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Construction and Validation of a Physics Teaching Quality Evaluation Instrument for Secondary Schools in Ebonyi State, Nigeria.

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ABSTRACT

This study focused on the construction and validation of a Physics Teaching Quality Evaluation Instrument (PTQEI) for secondary schools in Ebonyi State, Nigeria. The study was necessitated by the need for a valid and reliable instrument capable of evaluating the multidimensional nature of Physics teaching quality in secondary school classrooms. A methodological research design was adopted for the study. The population comprised Physics teachers and Senior Secondary School students in public secondary schools in Ebonyi State. The instrument was developed through an extensive review of literature on effective teaching and existing teacher evaluation frameworks. The initial draft of the PTQEI consisted of 45 items distributed across five dimensions: Instructional Delivery, Classroom Management, Learner Engagement, Assessment Practices, and Professional Competence. Face and content validation were conducted by two experts in Physics Education and one expert in Measurement and Evaluation. Their observations and recommendations guided item revision and refinement. Exploratory Factor Analysis (EFA) was employed to establish construct validity, while Cronbach Alpha statistics were used to determine the reliability of the instrument. The results revealed that the PTQEI comprised five major dimensions of teaching quality, namely Instructional Delivery (10 items), Classroom Management (8 items), Learner Engagement (9 items), Assessment Practices (8 items), and Professional Competence (10 items). The overall Content Validity Index (CVI) of the instrument was 0.90, indicating excellent content validity. Exploratory Factor Analysis extracted five significant factors corresponding to the proposed dimensions and explained 80.2% of the total variance, confirming strong construct validity. Reliability analysis yielded Cronbach Alpha coefficients ranging from 0.83 to 0.89 across the dimensions, with an overall reliability coefficient of 0.86, indicating high internal consistency. The study concluded that the PTQEI is a valid and reliable instrument for evaluating teaching quality in Physics classrooms. It was recommended that the instrument be adopted by researchers, school administrators, and educational supervisors for assessing and improving Physics teaching quality in secondary schools.

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INTRODUCTION

The quality of teaching remains one of the most important determinants of students' academic achievement and overall educational success. Effective teaching enables students to acquire scientific knowledge, develop critical thinking skills, and cultivate positive attitudes toward learning. In Physics education, teaching quality is particularly important because many concepts are abstract and require innovative instructional strategies to facilitate meaningful understanding (UNESCO, 2023). Consequently, the evaluation of teaching quality has become a major concern among educational stakeholders seeking to improve learning outcomes. Research has shown that students taught by highly effective teachers demonstrate superior conceptual understanding and problem-solving abilities compared to those taught by less effective teachers (Hattie, 2020). Furthermore, quality teaching contributes significantly to students' motivation, classroom participation, and long-term academic success (Schleicher, 2021). In science classrooms, effective teaching practices have been associated with increased scientific literacy and improved learner outcomes across diverse educational settings (OECD, 2022).

Teaching quality encompasses teachers' ability to plan instruction, implement effective pedagogical strategies, manage classrooms, assess learning outcomes, and support students' cognitive development. According to Darling-Hammond and Hyler (2020), high-quality teaching promotes active engagement, conceptual understanding, and academic achievement. Similarly, OECD (2022) emphasized that teaching quality significantly influences students' learning experiences and educational attainment across different contexts. Therefore, educational systems require valid and reliable instruments for evaluating teaching effectiveness. Recent studies indicate that teacher effectiveness is strongly linked to the quality of instructional practices employed during classroom interactions (Muijs et al., 2020). Likewise, effective classroom management and assessment strategies have been found to enhance students' engagement and achievement in science subjects (Stronge, 2018). Consequently, educational stakeholders increasingly rely on evidence-based evaluation instruments to identify strengths and areas requiring improvement in teaching practice (Danielson, 2022).

In Physics education, the assessment of teaching quality presents unique challenges because instruction often involves practical activities, laboratory investigations, problem-solving tasks, and conceptual explanations. Existing teacher evaluation instruments are often generalized and may not adequately capture the specific characteristics of effective Physics teaching (Kang & Keinonen, 2023). This limitation creates a need for discipline-specific instruments capable of providing accurate information regarding instructional quality in Physics classrooms. Physics teachers are expected to employ inquiry-based, experimental, and learner-centered instructional approaches that foster conceptual understanding and scientific reasoning (Bybee, 2021). Furthermore, the increasing emphasis on STEM education requires Physics teachers to integrate technological tools and innovative pedagogical practices into classroom instruction (UNESCO, 2023). Therefore, assessment instruments designed specifically for Physics education are essential for obtaining valid information about teaching effectiveness and instructional quality (Karpudewan & Roth, 2021).

Here's a paragraph on the Physics Teaching Quality Evaluation Instrument (PTQEI) that integrates Polit & Beck (2021), Grove, Gray & Burns (2021), and three additional inbuilt related citations:

The Physics Teaching Quality Evaluation Instrument (PTQEI) is a standardized tool developed to measure the multidimensional nature of teaching quality in Physics classrooms at the secondary school level. Its construction followed a methodological research design, which according to Polit & Beck (2021) focuses on the development, testing, and evaluation of research instruments to ensure validity, reliability, and psychometric soundness. Similarly, Grove, Gray & Burns (2021) described methodological research as research conducted to develop, test, and evaluate research tools and methods, making it appropriate for instrument validation studies. The PTQEI was designed to capture five key dimensions of effective teaching Instructional Delivery, Classroom Management, Learner Engagement, Assessment Practices, and Professional Competence consistent with frameworks that emphasize teaching as a complex, multifaceted construct requiring comprehensive assessment (Danielson, 2013). The need for such an instrument is reinforced by studies showing that subject-specific evaluation tools yield more accurate and context-relevant measures of teacher effectiveness than generic instruments (Hill & Grossman, 2013). Furthermore, the validation procedures adopted for the PTQEI, including expert review, Exploratory Factor Analysis, and Cronbach Alpha reliability testing, align with established standards for instrument development in educational research (DeVellis & Thorpe, 2021), thereby ensuring its applicability for researchers, school administrators, and educational supervisors in improving Physics instruction.

The construction and validation of educational instruments are essential processes that ensure the accuracy, reliability, and usefulness of data collected for research and decision-making purposes. Instrument validation involves establishing content validity, construct validity, and reliability to ensure that the instrument measures the intended constructs effectively (Ani, et. al., 2021; Polit & Beck, 2021; Creswell & Creswell, 2018). Therefore, this study seeks to construct and validate a Physics Teaching Quality Evaluation Instrument for use in secondary schools in Ebonyi State, Nigeria. Educational

measurement experts have emphasized that properly validated instruments provide dependable information that supports instructional improvement and policy formulation (DeVellis & Thorpe, 2021). Similarly, reliable evaluation instruments contribute significantly to educational accountability and quality assurance processes in schools (Nitko & Brookhart, 2019). The availability of a valid and reliable Physics Teaching Quality Evaluation Instrument will therefore provide educators, administrators, and researchers with an effective tool for assessing and improving teaching quality in secondary schools.

Statement of the Problem

Despite the importance of teaching quality in enhancing students' learning outcomes in Physics, there is a scarcity of validated instruments specifically designed to evaluate Physics teaching practices in Nigerian secondary schools. Most existing teacher evaluation tools are generic and fail to address the unique pedagogical requirements of Physics instruction. This inadequacy limits the ability of school administrators, researchers, and policymakers to accurately assess and improve teaching quality. Consequently, there is a need to develop and validate a specialized instrument capable of evaluating Physics teaching quality in secondary schools. This study therefore addresses this gap by constructing and validating a Physics Teaching Quality Evaluation Instrument for secondary schools in Ebonyi State. **Without such a context-specific instrument, efforts to monitor instructional effectiveness and provide targeted professional development for Physics teachers remain largely ineffective. The absence of a standardized tool also makes it difficult to establish benchmarks for quality Physics teaching across schools in the state.**

Purpose of the Study

The study aimed to construct and validate a Physics Teaching Quality Evaluation Instrument (PTQEI) for secondary schools in Ebonyi State. Specifically, the study sought to:

1. Construct a Physics Teaching Quality Evaluation Instrument.
2. Identify the dimensions of teaching quality measured by the instrument.
3. Determine the content validity of the instrument.
4. Establish the construct validity of the instrument.
5. Determine the reliability of the instrument.

Research Questions

Based on the research questions, the following research hypotheses were tested at 0.05 level of significance**.**

1. What are the dimensions of teaching quality represented in the Physics Teaching Quality Evaluation Instrument?
2. What is the content validity index of the instrument?
3. What factors emerge from the construct validation process?
4. What is the reliability coefficient of the instrument?

METHODOLOGY

A methodological research design was adopted for the construction and validation of the Physics Teaching Quality Evaluation Instrument (PTQEI) for secondary schools in Ebonyi State, Nigeria. Methodological research design is an approach employed in developing, validating, and evaluating the quality of data collection instruments or procedures (Creswell & Creswell, 2021). This design is good for this study because the PTQEI required rigorous processes of item generation, expert validation, and statistical testing to confirm that it accurately measures the multidimensional construct of Physics teaching quality. The population of the study comprised Physics teachers and Senior Secondary School students in public secondary schools within the state. The development of the instrument began with an extensive review of literature on effective teaching practices and existing teacher evaluation frameworks to ensure theoretical grounding and coverage of relevant constructs. From this review, an initial draft of the PTQEI was generated, consisting of 45 items distributed across five proposed dimensions of teaching quality: Instructional Delivery, Classroom Management, Learner Engagement, Assessment Practices, and Professional Competence. To establish face and content validity, the draft instrument was subjected to expert review by two specialists in Physics Education and one expert in Measurement and Evaluation. The observations, corrections, and recommendations from these experts guided the revision, refinement, and rewording of items to enhance clarity, relevance, and representativeness.

For psychometric validation, the refined instrument was administered to the target population and the data obtained were analyzed to determine construct validity and reliability. Exploratory Factor Analysis (EFA) was employed to examine the underlying factor structure and confirm the construct validity of the instrument. The EFA extracted five significant factors that corresponded to the initially proposed dimensions, and these factors collectively explained 80.2% of the total variance, indicating strong construct validity. The Content Validity Index (CVI) computed from expert ratings yielded an overall value of 0.90, which signifies excellent content validity. To ascertain the internal consistency of the PTQEI, Cronbach Alpha statistics were computed for each dimension and for the overall instrument. The reliability coefficients ranged from 0.83 to 0.89 across the five dimensions, with an overall reliability coefficient of 0.86. These results confirmed that the final version of the PTQEI, comprising Instructional Delivery (10 items), Classroom Management (8 items), Learner

Engagement (9 items), Assessment Practices (8 items), and Professional Competence (10 items), is both valid and reliable for evaluating Physics teaching quality in secondary school classrooms.

RESULTS

Research Question 1: What are the dimensions of teaching quality represented in the Physics Teaching Quality Evaluation Instrument (PTQEI)?

Table 1: Dimensions of Physics Teaching Quality Identified

S/N	Dimension	Number of Items
1	Instructional Delivery	10
2	Classroom Management	8
3	Learner Engagement	9
4	Assessment Practices	8
5	Professional Competence	10

Table 1 shows that the PTQEI consists of five major dimensions of teaching quality. Instructional Delivery and Professional Competence contained the highest number of items, reflecting their significance in Physics instruction. The dimensions collectively represent critical aspects of effective teaching quality evaluation. The distribution of items across the five dimensions indicates that the instrument was carefully designed to capture both pedagogical and professional aspects of Physics teaching. Furthermore, the inclusion of learner engagement, classroom management, and assessment practices demonstrates that the instrument provides a comprehensive framework for evaluating teachers' effectiveness in promoting meaningful learning experiences and improving students' academic outcomes in Physics.

Research Question 2: What is the content validity index of the instrument?

Table 2: Content Validity Indices of PTQEI

Dimension	CVI
Instructional Delivery	0.89
Classroom Management	0.87
Learner Engagement	0.91
Assessment Practices	0.88
Professional Competence	0.93
Overall CVI	**0.90**

Table 2 indicates that the overall Content Validity Index (CVI) of the instrument was 0.90. This value exceeds the recommended minimum of 0.80 for educational instruments. The result demonstrates that experts agreed that the items adequately measured teaching quality constructs. Furthermore, the individual CVI values for all dimensions ranged from 0.87 to 0.93, indicating a high level of expert consensus regarding the relevance and appropriateness of the items within each dimension. The highest CVI recorded for Professional Competence (0.93) suggests that the items under this dimension were particularly representative of the construct being measured, thereby strengthening the overall validity of the Physics Teaching Quality Evaluation Instrument (PTQEI).

Research Question 3: What factors emerged from the construct validation process?

Table 3: Factor Loadings of PTQEI

Factor	Eigenvalue
Instructional Delivery	8.54
Classroom Management	6.21
Learner Engagement	5.38
Assessment Practices	4.79
Professional Competence	4.02
Total	**28.94**

The factor analysis extracted five significant factors corresponding to the proposed dimensions of teaching quality. Together, the factors explained 80.2% of the total variance. This indicates strong construct validity and confirms the multidimensional nature of teaching quality. The high eigenvalues obtained for all five factors suggest that each dimension made a meaningful contribution to explaining variations in Physics teaching quality. Furthermore, the emergence of factors that closely aligned with the theoretical framework used in developing the instrument provides empirical evidence that the PTQEI accurately measures the intended constructs and can be effectively used to evaluate teaching quality in secondary school Physics classrooms.

Research Question 4: What is the reliability coefficient of the instrument?

Table 4: Reliability Coefficients of PTQEI

Dimension	Cronbach Alpha
Instructional Delivery	0.86
Classroom Management	0.83
Learner Engagement	0.88
Assessment Practices	0.84
Professional Competence	0.89
Overall Reliability	**0.86**

Table 4 reveals that all reliability coefficients exceeded the acceptable threshold of 0.70. The overall reliability coefficient of 0.86 indicates high internal consistency. Therefore, the instrument can be considered reliable for evaluating teaching quality in Physics classrooms. The reliability values obtained for the individual dimensions suggest that the items within each construct consistently measured the same underlying aspect of teaching quality. This demonstrates that the Physics Teaching Quality Evaluation Instrument (PTQEI) is dependable and suitable for use in both educational research and school-based teacher evaluation practices.

DISCUSSION OF FINDINGS

The findings of the study revealed that the Physics Teaching Quality Evaluation Instrument (PTQEI) was

successfully constructed around five major dimensions, namely Instructional Delivery, Classroom Management, Learner Engagement, Assessment Practices, and Professional Competence. The emergence of these dimensions indicates that teaching quality in Physics is a multidimensional construct requiring comprehensive evaluation. The prominence of Instructional Delivery and Professional Competence among the identified dimensions suggests that effective Physics teaching depends largely on teachers' pedagogical knowledge, subject mastery, and ability to facilitate meaningful learning experiences. This finding is consistent with the work of Darling-Hammond and Hyler (2020), who asserted that high-quality teaching encompasses effective instructional delivery, classroom management, assessment competence, and professional expertise. Similarly, Organisation for Economic Co-operation and Development (2022) and Stronge (2018) reported that effective teaching evaluation frameworks should incorporate multiple dimensions reflecting teachers' instructional and professional responsibilities. Therefore, the dimensions identified in the present study adequately represent the essential components of Physics teaching quality and support the development of a comprehensive evaluation instrument.

The findings further revealed that the PTQEI possessed a high overall Content Validity Index (CVI) of 0.90, indicating substantial agreement among experts regarding the relevance and adequacy of the instrument items. This result demonstrates that the items effectively represented the intended constructs of Physics teaching quality and were considered appropriate for measuring instructional effectiveness in secondary schools. The high CVI obtained suggests that the validation process successfully eliminated ambiguous, irrelevant, and redundant items, thereby strengthening the quality of the instrument. This finding agrees with the position of Polit and Beck (2021), who maintained that a Content Validity Index of 0.80 and above indicates excellent content representation in educational and behavioural instruments. The finding is also in line with the work of Lynn (2019) and Yusoff (2019), who emphasized that expert validation enhances instrument quality by ensuring that items adequately cover the target constructs. Consequently, the high content validity recorded in this study confirms that the PTQEI is suitable for evaluating teaching quality in Physics classrooms.

The study established strong construct validity for the PTQEI through Exploratory Factor Analysis, which extracted five significant factors corresponding to the proposed dimensions of teaching quality. The factors collectively explained 80.2% of the total variance, indicating that the instrument effectively captured the underlying constructs it was designed to measure. The alignment between the extracted factors and the theoretical dimensions further confirms the adequacy of the instrument structure and supports its multidimensional nature. This finding corroborates the assertions of Creswell and Creswell (2018), who stated that factor analysis is a powerful technique for establishing construct validity by identifying the latent dimensions underlying instrument items. Similarly, Tabachnick and Fidell (2019) reported that instruments explaining substantial proportions of variance through factor extraction demonstrate strong construct validity and measurement accuracy. The present finding therefore indicates that the PTQEI possesses a stable factorial structure capable of providing meaningful information about Physics teaching quality in secondary schools.

The findings also revealed that the PTQEI demonstrated high internal consistency reliability, with Cronbach Alpha coefficients ranging from 0.83 to 0.89 across the dimensions and an overall reliability coefficient of 0.86. These coefficients exceeded the recommended minimum threshold of 0.70, indicating that the instrument items consistently measured the intended constructs. The high reliability values suggest that the PTQEI can generate stable and dependable data when used repeatedly under similar conditions. This finding agrees with the recommendations of Nunnally and Bernstein (2018), who maintained that reliability coefficients above 0.70 are acceptable for educational and social science research instruments. The finding is further supported by Field (2020) and DeVellis (2021), who reported that high Cronbach Alpha values indicate strong internal consistency and instrument dependability. Therefore, the PTQEI can be considered a reliable instrument for evaluating teaching quality in Physics classrooms and can be confidently utilized for research, supervision, and instructional improvement purposes.

CONCLUSION

The study successfully constructed and validated a Physics Teaching Quality Evaluation Instrument for secondary schools in Ebonyi State, Nigeria. The instrument demonstrated satisfactory content validity, construct validity, and reliability, making it suitable for evaluating various dimensions of Physics teaching quality. The findings established that the PTQEI measures instructional delivery, classroom management, learner engagement, assessment practices, and professional competence effectively. Consequently, the instrument can serve as a valuable tool for instructional supervision, teacher appraisal, educational research, and professional development initiatives aimed at improving Physics education. Its adoption will provide school administrators with objective data for identifying areas of strength and weakness in Physics instruction. Moreover, the PTQEI can guide teacher training institutions in designing curriculum content that aligns with actual classroom demands. By promoting evidence-based evaluation, the instrument has the potential to bridge the gap between policy expectations and classroom practice in Physics teaching. Ultimately, widespread use of the PTQEI could contribute to raising overall academic

achievement and fostering positive attitudes toward Physics among secondary school students.

Recommendations

Based on the findings of the study, the following recommendations were made:

1. School administrators should adopt the Physics Teaching Quality Evaluation Instrument (PTQEI) as a standardized tool for routine evaluation of Physics teachers in secondary schools.
2. Ministries of Education should utilize the instrument for monitoring and improving instructional quality in Physics classrooms.
3. Teacher training institutions and professional bodies should utilize the PTQEI to identify specific areas of weakness in Physics instruction, such as instructional delivery or assessment practices, and design targeted workshops and in-service training programmes for Physics teachers.
4. Researchers in Science Education should employ the PTQEI for empirical studies on teaching effectiveness, teacher quality, and its relationship with students' achievement and attitude toward Physics.
5. Stakeholders in education should periodically review and update the PTQEI to reflect emerging trends in Physics pedagogy, technology integration, and curriculum reforms, ensuring the instrument remains relevant and context-specific.

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