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Validating a Framework for Quality of Service in Open Distance Electronic Learning

RESEARCH ARTICLE

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ABSTRACT

Open Distance Electronic Learning (ODeL) has gained immense popularity due to its flexibility, convenience, and accessibility. However, ensuring quality of service (QoS) in ODeL in developing countries such as Ghana remains a significant challenge. This paper proposes a QoS framework (QoSODeL) that uses security, network bandwidth management, and conflict management as key elements to support smart education in Africa. Structural equation modeling, based on data from 551 participants (476 students, 53 lecturers, and 18 administrators), was used to validate the model. The QoS constructs showed high internal consistency, with Cronbach's alpha values for security, bandwidth management, and conflict management exceeding 0.9, and the model demonstrated good fit with an RMSEA below 0.05. The findings indicate that achieving QoS in ODeL in Africa requires careful consideration of these key elements.

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INTRODUCTION

Open distance electronic learning (ODeL) is learning by synchronous and asynchronous means transferred through internet technologies (Saleem et al., 2022). Such means of learning are mostly referred to as online learning. The quality of ODeL is described as the ease of use and access to just-in-time support by lecturers and administrators of an institution leading to all students' satisfaction (Saleem et al., 2022). Quality of service in open distance electronic learning is a major challenge to address by institutions engaged in such education. Quality in higher education is conceptualized by (Harvey & Green, 2006) as five discrete but interrelated quality viewpoints: exceptional, perfection (or consistency), fitness for purpose, and value for money. Achieving quality of service in ODeL is complex and involves multiple dimensions. The dimensions include curriculum design and course content, learning context, prompt feedback, learning outcomes assessment, learning environments, and support services (Hénard & Roseveare, 2012). According to Zuhairi et al. (2020), maintaining quality in ODeL requires a comprehensive integrated online student support system as mandatory.

Quality of service in the online environment, in general, becomes a part of the entire assessment of all services provided by the institution. High-quality service delivery in a virtual environment is one of the most critical challenges, as it is required to become the primary competitive institutional strategy in service-oriented organizations (Kim & Kim, 2020). According to Demir et al. (2020), most universities in recent times attempt to comprehend the strategic and financial implications of learners' perception of value for money as the key determinant of the success of ODeL platforms and the educational system in general. Further states that most researchers have only concentrated on appropriate levels of learners' satisfaction in the e-learning system due to the impact on learners' motivation and their successful completion rate.

It is revealed that ODeL environment provides benefits necessary for quality of service in education. One benefit from the lecturers' perspective is that multiple instructors from different locations with varying profiles can participate, enriching them with cultural and educational knowledge. The 2022 Online Education Trends Report by BestColleges.com indicated that online education offers access to a wider range of programmes and up-to-date knowledge across multiple fields. It also emphasized that online learning enables students to benefit more from advances in information and communication technology. In addition, the report highlighted that online study allows learners to balance their academic, professional, and personal lives more efficiently and comfortably (Foto et al., 2022).

As opined by Sadikin & Hamidah (2020), a unique challenge faced by ODeL is the distance between students and lecturers who are far apart, such that direct interaction, guidance, and supervision of student's activities in the learning process is limited (Sadikin & Hamidah, 2020).

In the view of Balasubramaniam et al. (2009), the generic and possible challenges faced by a service-oriented system such as ODeL are that the system and its compositions meet end-user quality requirements. Service providers should understand the cost and risk of attaining quality requirements, realizing that system qualities frequently require trade-offs or built-in. Service providers need enough information on choosing between alternative services with the same functional capability as well as QoS procedure to monitor and enforce service level agreements (Nsamba et al., 2021). Therefore, it is essential to develop standards for QoS in ODeL.

The work of Öztürk indicates that ODeL is on track to assume the mainstream of education (Öztürk, 2024). However, there are factors that impact the quantity and quality of ODeL. These including industry, government, country laws, information and communication technology infrastructures, internet and mobile technology diffusion, finances, and the digital divide (Palvia et al., 2018), hampering learning satisfaction (Abuhassna et al., 2023).

Research conducted by Gallego Sánchez et al. (2021) on the analysis of relational coordination and its relationship with the quality of universities' online education systems indicated that a higher level of educational quality is led by high-level relational coordination. Relational coordination is a validated tool to measure and analyze communication and relationship quality among participants in any process considering functional organizational boundaries. It suffices that coordination among factors such as security, network bandwidth, and conflict resolution in ODeL is necessary for QoS. They further characterize achieving QoS in two areas. First is the general quality of the learning environment and methodology, suggesting the consideration of efficient organizational

processes in decision making. The second is the technical quality under two dimensions including navigation and design, and multimedia resources (Gallego Sánchez et al., 2021).

In the heat of the COVID-19 pandemic, many or almost all schools at all levels introduced online learning (Kelebogile Mudau et al., 2022) which propel several research to evaluate the QoS in online education. For example, Shahzad et al. (2021) evaluated the impact of QoS on systems and information on users' satisfaction, system use, and success of e-learning portals. The findings indicated that system quality significantly affects users' satisfaction and will provide success to e-learning portals. Online learning using WhatsApp Group was suggested by Wargadinata et al. (2020) as the most effective during the COVID-19 pandemic due to its ease of use and minimal data requirement. It was revealed that telephonic-learning in ODeL is ineffective due to several challenges (Rosenberg et al., 2023).

The security of online learning environments is crucial for maintaining the confidentiality and integrity of educational data, user authentication, protecting learners from cyber threats, and ensuring trust in online learning (Aboderin, 2015) (Salvador, Llerena and Nguyen, 2021). However, there is a lack of research on the specific security challenges faced by African ODeL systems and how QoS frameworks can address these challenges.

Limited bandwidth is a major challenge for ODeL in many African countries (Faturoti, 2022). Effective bandwidth management strategies are necessary to ensure that learners can access educational content without disruption (Samyan and St Flour, 2021). However, there is a lack of research on the effectiveness of different bandwidth management approaches in African ODeL contexts.

Conflicts can arise in online learning environments, such as between learners and instructors or between learners themselves. Effective conflict management strategies are necessary to maintain a positive learning environment and ensure that learners can fully engage with the educational content (Martínez-Martín and Lozano-Martín, 2021). However, there is a lack of research on conflict management in African ODeL contexts.

Overall, more research is needed to address these and other gaps in our understanding of QoS frameworks for ODeL in Africa, particularly related to security, bandwidth management, and conflict management. Addressing these gaps will be crucial for ensuring that African learners can fully benefit from technology-enabled learning.

However, an assessment by Adnan and Anwar (2020) on the effectiveness of online education during the COVID-19 pandemic in the view of undergraduate and graduate students in Pakistan revealed that the desired output in underdeveloped countries could not be achieved. This is not different from Africa where almost all countries are underdeveloped.

It is stated by Ortiz-López et al. (2020) that a major success factor and guarantee to recent implementation and development of education on virtual platforms is quality assessment initiatives, programs, and strategies. Therefore, establishing quality evaluation standards on the processes, phases, and tools in online education will guarantee more reliable and effective smart virtual teaching and learning.

This research seeks to provide the following as key contributions:

- To investigate the critical QoS elements in ODeL that are capable of reorganizing and adapting to changes to provide smart education.
- To propose a framework incorporating methods and schemes to implement QoS adaptation in an ODeL.

Quality of service is a key component of making the current educational system smarter. Still, methods and schemes are not organized appropriately to achieve QoS in an open-distance electronic learning environment.

As a result, the following questions are asked to guide the study;

- RQ1. What are the critical quality of service elements in an open distance electronic learning environment?
- RQ2. How can the quality of service elements in ODeL be determined and modeled for smart education?

This study delimits QoS to three core elements, secure assessment, bandwidth management, and conflict management, because they represent the most critical risks to the credibility, accessibility, and fairness of ODeL in our context. Other QoS dimensions such as content design, interface usability are acknowledged but treated as outside the present scope to allow rigorous, in-depth analysis of these high-impact factors.

LITERATURE

Open distance electronic learning has gained popularity in recent years as almost all educational institutions completely or partially conducted teaching and learning online during the COVID-19 pandemic. With the enhanced flexibility about time and place, learning methods, and all-inclusiveness in terms of adult learners, learners with dependents, full-time employed learners, or learners with disabilities are enrolling in ODeL (Daniels Rahimi & Cohen Zilka, 2023).

A myriad of accredited institutions for QoS in online education focuses on diverse criteria for accreditation. The Council of Reginal Accreditation Commission through member organizations employs a peer review process to evaluate QoS at different education levels (C-RAC, 2020). The Accrediting Commission for Community and Junior Colleges Western Association of Schools and Colleges evaluates online learning QoS based on the availability of accurate application of procedures to determine whether substantial interaction is provided between the teacher and the learner in courses offered by distance education (Accjc, 2022). The Higher Learning Commission employs a checklist for evaluating the QoS on the consistency of program quality and learning goals in all modes and locations of delivery (HLC, 2019). The Distance Education Accrediting Commission provides relevant criteria for online learning in a handbook that includes adequate design and delivery of materials applying readily available and reliable technology (DEAC, 2022). The Online Learning Consortium is a membership resource institution for advocating QoS in online teaching and learning via workshops, consulting, and research (Online Learning Consortium, 2023).

Most regulatory agencies for accrediting ODeL employ evidence-based approaches to formulate standards and evaluation criteria. One such evaluation criteria is the Quality Matters (QM) framework which sets national QoS benchmarks for institutions to adapt using rubrics that meet the needs of diverse sectors in online education (Butcher & Wilson-Strydom, 2020).

The Ghana Tertiary Education Commission (GTEC) has expressed its requirement for accrediting full open distance education and pointed out the network bandwidth challenges, and some other conflicting issues that affect the quality of service (GTEC, 2016). The commission has, therefore, approved blended learning which requires tertiary institutions to conduct teaching online for some periods and have face-to-face meetings at some other periods.

According to Delva et al. (2019), evidence-based approaches are used in setting standards and evaluation norms for accrediting educational institutions. A popular evaluation criterion with checklist and commission is the quality frameworks and guidelines referred to as the Quality Matters (QM) framework. QM, a nonprofit organization advocates for the establishment of standards for online and blended courses. ODeL course evaluation is usually performed through a faculty-oriented peer review procedure using an evidence-based tool or rubric. The QM standards rely on eight categories including course overview, learner objectives, and measurement assessment, materials and resources, learner engagement, course technology, learner support, and accessibility (Quality Matters, 2021).

Although, studies have revealed that QM standards can be employed to monitor and adequately provide QoS in ODeL (Adair & Shattuck, 2015; Hollowell et al., 2017), however, there are no intelligent frameworks for ensuring a secured cheating-free learning environment, bandwidth management, and conflict management.

To evaluate the QoS in online learning, Baradaran and Ghorban (2020) proposed 13 latent variables that include reliable infrastructure, benefits and financial support, government support, educational facilities, perception and knowledge, quality classes engagements, entrance conditions, meeting students' needs, educational process, planning and flexibility of courses, information exchange, and professors' opinion. A model is proposed for assessing the higher distance education quality based on information and communication technologies. The model constitutes five criteria that include; Relevance, Curriculum plan, Academy, Institutional environment, and Students. The model employed 36 indicators (of which 24 are quantitative

and 12 are qualitative) providing explicit assessment elements. Further validation of the model to ascertain effectiveness in evaluating the quality of distance education at the Central University of Ecuador (Mejía-Madrid & Molina-Carmona, 2016). This indicates that identifying QoS elements and establishing an associated framework requires further validation.

Research conducted by Du et al. (2018) employed a service blueprint method to determine the service process in online learning systems. The contribution is to identify the key issues affecting the quality of users' feelings and construct evaluation indicators of QoS in online education. The users' feelings are defined by how secure they feel, accomplishing their activities that require continuous bandwidth availability with conflict-free operations in the learning environment.

The University of Texas-Pan American considers the quality of service in ODeL in three facets that constitute course materials quality, presentation quality, and student service quality. The individual quality aspects are addressed independently but also prioritize the synergistic interplay among them (Davies et al., 2001). This means that conflict management as a collective measure of all other QoS concerns needs a complete synergistic interplay of all individual solutions.

Mursidi and Soeharto (2016) proposed DIECU Model meaning Deciding, Implementation, Evaluate, Check, and Upgrading cycle. The model is designed for continuous improvement for sustainable quality assurance. The underlining concept of the DIECU Model is Internal Quality Assurance which requires academic institutions to implement a cyclic activity quality assurance system that begins with deciding on established standards or measurements of quality assurance by the universities. Implementation of the established standards of quality assurance is the next activity in the cycle. It follows with evaluating the standards to ascertain the fulfillment of quality assurance. Then continue checking the outcome of the standards on educational quality and make the necessary upgrade if there are deficiencies in them (Mursidi & Soeharto, 2016). To provide quality of service support to learners in ODeL, biometric-based smarter learning is proposed (Dafoulas et al., 2019). There is a need to decide on the main quality elements, implement them appropriately, conduct frequent evaluations, and constantly check and upgrade to meet current technological requirements.

Research has revealed many factors that contribute to the QoS in online learning or ODeL that are not limited to the learner, instructor, learning platform, and instructional design (Shao and Kang, 2021; Yu, 2022); limited technology access, telecommunication services, and internet (Saleem et al., 2022); effort expectancy, performance expectancy, social influence, and service quality (Perera and Abeysekera, 2022), technology intelligence, services interactivity, ease of information use, and ease of system use (Zhai et al., 2023). These and related literature have done well in identifying the factors influencing the QoS in ODeL but have not proposed model(s) based on the factors to improve the ODeL QoS. To provide such a solution, Kim et al. (2023) conducted a text-mining exploration analysis to determine e-learning topics on review data and constructed an integrated framework using an information system success model. They further established an experienced-based e-learning success model and validated it with a survey. This study has introduced a significant dimension to improving QoS in ODeL. However, it considers similar general factors such as system quality, lecture content, teaching quality, online interaction, and achievement with no focus on the key significant QoS elements in ODeL, security, network bandwidth management, and conflict management. Hence, leave room for further investigation on security, bandwidth management, and conflict management to enhance QoS in ODeL.

SECURED AND CHEATING FREE EXAMINATION AS QoS ELEMENT

Security is one of the major concerns of achieving QoS in the ODel environment. In a study, Graf (2002) proposed a framework for two concrete solutions for providing an improvement on specific security requirements in ODeL. The first part of the framework introduces secure testing on the part of the student and the second deals with confidentiality and copyright. It is revealed that one significant security issue with ODeL is effectively conducting online examinations and assessments (Glorin, 2021). Properly conducting online examinations is crucial for guaranteeing the validity of the learning certificate. According to Glorin (2021), rigorous research must be conducted to ensure effective techniques are employed to prevent cheating in ODeL. Authentication is an important security concern for QoS in ODeL among availability, integrity, and confidentiality (Huu et al., 2016). According to Graf (2002), the

authentication of users is an elementary feature for an ODeL system because it is the basis for access control, billing, maintenance of learning materials, user profiles, and certification. All other security issues faced by ODeL platforms are minimized by implementing appropriate and secured authentication mechanisms (Costinela-Luminita, 2011).

NETWORK BANDWIDTH MANAGEMENT AS QoS ELEMENT

The agents in ODeL require optimal bandwidth to aid in the download and upload of course materials (Huu et al., 2016). According to Taha and Kavehrad (2004), a multi-class network guarantees QoS in a more quality-demanding application such as ODeL and proposed a virtual demand distribution algorithm for dynamic bandwidth allocation. Krishnakumar et. al proposed a technique that combines deep learning and mathematical optimization algorithms to predict QoS on a dataset based on network throughput (Hollowell et al., 2017). The work by Supiyati et al. (2022) establishes that real communication and collaboration in learning interactions in ODeL systems are integral factors of effective online learning. The quality of ODeL is largely determined by the effectiveness of communication and collaborative systems operated by students, lecturers, and administrators. This is made possible through the continuous availability of communication media such as network bandwidth.

CONFLICT MANAGEMENT AS QoS ELEMENT

Many factors that constitute QoS parameters in ODeL include performance, cost, usability, and security. These four factors have been used to determine the overall quality of web services employing the Hidden Markov Model (Thirumaran et al., 2020). They elaborate on performance parameters as a measure of response time, execution time, turnaround time, availability time, and reliability. The cost is considered development cost and throughput whereas security includes authentication, integrity, authorization, nonrepudiation, and availability. The usability parameter includes service usage, user repudiation, reviews and ratings, feedback, and reviews (Thirumaran et al., 2020). These are critical factors in conflict management in web service platforms like ODeL. Issues relating to QoS in cloud computing e-learning applications are extensively reviewed, and a model for resolving the conflicts is proposed (Upadhyaya & Ahuja, 2017). It is pointed out that all ODeL services need to ensure that every service encounter is proactively managed to enhance QoS (Xu et al., 2009). However, Hershey et al. (2015) opine that the success of ODeL services increasingly depends on proper identification and understanding of the conflicting issues and variables related to QoS. Identifying such conflicting issues should be all-inclusive and not depend only on service level agreements made by service providers which have been observed to be mostly minimal on user-specific QoS criteria (Upadhyaya & Ahuja, 2017). Significant studies have been conducted on the quality of service in higher education. For instance, Kim-Soon et al. (2014) studied the relationship between the quality of e-service supporting learning, and the frequency of use of tools and learning resources for research and communication, administration, coordination, and evaluation. The satisfaction of students on ODeL platform on the QoS is affected by the online payment method which is considered a transaction conflict (Nasution et al., 2019).

CROSS REGINAL COMPARISAON OF QoS ELEMENTS

Cross-regional studies on QoS in ODeL reveals that secure assessment, bandwidth management, and conflict management are central but unevenly implemented across contexts. In Asian and African open universities, quality frameworks increasingly embed these elements within broader QA and accreditation systems, yet institutional capacity and infrastructure strongly shape outcomes (Weimin & Dhanarajan, 1999).

Academic integrity is paramount as QoS element with varying technological and regulatory solutions adopted by different regions (Slusky, 2020). The Asian and European institutions deploy AI-based online proctoring to address cheating in online examination. On the contrary, the African open universities mainly rely on blended models with secure face-to-face exam centers, continuous online assessment, or low bandwidth proctoring tools to mitigate limited connectivity while still reducing cheating (Amrane-Cooper et al., 2022; Fynn & Mashile, 2022).

QoS research stresses that stable bandwidth, low latency, and minimal packet loss are prerequisites for high-quality synchronous ODeL, particularly in video lectures, virtual labs, and

conferencing. High-income regions typically use QoS-aware campus networks, traffic shaping, and adaptive streaming to guarantee throughput for learning applications, whereas many African and rural Asian institutions still depend on heterogeneous Wi-Fi, satellite, or WiLD links that degrade sharply under load (Hussain & N, 2016).

Across regions, quality frameworks emphasize that conflicts around assessment fairness, workload, and communication must be actively managed to sustain trust in ODeL systems (Rassia & Manousou, 2025). Asian and European open universities often institutionalize grievance procedures, clear academic-integrity policies, and rapid escalation channels, while many African institutions still rely heavily on instructor-level resolution and informal mechanisms that can leave students feeling unheard (Artyukhov et al., 2025). Studies of ODeL assessment practice suggest that transparent marking rubrics, timely feedback, and participatory policy development reduce disputes and improve perceptions of procedural justice, making conflict management an operational QoS indicator rather than a purely administrative concern (Artyukhov et al., 2025).

METHODS

Methods and tools employed in the research are the focus of this section. The methodologies for evaluating the QoS elements for establishing the framework for ODeL service quality are discussed. It also considers the research's ethical considerations, the data sources used, the data analysis techniques used, and the validity and reliability considerations.

RESEARCH METHOD

To present a framework for intelligent quality of service in ODeL, this research uses the mixed method design to identify, prepare for, and integrate essential quality factors in ODeL. Approaches for user authentication and bandwidth management are based on quantitative and experimental methods. Conflict resolution techniques are based on qualitative methods. The overall QoS for the ODeL framework (QoSODeL) is established based on the merge of the three models, which are identified as the main QoS factors in ODel. A quantitative approach is then used to validate the framework for service quality. For simulation and validation, data was gathered through a university learning management system.

A researcher or research team mixes elements of qualitative and quantitative research procedures in mixed methods research (such as the use of qualitative and quantitative viewpoints, data collection, analysis, and inference techniques) for the basic aims of increasing the breadth, depth, and consistency of understanding (Johnson et al., 2007; Schoonenboom and Johnson, 2017). Distinguishing the aim for mixing in mixed methods research, Greene et al. (1989) indicated that complementarity aims to elaborate, improve, illustrate, and clarify the findings of one approach with those of another method.

Based on an examination of the justifications for integrating qualitative and quantitative research that the authors of mixed methods studies have suggested, Bryman (2006) developed the following list of more specific justifications for doing mixed methods research:

- Credibility – refers to claims that using both methodologies improves the reliability of results. A qualitative approach is used to identify and ascertain the credibility of the QoS elements in ODeL.
- Illustration – putting "flesh on the bones" of "dry" quantitative conclusions, or using qualitative data to illustrate quantitative findings. The qualitative identification of the QoS elements is illustrated with quantitative experiments.
- Confirm and discover – in a single project, this comprises developing hypotheses using qualitative data and testing them with quantitative data. A quantitative survey is employed to confirm the QoS element based on qualitative research.
- Utility, also known as improving the usefulness of findings – is the idea that combining the two methodologies will make the results more valuable to practitioners and other people. This idea is more likely to be prominent in papers with an applied focus. A QoS model fashioned out of the combined methods serve as a prototype for ODeL institutions and other virtual learning platforms.

This research, therefore, adopts the experimental and survey techniques in quantitative methods and utilizes qualitative methods to propose a framework for QoS in ODeL.

RESEARCH PROCEDURES

The research was carried out at a university that engaged in blended teaching and learning activities in an open-distance electronic platform (Moodle). The university has three campuses and three learning centers with a total student population of 6270, 127 full-time lecturers with over 200 part-time lecturers, and 105 administrative staff. The participant involved in the research is categorized as follows:

- For bimodal biometric user authentication

The sample comprises 261 males and 87 females, with 69 majoring in Computer Science and 244 majoring in Information Technology. Students majoring in information technology who are majoring in education make up the remaining 35. We used 20 third-year Information Technology students who were not part of the above sample as the imposter data set during the authentication step to evaluate the system's false acceptance rate (FAR).

In the first database, 520 data samples were recorded, of which 200 were movie images of the agents when they were in different locations around campus and 320 were still pictures of the agents. 315 still photos and 195 video images totaling 510 samples were recorded for the second database. These were gathered from students both on and off campus, at various points in their residence halls. These served as the algorithm's training data. When the pupils were out of the classroom, 480 samples—290 still photographs and 190 motion images—made up the data set for a third database.

- For multimodal biometric user authentication

The experiment participants consisted of 245 undergraduate students in a Bachelor of Education in Information Technology program on the Moodle learning management system in an online course. These participants were from three different campuses of the affiliated institution of the researcher. Out of the 245 students, 220 were registered into the system and 25 non-registered represented as imposters.

- For bandwidth management in ODeL

In evaluating the bandwidth management model, the university's lecturers (or Professors), students, and administrators participated in the experiment. The three campuses in three regions of the country and three learning centers in three other regions participated in the experiment. The student population used were over 4,000 from five different faculties, of which two-thirds of them were distance and sandwich students who do most of their learning activities online, and over 600 faculty members and staff working at the university. About 250 constitute the university's teaching staff, of which the remaining are the non-teaching staff who were involved in the experiment.

The administrators in charge had to designate lecturers for the courses, add students to them so they could enroll in the class, and then finalize the courses. Students of the various classes were from different parts of the country and some international students.

- For QoSODeL Validation

A total of 551 participants constituting 476 students, 53 lecturers, and 18 university administrators participated in the study. The study was carried out during the first session of the 2022/2023 academic year. The participants were from the three campuses of the university. Confirmatory factor analysis (CFA) and structural equation modeling (SEM) were used for data analysis. Due to the analytic approach, it is required to take the participants' number into account. Researchers have proposed varying criteria for determining the study group size. According to Preacher and MacCallum (2002), the minimum sample size should range from 100 to 250 while Schumacker and Lomax (2012) indicated that many studies used participants ranging from 250 to 500 and are appropriate for SEM analysis. Consequently, it was decided that the sample size for this investigation was adequate.

In the first phase, qualitative data on user experience of on an implemented system were used to surface how students, lecturers, and administrators experience QoS in ODeL, with particular attention to secure assessment, bandwidth, and conflict management. Codes and themes from this phase were then transformed into measurable indicators: each dominant theme was converted into one or more Likert-type items. Overlapping or weak themes were merged, while themes with strong stakeholder consensus were prioritized. The resulting item pool thus represents a direct quantification of stakeholder narratives, allowing the subsequent survey and CFA/SEM to statistically test patterns that were grounded in the earlier qualitative evidence.

The qualitative phase involved participants from a limited sample, which may restrict the transferability of some themes to other ODeL contexts or regions. Only three QoS dimensions, secure assessment, bandwidth management, and conflict management, were operationalized; other important aspects such as pedagogical design, learner support services were beyond the scope of this study and may influence QoS in ways not captured by the model. All quantitative measures relied on self-reported perceptions, which are vulnerable to social desirability bias and recall error, particularly on sensitive issues such as cheating and conflict. Cross-sectional data prevent causal claims; the structural paths in the SEM represent associations at one point in time rather than longitudinal change.

After initial pool of items was drafted from the qualitative themes a pilot testing and pre-CFA screening was conducted. The revised item set was piloted with a small sample of ODeL students and staff. Items with extreme skewness, very low item–total correlations, or weak loadings in an exploratory factor analysis (e.g., < 0.40 on the intended factor or strong cross-loadings) were deleted or reallocated. Redundant items with very high inter-item correlations were trimmed to keep the scales parsimonious. Only items that demonstrated conceptual alignment, acceptable reliability, and clean factor structure in the pre-CFA analyses were retained for the confirmatory factor analysis and structural modeling.

DATA COLLECTION TOOLS

Different instruments were used for data collection. Data for the user authentication experiments were obtained using a client-server on ODeL platform to gather male and female real-life data sets through the user machine-enabled web camera and keyboard.

SolarWinds bandwidth monitoring tool interfaced with an application based on the proposed model to monitor the network bandwidth. The e-Tutor learning management system was hosted on a single server that provides access to services. This research used such tools due to real-time tracking and network performance monitoring. Alerts are easily configured for correlated events, sustained situations, and complicated blends of device states. Monitoring network device and interface availability as well as performance metrics of bandwidth usage is the key to its acceptance.

A literature survey was conducted to identify smart education models useful for ODeL for reconstruction to incorporate conflict management to make ODeL platform smarter. Data collection for validation of the QoS elements in ODeL was through a questionnaire administered using the Microsoft Office form.

VALIDITY AND RELIABILITY MEASURES

This study has received ethical clearance from the relevant ethics committees, ensuring that all research activities were carried out in compliance with accepted ethical norms. Following a careful examination of the research design, which considered participant anonymity, informed consent, and the study's possible risks and benefits, ethical approval was given. Prior to participation, each person gave their agreement, and during the whole research procedure, their rights and welfare were upheld. This approval (refer in appendix) guarantees the integrity and accountability of the research by attesting to the study's adherence to ethical standards and norms.

RESEARCH DESIGN: DEVELOPMENT OF QoSODeL MODEL AND VALIDATION

The overall quality of service model for open distance electronic learning (QoSODeL) follows the integration of all the QoS elements. This integration is presented in Figure 1.

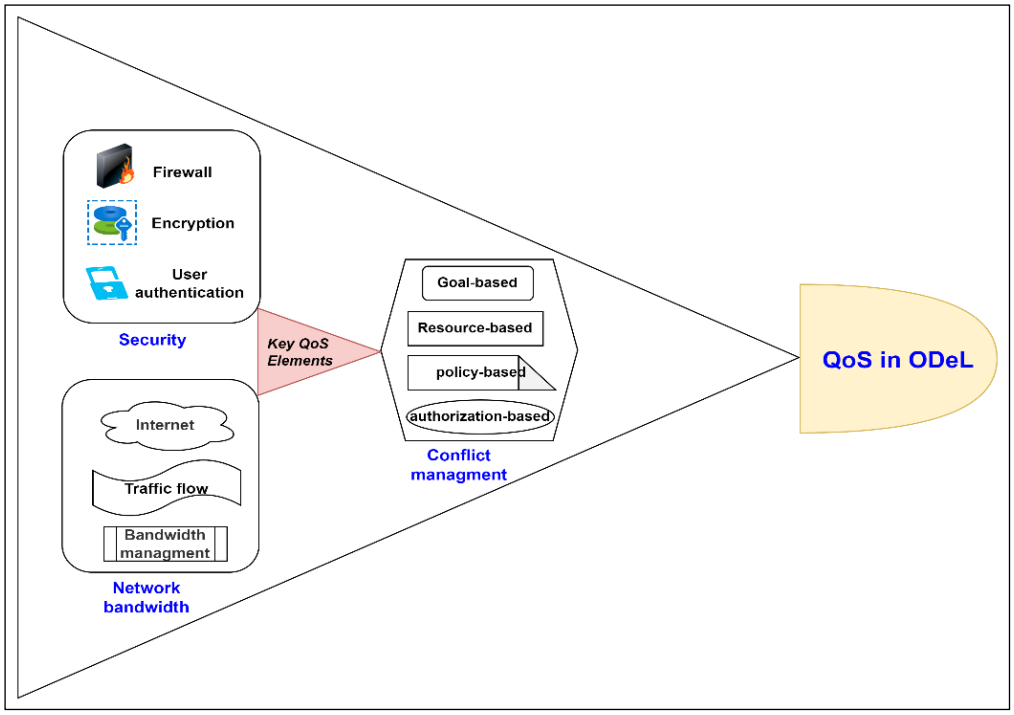

Figure 1 A model for quality of service in ODeL (QoSODeL).

The model constituents are the critical elements for QoS in ODeL which are evaluated in the works of (Amoako and Osunmakinde, 2020, 2022; Amoako, 2022).

VALIDATION OF QoSODeL

With respect to the validation of QoSODeL model, the data collection tool was a self-administered questionnaire through the application of Microsoft Office forms. The first part of the questionnaire constituted the data on profile; gender, age, designation, and study level of students of respondents. The second part employs the SERVQUAL model to obtain the data on the QoS in ODeL which each quality elements identified through the five dimensions (assurance, reliability, tangible, empathy, and responsiveness).

The updated SERVQUAL model that was suggested by Parasuraman et al. (1985) was employed in this research to evaluate the QoS based on security, network bandwidth management, and conflict management in the ODeL environment.

A significant number of works in the literature show the use of the SERVQUAL framework to assess service quality in many institutions (Wang et al., 2015). SERVQUAL was used in cross-sectional research to gauge students' quality of experience (Aboubakr & Bayoumy, 2022). Considering the implementation in academic institutions (Gilavand & Maraghi, 2019; Misaii et al., 2019), the summary of the questions for performance assessment of QoS dimensions is presented as:

- Assurance: Knowledge of systems, civility, and their capacity to inspire confidence. For example, standardized system requirements implementation to ensure security and cheating-free examination.
- Reliability: the capacity to carry out essential service accurately and dependably. This is to ensure the consistent availability of functional system resources such as appropriate bandwidth allocation.
- Tangible: This includes the physical surroundings, tools, and personnel appearance. This is to ensure consistent availability of learning resources, suitable study, and service timetables in order to prevent conflict.
- Empathy: Considerate and individualized attention that the institution provides to learners. For instance, instructors and staff are empathetic, enough advisors and staff to address learners' problems. In our case, minimizing ODeL conflict.
- Responsiveness: willingness to assist students and deliver quick service. This includes clear communication from the teachers and a system for receiving feedback, simple

access to the system and materials, courteous instructors and staff who give learners excellent service, and rapid turnaround times for services. This takes into consideration the three ODeL QoS elements in this research.

The questionnaire consisted of 25 items of which the first part with 4 items seeks to identify the significant profile of the respondents. On a 5-point Likert scale, the other 21 items collect the QoS determined by SERVQUAL: "strongly agree" (5), "agree" (4), "unsure" (3), "disagree" (2), and "strongly disagree" (1).

DATA ANALYSIS

The key elements for constructing an intelligent model for QoS in ODeL were accomplished through approaches for both quantitative and qualitative data analysis. The experimental process for user authentication used cross-validation based on the leave-p-out method (Liu, 2019) which 40 space difference intervals are taken into account for both testing and training for facial and voice recognition whereas an interval of 20 was used for keystroke dynamics authentication. To help assess the sensitivity and specificity of the data set, the researchers used a receiver operating characteristics curve. A confusion matrix was used to evaluate how well the data were categorized (Amoako & Osunmakinde, 2020). The study of the developed bandwidth management model's accuracy and precision was done by calculating the mean square error, mean absolute error, and root mean square error (Amoako & Osunmakinde, 2022). In the analysis of conflict management for QoS in ODeL for smart education, thematic analysis was used. The selected models for smart education in ODeL were examined to identify the thematic concepts to reconstruct the models to incorporate conflict management (Amoako, 2022). Thematic analysis has been found to be useful for qualitative research (Sharifi, 2022; Castleberry & Nolen, 2018) and for developing theoretical frameworks (Vaismoradi et al., 2013).

The overall intelligent QoS model, QoSODeL was analyzed by uploading the collected data from the respondents on the questionnaire administered on Office Form into Statistical Package for the Social Sciences (SPSS). The analysis of the QoS elements employed exploratory and confirmatory factor analyses and the construction of a structural equation model (SEM). The demographic features of the participants were examined. In factor analysis, it is stated that when a scale's Cronbach Alpha (α) value is .60 or higher, it is regarded as dependable; if it is .80 or higher, it is regarded as highly reliable (Kalayci, 2010). Field (2017) asserts that a scale with a value above .70 can be deemed to have an adequate reliability coefficient.

Particularly in the social sciences, the boundary value of factor loads can be decreased below 0.30 when the item quantity in a scale is constrained in confirmatory factor analysis (CFA) and exploratory factor analysis (EFA). Additionally, even though a factor load below 0.30 affects the content validity, studies can be done without removing the linked item from the scale (Osborne, 2014). Researchers utilized the AMOS 24.0 tool to conduct scale-level CFA and SEM analyses of the correlations (Shek & Yu, 2014). CFA typically is used after EFA to produce more precise statistical results (Kline, 2015). A SEM was also developed, and it is now a highly favored model because it is superior to other models for experimental or survey research that adheres to the concept of discovery and confirmation (Bagozzi & Yi, 2012; Hurley, 2022). This research, therefore, employed these to confirm the QoS elements suitable for constructing an intelligent model for ODeL.

FINDINGS AND DISCUSSION

Based on the defined QoS factors, this section discusses and evaluates the overall quality of services in ODeL. The results of the quantitative survey to validate the QoS elements in ODeL are analyzed.

EVALUATION OF DEMOGRAPHIC DATA

In Table 1, the status of the participant distribution is presented indicating over 88 percent were students. This is very useful because the students are the most beneficial stakeholders in the QoS of ODeL. Table 2 displays the participants' gender breakdown.

STATUS	FREQUENCY	PERCENTAGE
Administrator	14	2.5
Lecturer	49	8.9
Student	488	88.6
Total	551	100.0

Table 1 Status distribution.

Table 1 presents the status of distribution of the participants which indicate students as the highest participants with administrators being the least.

GENDER	FREQUENCY	PERCENTAGE
Male	471	85.5
Female	78	14.5
Total	551	100

Table 2 Gender distribution.

The results in Table 2 show a majority of male respondents, i.e., about four times more males than females in the institution. Table 3 presents the age ranges of the respondents.

AGE RANGE	FREQUENCY	PERCENTAGE
Less than 20	5	0.9
20–25	43	7.8
26–30	173	31.4
31–35	162	29.4
36–40	80	14.5
41 and above	88	16.0
Total	551	100

Table 3 Age range distribution.

The results in Table 3 show that over 60 percent of the respondents ages from 26 to 35. This indicates that most of the respondents in the age range were familiar with technology and were able to provide reliable responses. Considering the students, the distribution of their levels was obtained as presented in Table 4.

STUDENT LEVEL	FREQUENCY	PERCENTAGE
Level 100	5	1.0
Level 200	64	13.1
Level 300	145	29.7
Level 400	238	48.8
Postgraduate	36	7.4
Total	488	100

Table 4 Student level.

Table 4 shows that most of the students who took part in the survey were in levels 300 and 400. This is quite significant for the determination of the QoS in the ODeL platform since they have had enough experience in the university than the lower levels. They also participated in both online and face-to-face classroom instruction at the university.

QoSODeL MODEL VALIDATION

This research used the Analysis of Moment Structure – AMOS version 23 program, as mentioned in the methodology, for the CFA of scales and SEM to identify the correlations. Figure 2 displays the SEM in detail.

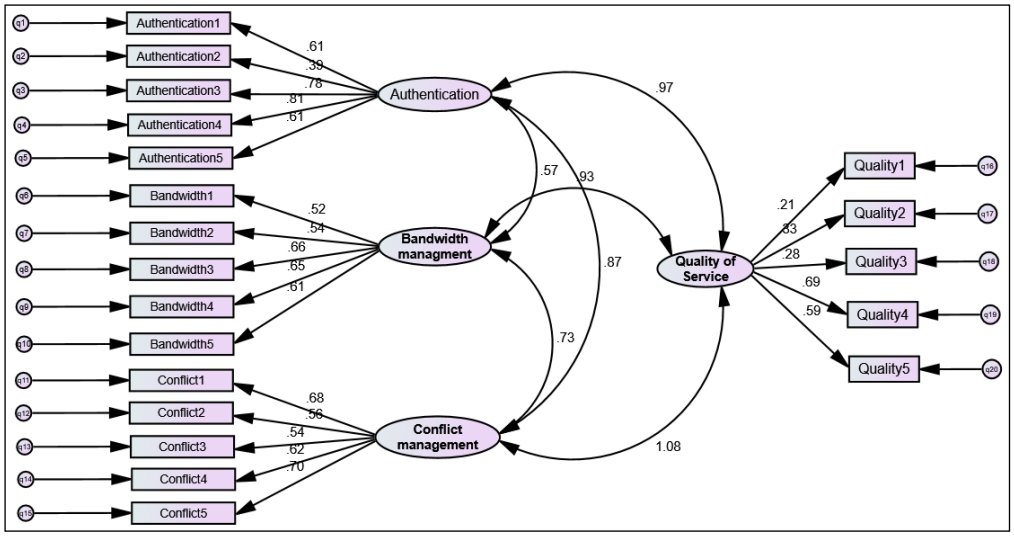

Figure 2 Confirmatory factor analysis model of the scale of QoSODeL.

The Intelligent Quality of Service Model for ODeL involves three factors and 25 items established based on SERVQUAL model. Internal consistency analysis performed by Cronbach Alpha revealed that the total scale's internal consistency was α = .924. Five-point Likert-type items on the scale were assessed as "strongly agree", "agree", "unsure", "disagree", or "strongly disagree". Furthermore, the scale's CFA was performed, and it was found that the fit indices were within acceptable boundaries.

First, all items under the overall quality of service aspect in the data collected for this study were changed to positive. For factor analysis, the data were suitable since the values of Chi-square (CMIN) = 1521.762, degrees of freedom (DF) = 1064, and likelihood ratio (p) = .000 are all in the acceptable range.

Table 5.9 shows the indexes and parameters that make up the model fit results in AMOS. The results are compared with the acceptable fit values referenced by Uedufy (2022).

Table 5 Model fit results.

FIT INDEX	MEANING	MODEL FIT RESULTS	RECOMMENDED VALUES	SOURCE
Likelihood Ratio	P-value	**0.000**	**≥ 0.05**	(Joreskog & Sorbom, 1996)
CMIN/DF	Chi-square divided by Degree of Freedom	**1.430**	**≤ 3** = acceptable fit	(Kline, 1998)
			≤ 5 = reasonable fit	(Marsh & Hocevar, 1985)
GFI	Goodness of Fit Index	**0.921**	**1** = perfect fit	
			≥ 0.95 = excellent fit	(Kline, 2005)
			≥ 0.9 = acceptable fit	(Hu & Bentler, 1998)
AGFI	Adjusted Goodness of Fit Index	**0.911**	**≥ 0.90** = acceptable fit	(Tabachnick & Fidell, 2007)
CFI	Comparative Fit Index	**0.920**	**1** = perfect fit	
			≥ 0.95 = excellent fit	(West, Meserve & Stanovich, 2012)
			≥ .90 = acceptable fit	(Fan, Thompson & Wang, 1999)
RMSEA	Root Mean Square Error of Approximation	**0.044**	**≤ 0.05** = reasonable fit	(MacCallum, Browne & Sugawara, 1996)
RMR	Root Mean Squared Residual	**0.054**	**≤ 0.05** = acceptable fit	(Diamantopoulos & Siguaw, 2000)
			≤ 0.07 = acceptable fit	(Steiger, 2007)
SRMR	Standardized Root Mean Squared Residual	**0.045**	**≤ 0.05** = acceptable fit	(Diamantopoulos & Siguaw, 2000)
CN	Critical N	**230**	**≥ 200** = acceptable fit	(Joreskog & Sorbom, 1996)

The results in Table 5 show that the model matched the gathered data. The objects' factor loads ranged from 0.21 to 1.08. The internal consistency coefficient scale had the following Cronbach Alpha values: user authentication is a key factor in ODeL QoS = 0.94, bandwidth management is a key factor in ODeL QoS = 0.88, proactive conflict management is a key factor in ODeL QoS = 0.96 and overall scale = 0.94. The value of 57.183% of this three-factor scale explains the total variance.

CFA was used to test the structure created by EFA. The modification indices (M.I.) were considered to determine the scale's proper (fit) values in terms of fit indices. In accordance with the modification indexes and suggestions, four items were removed from the scale, and four error covariances were generated (q2, q16, q17, and q18).

Compactly, the relative chi-square is low (CMIN/DF = 1.43), and absolute fit indices (GFI = 0.921, AGFI = 0.911) exceed the 0.90 threshold, suggesting acceptable global fit. Incremental indices (CFI = 0.920) also surpass 0.90, and error indices (RMSEA = 0.044, SRMR = 0.045, RMR = 0.054) are below commonly used cut-offs, indicating small residual misfit. Finally, CN = 230 is above 200, supporting model stability for the available sample.

It is therefore evident that achieving quality of service in ODeL requires the consideration of secure cheating-free examination based on suitable authentication techniques with appropriate network bandwidth allocation schemes and a proactive conflict management model.

Across regions, ODeL quality discussions show clear contrasts. In high-income systems (Europe, North America, parts of Asia), secure e-assessment, network performance, and student support are often embedded in mature QA regimes and backed by strong infrastructure and regulation (Farid et al., 2018). In many African and low-resource contexts, the same three areas emerge as binding constraints, limited bandwidth, fragile exam security, and weak conflic-thandling procedures directly undermine learner trust and completion (Lifuka, 2025). The focuse on this triad is empirically defensible as targeting the most problematic QoS gaps. Conceptually, the triad sits well with SERVQUAL, such that secure assessment extends reliability and assurance, ensuring accurate, trustworthy, cheating-resistant service. Bandwidth management underpins reliability and tangibles affirming the technical service platform actually works when needed. Conflict management operationalizes responsiveness, empathy, and assurance, promoting fair, timely handling of disputes and complaints.

Therefore the QoSODeL model is a contextspecific elaboration of SERVQUAL for high-stakes ODeL: it retains SERVQUAL's human-service dimensions but makes the digital infrastructure (bandwidth) and academic integrity (secure assessment) explicit because they are central to distance learning but only implicit in the original scale.

However, some studies report that students prioritise content quality, instructor presence, or ease of use above security or conflict procedures, especially in low-stakes courses; others find that good pedagogical and social support can compensate to some extent for bandwidth problems (Ramdass & ŊEmavhola, 2018). The QoSODeL is a complementary to the overall QoS to prior research to highlight a broad set of QoS drivers. The evidence of this research suggests that, in credential-oriented ODeL in resource-constrained settings, failures in secure assessment, bandwidth, or conflict resolution are non-negotiable bottlenecks that can negate improvements in other SERVQUAL dimensions.

CONCLUSION, IMPLICATIONS AND SUGGESTIONS

This study investigated QoS elements concentrating on security with specific reference to authenticating examinees to provide cheating-free ODeL. The second element is bandwidth management focusing on allocating limited bandwidth to massive users on ODeL platform using Moodle. The third element is conflict management with the view of establishing a proactive conflict management model in ODeL. The evaluations of the three key elements referenced from existing works (Amoako & Osunmakinde, 2020, 2022; Amoako, 2022) provided significant results to improve the QoS in ODeL and therefore serve as key elements of QoS framework for ODeL in Ghana as a case and in Africa as a whole. The results of the survey based on the SERVQUAL and validated through confirmation factor analysis indicate that security, bandwidth management, and conflict management are key factors to achieving quality of service in open distance electronic learning in the Ghanaian context. However, there are other significant factors that are necessary for QoS in ODeL that this research could not consider.

The implications of proposing a framework for ODeL based on security, bandwidth management, and conflict management are significant. Such a framework could help to ensure that ODeL is safe, reliable, and effective for learners and educators. It could also help to address some of the challenges of online learning, such as cyber-attacks, bandwidth limitations, and conflicts. By addressing these challenges, a framework for ODeL could improve the quality of online learning

and increase the number of learners who can benefit from it. The implementation of such a framework would require cooperation and collaboration among stakeholders in the education sector, including educators, policymakers, and technology providers.

Quality of service is a key component of making the current educational system smarter. Still, methods and schemes are not organized appropriately to achieve it in an open-distance electronic learning environment. The research achieved this objective with the construction of the intelligent model for quality service in ODeL (QoSODeL) based on the integration of the QoS elements evaluated. The QoSODeL model is then validated with a survey of the participants in the experimental processes using the SERVQUAL model. The analysis was accomplished with a confirmatory factor analysis using AMOS. It was evident from the analysis results as benchmarked with the recommended standard model fit values such as P-value, Comparative Fit Index, Goodness of Fit Index, and the others were within range. It is therefore concluded that QoS in ODeL is dependent on secure cheating-free examination, appropriate network bandwidth distribution, and proactive conflict management in the context of Ghana.

It is worth stating the following actionable recommendations:

- Institutions should prioritise hardening secure online assessment by combining multi-factor authentication, lockdown browsers, and structured invigilation policies, and auditing exam logs after each high-stakes sitting.
- Network units should implement bandwidth-management policies that prioritise examination traffic and core learning platforms during assessment windows, with contingency offline or low-bandwidth options for students in poorly connected regions.
- Student affairs offices should formalise conflict-management procedures for ODeL (clear grievance channels, time-bound resolution standards, and transparent communication of outcomes) to sustain trust in remote assessment decisions.

Further future research will focus on:

- Conducting a comparative cross-regional studies that empirically test how the secure-assessment, bandwidth, conflict triad predicts persistence, achievement, and satisfaction in different ODeL systems.
- The use of longitudinal or experimental designs to examine whether specific interventions such as new proctoring tools, bandwidth-prioritisation policies, or redesigned grievance processes) causally improve QoS perceptions and learning outcomes.

DATA ACCESSIBILITY STATEMENT

The authors can make the data available upon request found in the link below.

https://doi.org/10.5281/zenodo.17970013.

SUSTAINABLE DEVELOPMENT GOALS

This study is linked to the following SDG(s): Quality education (SDG 4).

ETHICS AND CONSENT

This research received ethical clearance from the UNISA College of Science Engineering and Technology Ethics Committee with reference number: 2021/CSET/SOC/050.

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COMPETING INTERESTS

The authors have no competing interests to declare.

AUTHOR CONTRIBUTIONS

Prince Yaw Owusu, Amoako: Conceptualization, methodology, formal analysis, investigation, data curation, visualization, writing—original draft preparation, writing—review and editing; Ernest Mnkandla; supervision, project administration, Resources, writing—review and editing; Michael Agyemang Adarkwah; Formal Analysis, data curation, writing—review and editing. All authors have read and agreed to the published version of the manuscript.

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