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## **EDITORIAL**

Journal of Science Education and Research (JSER) is a peer-reviewed published Bimonthly. It aimed at advancing knowledge and professionalism in all aspects of educational research, including but not limited to innovations in science education, educational technology, guidance and counselling psychology, childhood studies and early years, curriculum studies, evaluation, vocational training, planning, policy, pedagogy, human kinetics, health education and so on. JSER publish different types of research outputs including monographs, field articles, brief notes, comments on published articles and book reviews.

We are grateful to the contributors and hope that our readers will enjoy reading these contributions.

**Prof. Patrick C. Igbojinwaekwu**

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**DEVELOPMENT AND VALIDATION OF PHYSICS TEACHERS' TEACHING EFFECTIVENESS SCALE IN ANAMBRA STATE**

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**Abstract**

*The purpose of the study was to develop and validate a Physics teachers' teaching effectiveness scale in Anambra State, Nigeria. Four research designs with instrumentation research design were employed for the study. The participants for the study were made up of all the 6,092 Senior Secondary School two (SS2) students offering Physics in the 266 public secondary schools in Anambra State. The sample size of this study comprised 1,900 students drawn from the population for factor analysis and reliability testing using simple random and proportionate sampling techniques. A total of 68 items were generated using Rasch model as initial draft of the instrument which was subjected to preliminary validation to obtain 60 items. The 60 items which constituted the second draft of the instrument were trial-tested to obtain 43 items. The 43 items that constituted the third draft were subjected to factor analysis to obtain 30 items that composed the final draft of the Physics Teachers' Teaching Effectiveness Scale (PTTES). Data collected were analyzed using principal factor analysis, varimax rotation, Cronbach alpha, mean, standard deviation and paired t-test. The findings of the study revealed that PTTES is a valid and reliable instrument for ascertaining the teaching effectiveness of Physics teachers in secondary schools. Based on the findings, it was recommended among others that school administrators should ensure that the present reliable Physics teachers' teaching effectiveness scale is employed to ascertain the teaching effectiveness of Physics teachers in secondary schools. This will enable school administrators to know if it is necessary to organize conferences for Physics teachers on the need to improve their teaching effectiveness.*

**Keywords:** Development, Validation, Physics Teachers', Teaching Effectiveness Scale

## **Introduction**

Science education is pivotal for the scientific and technological advancement of any nation. Put differently, the growth and development of any nation hinges considerably on the level of its scientific and technological advancement. It is in recognition of this inalienable fact that the National Policy on Education upheld that science education should among other things equip students to live effectively in our modern age of science and technology (Federal Government of Nigeria, FGN, 2014). Science education is taught at different levels of education especially secondary education as Biology, Chemistry, Physics, Mathematics among others.

Physics is one of the science subjects that focuses on matter, energy and the relationship that exists between them. Physics is a senior secondary school subject that focuses on physical principles and laws that govern the universe (Ugwu and Akano, 2019). Physics is the theoretical and methodological foundation of natural science, hence, it is famously known as the Fulcrum of all science. Furthermore, its modern objective in a senior secondary school focuses on introducing weirdness of the very small (quantum mechanics) and very fast (relativity) with space and time through using core concept like: wave-particle duality, the photo electric effect, Borh's model atomic system, mass-energy equivalence and basic radioactivity, which aim at building fundamental understanding and critical thinking paving way for the thought on how physics evolved beyond classical ideas, thereby preparing them for high level physics and competitive examination. Physics is considered a pre-requisite for the study of engineering, medicine, physical science and other applied science courses in the university.

The study of Physics equips students with mathematical skills; instructs learners in the art of critical thinking, how to pose questions as well as how to solve problems (Agommuoh, 2014). Going further, Agommuoh stated that the study of Physics enhances the comprehension of the interplay of forces in nature and aids in the development of modern technology through the application of its principles to modern invention. Physics as science subject is conceived in generic terms to be quite intellectually stimulating, vast, mathematical and practical in nature. It touches virtually all aspects of science, ranging from mathematics, biology and chemistry.

Although Physics plays a crucial role in secondary education, students' performance on external examinations remains unsatisfactory. Physics students in Anambra State have consistently fallen short of the expected academic standards.

Teaching effectiveness centres on a teacher's professional qualification, experience and ability to drive home a lesson to the understanding of learners. Schachter (2012) defined effective teaching as observable teacher characteristics or practices such as learning environment, instructional delivery, personal qualities and student assessment. According to Ko, Summons and Bakkum (2013), it focuses on a teacher's: possession of appropriate and sufficient knowledge of the subject matter; evaluation of the students, identification of students' appropriate learning needs and requirements and possession of skills regarding the usage of questions to engage and challenge the students. Instructional delivery, students' assessment, motivation, learning environment, teachers' personal quality, motivation and subject content knowledge are indicators among others used to measure teachers' effectiveness (Aina, Olanipekun and Garuba, 2015). Agha (2017) stated that the best way to assess teachers' teaching effectiveness is to look at their on-the-job performance, including what they do in the

classroom and how much progress their students make on the achievement tests which is enhanced through routine inspections and assessments carried out on the physics teachers to ensure they are performing effectively by Post Primary School Service Commission (PPSSC) Awka Anambra State. Agha added that the most influential contributing factor to students' achievement is teachers' teaching effectiveness.

Physics teachers' teaching effectiveness is measured by their exposure to five principles of effective teaching in Physics which are: dealing with students' existing ideas and conception, encouraging students to apply new concepts or skills into different contexts, encouraging students' participation in lesson, encouraging students inquiry and encouraging co-operative learning among students (Agommuoh, 2014). Furthermore, Ugwu, Fagbenro and Akano (2019) posited that Physics teachers' teaching effectiveness embodies these factors: knowledge of subject matter, coverage of content, presentation and development of lesson, use of evaluation skills, managing and control of classroom, personality characteristics and use of the laboratory. Thus, it is expected that effective Physics teachers participate in work activity that result in effective learning and improved students' performance.

Teachers' teaching effectiveness is very essential to students' learning and by extension their academic performance in Physics. This is to say that ineffective Physics teaching will lead to a decline in students academic performance of students will be adversely affected. More so, Aina (2013) faulted lack of adequate interaction between teacher and student as one of the reasons Physics students do not perform well academically. Interestingly, lack of adequate student-teacher interaction could be linked to lack of Physics teachers' teaching effectiveness. Corroborating the above assertion, Ugwu, Fagbenro and Akano (2019) maintained that lack of teachers' teaching effectiveness is

the reason why a good number of secondary school students seem to give the impression that they found Physics more difficult and uninteresting than any other subject in the school curriculum even when Physics is the theoretical and methodological foundation of natural science.

Obviously, the lack of interest of students in Physics and the difficult nature of the subject to secondary school students reinforce the need for Physics teachers' teaching effectiveness. This is because, learning to teach effectively requires a great deal of effort and expertise. One potential way of addressing this is by making use of a valid and reliable instrument functioning as a research tool in the teacher effectiveness domain. This study is intent on achieving that using rash model.

Rasch model is considered an effective tool for assessing constructs validity and reliability of the instrument (Ali and Shehab, 2020). It is a technique that is utilized to measure latent traits (Azrilah, Mohd Saifuddin and Azamin, 2013). The uniqueness of this model is that, it could determine whether respondents have a clear understanding of the variables that are being measured (Ghazali, 2017). Ghazali added that Rasch model can be adopted for the assessment of construct validity and reliability by identifying the scale rating, uni-dimensionality, item polarity, item fit, item difficulty index, item reliability, person reliability and separation index.

According to Bond and Fox (2012), Rash model ensures the management of sample ability and item difficulty on the same logits scale for the prediction of the sample ability. As averred by Boone, Staver, and Yale (2014), the Rasch model provides item and person fit statistics, enhancing measurement accuracy by ensuring each item on the scale contributes meaningfully to assessing teaching effectiveness. This can help

capture a clearer picture of Physics teachers' effectiveness. As in the expressions of Bond and Fox (2015), the Rasch model enables scores to be placed on a linear scale. This makes it easier to interpret individual teacher performance and compare results across teachers in different schools or zones within Anambra. It also allows the scale to be invariant across various sub-groups (e.g., years of experience or training background), which is particularly important in diverse educational settings. These considerations highlight the need to develop and validate an instrument on Physics teachers' teaching effectiveness.

Development of an instrument entails the construction of an instrument either from literature or focused group discussion with the potential respondents. On the hand, validation deals with the determination of the suitability and usability of the generated items in the instrument for research purposes by experts in relevant areas. Interestingly, the process of development begins with the generation of items. This is seconded by preliminary validation. Third, the generated items are trial-tested. Fourth, item analysis is carried out to remove the bad items while retaining the good items. Fifth, factor analysis is carried out to ascertain the evidence of construct validity. Lastly, the validity, reliability and norms of the instrument are ascertained.

Validity refers to the measure of extent to which an instrument, specifically, measures what it is supposed to measure (Okoye, 2015). Going further, Okoye noted that validity of a test or an instrument therefore, is contingent upon the purpose for which the test or instrument was developed. The implication is that an instrument which is valid for one purpose may not be valid for another. More so, Okoye stated that there are three major types of validity viz: Content, Criterion-related and Construct validity. Construct validity would be taken into consideration in the current study.

Construct validity deals with the extent to which an instrument is said to measure a theoretical construct or traits such as attitude, self-efficacy, among others. It is the degree to which inference about underlying traits can be made based on scores on a measure. Okoye (2015) pointed out that trait measures are constructs in the sense that they are things that scientists literally put together to account for phenomenon in the world. In other words, they do not exist as visible event in daily life. For instance, creativity, self-efficacy, attitude, intelligence, motivation and anxiety do not represent simple observable events, instead “they stand for traits which are used in the explanation of human behaviour.

Reliability of a test refers to the degree of consistency or stability, which the test exhibits (Nworgu, 2015). Put differently, it deals with how reproducible such test results are when the measurement is repeated on various occasions. According to Iji (2014), a reliable instrument is relatively free from errors of instrument so that the scores obtained on the instrument are close in numerical value to the true scores. Therefore, it can be inferred that reliability concerns itself with the consistency of an instrument in measuring specified constructs, without being seen to indicate different things on different administrations of the same instrument.

In Anambra State, effort has been made to develop scales that could measure teachers’ efficacy, though many were either adapted or developed without strictly following modern psychometric approaches, which may affect their validity and reliability. One of such scales is the Teacher Efficacy Scale (TES), which often evaluate teachers’ perceived ability to handle classroom management, instructional strategies, and student engagement (Eze and Mba, 2020). However, the validation processes of these scales have sometimes relied heavily on expert judgment or traditional reliability measures

like Cronbach's alpha, without a full application of advanced validation frameworks like the Rasch model. This can lead to limitations in accurately assessing individual teaching competencies across diverse contexts especially in a sensitive subject like Physics. The researcher as a Physics teachers in the State also observed that there is the unavailability of an instrument in secondary schools for measuring Physics teachers' teaching effectiveness using Rash model in Anambra State. Against this backdrop, developing and validating Physics teachers' teaching effectiveness scale using Rasch model in Anambra State is a worthy research.

### **Statement of the Problem**

The pivotal role of Physics in science education has made its effective teaching a matter of necessity. More so, the unsatisfactory performance of most Physics students has reinforced the need to treat Physics teachers' teaching effectiveness with a sense of urgency. It has further placed a burden on Physics teachers to exude teaching effectiveness in the teaching-learning process (Eze and Mba, 2020)

An intent at secondary schools in Anambra State will reveal that most Physics students seem to lack interest in the subject given that some of them perceive it as being difficult. This has raised questions as to whether the Physics teachers are effective in their instructional delivery. The development and validation of Physics teachers' teaching effectiveness scale has become more necessary than ever before given its unavailability in secondary schools in Anambra State as observed by the researcher as the evaluation, monitoring, inspection and assessments carried out by the Post Primary School Service Commission is not always effective due to the lack experience for the job by some of

the staff. It is in view of the foregoing that the researcher seeks to develop and validate a Physics teachers' teaching effectiveness scale using Rasch model in Anambra State.

### **Research Questions**

The following research questions were formulated to guide the study:

1. How valid are the items of the Physics teachers' teaching effectiveness scale (PTTES)?
2. What is the reliability coefficient of PTTES?

### **Methodology**

This study utilized instrumentation research design. The population of the study consist of 6,092 Senior Secondary two (SS II) students offering Physics in the 266 public secondary schools in Anambra State. The sample size of this study comprised 1900 SS II students in the 266 public secondary schools in Anambra State. . A total of 300 students were used for trial testing of the instrument initially developed, 600 students for factor analysis while 1000 students were used for reliability testing using simple random sampling and proportionate sampling techniques. The instrument used in the study is titled 'Physics Teachers' Teaching Effective Scale'. The key characteristics of the instrument include: (a) Content domain such as planning of instruction, instructional delivery, use of evaluation skills, classroom management, personality traits and use of laboratory. These domains would be informed by existing frameworks and tailored to the unique demands of teaching Physics, such as practical lab skills and the ability to explain complex scientific concepts. (b) Item Format: The items are to be in Likert-type format (e.g., strongly disagree to strongly agree), allowing for ordinal

responses that can capture varying levels of agreement or frequency. Each item are positively worded and directly related to observable behaviors and attributes of effective Physics teaching. (c). Validation and Pilot Testing: Following the initial development, the instrument would undergo content validity checks with experts in educational measurement and experienced Physics educators. A pilot test helped ensure item clarity, relevance, and coverage, allowing for revisions based on feedback. (d). Factor analysis (via Rasch model analysis) employed to ensure items measure a unidimensional construct of teaching effectiveness, or to refine it into clear subdimensions. Using the Rasch model, the instrument was analyzed for item fit, item difficulty, and response category functioning. The Rasch model also help ensure that the scale maintains interval-level measurement, making the results interpretable in a consistent manner. (d). Reliability and Consistency: Internal consistency, typically measured by Rasch-based reliability indicators, would be calculated to verify the consistency of responses across items. This consistency ensures that the scale is reliable for assessing teaching effectiveness over repeated measurements or among different groups of respondents.

### **Validation of the Instrument**

Procedures for Development and Validation of Instrument:

There are seven procedures for instrument development and validation. They include:

Item generation: Here, the initial draft of 68 items for PTTES was constructed.

Preliminary validation of instrument: At this stage, the initial draft of 68 items in the Physics Teachers' Teaching Effectiveness Scale (PTTES) were validated by presenting it along with the purpose and research questions for the study to three experts; two in the Department of Educational Foundations and the other in the Department of Science

Education, all at Nnamdi Azikiwe University, Awka. They were requested to objectively look at the appropriateness of wordings and constructive suitability of PTTES to ensure its validity for the study. The experts' objective inputs were considered in the modification of the items in the PTTES as and where necessary

Second draft of the instrument: In view of the experts' inputs and the consequent modification of the items in the PTTES, the 61 items that survived were assembled to constitute the second draft of the PTTES .

Trial testing: At this stage, the 60 items that survived face and content validation were administered on 300 Physics students.

Item analysis: To ascertain the items that constituted the third draft, item-total correlation was employed for item analysis. An item was accepted if its correlation value fell between 0.3 and 0.7.

Factor analysis: To ascertain the uni-dimensionality of PTTES, factor analysis was carried out on the third draft of PTTES by administering its items of PTTES that survived to 600 Physics students which are outside the sampled ones. According to Okoye (2015), the criteria for accepting items for the final draft will depend on the factor that has at least four items adequately loaded on it.

Establishment of reliability of the Instrument: Administration of PTTES was carried out on 1000 students from the area of study after factor analysis. Reliability was established using Cronbach alpha method.

### **Reliability of the Instrument**

Reliability of PTTES is part of the objectives of the study. To this end, both the initial and later reliability approaches were covered in execution of the study's reliability.

### **Method of data collection**

The initially developed items for the Physics Teachers' Teaching Effectiveness Scale were administered to a smaller, representative sample of Physics teachers and students. This pilot group was not part of the main study sample but was crucial for item refinement and initial Rasch analysis. During the pilot phase, feedback was collected from participants (both students and teachers) to identify any ambiguities in the items and refine language as necessary. Observations of response patterns were also noted to ensure clarity.

Following the pilot, the validated and refined scale was administered to a larger sample drawn from the main study population (SS1 students in selected secondary schools). Based on the sampling design, the scale was distributed to teachers and students in three randomly selected education zones within Anambra State, with further random selection of schools and students within these zones. Teachers and students received clear instructions on how to complete the scale, and a brief explanation was given to ensure understanding of the purpose of the study and promote honest responses. To minimize variability due to external factors (e.g., school schedules, teaching conditions), the data collection period was standardized across schools and was conducted within a two-week period.

The researcher and three research assistants were present on-site during data collection to address questions, ensure confidentiality, and monitor the completion process. For teacher evaluations by students, anonymity was assured to minimize potential bias or fear of reprisal, thus fostering more accurate and candid responses. After data collection, responses were coded and entered into a statistical software package for analysis. The data were screened for completeness, with any missing responses or anomalous patterns identified and handled according to the study's missing data strategy. The carefully structured data collection process ensured data integrity, adherence to ethical standards, and relevance for subsequent Rasch analysis, ultimately contributing to the development of a reliable and valid Physics Teachers' Teaching Effectiveness Scale.

### **Method of Data Analysis**

Research Question 1 was answered using principal factor and varimax rotation of factor analysis, Research Question 2 was answered using Cronbach alpha method while that of Research Question 3 was answered using mean and standard deviation. For Research Question 1, any factor that is up to 0.5 is not rejected. For Research Question 2, any value between 0.70 to 1.00 is not rejected while mean values between 2.50 and 4.00 is not rejected; otherwise it will be rejected.

### **Results**

#### **Table 4. 1**

KMO and Bartlett's Tests

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.608
Bartlett's Test of Sphericity	Approx. Chi-Square	1754.172
	Df	416
	<i>p</i> -value.	.000

Table 1 shows the KMO and Bartlett’s tests for determining the adequacy of sample size for factor analysis. The test value of .608 indicates that the sample is in support of the use of factor analysis. This is so given that the value is within the 0.50 adequacy criterion indicated by Field (2018). Besides, the Bartlett’s tests of sphericity is significant at  $p < 0.001$  which indicates that the correlation matrix has significant correlations among at least some of the variables.

**Table 4.2**

<b>Total Variance Explained</b>						
Component	Initial Eigen values			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	7.313	14.250	06.250	7.313	14.250	06.250
2	5.479	13.917	28.167	5.479	13.917	28.167
3	3.449	12.907	40.074	3.449	12.907	40.074
4	1.908	11.231	53.305	1.908	11.231	53.305

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5	.995	9.579	61.884	.995	9.579	61.884
6	.994	7.246	69.130	.994	7.246	69.130
7	.985	3.932	73.552	.985	3.932	73.552
8	.965	1.839	74.901	.965	1.839	74.901
9	.960	1.365	76.266	.960	1.365	76.266
10	.945	1.298	77.564	.945	1.298	77.564
11	.932	1.172	78.736	.932	1.172	78.736
12	.926	1.125	79.861	.926	1.125	79.861
13	.917	1.057	80.918	.917	1.057	80.918
14	.882	1.002	81.920	.882	1.002	81.920
15	.879	0.948	82.868	.879	0.948	82.868
16	.866	0.947	83.815	.866	0.947	83.815
17	.843	0.944	84.759	.843	0.944	84.759
18	.792	0.930	85.689	.792	0.930	85.689
19	.774	0.901	86.590	.774	0.901	86.590
20	.739	0.890	87.480	.739	0.890	87.480

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21	.697	0.872	88.352	.697	0.872	88.352
22	.639	0.867	89.219	.639	0.867	89.219
23.	.616	0.847	90.066	.616	0.847	90.066
24.	.603	0.844	90.910	.603	0.844	90.910
25.	.592	0.830	91.740	.592	0.830	91.740
26.	.574	0.801	92.541	.574	0.801	92.541
27.	.569	0.790	93.331	.569	0.790	93.331
28.	.557	0.772	94.053	.557	0.772	94.053
29.	.549	0.767	94.820	.549	0.767	94.820
30.	.542	0.640	95.460	.542	0.640	95.460
31.	.492	0.532	95.992	.492	0.532	95.992
32.	.474	0.501	96.493	.474	0.501	96.493
33.	.469	0.420	96.913	.469	0.420	96.913
34.	.457	0.418	97.331	.457	0.418	97.331
35.	.441	0.379	97.710	.441	0.379	97.710
36.	.340	0.375	98.085	.340	0.375	98.085

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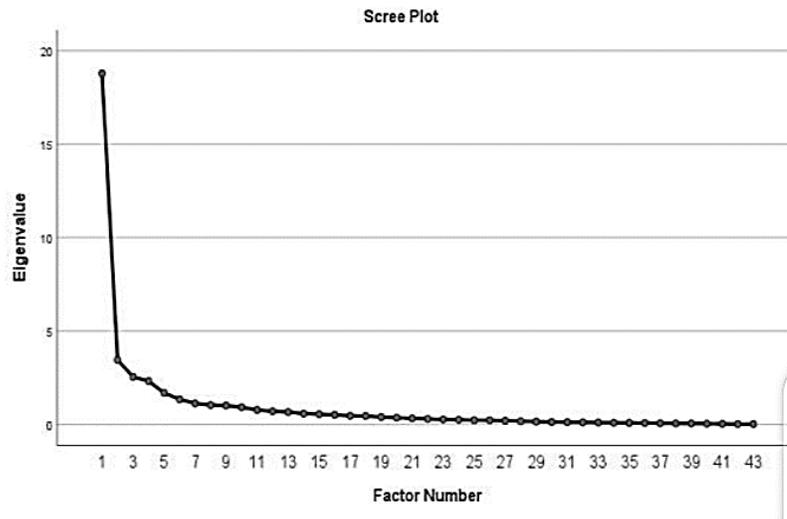
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37.	.292	0.343	98.430	.292	0.343	98.430
38.	.270	0.310	98.740	.270	0.310	98.740
39.	.254	0.291	99.031	.254	0.291	99.031
40.	.187	0.250	99.281	.187	0.250	99.281
41.	.179	0.246	99.527	.179	0.246	99.527
42.	.165	0.243	99.770	.165	0.243	99.770
43.	.153	0.230	100.000	.153	0.230	100.000

---

Extraction Method: Principal Component Analysis.

Principal Component method was used for the extraction of four factors from the 43-item PTES. From the number, a total of 4 factors were extracted. These 4 factors explained 53.305% of the variance in the whole data. This indicates that greater proportion of the variance in the data was explained by the factors extracted. While the 4th factor extracted contributed 11.231% to the total variance explained, the 1<sup>st</sup> factor contributed 14.250% to the total variance explained.



**Figure 2:** Scree Plot

The scree plot as seen in Figure 2 indicates that there are four meaningful factors for extraction. Initial retention of the four factors is supported by the total variance of 53.305% accounted by the four factors. Equally, retention of the three factors meets Kaiser's (1960) criteria for retaining factors with Eigen values greater than 1.

**Research Question 1:** How valid is the PTTES?

This question is answered, using factor analysis. The result is presented in Tables 1, 2 and 3.

**Table 4. 3**

Rotated Component Matrix for the 4 Factors Retained with the Factor Loadings

	1	2	3	4
Item 1	.720	3.23	4.20	
Item 2	.502	2.34	3.45	
Item 3	.692	3.03	4.23	
Item 4	.421	3.24	4.02	
Item 5	.770	5.01	4.53	
Item 6	.569	.426	4.21	
Item 7	.753	2.31	-.341	
Item 8	.602	.504	-.401	
Item 9				
Item 10				
Item 11	.592	.349	.423	
Item 12				
Item 13				
Item 14	.302	.654	.351	
Item 15	.307	.325	.312	
Item 16	.316	-2.92	.351	
Item 17		.528	.721	.491
Item 18		.819	.706	
Item 19				
Item 20		.552		

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Item 21		.872		
Item 22				
Item 23				
Item 24				
Item 25		.603		.371
Item 26		.492		.318
Item 27		.532		
Item 28				
Item 29			.320	
Item 30			.579	
Item 31		.308	.429	.316
Item 32				
Item 33			.308	
Item 34			.520	
Item 35		.321	.416	.405
Item 36				
Item 37		.204	.315	.314
Item 38				
Item 39	.424	-.314		.520
Item 40		-3.10	.402	.481
Item 41		-.305	.315	.329
Item 42	.397		.546	.612
Item 43				.493

---

Data in Table 3 show the factor loadings for each of the items. An important factor loading was determined using the 0.3 criterion. With a view to enhancing interpretation of the rotated matrix, all loadings below 0.3 are excluded from the Table based on the stipulation of Field (2018). Details in Appendix F, Page 104.

**Research Question 2:** What is the reliability coefficient of PTTES?

This question is answered using Cronbach alpha. The result is presented in Table 4.

**Table 4.4**

Reliability of PTTES and its Sub-Scale based on Cronbach Alpha

Scale Dimension	No of items	Items	Cronbach Alpha
Planning of Instruction	9	1, 2, 3, 4, 5, 6, 7, 8, 11	.81
Instructional Delivery	9	14, 15, 17, 18, 20, 21, 25, 26, 27	.72
Use of Evaluation Skills	7	29, 30, 31, 33, 34, 35, 37	.78
Use of the Laboratory	5	39, 40, 41, 42, 43	.75
Entire Scale	30		.77

Table 4 shows that the reliability coefficient of the sub-scales of planning of instruction, instructional delivery, use of evaluation skills and use of laboratory are .81, .72, .78 and .75 respectively. The overall reliability of PTTES is .77 which is above 0.70. This indicates that PTTES is reliable.

## **Discussion**

### **Development of PTTES**

The development of the Physics Teachers' Teaching Effectiveness Scale (PTTES) was guided by standard psychometric principles aimed at creating a valid and reliable tool for measuring teaching effectiveness among Physics teachers in Anambra State. The initial scale consisted of 43 items designed to assess multiple dimensions of teaching effectiveness. These items were generated to reflect critical aspects of instructional planning, delivery, assessment, and laboratory engagement. A sample that met the minimum requirements for factor analysis was used to validate the structure of the scale. The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was .608, indicating that the sample size was adequate for factor analysis according to Field (2018), who recommends a minimum KMO value of .50. Additionally, the Bartlett's test of sphericity was significant at  $p < .001$ , signifying that the correlation matrix was suitable for factor extraction. Principal Component Analysis (PCA) was employed as the extraction method. The analysis led to the extraction of four distinct factors from the original 43 items. The four components explained a cumulative total variance of 53.305%, which is considered acceptable in social science research. Specifically, the first factor accounted for 14.250% of the variance, while the fourth factor contributed 11.231%. This distribution supports the multidimensional nature of the construct being measured.

Furthermore, the scree plot confirmed the retention of four meaningful components, as there was a noticeable drop in Eigenvalues after the fourth factor. The scale's structure aligns with theoretical expectations and empirical criteria, suggesting that the development phase of PTTES successfully produced a multidimensional

instrument grounded in robust statistical analysis. The foregoing indicates that the development process was grounded in empirical adequacy and theoretical relevance. This developmental procedure aligns with the study by Kao, Sai, and Shih (2014), who developed a self-efficacy scale in Taiwan. Their structured development involving three sub-scales and the use of instrumentation design provides a comparable process of systematically designing a multidimensional instrument. Similarly, Ugochukwu (2015) developed an evaluation tool for nursing students' practical skills, showing how clear definition and item construction contributed to the instrument's robustness. Ghazali (2017) also exemplified rigorous instrument development, carefully calibrating item structure and establishing item difficulty, which complements the careful design process of PTTES.

Obviously, the PTTES measured what it set out to measure. Thus, factors with less than three items each were not included as stipulated by Costello and Osborne (2005). Gleaning from the findings of the current study, t factor analysis has not only detected irrelevant items but has provided for the extraction of valid factors from the data set of PTTES. The finding of the study is consistent with that of El-Hajjar (2018) that construct validity of a measurement is the amount to which it really measures what it claims to measure. Put differently, there has to be consistency in what an instrument intends to measure and what it ultimately measures. The finding of the current study is further consistent with by the position of Okoye (2015) that trait measures are constructs in the sense that they are things that scientists literally put together to account for phenomenon in the world.

### **Validity of the Developed PTTES**

The validity of the Physics Teachers' Teaching Effectiveness Scale (PTTES) was rigorously assessed through factor analysis to confirm its construct validity. Construct validity was supported by the application of Principal Component Analysis (PCA), which revealed a clear and interpretable four-factor solution. This finding is consistent with theoretical frameworks that view teaching effectiveness as a multifaceted construct comprising planning of instruction, instructional delivery, assessment strategies, and laboratory usage. The adequacy of the sample size for such analysis was confirmed by a KMO value of .608 and a statistically significant Bartlett's test of sphericity ( $p < .001$ ), indicating sufficient inter-correlations among the items for reliable factor extraction. The criteria for factor retention were met using Kaiser's rule, which recommends retaining factors with Eigenvalues greater than 1 (Kaiser, 1960). This led to the retention of four factors that accounted for a combined variance of 53.305%, further supporting the scale's construct validity. Moreover, item loadings on these factors were examined using a minimum threshold of 0.3, in line with the recommendation of Field (2018). Loadings below this threshold were excluded to enhance the interpretability of the rotated matrix, ensuring that only items with meaningful contributions to the factors were retained. This rigorous item analysis contributed to the internal validity of the instrument by confirming that items clustered meaningfully under relevant dimensions of teaching effectiveness. Thus, the evidence provided by the factor analysis supports the structural integrity and construct validity of the developed scale. The scree plot further justified the four-factor retention, reflecting the conceptual clarity embedded in the instrument.

Empirical studies support this validation approach. For example, Okeaba and Esomonu (2016) conducted a factor analysis on their inventory for measuring students' integration into university academic culture, identifying meaningful item loadings and establishing norms. Their use of factor analysis aligns closely with the procedures adopted in the current study. Additionally, Opara and Magnus-Arewa (2017) validated a Mathematics Achievement Test and reported that the instrument met psychometric standards of validity and reliability. Furthermore, Maulana, Helms-Lorenz, and van de Grift (2014) validated a tool to assess teaching behavior perceptions, using Rasch modeling to demonstrate construct representativeness, a conceptually similar approach to that used in the validation of PTTES. Waheed (2018) also demonstrated validation using Rasch model principles and correlational analysis to align findings with existing competency literature, affirming construct validity in a higher education context.

#### **Reliability of the Developed PTTES**

The reliability of the Physics Teachers' Teaching Effectiveness Scale (PTTES) was established through internal consistency analysis using Cronbach's alpha. This method is widely accepted for evaluating the reliability of multi-item scales. The reliability coefficients for each of the four sub-scales were found to be satisfactory: Planning of Instruction (.81), Instructional Delivery (.72), Use of Evaluation Skills (.78), and Use of Laboratory (.75). Each of these coefficients exceeds the commonly accepted minimum threshold of .70 for acceptable reliability, indicating that the items within each sub-scale consistently measure the same underlying construct. The overall reliability coefficient for the entire scale was .77, further confirming the internal consistency of the instrument. This value suggests that the PTTES is a stable and dependable measure of teaching effectiveness among Physics teachers. Given that the

reliability indices of both the sub-scales and the entire instrument fall within the desirable range, the scale can be confidently used for both diagnostic and evaluative purposes in educational settings. These findings reinforce the utility of the PTTES in assessing the competencies of Physics teachers in delivering effective instruction. The scale's demonstrated reliability supports its potential application in teacher appraisal, professional development, and research contexts focused on teaching quality in secondary education. The findings of the study showed that PTTES is a reliable instrument. Thus, the variables within each of the factors are deemed internally consistent. All the items in each of the factors had reliability coefficients above 0.70; indicating that PTTES is reliable. This in tandem with the assertion of Shrestha (2021) that the adequate threshold value for Cronbach alpha should be  $>0.70$ . In other words, the variables within the factors are considered to be internally consistent if their reliability coefficient values are equal or more than 0.70. Comparable results were obtained in Ugochukwu's (2015) study, where the reliability coefficient for a nursing education instrument was 0.90 overall, with sub-sections ranging between 0.51 and 0.79, and inter-rater reliability of 0.73. Similarly, Opesemowo et al. (2018) conducted reliability testing using multiple approaches—Cronbach alpha, split-half, and Guttman coefficients—reporting coefficients between 0.76 and 0.78 for their final instrument, validating its internal consistency. These results affirm the robustness of multi-method reliability assessment used in the current study. Also, Okeaba and Esomonu (2016) reported a Cronbach alpha of 0.926 for their 27-item inventory, reinforcing the importance of high internal consistency in psychological and educational measurement.

### **Conclusion**

Based on the findings of the study, the conclusion was that PTTES is a valid and reliable instrument for ascertaining the teaching effectiveness of Physics teachers in secondary schools in Anambra State.

### **Recommendations**

Based on the findings of the study, recommendations were made. They are thus outlined:

1. School administrators should ensure that the present valid instrument is used to determine the teaching effectiveness of Physics teachers in secondary schools. This is with a view to identifying teachers who are effective in their teaching of Physics.
2. School administrators should ensure that the present reliable Physics teachers' teaching effectiveness scale is employed to ascertain the teaching effectiveness of Physics teachers in secondary schools. This will enable school administrators to know if it is necessary to organize conferences for Physics teachers on the need to improve their teaching effectiveness.
3. Curriculum planners should make revision in the curriculum to prioritize Physics teachers' teaching effectiveness. That way, ineffectiveness would be addressed for quality instructional delivery.

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