning resources provide challenges and engage learning programs for VTE students. Their quality and quantity must be good enough for the VTE educational system to work well and for students to do well in VTE programs.
- Governance and management: measured across five items. The managerial process provides direction to ensure that VTE educational systems achieve objectives for effective and efficient accountability.

The process domain is about what teachers do in the training delivery process to ensure that tools and content of learning skills and knowledge are presented to learners effectively.

- Quality of instruction: is measured by six items covering the adequacy and appropriate use of teaching methods and pedagogy for achieving VTE objectives. It includes everything teachers, and students do in the classroom to prepare and meet students' needs.
- Classroom management measures six items that cover the effectiveness of a lecture in using time and resources in a classroom. It is a vital part of a teacher's ability to create a safe and effective learning environment where they can teach, and students learn well.
- The teaching climate: is measured by four items that cover the conduciveness of teaching conditions for lecturers and students. A teaching climate creates a highly valued environment for teaching and learning.
- Assessment and evaluation: are measured by five items, which cover feedback on quality teaching and identify lecturer and student strengths and weaknesses. Assessment and evaluation help teachers determine what, how much, and how well their students learn. They also help teachers make decisions about student learning and report quality improvements.
- Monitoring and supervision: measured by six items that cover the effectiveness of the lecturers in maintaining standards. The teacher's and student's performances in the classroom are monitored and supervised to improve teaching and learning activities.

Outputs are the results that show how well VTE students and graduates can do their jobs and what they want to do with their lives. As a result, the outputs or outcomes of students and graduates determine their occupational competence and aspirations.

- Creativity: is measured by nine items that assess the competency to create and transform new ideas into reality. Moreover, the graduates generate a method of transforming new ideas into new value.
- Innovation: is measured by four items to assess graduates' implementation of creative inspiration. So, combining the ideas and knowledge to create new value for customer satisfaction and correctly using technology will contribute to nation-building.
- Graduate employability: is measured by six items that cover satisfaction in terms of self-employment or employment.

So, achieving the VTE objectives, the students and graduates will have the necessary competencies to pave the way for employability.

Administration of instrument. Systematic sampling distribution of 32% to each institution led to the distribution of 275 questionnaires to six colleges of education. Before beginning the research, research committees of all colleges of education provided ethical approval. The participants were offered with consent letter to ensure their responses' anonymity and confidentiality. Therefore, out of 275 sets of questionnaires, 259 questionnaires were returned. Table 1 shows the distribution rate of the questionnaires.

Results

The results of the data analysis are as follows:

Data analysis: exploratory factor analysis EFA. Finding the right QA constructs items for teaching and learning within the input domain was done using exploratory factor analysis. The KMO-criterion sample adequacy identified was 0.863, referred to as meritorious (Babenko et al., 2020). An identity matrix (chi-square = 864.403, df. = 231, P = 0.000) was established by Bartlett's test for sphericity, which was adequately significant as shown in Table 2.

Three of the 25 items had low loadings, so the entire data set of 22 items was subjected to an EFA analysis. The study employed principal component analysis (PCA) and orthogonal varimax rotation techniques. As PCA summarizes and reduces data and defines the factors required to represent the structure of a variable and extract as much variance as possible from a data set with each component (Samuels, 2016; Wipulanusat et al., 2017). The result shows four factors with eigenvalue factors of 7.626, 3.839, 3.839, and 2.088, respectively. The initial eigenvalues indicated the explained factor 1 teaching resources (TR) as 34.662%, factor 2 curriculum content (CC) explained 17.448%, factor 3 governance and management (GM) explained 17.217%, and factor 4 student admission (SA) explained 9.493% of the variances. As these four factors explain, 78.819 percent of the absolute difference and the value is appropriate, as shown in Table 3.

In the outcome of the EFA results, three items were deleted due to low loadings in the rotated component matrix. The rotated component matrix displayed four significant factor loadings, ranging from 579 to 903 for factor 1, from 522 to 869 for factor 2, from 587 to 840 for factor 3, and from 676 to 839 for factor 4, respectively, as shown in Table 4.

Furthermore, under the process domain, there are five factors. These include monitoring and supervision (MS), quality of instruction (QI), classroom management (CM), assessment and evaluation (AE), and teaching climate (TC). After removing five original 32 items, the remaining 27 were analyzed using factor analysis. The KMO sample adequacy was 0.567 and the identity matrix (chi-square = 953.493, df. = 351, P = 0.000) demonstrated by Bartlett's test for sphericity that the result supported the validity of the factor analysis's usage as shown in Table 5.

From the EFA analysis, the eigenvalues of the factors include 5.286, 4.430, 3.680, 3616, and 3.611, respectively. According to the initial eigenvalues of the five factors, factor 1 monitoring and supervision (MS) accounted for 19.578% of the variance, factor 2 quality of instruction (QI) for 16.407%, factor 3 classroom management (CM) for 13.631%, factor 4 assessment and evaluation (AE) for 13.391%, and factor 5 teaching climate (TC) for 9.671% of the variances. These five factors explained 72.679% of the cumulative variance, which was considered appropriate. Table 6 shows that the absolute percentage difference was more significant than the acceptable threshold value of 50%.

Owing to low loading from the rotated component matrix of the questionnaire items, from the analysis of factor analysis (EFA) results. The rotated component matrix showed relevant loadings of five factors. Factor 1 loading ranges from 0.765 to 0.869; factor 2 loading ranged 0.637 to 0.859; factor 3 ranges 0.633 to 0.776, factor 4 loading ranged 0.633 to 0.765. 603 to 0.868, and factor 5 ranges from 0.586 to 0.764, respectively, as shown in Table 7.

More so, under the output domain, there are three factors: graduate employability (GE), innovation (IN), and creativity

Table 1 Response rate from respondents.

S/ NO	Institution	Questionnaire	
		Distributed	Received
1.	COE, Hong	31	31
2.	COE, Zing	45	42
3.	COE, Azare	38	36
4.	FCOE (T)Gombe	60	55
5.	FCOE (T) Potiskum	52	49
6.	College of education science and technology, Bama	49	46

Table 2 The KMO and Bartlett's test of sphericity of input QA for teaching and learning constructs.

KMO and Bartlett's test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.863
Bartlett's Test of Sphericity	Approx. Chi-Square	864.403
	Df	231
	Sig.	0.000

Table 3 The component and total variance explained of input QA for teaching and learning constructs.

Total variance explained								
Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative
12.297	55.895	55.895	12.297	55.895	55.895	7.626	34.662	34.662
2.535	11.521	67.415	2.535	11.521	67.415	3.839	17.448	52.110
1.416	6.435	73.850	1.416	6.435	73.850	3.788	17.217	69.327
1.093	4.968	78.819	1.093	4.968	78.819	2.088	9.492	78.819

Extraction method: principal component analysis.

Table 4 Rotated component matrix of input QA factor structures and loadings.

Code	Number of Indicators (items)	Factor 1	Factor 2	Factor 3	Factor 4
TR1	Offices for staff in VTE programs are adequate.	0.579			
TR2	Machines are functional in VTE programs' workshops.	0.749			
TR3	Tools/equipment are adequate for VTE programs.	0.721			
TR4	Well-equipped ICT center for VTE programs is available.	0.784			
TR5	There are adequate laboratories/workshops for VTE programs.	0.891			
TR6	Consumable materials for practical VTE courses are sufficient.	0.886			
TR7	There are adequate professional qualified lecturers.	0.797			
TR8	There is a well-equipped library for VTE research.	0.903			
TR9	TVE programs have sufficient facilities.	0.849			
TR10	The students-lecturer ratio is observed during admission into VTE programs.	0.799			
CC11	Curriculum implementation in VTE is based on competencies as approved by NCCE.		0.732		
CC12	Approved VTE curriculum contents meet the labor market demands.		0.758		
CC13	The VTE curriculum addresses sustainable technological development.		0.818		
CC14	The VTE curriculum contains objectives for assessing the achievements of learning.		0.869		
CC15	The teaching organization specified in the VTE curriculum is appropriate for lecturers.		0.522		
GM16	Influence implementation of the quality assurance guidelines.			0.587	
GM17	Make VTE stakeholders more transparent to strengthen cooperation.			0.766	
GM18	Management holds regular meetings to ensure quality assurance in VTE programs.			0.840	
GM19	Management supports reformed policies to improve quality assurance in VTE programs.			0.804	
GM20	VTE stakeholders are aware of emerging technologies to strengthen their commitment.			0.814	
SA22	Students possess five credit entry requirements for admission into VTE programs.				0.676
SA23	Admission into the VTE programs is in accordance with the NCCE Minimum Standard.				0.834
SA21	The JAMB admission policy is followed in the VTE Programs.				Removed
SA25	The admission process in the VTE programs is transparent.				Removed
SA24	Suitable students are admitted into VTE programs.				Removed

Extraction method: principal component analysis.

Table 5 The KMO and Bartlett's test of sphericity of process QA for teaching and learning construct.

KMO and Bartlett's test			
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.			0.567
Bartlett's Test of Sphericity	Approx. Chi-Square		953.493
	Df		351
	Sig.		0.000

(CR). Owing to low loadings, two items were removed from the rotated component matrix. The sample adequacy revealed that the KMO-criterion was 0.795, referred to as middling (Babenco et al., 2020). The value is adequate because it exceeds the threshold value of 0.50 (Kaiser, 1974; Weide & Beauducel, 2019). Thus, an identity matrix (chi-square = 718.064, df = 171, P = 0.000) as illustrated by the Bartlett's test for sphericity was significant. As such, the results were appropriate for EFA analysis, as shown in Table 8.

The initial eigenvalues showed from the EFA results for the three constructs were that factor 1 creativity explained 34.003% of the variance, factor 2 innovation explained 24.705% of the variance, and factor 3 graduate employability explained 16.319% of the variance. These three factors explained 75.027% of the cumulative percentage variance, much greater than the 50% acceptable value (Samuels, 2016; Watkins, 2018). Therefore, the eigenvalues of the factors are 6.461, 4.694, and 3.101, respectively, as shown in Table 9.

Thus, due to low loadings, two items were removed from the rotated component matrix. The rotated component matrix indicated meaningful loadings of three factors. As shown in Table 10, factor 1 loading ranged 0.598 to 0.868, factor 2 loading ranged from 0.609 to 0.845, and factor 3 loading ranged from 0.736 to 0.838.

Internal consistency reliability. The internal consistency estimates the equivalence of sets of items from the test, and the reliability measurement assumes that the construct's indicators are measured (Taber, 2018). Cronbach's alpha (α) assesses the internal consistency and reliability. Cronbach's alpha represents the average correlations among items on 5-point Likert scales. The reliability coefficients of the four constructs under the input domain ranged from 0.879 to 0.964, the reliability coefficients of the five constructs under the process domain ranged from 0.845 to 0.942, and the reliability coefficients of the three constructs under the output domain ranged from 0.835 to 0.957, respectively. These alpha values indicate good internal reliability. Therefore, the questionnaire was considered reliable and could represent what it was supposed to measure because the alpha values were sensitive to the items. However, with the items deleted, the reliability improved, as stated in Table 11.

Discussion

To the best of the authors' knowledge, this study is the first to develop and validate a questionnaire to assess QA for teaching and learning in VTE based on input, process, and output quality measures. In the development of the item pool, the themes emerged from qualitative findings to build on related constructs that guided the development of the questionnaire items. The researchers drafted questionnaire items based on a critical review of the current literature, assessment tools, and qualitative research interview data. The items were generated from the perspective of quality managers, VTE administrators, and VTE lecturers and verified by the published literature on the fields of quality assurance in teaching and learning. This approach guaranteed the content validity of the tool at the commencement of the study. Moreover, it fine-tunes the relevance of the instrument's development to become more highly recommended by researchers (Bai et al., 2018; van der Scheer et al., 2019). This study has 78 items, which have 12 subscales, such as curriculum content, teaching

Table 6 The components and total variance explained of process QA for teaching and learning construct.

Total variance explained									
Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	9.934	36.791	36.791	9.934	36.791	36.791	5.286	19.578	19.578
2	5.475	20.279	57.070	5.475	20.279	57.070	4.430	16.407	35.985
3	1.802	6.673	63.744	1.802	6.673	63.744	3.680	13.631	49.617
4	1.333	4.937	68.681	1.333	4.937	68.681	3.616	13.391	63.008
5	1.080	3.998	72.679	1.080	3.998	72.679	2.611	9.671	72.679

Extraction method: principal components analysis.

Table 7 Rotated component matrix of process QA factor structures and loadings.

S/NO	Number of indicators (items)	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
MS21	Assist administrators in identifying quality lecturers in VTE programs.	0.799				
MS22	Check/balance lecturers and students for effective performance.	0.869				
MS23	Influences VTE program reforms.	0.773				
MS24	VTE lecturers monitor/record the progress of students.	0.765				
MS25	Provide feedback on the quality of the VTE learning experience.	0.844				
MS26	Encourages management to use reports to maintain standards in VTE programs.	0.814				
MS20	Supervision creates an awareness of sound philosophies in lecturers.	Deleted				
Q11	Lecturers develop lesson plans in VTE programs for effective teaching.		0.830			
Q12	Learning activities are considered in developing a VTE lesson plan.		0.859			
Q13	Instructional strategies in VTE program courses are inadequate.		0.774			
Q14	Teaching methods matched with learning content in VTE programs.		0.768			
Q16	VTE lecturers are flexible in their assigned instructional duties.		0.637			
TC11	The learning environment for teaching VTE program courses is conducive.		0.688			
Q15	Teaching methods relate theory to practice in VTE program courses.		Deleted			
Q17	Modern technologies are used to aid teaching in VTE program courses.		Deleted			
Q18	VTE lecturers are adequate in their instructional duties.			0.693		
CM14	There is an efficient use of lesson time in VTE programs.			0.733		
CM15	VTE lecturers coordinate teaching materials for effective teaching.			0.642		
CM16	VTE lecturers managed their classrooms for conducive lessons to take place.			0.735		
CM17	VTE lecturers observe teaching ethics.			0.633		
CM18	VTE lecturers enforce consequences on students that break the rules/regulations.			0.776		
CM19	VTE lecturers' training delivery impacts good learning outcomes.			Deleted		
AE28	Provides feedback on the effectiveness of instructions.				0.603	
AE29	Judging the quality of VTE students' performance.				0.868	
AE30	Improving teaching quality in VTE program courses.				0.768	
AE31	Motivates students' learning outcomes in VTE program courses.				0.704	
AE32	Provides feedback on the implementation of the program's curriculum.				0.722	
AE27	Identify academic weaknesses in VTE programs.				Deleted	
TC9	Learning in VTE programs is not facilitated when students are stressed.					0.764
TC10	Students learn more effectively when they are emotionally secure.					0.738
TC12	Learning is not facilitated when students are anxious.					0.586
TC13	VTE's conducive teaching atmospheres make students learning interesting.					0.726

Extraction method: principal component analysis.

Table 8 KMO and Bartlett's test of sphericity of output QA for teaching and learning construct.

KMO and Bartlett's test	
Kaiser-Meyer-Olkin measure of sampling adequacy.	0.795
Bartlett's test of sphericity	Approx. Chi-Square
	Df
	Sig.
	718.064
	171
	0.000

resources, student admission, governance and management, quality of instruction, classroom management, monitoring and supervision, assessment and evaluation, teaching climate, and creativity, innovation, and employability.

Experts chosen for their knowledge of quality control and teaching in VTE training validated the questionnaire item pool, which could improve the questionnaire's face and content

validity. Exploratory factor analysis assesses the construct validity of the QATL as part of the evaluation of the questionnaire's psychometric properties. In the study, the EFA of the QATL yielded twelve factors identified based on input, process, and output models that explained variance in the study. The identification and separation of correlated and uncorrelated variables were possible through PCA. As a result, 68 items appeared suitable for ensuring quality assurance in teaching and learning.

From the EFA analysis, the input quality loadings of the items on the four factors extracted seem to show convergence among the measures. Although items SA21, the JAMB admission policy is followed in VTE programs, SA24, suitable students are admitted into VTE programs, and SA25, the admission process in VTE programs is transparent, were deleted due to low loadings. Thus, the structure of item loadings supports the actual data and validity of the four factors. In input measures, factor 1 teaching resources (TR) explained 34.662% of the variance, facet 2. curriculum content (CC) explained 17.448%, factor 3 governance and management (GM) explained 17.217%, and factor 4 student

Table 9 The components and total variance explained of output QA for teaching and learning construct.

Total variance explained

Component	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	10.839	57.048	57.048	10.839	57.048	57.048	6.461	34.003	34.003
2	1.758	9.252	66.300	1.758	9.252	66.300	4.694	24.705	58.708
3	1.658	8.727	75.027	1.658	8.727	75.027	3.101	16.319	75.027

Extraction method: principal components analysis.

Table 10 Rotated component matrix of output QA factor structures and loadings.

S/NO	Number of indicators (items)	Factor 1	Factor 2	Factor 3
IN13	VTE graduates are capable of applying technologies in their workplaces.	0.598		
CR14	VTE graduates can generate ideas.	0.725		
CR15	VTE graduates have work-knowledge competence in their chosen occupations.	0.868		
CR16	VTE graduates have thinking skills.	0.798		
CR17	Ability to enhance sustainable development in VTE programs.	0.816		
CR18	Ability to facilitate meaningful VTE learning experiences.	0.775		
CR19	Ability to participate in creative thinking.	0.865		
CR20	Capacity to create new ideas to improve learning outcomes.	0.709		
CR21	Ability to implement new changes to accelerate national development.	0.834		
IN9	VTE graduates have the necessary skills for the labor market.		0.821	
IN10	VTE students innovate to promote community services.		0.726	
IN11	VTE graduates have the competency to improve technology teaching.		0.845	
IN12	Offer a skilled workforce in a service field.		0.609	
IN8	VTE students are equipped with the skills and knowledge required.		Deleted	
GE3	VTE graduates secure employment without difficulty.			0.838
GE4	VTE graduates work effectively to contribute to the country's socio-economic development.			0.736
GE5	VTE graduates demonstrate fluent communication skills.			0.783
GE6	VTE graduates demonstrate vocational skills effectively.			0.786
GE7	VTE graduates have adequate technical skills.			0.788
GE1	VTE graduates have the ability to solve problems.			0.752
GE2	VTE graduates work on their initiative.			Deleted

Extraction method: principal component analysis.

Table 11 Reliability coefficient, mean and standard deviation values.

Domain	Quality standard components	Items	Mean	Standard deviation	Cronbach's Alpha values
Input Domain	Teaching Resources (TR)	10	2.909	0.986	0.964
	Curriculum Content (CC)	5	3.868	1.093	0.924
	Governance and management (GM)	5	3.600	0.869	0.885
	Student admission (SA)	2	3.159	1.028	0.879
Process Domain	Monitoring and Supervision (MS)	6	3.869	0.908	0.942
	Quality of instruction (QI)	6	3.549	0.814	0.897
	Classroom management	6	3.496	0.805	0.881
	Assessment and evaluation (AE)	5	4.049	0.738	0.881
Output Domain	Teaching Climate (TC)	4	4.128	0.767	0.845
	Creativity (CR)	9	3.750	0.764	0.957
	Innovation (IN)	4	3.811	0.617	0.835
	Graduate employability (GE)	6	3.614	1.043	0.928

admission (SA) explained 9.493% of the variance. The four input factors explained 78.819% of the total cumulative variance.

The EFA result eliminated the process quality loadings of the items on the five factors extracted below because of low loadings. These items are as follows: MS20 supervision creates an awareness of sound philosophies in lecturers, CM19 VTE lecturers' training delivery impacts good learning outcomes, QI5 Teaching methods relate theory to practice in VTE program courses, QI7

Modern technologies used to aid teaching in VTE program courses, and AE27: Identify academic weaknesses in VTE programs. Hence, the structure of item loadings supports the actual data and validity of the four factors. In the process measures, factor 1 monitoring and supervision (MS) explained 19.578% of the variance, factor 2 quality of instruction (QI) explained 16.407%, factor 3 classroom management (CM) presented 13.631%, factor 4 assessment and evaluation (AE) explained

13.391% of the variance. Factor 5 teaching climate (TC) explained 9.671%. Then the five process factors accounted for 72.679% of the total cumulative variance.

From the EFA analysis, the three factors that showed convergence among the measures based on the three factors extracted from the results are IN8 VTE students equipped with the skills and knowledge required and GE2 VTE graduates working on their initiative. Thus, the structure of item loadings supports the actual data and validity of the three factors. The output measures explained 34.003% of the variance, factor 2 innovation explained 24.705%, and factor 3 graduate employability explained 16.319%. These three factors explained 75.027% of the total cumulative percentage variance. Cronbach's alpha measures the internal consistency and reliability of the QATL and its 12 subscales. All are greater than 0.835, which indicates that the 12 subscales' reliability is highly satisfactory (Taber, 2018). Thus, from the purposive sampling approach adopted, the sample data used in the research analyses came from various colleges of education, both federal and state, offering VTE programs. We believe that the sample collected reached a level of heterogeneity. From the findings, the QATL can be considered a valid and reliable instrument for evaluating the quality components of QA practices for teaching and learning in VTE. In addition, the questions and structures can accurately represent the diversity needed to capture the full range of factors relevant to quality assurance for teaching and learning in VTE in some developing nations.

Limitations. This study provides intriguing insights and attempts to address quality assurance in teaching and learning using sound literature and methodological foundations. However, there is measurable scope for further investigation. The following study limitations may present opportunities for future researchers: First, consider the sample's characteristic limitations. The study collected data from 259 respondents; future studies can increase the sample size to obtain diverse responses. The study elicited information from quality managers, administrators, and lecturers. In future research, students' opinions can be evaluated in QA practices for teaching and learning in VTE programs, especially during the psychometric evaluation stage, because students are at stake if quality assurance is lacking in VTE educational systems.

Furthermore, due to time constraints, only six colleges of education in the northeast region were sampled. Researchers could sample more areas in future studies to test the construct validity and reliability of the new measure so that the new scale can be used in more places to improve the generalizability of results. Also, although this study was limited to VTE programs offered at the colleges of education in Nigeria, future studies can test the validity and reliability of quality components of quality assurance practices for teaching and learning in VTE programs worldwide. Different cultural contexts and approaches to data treatment may diversify future studies. Also, further studies may use the instrument in various institutional training programs. However, this study was the first step in developing and validating a quality assurance instrument for teaching and learning in VTE. One of the instrument's limitations has to be the disproportionate number of items across factors. So, to ensure the tool is valid and reliable, the relationship between the number of items and the sample size needs to be considered.

Conclusion

The QATL is a reliable and valid instrument for assessing the quality components of QA practices for teaching and learning in VTE. Although more research is needed to strengthen the future

development of the QATL, preliminary findings suggest that this tool is a well-validated and practically comprehensive instrument for QA in teaching and learning in VTE programs and other quality assurance aspects. Quality factors for teaching and learning in VTE programs were examined and revealed high internal consistency and reliability in all the elements. The assessment of input, process, and output measures identify and provide valuable information for improving teaching and learning effectiveness. They also affect quality assurance for teaching and learning and could be used to strengthen VTE education systems.

Data availability

The data supporting the findings of this study are available upon request from the corresponding author.

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References

- Akareem HS, Hossain SS (2016) Determinants of education quality: what makes students' perception different? *Open Rev Educ Res* 6:52–67
- Aryal BP (2020) Financing technical and vocational education and training in Nepal. *J Educ Res* 10(1), 58–80
- Awodun AO, Boris OO (2020) Ensuring internal quality assurance in colleges of education in Nigeria: benefits and challenges. *Int J Res Innov Soc Sci IV(XI)*, 246–253
- Ayeni AJ (2017) Teachers' Classroom Management and Quality Assurance of Students' Learning Outcome in Secondary Schools in Ondo State, Nigeria. *J Soc Admin Sci*. <https://doi.org/https://www.researchgate.net/publication/318720481>
- Babenko V, Perevozova I, Kravchenko M, Krutko M, Babenko D (2020) Modern processes of regional economic integration of Ukraine in the context of sustainable development. The International Conference on Sustainable Futures: Environmental, Technological, Social and Economic Matters (ICSF 2020). vol. 166, 12001. Published online 22 Apr 2020
- Bai Y, Li J, Bai Y, Ma W, Yang X, Ma F (2018) Development and validation of a questionnaire to evaluate the factors influencing training transfer among nursing professionals. *BMC Health Serv Res* 18(1):1–9. <https://doi.org/10.1186/s12913-018-2910-7>
- Bateman A, Coles, M (2017) Towards quality assurance of technical and vocational education and training. In: UNESCO Bangkok. <https://eric.ed.gov/?id=ED592547>
- Braun V, Clarke V (2006) Using thematic analysis in psychology. *Qual Res Psychol* 3(2):77–101
- Choiriyah S, Kumaidi KB (2018) Developing delta internal quality assurance to evaluate the quality of Indonesian Islamic universities. *J Soc Stud Educ Res* 9(3):177–197. <https://doi.org/10.17499/jsser.36092>
- Darling-Hammond L, Flook L, Cook-Harvey C, Barron B, Osher D (2020) Implications for the educational practice of the science of learning and development. *Appl Dev Sci* 24(2):97–140. <https://doi.org/10.1080/10888691.2018.1537791>
- Garira E (2020) A proposed unified conceptual framework for quality of education in schools. *SAGE Open*. <https://doi.org/10.1177/2158244019899445>
- Ghavifekr S, Rosdy WAW (2015) Teaching and learning with technology: Effectiveness of ICT integration in schools. *Int J Res Educ Sci* 1(2):175–191. <https://doi.org/10.21890/ijres.23596>
- Kaiser H (1974) Analysis of factorial simplicity. *Psychometrika* 39(1):31–36
- Karam M, Fares H, Al-majeed S (2021) Quality assurance framework for the design and delivery of virtual, real-time courses. *Information* 12(2):93
- Knekta E, Runyon C, Eddy S (2019) One size doesn't fit all: Using factor analysis to gather valid evidence when using surveys in your research. *CBE Life Sci Educ* 18(1):1–17. <https://doi.org/10.1187/cbe.18-04-0064>
- Matorera D (2018) Quality management systems in education. *Intech* <https://doi.org/10.5772/intechopen.71431>
- Mohammad Gasmelseed AM (2021) Quality assurance practices in public technical and vocational education and training institutions in the Khartoum State-Sudan. *J Educ Soc Res* 11(5):21–31. <https://doi.org/10.36941/jesr-2021-0102>
- Moodley VR (2019) Towards a culture of quality assurance in optometric education in sub-Saharan Africa. *Afri Vis Eye Health* 78(1):1–8. <https://doi.org/10.4102/aveh.v78i1.462>

- Netshifhehe L, Nobongoza V, Maphosa C (2017) Quality assuring teaching and learning processes in higher education: a critical appraisal. *J Commun* 7(1):65–78. <https://doi.org/10.1080/0976691x.2016.11884884>
- Nogueira KSC, Fernandez C (2018) The reliability of an instrument to measure teacher knowledge from learners' perspective in the context of PIBID. *Probl Educ 21st Century* 76(1):69–86. <https://doi.org/10.33225/pec/18.76.69>
- OECD netFWD (2019) *Philanthropy and Education - Quality Education for all: Lessons and Future Priorities*, OECD Development Centre, Paris
- Okeke OJ (2019) Quality assurance in teaching and learning in tertiary institutions in Nigeria. *SSRN Electronic J*, June. <https://doi.org/10.2139/ssrn.2193791>
- Okorafor AO, Nnajiifo FN (2017) European Journal of Education Studies TVET policies and practices in Nigeria : why the GAP. 612–624. <https://doi.org/10.5281/zenodo.494996>
- Okoro C, Musonda I, Agumba J (2019) Validity and reliability of a questionnaire developed to explore nutrition determinants among construction workers in Gauteng, South Africa. *South African J Clin Nutr* 32(2):32–39. <https://doi.org/10.1080/16070658.2018.1438337>
- Okoye R, Arimonu MO (2016) Technical and vocational education in Nigeria: issues, challenges and a way forward. *J Educ Pract* 7(3):113–118
- Onwusa SC (2021) The issues, challenges and strategies to strengthen technical, vocational education and training in Nigeria. *Int J Res Innov Soc Sci* 5(5):48–59. <https://doi.org/10.47772/ijriss.2021.5502>
- Oviawe JI (2018) Revamping technical vocational education and training through public-private partnerships for skill development. *Makerere J High Educ* 10(1):73–91
- Oviawe JI (2020) Technical education lecturers' knowledge of students' engagement in application of interactive instructional strategies. *J Technol Humanit* 1, 1–10
- Rahman MRA, Mohd Nor MY, Abdul Wahab JL (2021) Does total quality management influence teacher quality? An empirical analysis. *Int J Acad Res Bus Soc Sci* 11(1):250–260. <https://doi.org/10.6007/ijarbss/v11-i1/8381>
- Randahn S, Niedermeier F (2017) Quality assurance of teaching and learning in higher education institutions. Module 3. In: *Training on internal quality assurance series*. <https://doi.org/10.17185/duerpublico/43224>
- Said A (2018) Vocational teaching-learning through the eyes of undergraduate, vocational students in Malta: a qualitative exploratory study. *Int J Res Vocat Educ Train* 5(1):42–63. <https://doi.org/10.13152/IJRVET.5.1.3>
- Samuels P (2016) *Advice on exploratory factor analysis*. Centre for Academic Success, Birmingham City University, June 2
- Taber KS (2018) The use of Cronbach's alpha when developing and reporting research instruments in science education. *Res Sci Educ* 48(6):1273–1296. <https://doi.org/10.1007/s11165-016-9602-2>
- UNESCO-UNEVOC (2017) *A synthesis of best practices in TVET quality assurance in selected South Asian countries*. UNEVOC Network
- Van der Scheer EA, Bijlsma HJE, Glas CAW (2019) Validity and reliability of student perceptions of teaching quality in primary education. *Sch Eff Sch Improv* 30(1):30–50. <https://doi.org/10.1080/09243453.2018.1539015>
- Watkins MW (2018) Exploratory factor analysis: a guide to best practice. *J Black Psychol* 44(3):219–246. <https://doi.org/10.1177/0095798418771807>
- Weide AC, Beauducel A (2019) Varimax rotation based on gradient projection is a feasible alternative to SPSS. *Front Psychol* 10:1–14. <https://doi.org/10.3389/fpsyg.2019.00645>
- Wipulanusat W, Panuwatwanich K, Stewart RA (2017) Exploring leadership styles for innovation: An exploratory factor analysis. *Eng Manage Prod Ser* 9(1):7–17. <https://doi.org/10.1515/emj-2017-0001>
- Wulandari SS, Trisnawati N, Suratman B, Narmaditya BS (2020) Factors affecting the quality of education: a comparison study in vocational high school in East Java. *Int J Psychosoc Rehabil* 24(07):8742–8747. <https://doi.org/10.37200/IJPR/V24I7/PR270855>
- Yang C.-C (2017) The evolution of quality concepts and the related quality management. *Intech, i(tourism)*, 13. <https://doi.org/10.5772/67211>
- Zelt S, Recker J, Schmiedel T (2018) Development and validation of an instrument to measure and manage organizational process variety. *PLoS ONE* 13(10):e0206198

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Author contributions

All the authors contributed equally to this work

Competing interests

The authors declare no competing interests.

Ethical approval

Ethical approval was obtained from the college of education's Research Ethics Committee of Hong, Azare, Bama, Gombe, Zing, and Potiskum. All procedures in this research followed relevant research guidelines and regulations. The methods used adhered to the tenets of the Declaration of Helsinki.

Informed consent

Before the research survey questionnaire, the participants were given a consent form, having read through and comprehended the study's purpose and objectives. All those who understood the purpose and goals of the research participated. The consent form included the authors' contact information for inquiries about the study and withdrawal from participation. We believe that the participants provided informed consent and that the institution's ethics committee granted permission to conduct the research. More so, the questionnaire survey instrument does not have any identifiable information.

Additional information

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