CONFIRMATORY FACTOR ANALYSIS FOR INSTRUMENTS OF INNOVATIVE TEACHING PRACTICES FOR TEACHERS OF 21ST CENTURY CLASSROOM: PRELIMINARY FINDINGS

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Abstract: *Nigeria schools have adopted changes and innovation in teaching and learning. With this changes, efforts have been put in place by the government so that teachers can integrate innovative teaching to enhance students' engagement in the classroom. This study aimed to examine confirmatory factor analysis for instruments of innovative teaching practices for teachers of 21st century classroom: a preliminary finding. Quantitative research was adopted in the study. A purposive sampling technique was adopted to selected 200 teachers in Kwara State public schools. The instrument of innovative teaching practice had five dimensions (flipped classroom, google classroom-assisted learning; design-thinking process; project-based learning*

and blended learning) with 25 items. The Confirmatory factor analysis using maximum likelihood estimation technique (AMOS version 18) was performed to determine validity and reliability of the instrument. Confirmatory factor analysis had 16 items after removed the items with poor loadings. The findings of first order CFA analysis revealed that the model fit the data where fitness indexes were significant. Also, the finding further showed that second order analysis fitness indexes were satisfactory where the dimensions of ITP have significant value on main variable. The second order measurement model of innovative teaching practices was free from offending values with all fit statistics well above the set threshold. The innovative teaching practices questionnaire was proven to have a strong measurement model as well as reliable constructs. The study suggested that ITP instruments consider to be suitable for use by teachers of 21st century classroom at enhancing students' engagement in the classroom.

Keywords: *confirmatory factor analysis; innovative teaching practices; Structural Equation Modeling.*

Introduction

The policy of Nigeria government on the innovation practices in public schools' centre on integrating digital technology promotion of STEM (Science, Technology, Engineering, and Mathematics) as well as skills for self-survival. The national digital learning policy (2023) and national policy on ICT in education stated that digitalization of teaching would help in improve students' academic performance (Osakwe, 2013; Suleiman, 2020; Ibe & Ikokwu, 2025). The development and transformation of education have been tropical issue. According to the national policy on education which expressed that the adoption of technology in education is for national development (Matthew et al., 2022; Oghuvbu et al., 2022; Oluwagbemileke, 2024). There is monumental development in technology utilization which has demanded technological change in schools. So, transforming education in line with new technological change is necessary (Chris et al., 2015; Adewoye & Salau, 2021).

As a matter fact, innovation utilization has been seen in all area of educational practices for students' engagement. Information and communication technology (ICT) in education has led to tremendous change and innovation (Chris et al., 2015; Baba & Odiba, 2015;

Anikweze & Kanu, 2018; Gbesoevi et al., 2025). Computer aided learning is not merely used for instructional purpose but also as a tool for facilitate learning. Technologies are significant to transform the learning in the classroom. School needs to integrate technology for the student's learning outcome and teachers need to use it to support teaching (Zhanget al., 2020; Ibe & Ikokwu, 2025; Gbesoeviet al., 2025). Innovative practice aimed to introduce flipped classroom, google classroom-assisted learning; design-thinking process; project-based learning and blended learning.

It is germane to note that primary reason for innovative teaching practices in public schools in Nigeria is to bring new ideas replace existing system so as to enhance students' performance in the classroomw. Ejiofor and Ibara (2022) pointed that secondary education in Nigeria require new teaching techniques, information technology and communication, better ways of computing students result, blended learning so as to relevant in modern world of globalization with the purpose of achieving educational goals. However, several studies on innovative teaching practices ignored to subject instrument of innovative teaching practices to confirmatory factor analysis. Sensing this gap, this prompt the researcher to examine confirmatory factor analysis for instruments of innovative teaching practices for teachers of 21st century classroom: a preliminary finding. Based on this, these following research objectives were established.

1.   To determine first order confirmatory factor analysis for innovative teaching practice constructs
2.   To determine second order confirmatory factor analysis for innovative teaching practices constructs
3.   The Assessment of validity and reliability for measurement model innovative teaching practices constructs

Literature Review
Defining Innovative Practices
The integration of innovativeness in education has gain prominence among the scholars on the role it plays in educational practices (Garcia & Sylvan, 2011; Hang & Van, 2020; Moreno-Guerrero et al., 2020; Blomeke et al., 2021; Ibe & Ikokwu, 2025). Various definitions of innovativeness have been made in different fields. Education is also an effective instrument to transform students in all levels of education. In the same vein, quality education to be attainable, the utilization of innovative teaching practices must be use to engage students in the classroom (Puranik, 2020; Blomeke et al., 2021; Ibe & Ikokwu, 2025). Therefore, innovative teaching is the use of technology into teaching and learning in the classroom to establish a robust learning experience

for students (Khairmar, 2015; Garzon Artacho et al., 2020; Gbesoeviet al., 2025). As world witness changing in education, teachers are require to have the capability to innovate the schools with new ideas and technology that would give in-depth understanding to the students. Innovative teaching is the process which starts with the providing a solution to a problem or injecting new ideas (Scott & Bruce, 1994; Garzon Artacho et al., 2020; Blomeke, et al., 2021; Ibe & Ikokwu, 2025). The increasing interest in the development of innovative skills in educational contexts has led to studies on the development of innovative practices in teacher education (Tyunnikov, 2017; Gbesoeviet al., 2025).

Additionally, Kalyani and Rajasekaran (2018) pointed that innovative teaching is novelty and creativity of teachers that transform the method and style of teaching and learning in the classroom situation. All the countries today are implementing new methods, ideas and technology to fostering students understanding of the lesson. In fact, innovative teaching is essential for the growth of present educational system for the achievement of students' potential (Kalyani & Rajasekaran, 2018; South-East, 2025). Teachers mastering of innovative teaching is a primary factor for the success innovative teaching. Teachers are expected to exhibit strong communication and collaboration skills, technology expertise, innovative and creative thinking, and problem-solving skills to help learners acquire these skills (Larson & Miller, 2011; Simanjuntak et al., 2021; Kwangmuang et al., 2021; South-East, 2025).

Likewise, teaching innovation can be seen as creation of new ideas, techniques, theories, and solutions that can be use classroom for the purpose of understanding the lesson. Numerous researchers across the globe agreed that creativity and innovation are important areas that can be used to facilitates effective learning in the school (Bowen et al., 2010; Kahramonovna et al., 2021; Blomeke, et al., 2021; South-East, 2025). The utilization of information technologies for teaching in the classroom and the introduce new equipment in the educational process make it possible to realize one of the main goals of student engagement (Durairaj, 2016; Al-Rahmi et al., 2020; Ibe & Ikokwu, 2025).

Conceptualized Confirmatory Factor Analysis (CFA)

Confirmatory Factor Analysis (CFA) can be regarded as powerful technique in analysis data in the field of research. CFA allows researcher to test the hypotheses of relationship between the observed variable and their underlying latent construct(s) exists (Steiger, 1990; Suhr, 2006). Some of the proponents of CFA affirmed that researchers must have a powerful theory underlying their measurement model before analyzing data. However, CFA relies on several statistical tests

to determine the adequacy of model fit to the data. The chi square test indicates the amount of difference between expected and observed covariance matrices. More so, the probability or significance level must be greater than 0.05 when chi-square is close to zero. Also, CFA provides a more explicit framework for confirming prior notions about the organization of a domain of content.

Likewise, CFA has become one of most commonly used statistical procedures in applied research (Brown, 2015). CFA is quite equipped to solve different kinds of questions that researchers often demand for. CFA is usually used during the process of scale development to examine the latent structure of a test instrument (e.g. a questionnaire). In this situation, CFA is put forward to verify the number of underlying dimensions of the instrument (factors) and the pattern of item-factor relationship (factor loadings). It is help in determine a particular test to be scored. It is well noted for analytic tool for other aspect psychometric evaluation. Even though, it may be used to estimate the scale reliability of test instrument in a manner that avoids the problems of traditional techniques (e.g. Cronbach's alpha). CFA has been regarded as an effective tool for constructs validation in the behavioral and education. The outcome of CFA can provide compelling evidence of the convergent and discriminant validity of theoretical constructs. Table 1 showed Comparison of Goodness-of-Fits Measure of the confirmatory factor analysis.

Table 1. Comparison of Goodness-of-Fit Measure of the confirmatory factor analysis

	Level of Acceptance					
Fit index	Schumacker Lomax (2004)	Reisinger & Mavondo (2007)	Hair et al., (2010)	Gaskin (2012)	Bagozzi & Yi (2012)	Acceptance value
χ^2 value	-	Low value (relative to df with p<0.05	m< 12: insignificant (p> 0.05) m>12: significant (p>0.05)	Insignificant - good fit; significant unsatisfactory	-	N>250, m >30significant χ^2 value is expected

χ²/Df	1 to 5	< 2 or < < 3		<2 or <5	< 3	1 to 5
CFI	-	Value close to 1 > 0.9 good	>0.9	> 0.9	≥ 0.93	> 0.9
RMSEA	< 0.05	< 0.08 <0.05 good	0.03 to 0.0	< 0.05 good < 0.08 adequate	≤ 0.07	< 0.8
TLI	0 to1	Value close to 1 > 0.9 good	> 0.9	> 0.9	≥0.07	> 0.9

Note: $\chi2$=chi-square, df=degree of freedom, CFI=comparative fit index, RMSEA=Root mean square error of approximation, TLI=Tucker-Lewis index, m=number of observed variables

Methodology
Quantitative research design was employed in this study. Creswell (2017) posited that quantitative research is a type of research that try to seek response from the subject and they differ from one another. Hair et al. (2010) pointed that quantitative research is most common form of research for collecting data from target respondents specify in the study. The researcher personally went to all selected schools to collect the data. Furthermore, the study employed purposive sampling method and it is part of the non-probability sampling technique. The purposive sampling was used for sampling because of the knowledge and judgement where participants were selected that related to conditions put in place by the researcher (Guarte & Barrios, 2006).
The sample comprised of experience teachers who had teach for more five years. Equally, other criteria were the schools who had established for ten years with high performing record in the state. Self-administer questionnaires was done by the researcher to elicit data. The questionnaires personally distributed by the researcher and research

assistant through personal interaction. This would make researcher to interact with the respondents and to clarify questions that are vague. Creswell (2017) opined that self-administer questionnaire is the common practice in the research and appropriate for quantitative research like this research. Penultimately, 200 questionnaires were used for data analysis.

There were five dimensions formulated to measured innovative teaching. The section A of the instrument contained items of flipped classroom with items. Section B of the questionnaire comprised of the items of goggle classroom assisted learning using five items. The section C had items related to design-thinking process with five items and section D of the instrument had the items of project-based learning using five items. Section E was the items of blended learning. Therefore, all these instruments were based on five-point Likert-type scale ranging from (1) strongly disagree and (5) strongly agree, was used to measure each variable to verify the level of agreement by the selected participants of the study.

Similarly, reliability test, assessment of data normality, confirmatory factor analysis, second order analysis and validity were performed in the study. Cronbach Alpha coefficient was employed to determine internal consistency. Principal component factor analysis and Confirmatory factor analysis (CFA) was performed to determine the validity and confirmatory of constructs. Assessment of data normality was also performed.

Additionally, Confirmatory Factor Analysis (CFA) was used on the hypothesized measurement model with the use of Analysis Moment of Structure - AMOS version 18. Next, to determine the underlying constructs and the items of the study, construct validity is done equally performed. Construct validity entails convergent and discriminant validity. With this, Convergent Validity was examined based on the coefficient of each item loaded as well composite reliability of a latent variable (Hair et al., 2010). The value of composite reliability which greater than 0.70 show that composite reliability is strong and significant (Hair et al., 2010). In the same vein, discriminant validity was assessed by average variance extracted for all for study constructs which must be < 0.9. If the value is below 0.9, the discriminant validity is accomplished (Hair et al., 2017).

Table 2
Cut-off values for composite and discriminant validity

Indicators	Cut-off value	Source

a. Kaiser-Meyer-Olkin (KMO) Unacceptable:<0.50, Miserable:>0.50, Mediocre:>0.60, Milddling:>0.70, meritorious:>0.80, Marvelous >0.90 (Hair et al.; 2010)	Recommended value of 0.60 or above	Hair et al., 2010; Huck & Muller, 2012; Pallant, 2011; Tabachnick & Fidell, 2006
b. Bartlett's Test of Sphericity	Significant at < 0.05	(Hair et al., 2010)
c. Anti-Image correlation: individual sampling adequacy (MSA)	.0.5	(Coakes & Steed, 2003; (Hair et al., 2010)
Inter adequacy d. communalities (variables are well defined by the solution-low values require removal	> 0.3 > 0.4 > 0.5	(Tabachnick & Fidell, 2006) (Gaskin, 2012) (Hair et al., 2010)
e. Convergent validity Factor loading based on sample size	Above sufficient factor loading to retain the item	(Hair et al., 2010)
f. Discriminant validity * Cross-loadings the difference between factor loading and cross-loading that is less than 0.2 would be considered deletion	No significant cross-loading (< 0.3)	(Bhattacherjee, 2012; Garson, 2013; Hair et al., 2010; Pallant, 2011)

Results of the Findings
Assessment of Data Normality
Prior to perform confirmatory factor analysis, assessment of preliminary test was determined if the data were normally distributed. In order to perform CFA, the sample size must be adequately. Confirmatory factor analysis requires a larger sample size. According to sample rule, Hair et al. (2010) suggested 50 observations as a minimum size in order to conduct CFA, but at the same time prefer sample size of 100 or more than that. In addition, sample to variables ratio, the recommended a minimum of 5:1 ratio e.g. five observations for each of the variables to be analyzed or 10:1 also acceptable. Based on literatures explored on the number of sample size, this study used 200 so that good criterion can be met. The skewness and kurtosis must fell within the range of ±2. The skewness and kurtosis generated in this study indicated that the data is normally distributed as shown Table 3. Therefore, as no violations were discovered, the data was considered for further analysis.

Table 3. Analysis of normality of the data

Items	N	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
FC1	200	3.94	1.150	-1.283	.172	1.067	.342
FC2	200	3.51	1.393	-.742	.172	-.793	.342
FC3	200	3.88	1.362	-1.131	.172	.022	.342
FC4	200	3.60	1.338	-.866	.172	-.463	.342
FC5	200	3.74	1.273	-.829	.172	-.447	.342
GC1	200	4.23	1.001	-1.994	.172	2.157	.342
GC2	200	3.57	1.391	-.780	.172	-.726	.342
GC3	200	4.04	1.097	-1.508	.172	1.883	.342
GC4	200	3.77	1.251	-.956	.172	-.196	.342
GC5	200	3.81	1.250	-1.133	.172	.249	.342
DTP1	200	4.26	.915	-1.415	.172	2.086	.342

DTP2	200	3.44	1.362	-.595	.172	-1.004	.342
DTP3	200	3.98	1.186	-1.275	.172	.864	.342
DTP4	200	3.62	1.366	-.841	.172	-.567	.342
DTP5	200	3.50	1.378	-.698	.172	-.748	.342
BP1	200	4.27	.939	-1.668	.172	3.019	.342
BP2	200	3.43	1.362	-.575	.172	-1.019	.342
BP3	200	3.98	1.178	-1.341	.172	1.030	.342
BP4	200	3.72	1.161	-.993	.172	.252	.342
BP5	200	3.98	1.098	-1.341	.172	1.299	.342
BL1	200	4.18	1.036	-1.518	.172	1.964	.342
BL2	200	3.53	1.272	-.719	.172	-.563	.342
BL3	200	4.01	1.173	-1.377	.172	1.160	.342
BL4	200	3.49	1.385	-.609	.172	-.935	.342
BL5	200	3.73	1.235	-1.090	.172	.241	.342

Note: All the items have a minimum value of 1 and a maximum value of 5.

The Assessment of Confirmatory Factor Analysis for Innovative Teaching

SEM is use to determine the confirmatory factor analysis for flipped classroom, google classroom-assisted learning; design-thinking process; project-based learning and blended learning with details techniques. The goodness of fit, convergent validity, discriminant validity, construct reliability and second order CFA test were also assessed. Several omnibus fit indices were used to estimate latent factors parameter, the root mean square error of approximation (RMSEA) value of .05 to .08 or .10 below, the less the better, the CMIN/DF of 1 to 5, the Tucker-Lewis Index (TLI) of goodness-of–fit (AGFI) of .90 or above, the root mean residual (RMR) of less than .05, the goodness-of-fit index (GFI) of .90 or larger, the Hoelter's critical number (CN) of estimate adequate or sufficient sample size for the model fit rather than focusing on model fit entirely (Tabachnick & Fidel, 2006). In addition, the chi-square degree of freedom ($\chi 2/df$) of a 3.49 cut off ratio is also recommended as a goodness of fit between

"observed and reproduce correlation matrices" the above statistical calculation requirements and other relevant fit indices were suggested as indicatives that the models "fit the input data well (Pintrich, 1991; Tabachnick & Fidel, 2006).

Therefore, as shown in Figure 1 on the constructs of innovative teaching which include flipped classroom, google classroom-assisted learning; design-thinking process; project-based learning and blended learning. When these five constructs measuring innovative teaching practices were first run, the fitness index was not met due to some small load of items. The items below .60 caused the model to have poor fit. According to Hair et al. (2010) expressed that any items below .60 should be remove from the hypothesized model. Based on this, all the items below .60 were removed instantly. The items removed were FC4, GC1, GC5, DTP1, DTP3, BP1, BP5, BL1, BL5. When these items were removed, the fitness indexes improved instantaneously. The results of fitness indexes were $\chi2=645.225$, $\chi2/df=2.705$, P=.000, DF= 241, TLI=.923, CFI=.914 and RMSEA=.052. these results of measurement model indicated that the data fit the hypotheses model and further analysis can be performed. See Figure 1 and Table 4 for the result of standardized regression weights.
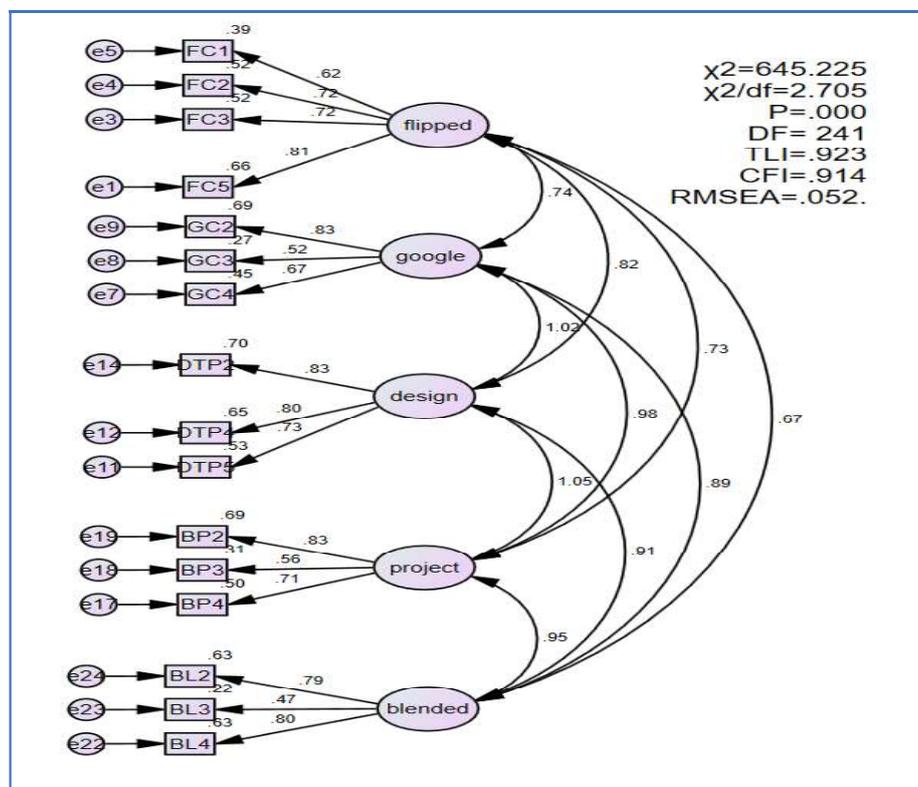

Figure 1. Confirmatory Factor Analysis for Innovative Teaching

Note: FC=flipped classroom; GC=google classroom-assisted learning; DTP=design-thinking process; BP=project-based learning; BL= blended learning

Table 4. Standardized Regression Weights

Items	Path	Constructs	Estimate loadings
FC5	<---	Flipped Classroom	.812
FC3	<---	Flipped Classroom	.718
FC2	<---	Flipped Classroom	.719
FC1	<---	Flipped Classroom	.622
GC4	<---	Google Classroom-Assisted Learning	.669
GC3	<---	Google Classroom-Assisted Learning	.524
GC2	<---	Google Classroom-Assisted Learning	.833
DTP5	<---	Design-Thinking Process	.730
DTP4	<---	Design-Thinking Process	.804
DTP2	<---	Design-Thinking Process	.834
BP4	<---	Project-Based Learning	.705
BP3	<---	Project-Based Learning	.559
BP2	<---	Project-Based Learning	.830
BL4	<---	Blended Learning	.795
BL3	<---	Blended Learning	.473
BL2	<---	Blended Learning	.793

Second Order Analysis for Innovative Teaching Construct
The second order analysis was performed for innovative teaching practices constructs. The fitness indexes for the second order were satisfactory. The results of fitness indexes were $\chi2$=645.225, $\chi2$/df=2.705, P=.000, DF= 241, TLI=.923, CFI=.914 and RMSEA=.052. In fact, the second order measurement model of innovative teaching practices was free from offending values with all fit statistics well above the set threshold. The results of five-factor innovative teaching model validated proved a satisfactory factorial validity, signifying that the core of the innovative teaching model could be represented by five general factors (flipped classroom, google classroom-assisted learning; design-thinking process; project-based learning and blended learning). These results were supported by Hair et al. (2010) in this study. The fitness indexes for the second order were satisfactory. the second order measurement model of innovative teaching was free from offending values with all fit statistics well above the set threshold. See Figure 2 and Table 5 for more details.

Figure 2. Second Order Analysis for Innovative Teaching Construct
Note: FC=flipped classroom; GC=google classroom-assisted learning; DTP=design-thinking process; BP=project-based learning; BL= blended learning

Table 5. Standardized Regression Weights

Constructs	Path	Main Construct	Estimate Factor Loadings
Flipped classroom	<---	Innovative	.749
Google Classroom-Assisted Learning	<---	Innovative	.979
Design-Thinking Process	<---	Innovative	1.026
Project-Based Learning	<---	Innovative	1.022
Blended Learning	<---	Innovative	.922

Table 6. The Assessment of Validity and Reliability for Measurement

Constructs	Items	Factor loading	Cronbach Alpha (above 0.6)	Composite Reliability (CR) (Above 0.60)	Average Variance Extracted (AVE) (Above 0.50)
Flipped Classroom	FC1	0.62	0.724	0.845	0.58
	FC2	0.72			
	FC3	0.72			
	FC4	This item was deleted due to low factor loading			
	FC5	This item was deleted due to low factor loading			
Google Classroom-Assisted Learning	GC1 0.60	This item was deleted due to low factor loading			
	GC2	0.83	0.676	0.894	
	GC3	0.52			
	GC4	0.67			

	GC5	This item was deleted due to low factor loading		
Design-Thinking Process	DTP1 0.68	This item was deleted due to low factor loading		
	DTP2	0.83	0.826	0.990
	DTP3	This item was deleted due to low factor loading		
	DTP4	0.80		
	DTP5	0.73		
Project-Based Learning	BP1 0.71	This item was deleted due to low factor loading		
	BP2	0.83	0.730	0.765
	BP3	0.56		
	BP4	0.71		
	BP5	This item was deleted due to low factor loading		
Blended Learning	BL1 0.76	This item was deleted due to low factor loading		
	BL2	0.79	0.762	0.808
	BL3	0.47		
	BL4	0.80		
	BL5	This item was deleted due to low factor loading		

Table 7. The Discriminant Validity of the Constructs

Constructs	Flipped Classroom	Google Classroom-Assisted Learning	Design-Thinking Process	Project-Based Learning	Blended Learning
Flipped Classroom	0.82				
Google	0.74	0.85			

Classroom-Assisted Learning				
Design-Thinking Process	0.82	0.1.02	0.86	
Project-Based Learning	0.98	0.73	0.1.05	0.88
Blended Learning	0.67	0.89	0.95	0.95	0.90

Discussion, Conclusion and Suggestions for Future Study
The results found in this study showed Cronbach Alpha value for all the five dimensions measuring innovative teaching practices was high and significant which was great her than 0.60 as suggested by Hair et al., (2010). Meanwhile, the confirmatory factor analysis was used which showed a satisfactory fitness indexes and loading greater than 0.60 which means the model fit the data. The assessment of fit (overall fit) for the model shows that it fits and can be accepted based on the indicators suggested by Hair et al. (2010) which indicate that data from the sample fit the innovative teaching practices model. Then, the results of convergent validity and discriminant validity of this study meet the acceptable value as well as fulfil the multivariate analysis rule of thumb. Therefore, the instruments developed was deemed fit to be used for innovative teaching practices containing these five factors. In fact, the primary focus of the instruments was to utilise in the Nigeria educational system by the teachers of 21st centuries. Nevertheless, the incoming study is needed to use bigger sample to further validate the validity of the instruments so as to see the real picture of the situation.
Hence, this current study has showed the preliminary evidence of the instrument validity. The results are expected contribute immensely to enhance students' engagement in the classroom using innovative teaching practices. Of course, the findings might also be used to sensitize stakeholder in education and policy makers by knowing innovative teaching practices instruments which can be suggested for Nigeria schools. The use of relevant instruments would help teachers and students in preparing for changes and innovation that occur in educational system. Thus, using the established innovative teaching

instruments, it can predict effective learning outcome in Nigeria schools with huge competitive advantage.

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