Conceptions of Teaching, Learning and Instructional Practices: Multi-group Analysis of Pre-service Chemistry and Physics Teachers

Concepciones sobre la enseñanza, el aprendizaje y las prácticas pedagógicas: Análisis multigrupo de profesores de Química y Física en formación inicial

Concepções sobre o ensino, a aprendizagem e as práticas pedagógicas: análise multigrupo de futuros professores de Química e Física

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Abstract: Conceptions of teaching and learning as well as instructional practices, are generally characterized as either student-centered or teacher-centered. This study explores the relationship between

pre-service teachers' conceptions of teaching and learning, and their instructional practices, examining whether the relationship differs across science teacher education programs. Data were collected from final-year preservice chemistry and physics teachers who had completed their teaching practicum. A multi-group structural equation model was employed to assess the invariance of the relationship across the two groups. Existing research instruments identified in the literature were adopted for the study. The results indicated that differences existed between the groups; however, these differences were not statistically significant. The findings highlight the importance of considering pre-service teachers' conceptions of teaching and learning in teacher education programs to promote effective instructional practices tailored to the specific needs of different educational settings.

Keywords: instruction, learning, chemistry, physics, teachers.

Resumen: Las concepciones sobre la enseñanza y el aprendizaje, así como las prácticas pedagógicas, suelen caracterizarse como centradas en el estudiantado o centradas en el profesorado. Este estudio explora la relación entre las concepciones de los profesores en formación inicial sobre la enseñanza y el aprendizaje, y sus prácticas pedagógicas, examinando si dicha relación difiere entre programas de formación docente en ciencias. Se recopilaron datos a partir de profesores en formación inicial, en calidad de estudiantes del último año de las carreras de enseñanza de Química y Física, quienes habían completado su práctica docente. Se empleó un modelo de ecuaciones estructurales multigrupo para evaluar la invarianza de la relación entre ambos grupos. Se adoptaron instrumentos de investigación existentes, identificados en la literatura, para el desarrollo del estudio. Los resultados indicaron que existían diferencias entre los grupos; sin embargo, estas diferencias no fueron estadísticamente significativas. Los hallazgos resaltan la importancia de considerar las concepciones de los profesores en formación inicial sobre la enseñanza y el aprendizaje dentro de los programas de formación docente, con el fin de promover prácticas pedagógicas eficaces y adaptadas a las necesidades específicas de los distintos contextos educativos.

Palabras claves: enseñanza, aprendizaje, química, física, profesorado.

Resumo: As concepções sobre ensino e aprendizagem, assim como as práticas pedagógicas, costumam ser caracterizadas como centradas no aluno ou centradas no professor. Este estudo investiga a relação entre as concepções de professores em formação sobre ensino e aprendizagem e suas práticas pedagógicas, analisando se essa relação difere entre programas de formação de professores de ciências. Os dados foram coletados com professores de Química e Física em formação, matriculados no último ano do curso e com estágio docente concluído. Utilizou-se um modelo de equações estruturais multigrupo para avaliar a invariância da relação entre os dois grupos. O estudo adotou instrumentos de pesquisa previamente identificados na literatura. Os resultados indicaram diferenças entre os grupos; contudo, essas diferenças não foram estatisticamente significativas. As conclusões ressaltam a importância de considerar as concepções dos professores em formação sobre ensino e aprendizagem nos programas de formação docente, a fim de promover práticas pedagógicas eficazes e adequadas às necessidades dos diferentes contextos educacionais.

Palavras-chave: ensino, aprendizagem, química, física, professores.

INTRODUCTION

Conception of teaching and learning are also known as pedagogical beliefs whether teacher-centered or student-centered directly inform how a teacher or instructor prepares and designs lessons, select instructional materials and develops a student-teacher relationship. Teachers with the learner centered beliefs tend to implement student friendly approaches during teaching and learning activities, adapt and create instructional

material that drives student curiosity, promote engagement and improve their cognition level. Several previous reports indicated that pedagogical beliefs are the primary drivers of teacher's instructional practice, shaping how a classroom instruction is delivered to enhance meaningful learning and understanding. Samuelowicz and Bain (2001) and Richardson et al. (1991) asserted that teachers' beliefs about teaching and learning serve as basis for implementing instructional methods. Almunawaroh and Steklacs (2025) asserted that English as a Foreign Language (EFL) secondary school teachers' pedagogical content knowledge and beliefs influence their approach to using instructional materials, influencing both constructivist and transmissive/contemporary beliefs. Constructivist instructional practice is plagued with numerous challenges which hindered its full implementation by the teachers and instructors. Auslander et al. (2023) opined that seasoned elementary teachers struggle with implementing learner centered and equitable instructions due to challenges like multiple student responsibilities and prescribed activities-based lesson plans.

Yang et al. (2020) asserted that pre-service mathematics teacher' beliefs about mathematics and conceptions of teaching and learning strongly predicted the inquiry-oriented instructional practice. Yousaf et al. (2021) asserted that Pakistani university teachers' classroom instructional practices are significantly correlated with their pedagogic beliefs. Muhtarom et al. (2019) submitted that prospective mathematics teachers with constructivist and learner centered beliefs with good pedagogical content knowledge can teach students effectively in a dynamic and creative-based learning environment.

Teachers' beliefs about grammar can influence their pedagogical practices significantly leading to formulating approaches and reducing attention to grammar in writing (Watson, 2015). Inan and Bolliger (2024) asserted that an online teacher or instructor with learner centered or constructivist beliefs tend to choose more student-centered activities, but traditional teaching practice co-exist with these beliefs. Early career teachers' pedagogical beliefs align with university core values, but their diverse practice suggests a need for a framework to understand teaching development and the interplay between teaching beliefs and instructional practice (Stegeager et al., 2024). Studies like Chen et al. (2024), Stegeager et al. (2024) and Auslander et al. (2023) reported that teacher's stated beliefs do not always align with their observed classroom practices. The current study tends to verify the reports of the above sources. Fostering reflective practice and supporting positive conception of teaching and learning can enhance quality instruction.

Adoption of student's centered method of instruction in science and its related subjects are grounded in constructivist and social-constructivist learning theories. Teachers with knowledge construction or conceptual changes are more likely to adopt strategies that will aid student's understanding of abstract concepts in science's laws, facts, principles and theories that are relevant to nation building. Structural equation model (SEM) is a modern statistical method that determines the complex relationship among variables. This method merges factor analysis and multiple regression that allows researchers in psychology, education, marketing and health to correct measurement errors, analyze direct and indirect (moderation and mediation) impacts of exogenous variables on endogenous variables (Pedagogical/Instructional Beliefs and Instructional Practices). Francis (1988) asserted that structural equation model is a method designed for testing complex hypotheses within networks or relationships. Therefore, the general objective of this study was to examine the structural relationships between conceptions of teaching and learning and instructional practices and to determine whether these relationships differ between pre-service chemistry and physics teachers using multi-group structural equation modeling. To achieve this objective, two specific objectives were established: (1) to determine the effects of the dimensions of conceptions of teaching and learning on the instructional practices of pre-service chemistry and physics teachers, and (2) to determine whether the effects of these dimensions on instructional practices differ significantly between the two groups of pre-service teachers. The following table presents a review of relevant studies, highlighting their samples, variables, key findings and primary contributions to the field.

Previous Studies

Table 1.
The following previous studies were reviewed as related to the current study

Authors	Method	Sample	Exogenous Variables	Mediating variables	Main finding	Contribution
Zhang et al. (2025)	SEM	516 English teachers from varied universities	Emotion regulation & pedagogical beliefs	Classroom practices	Pedagogical beliefs significantly correlated with teacher engagement.	Study shows variables interconnection, their significance shaping teaching effectiveness and learning experience
Yilmaz and Sahim (2011)	Traditional correlation	460 pre-service teachers	Pedagogical beliefs	--	No significant correlation between epistemology and teaching- learning.	Study provides empirical contribution to literature.
Lee et al. (2024)	SEM	182 early childhood education teachers (Korea, Spain and Germany)	Pedagogical beliefs	--	Koreans had constructivist beliefs compared to Spanish and higher instructional beliefs than Germans.	Study highlights cultural and contextual factors shaping pedagogical beliefs and early childhood education in those countries.
Angel et al. (2009)	SEM	7008 secondary teachers	Epistemological beliefs	Pedagogical beliefs	Significant relationship with constructivism, traditional teaching and epistemology.	Study contributes to Chinese cultural context.
Lee et al. (2013)	SEM	1008 secondary teachers	Epistemological beliefs	Pedagogical beliefs	Constructivist conception correlated with standard instruction, but the traditional one was negative	Study supports constructivist t-oriented curriculum.
Sendurur (2018)	Qualitative	20 IT pre-service teachers	Pedagogical beliefs	--	IT pre-service teachers tended towards pedagogy but failed to transfer into practice.	Study emphasizes constructivism and practices.
Bahcivan et al. (2019)	SEM	1499 pre-service teachers	Epistemological beliefs	Teaching - learning conception and pedagogy	Constructivist and traditional conceptions predicted technology integration	Study emphasizes that epistemology supports technology integration.
Alt (2018)	SEM	303 science teachers	Conception of teaching and learning	--	Constructivism exerted moderate effects on teacher's efficacy dimensions.	Study advocates constructivist information, communication and technological teaching-learning.

Source: Online Database.

Table 1 summarizes previous studies on epistemological beliefs, pedagogical beliefs, conceptions of teaching and learning, and instructional practices. Overall, the findings indicate that constructivist-oriented beliefs are generally associated with more effective instructional practices, while contextual and cultural factors also play an important role in shaping teachers' beliefs and classroom approaches. Drawing on these findings, the present study hypothesizes that constructivist and traditional conceptions of teaching and learning significantly predict standard contemporary, focused, and flexible group instructional practices among pre-service chemistry and physics teachers, and that these structural relationships differ significantly between the two groups.

MATERIALS AND METHODS

This study employed a correlational research design and utilized multi-group structural equation modeling (MGSEM), a multivariate statistical technique, to examine the relationships between conceptions of teaching and learning and instructional practices and to determine whether these relationships differed between pre-service chemistry and physics teachers. The target population consisted of undergraduate Chemistry and Physics education students enrolled in faculties of education at Nigerian universities who had completed their teaching practicum and classroom observation activities. A convenience sample of 301 pre-service teachers meeting these criteria participated in the study. These participants were considered suitable for the study because they had acquired relevant teaching experience through their teacher preparation programs. Convenience sampling was employed due to the accessibility and availability of eligible participants during the data collection period.

Table 2 described the demographic profiles of the respondents. 196 respondents representing 65.1% were pre-service chemistry teachers while 105 respondents representing 34.9% were pre-service physics teachers. The categories of the respondents involve 102 female students representing 33.9% of the total respondents' size, 199 malestudents representing 66.1% of the total respondents.

Table 2.
Demographic Profile of the Respondents

		N	%
Course of Study	Chemistry Education	196	65.1
	Physics Education	105	34.9
Gender	Female	102	33.9
	Male	199	66.1
Total		**301**	**100**

Source: Field Work, 2025.

The adapted and adopted constructs' instrument as shown in Table 3 from previous literature on conception of teaching and learning, and instructional practices saved in Google form were shared via the respondents' group WhatsApp. The analysis utilized 301 responses retrieved from an online survey via Google form. A general criterion for sample size selection is encouraged by multivariate methods like structural equation modeling. The multiple-choice grid on a Google form with the build elements was uploaded, and the link was shared on WhatsApp with the responders' group.

Thus, Table 3 presents the conceptual definitions of the constructs examined in this study and their corresponding sources. The constructs are organized into two broad categories: conceptions of teaching and learning and instructional practices. Conceptions of teaching and learning comprise two dimensions—constructivist and traditional—representing contrasting views of how knowledge is acquired and transmitted. While the constructivist conception emphasizes learners' active participation in knowledge construction through experience, reflection, and social interaction, the traditional conception views the teacher as the primary source of knowledge. Instructional practices are represented by three dimensions: standard contemporary, focused, and flexible group instructional practices. Together, these constructs provide theoretical foundation for examining the relationships between conceptions of teaching and learning and instructional practices among pre-service chemistry and physics teachers.

Table 3.
Constructs' Meaning and Source

Construct	Construct's Meaning	Source
Pedagogical/Instructional Beliefs/ Conception of Teaching and Learning	Underlying convictions, attitudes and philosophies about how learning and teaching activities take place	Ertmer (2005); Snider and Roehl (2007) and Sulaiman et al. (2022)
Constructivist Conception of Teaching and Learning	The learner is an active constructor of knowledge through experience, reflection and social interaction	Dennick (2016)
Traditional Conception of Teaching and Learning	The teacher is the passive recipient of information	O'Connor (2022) and Shah (2019)
Instructional/Pedagogical Practice	Planned teaching activities, approaches and interactions employed to aid learning	Lowell and Urena-Rodriguez (2023)
Standard Contemporary Instructional Practice	Practice characterized by student-centered, technology integration and skill focused approach	Akram et al. (2024) and Fries et al. (2020)
Focused Instructional Practice	Practice deliberately focused on specific learning goals, skills and content areas	Collins and Ruivivar (2020); and Spada and Lightbown (2008)
Flexible Group Instructional Practice	Students' are organized into groups-based learning objectives, needs and specific activities	Dhakal (2025) and Mckeen (2019)

Source: Previous Literature.

DISCUSION OF RESULTS

This section discusses the findings of the study in relation to the research objectives and existing literature on pre-service teachers' conceptions of teaching and learning and their instructional practices. Although some differences were observed in the relationships between these constructs among pre-service chemistry and physics teachers, the differences were not statistically significant. The findings are interpreted in light of current theoretical perspectives and empirical evidence, with consideration of their implications for teacher education programs and the preparation of future science teachers.

Measurement Model

The analysis in Table 4 below report the convergent validity. The table contains the various reliability and validity indexes of the measured constructs in the model. Cronbach Alpha values measure the internal consistency and by extension the extent to which items of a variable are correlated. The Cronbach Alpha's value closer to 1 indicate stronger internal consistency. The composite reliability (rho_a) is also alternative means of calculating the internal consistency of the constructs. Average variance extracted (AVE) measures the amount of variance captured by the construt in relation to the amount of variance due to measurement error. Average Variance Extract value indicated validity index with various authors accepted standard. The Table 4 divided into A. B. & C. show the reliability and validity indexes of chemistry and physics pre-service teachers responses on the constructs in the model.

Table 4.
Convergent Validity shows construct correlation

A. Complete	SEM		
Constructs	**Cronbach's alpha**	**Composite reliability (rho_a)**	**Average variance extracted (AVE)**
Constructivist Conception of Teaching and learning	0.651	0.668	0.491
Flexible Grouped Instructional Practices	0.347	-0.765	0.253
Focused Instructional Practice	0.308	0.404	0.439
Standard Contemporary Instructional Practice	0.365	0.408	0.317
Traditional Conception of Teaching and learning	0.274	0.651	0.362

B. Pre-service Chemistry Teachers	SEM		
Constructs	**Cronbach's alpha**	**Composite reliability (rho_a)**	**Average variance extracted (AVE)**
Constructivist Conception of Teaching	0.649	0.670	0.486
Flexible Grouped Practices	0.372	-0.763	0.310
Focused Instruction	0.371	0.608	0.462
Standard Contemporary Practice	0.360	0.356	0.307
Traditional Conception of Teaching	0.309	0.644	0.357

C. Pre-service Physics Teachers	SEM		
Constructs	**Cronbach's alpha**	**Composite reliability (rho_a)**	**Average variance extracted (AVE)**
Constructivist Conception of Teaching	0.657	1.087	0.456
Flexible Grouped Practices	0.289	-0.089	0.364
Focused Instruction	0.108	0.416	0.411
Standard Contemporary Practice	0.370	0.575	0.378
Traditional Conception of Teaching	0.179	0.676	0.384

Source: Field Work, 2025.

The Heterotrait–Monotrait (HTMT) ratio of correlations was used to assess discriminant validity among the constructs in the model. The results presented in Table 5 indicate that most HTMT values were below the recommended threshold of 0.85, suggesting adequate discriminant validity and demonstrating that the constructs are generally distinct from one another. However, the HTMT values between Focused Instructional Practice and Standard Contemporary Instructional Practice (0.868), and between Standard Contemporary Instructional Practice and Traditional Conception of Teaching and Learning (0.962), exceeded the recommended threshold. These results suggest potential discriminant validity issues between these pairs of constructs.

Table 5:
Complete Discriminant for Pre-service Chemistry and Physics Teachers

Complete					
	Constructivist Conception of Teaching and Learning	**Flexible Grouped Practices**	**Focused Instruction**	**Standard Contemporary Practice**	**Traditional Conception of Teaching and Learning**
Constructivist Conception of Teaching and Learning	NA				
Flexible Grouped Practices	0.219				
Focused Instruction	0.244	0.696			
Standard Contemporary Practice	0.302	0.225	0.868		
Traditional Conception of Teaching and Learning	0.528	0.395	0.414	0.962	NA

Source: Field Work, 2025.

Table 6 presents the HTMT ratios used to assess discriminant validity among the constructs for pre-service chemistry teachers. Most HTMT values were below the recommended threshold of 0.85, indicating that the corresponding constructs were empirically distinct. However, the HTMT values between Focused Instructional Practice and Standard Contemporary Instructional Practice (1.087), and between Standard Contemporary Instructional Practice and Traditional Conception of Teaching and Learning (0.951), exceeded the acceptable threshold. These results suggest insufficient discriminant validity between these pairs of constructs, indicating potential conceptual overlap.

Table 6.
Discriminant Validity table for Pre-service Chemistry Teachers only

Pre-service Chemistry Teacher					
	Constructivist Conception of Teaching and Learning	**Flexible Grouped Practices**	**Focused Instruction**	**Standard Contemporary Practice**	**Traditional Conception of Teaching and Learning**
Constructivist Conception of Teaching and Learning	NA				
Flexible Grouped Practices	0.269				
Focused Instruction	0.252	0.619			
Standard Contemporary Practice	0.408	0.281	1.087		
Traditional Conception of Teaching and Learning	0.541	0.419	0.456	0.951	NA

Source: Field Work, 2025.

Evidence from Table 7 suggests the HTMT ratios for the pre-service physics teachers, where results indicate adequate discriminant validity for most constructs, as the HTMT values were below the recommended threshold of 0.90, suggesting that the constructs are sufficiently distinct from one another. However, the HTMT value between Standard Contemporary Instructional Practice and Traditional Conception of Teaching (0.986) exceeded the acceptable threshold, indicating a lack of discriminant validity between these two constructs and suggesting potential conceptual overlap.

Table 7.
Discriminant Validity table for Pre-service Physics Teachers only

Pre-service Physics Teacher					
	Constructivist Conception of Teaching	Flexible Grouped Practices	Focused Instruction	Standard Contemporary Practice	Traditional Conception of Teaching
Constructivist Conception of Teaching	NA				
Flexible Grouped Practices	0.247				
Focused Instruction	0.327	0.817			
Standard Contemporary Practice	0.187	0.263	0.571		
Traditional Conception of Teaching	0.628	0.361	0.374	0.986	NA

Source: Field Work, 2025.

The results in Table 8. A below supported that traditional conception of teaching and learning dimension significantly correlated with standard contemporary instructional practice in the complete result (Combination of pre-service chemistry and physics teachers). The multi-group analysis of pre-service chemistry and physics teachers' traditional conception of teaching and learning dimension of the pedagogical beliefs significantly correlated and predicted their standard contemporary instructional practice. The complete result of the study revealed that constructivist conception of teaching and learning had positive, negative, low and non significant relationship with flexible grouped instructional practices (β=0.128, p>.05), focused instructional practice(β=-0.122, p>.05), and standard contemporary instructional practice (β=0.126, p>.05). The traditional conception of teaching and learning had low, substantial, negative, positive, significant and non-significant relationship with flexible grouped instructional practices (β=-0.028, p>.05), focused instructional practice (β=-0.003, p>.05), and standard contemporary instructional practice (β=0.549, p<.05).

Table 8.A.
Complete Coefficient Table of Pre-service Chemistry and Physics Teachers' Pedagogical/Instructional Beliefs/Conception of Teaching and Learning and Instructional Practices.

Complete				
	Path Coeff. (β)	Mean Coeff.	T statistics	P values
Constructivist Conception of Teaching ➜ Flexible Grouped Instructional Practice	0.128	0.051	0.883	0.377
Constructivist Conception of Teaching ➜ Focused Instructional Practice	-0.122	-0.121	1.316	0.188
Constructivist Conception of Teaching ➜ Standard Contemporary Instructional Practice	0.126	0.113	1.842	0.066
Traditional Conception of Teaching ➜ Flexible Grouped Instructional Practice	-0.028	0.003	0.374	0.709
Traditional Conception of Teaching ➜ Focused Instructional Practice	-0.003	0.026	0.031	0.975
Traditional Conception of Teaching ➜ Standard Contemporary Instructional Practice	0.549	0.554	16.195	0.000

Source: Field Work, 2025.

Table 8.B for the pre-service chemistry teachersindicated that constructivist conception of teaching and learning had positive, negative, low and non signifcant relationship with flexible grouped instructional practices (β=0.156, p>.05), focused instructional practice(β=-0.101, p>.05), and standard contemporary instructional practice (β=0.143, p>.05). The traditional conception of teaching and learning had low, substantial, negative, positive, significant and non-significant relationship with flexible grouped instructional practices (β=-0.022, p>.05), focused instructional practice (β=0.058, p>.05), and standard contemporary instructional practice (β=0.508, p<.05).

Table 8.B.
Coefficient Table of Pre-service Chemistry Teachers' Pedagogical/Instructional Beliefs/Conception of Teaching and Learning and Instructional Practices.

Pre-service Chemistry Teachers				
	Path Coeff. (β)	**Mean Coeff.**	**T statistics**	**P values**
Constructivist Conception of Teaching ➜ Flexible Grouped Instructional Practice	0.156	0.114	1.061	0.289
Constructivist Conception of Teaching ➜ Focused Instructional Practice	-0.101	-0.103	0.888	0.375
Constructivist Conception of Teaching ➜ Standard Contemporary Instructional Practice	0.143	0.128	1.514	0.130
Traditional Conception of Teaching ➜ Flexible Grouped Instructional Practice	-0.022	0.001	0.250	0.803
Traditional Conception of Teaching ➜ Focused Instructional Practice	0.058	0.080	0.521	0.602
Traditional Conception of Teaching ➜ Standard Contemporary Instructional Practice	0.508	0.516	10.157	0.000

Source: Field Work, 2025.

Evidence from Table 8.C for the pre-service physics teachers Table 8.C demonstrated that constructivist conception of teaching and learning had positive, negative, low and non signifcant relationship with flexible grouped instructional practices (β=-0.139, p>.05), focused instructional practice(β=-0.236, p>.05), and standard contemporary instructional practice (β=0.110, p>.05). The traditional conception of teaching and learning had low, substantial, negative, positive, significant and non-significant relationship with flexible grouped instructional practices (β=-0.007, p>.05), focused instructional practice (β=-0.091, p>.05), and standard contemporary instructional practice (β=0.650, p<.05).

Table 8.C.
Coefficient Table of Pre-service Physics Teachers' Pedagogical/Instructional Beliefs/Conception of Teaching and Learning and Instructional Practices.

Pre-service Physics Teachers				
	Path Coeff. (β)	**Mean Coeff.**	**T statistics**	**P values**
Constructivist Conception of Teaching ➜ Flexible Grouped Instructional Practice	-0.139	-0.118	0.686	0.493
Constructivist Conception of Teaching ➜ Focused Instructional Practice	-0.236	-0.174	1.011	0.312
Constructivist Conception of Teaching ➜ Standard Contemporary Instructional Practice	0.110	0.099	1.312	0.190

(continued)

Table 8.C (continued)

Pre-service Physics Teachers				
	Path Coeff. (β)	**Mean Coeff.**	**T statistics**	**P values**
Traditional Conception of Teaching ➜ Flexible Grouped Instructional Practice	-0.007	0.001	0.052	0.958
Traditional Conception of Teaching ➜ Focused Instructional Practice	-0.091	-0.044	0.702	0.483
Traditional Conception of Teaching ➜ Standard Contemporary Instructional Practice	0.650	0.662	13.834	0.000

Source: Field Work, 2025.

Overall, the results indicate that teachers who hold stronger traditional conceptions of teaching and learning tend to report higher levels of standard contemporary instructional practices. In contrast, neither traditional nor constructivist conceptions significantly predict focused instructional practices or flexible grouped instructional practices.

On the other hand, the values in Table 9 below analyzed the coefficient of determination of the exogenous construct's dimensions on endogenous' construct's dimension. The results indicated that pedagogical belief dimensions explained 1.8% of the respondents' flexible grouped practices, 1.5% of the standard focused instructional practice and 30.6% of the standard contemporary instructional practice. The multi-group analysis results indicated that pre-service chemistry teachers' pedagogical beliefs explained 1.4% of the focused instructional practice, 27.8% of the standard contemporary instructional practice and 1.4% of the flexible grouped instructional practice while pre-service physics teachers' pedagogical beliefs explained 5.4% of focused instructional practice, 5.0% of the flexible grouped instructional practice and 40.1% of the standard contemporary instructional practice. The following presents the **coefficient of determination (R^2)** and **Adjusted R^2** values for the three instructional practice constructs in the complete sample and in the two subgroups (pre-service chemistry teachers and pre-service physics teachers).

Table 9.
Coefficient of determination (R^2) and Adjusted R^2 values

Complete			**Pre-service Chemistry Teacher**			**Pre-service Physics Teacher**		
	R^2	**Adjusted R^2**		**R^2**	**Adjusted R^2**		**R^2**	**Adjusted R^2**
Flexible Grouped Practices	0.018	0.014	Flexible Grouped Practices	0.025	0.019	Flexible Grouped Practices	0.019	0.005
Focused Instruction	0.015	0.011	Focused Instruction	0.014	0.008	Focused Instruction	0.054	0.041
Standard Contemporary Practice	0.306	0.303	Standard Contemporary Practice	0.278	0.274	Standard Contemporary Practice	0.401	0.393

Source: Field Work, 2025.

Regarding the pedagogical beliefs' dimension, Table 10 below shows the effect size on the instructional practice's dimensions. The results revealed that traditional conception of teaching and learning dimension of the pedagogical beliefs had moderate effect size on standard contemporary instructional practice in complete.

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The multi-group analysis discoveredthat pre-service chemistry and physics teachers' traditional conception of teaching and learning dimensions ofpedagogical beliefs had moderate and substantial effect size on the other dimensions of standard contemporary instructional practice.

Table 10.
Effect Size (f^2) which measures the strength of the contribution of an exogenous (predictor) variable to an endogenous (outcome) variable.

Complete		Pre-service Chemistry Teacher		Pre-service Physics Teacher	
Constructivist Conception of Teaching ➜ Flexible Grouped Practices	0.017	Constructivist Conception of Teaching ➜ Flexible Grouped Practices	0.025	Constructivist Conception of Teaching ➜ Flexible Grouped Practices	0.019
Constructivist Conception of Teaching ➜ Focused Instruction	0.015	Constructivist Conception of Teaching ➜ Focused Instruction	0.010	Constructivist Conception of Teaching ➜ Focused Instruction	0.056
Constructivist Conception of Teaching ➜ Standard Contemporary Practice	0.023	Constructivist Conception of Teaching ➜ Standard Contemporary Practice	0.028	Constructivist Conception of Teaching ➜ tandard Contemporary Practice	0.019
Traditional Conception of Teaching ➜ Flexible Grouped Practices	0.001	Traditional Conception of Teaching ➜ Flexible Grouped Practices	0.000	Traditional Conception of Teaching ➜ Flexible Grouped Practices	0.000
Traditional Conception of Teaching ➜ Focused Instruction	0.000	Traditional Conception of Teaching ➜ Focused Instruction	0.003	Traditional Conception of Teaching ➜ Focused Instruction	0.008
Traditional Conception of Teaching ➜ Standard Contemporary Practice	0.431	Traditional Conception of Teaching ➜ Standard Contemporary Practice	0.358	Traditional Conception of Teaching ➜ Standard Contemporary Practice	0.668

Source: Field Work, 2025.

The findings presented in Table 11 show the results of the multi-group analysis comparing the structural relationships between pedagogical beliefs and instructional practices among pre-service chemistry and physics teachers. Positive difference values indicate stronger relationships for pre-service chemistry teachers, whereas negative values indicate stronger relationships for pre-service physics teachers. The results revealed that the relationships between constructivist conception of teaching and learning and flexible grouped instructional practice, focused instructional practice, and standard contemporary instructional practice, as well as the relationship between traditional conception of teaching and learning and focused instructional practice, were stronger among pre-service chemistry teachers. However, none of these differences were statistically significant. In contrast, the relationships between traditional conception of teaching and learning and flexible grouped instructional practice, and between traditional conception of teaching and learning and standard contemporary instructional practice, were stronger among pre-service physics teachers. Nevertheless, only the difference in the relationship between traditional conception of teaching and learning and standard contemporary instructional practice was statistically significant ($\Delta = -0.141$, $p = 0.033$). Overall, the findings suggest that the structural relationships were largely similar across the two groups, with the exception of the relationship between traditional conception of teaching and learning and standard contemporary instructional practice.

The **difference in value** represents the difference in path coefficients between the two groups (Chemistry – Physics), while the **p-value** indicates whether the difference is statistically significant.

Table 11.
Multi-Group Analysis of Structural Relationships

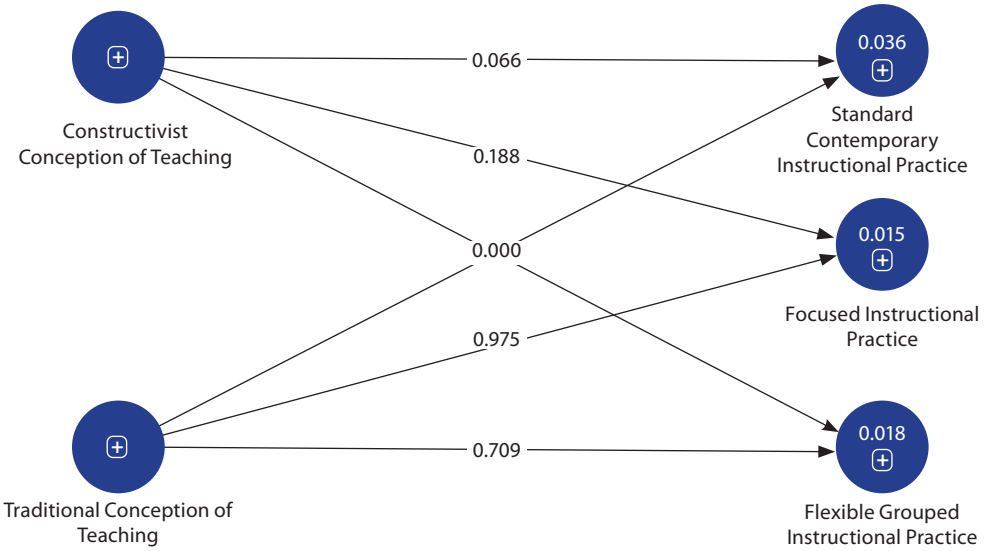
	Difference (Pre-service Chemistry Teachers - Pre-service Physics Teachers)	2-tailed (Pre-service Chemistry Teachers vs Pre-service Physics Teachers) p-value
Constructivist conception of teaching and learning ➜ Flexible Grouped Instructional Practices	0.294	0.277
Constructivist conception of teaching and learning ➜ Focused Instructional Practice	0.134	0.410
Constructivist conception of teaching and learning ➜ Standard Contemporary Instructional Practice	0.033	0.712
Traditional conception of teaching and learning ➜ Flexible Grouped Instructional Practices	-0.015	0.925
Traditional conception of teaching and learning ➜ Focused Instructional Practice	0.148	0.392
Traditional conception of teaching and learning ➜ Standard Contemporary Instructional Practice	-0.141	0.033

Source: Field Work, 2025.

Finally, Figure 1 presents the structural equation modeling results for the complete sample. The reported path coefficients, significance values, and coefficients of determination (R^2) provide evidence regarding the relationships between conceptions of teaching and learning and instructional practices.

To complement these results, Figure 1 provides a graphical representation where values displayed on the arrows represent the p-values of the structural paths, whereas the values within the endogenous constructs indicate the corresponding R^2 values (explained variance).

Figure 1.
Graphical Output of the Relationships among the Constructs



Source: Field Work, 2025.

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CONCLUSIONS

This study examined the relationship between pre-service chemistry and physics teachers' conceptions of teaching and learning and their instructional practices using a multi-group structural equation modeling approach. The findings showed that constructivist and traditional conceptions of teaching and learning explained only a small proportion of the variance in Flexible Grouped Instructional Practices and Focused Instructional Practices in both groups. However, these conceptions demonstrated a moderate explanatory power for Standard Contemporary Instructional Practice, particularly among pre-service physics teachers.The effect size analysis further revealed that constructivist conceptions generally exerted small effects on instructional practices, whereas traditional conceptions showed a moderate to large effect on Standard Contemporary Instructional Practice.

The multi-group analysis showed that most structural relationships did not differ significantly between pre-service chemistry and physics teachers, suggesting that the influence of pedagogical beliefs on instructional practices is largely similar across the two teacher education programs.Only one significant difference was identified, namely the relationship between traditional conception of teaching and learning and Standard Contemporary Instructional Practice.Overall, the findings suggest that conceptions of teaching and learning contribute to explaining certain instructional practices, especially Standard Contemporary Instructional Practice, but are insufficient to fully account for variations in instructional practice preferences.

The study achieved its objectives by examining the structural relationships between conceptions of teaching and learning and instructional practices and by determining whether these relationships differed between pre-service chemistry and physics teachers. These findings contribute to the growing body of literature on conceptions of teaching and learning and instructional practices and provide insights for teacher education programs seeking to strengthen the alignment between teachers' beliefs and classroom practices. Given the relatively low explanatory power observed for Flexible Grouped and Focused Instructional Practices, future research should investigate additional factors that may influence instructional practices, such as teaching self-efficacy, pedagogical content knowledge, contextual factors, and teacher preparation experiences.

AUTHOR CONTRIBUTIONS

Yahaya Wasiu Olayinka: conceptualization, data curation, formal analysis, research, methodology, project administration, resources, software, visualization, writing – original draft, writing – review and editing.

Akanbi Abdulrasaq Oladimeji: conceptualization, data curation, formal analysis, research, methodology, resources, writing – original draft, writing – review and editing.

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REFERENCES

Akram, M., Salleh, S., & Zia, K. (2024).Exploring contemporary teaching methods: a self-reflective study from an educator self-reflective teaching degree.*International Journal of Academic Research in Progressive Education and Development,* 305-301. https://doi.org/10.6007/IJARPED/v13-i4/23211

Almunawaroh, N., &Steklacs, J. (2025). The interplay of secondary EFL teachers' pedagogical beliefs and Pedagogical content knowledge with their instructional materials use approach orientation. *Heliyon, 11*. https://doi.org/10.1016/j.heliyon.2025.e42065.

Alt, D. (2018). Science teachers' conceptions of teaching and learning, ICT efficacy, ICT professional development and ICT practices enacted in their classrooms. *Teaching and Teacher Education, 73*, 141-150.

Angel, K. W., Chan, K., & Lai, P. (2009).Revising the relationships of epistemological beliefs and conceptions about teaching and learning of pre-service teachers in Hong Kong. *Asia-Pacific Education Researcher* (De La Salle University Manila), 18(1), 1.

Auslander, S., Myers, K., Bingham, G., &Tanguay, C. (2023).Exploringthe Pedagogical practices of seasoned elementary mathematics teachers and connections with their content knowledge and beliefs. *School Science and Mathematics, 123*, (4-5), 168-183. https://doi.org/10.1111/ssm.12591

Bahcivan, E., Gurer, M. D., Yavuzalp, N., &Akayoglu, S. (2019). Investigating the relation among pre-service teachers' teaching/learning beliefs and educational technology integration competencies: structural equation modeling. *Journal of Science Education and Technology*.https://doi.org/10.1007/s10956-019-09788-6

Blomeke, S. (2012). Does greater teacher knowledge lead to student orientation? The relationship between teacher knowledge and teacher beliefs. Munster, New York, Munchen, Berlin. 16-37. https://doi.org/10.25656/01:21030

Chen, S., Philips, B., & Dong, S. (2024). Unpacking the language teaching belief-practice alignment among preschool teachers serving children from low-SES backgrounds.*Teaching and Teacher Education,140*. https://doi.org/10.1016/j.tate.2023.104465

Collins, L., Ruivivar, J. (2020). Form-focused instruction. *The Encyclopedia of Applied Linguistics*.https://doi.org/10.1002/9781405198431.wbeal0432.pub2

Dennick, R. (2016). Constructivism: reflections on twenty-five years teaching the constructivist approach in medical education. *International Journal of Medical Education, 7,* 200-205. https://doi.org/10.5116/ijme.5763.de11.

Dhakal, B. (2025). Optimizing reading instruction through flexible grouping practices. *KMC Journal, 7*(1), 185-203. https://doi.org/10.3126/kmcj.v7i1.75131

Ertmer, P. (2005). Teacher pedagogical beliefs: the final frontier in our quest for technology integration.*Educational Technology Research and Development, 53*, 25-39. https://doi.org/10.1007/BF02504683.

Francis, D. J. (1988). An introduction to structural equation model. Journal of Clinical and Experimental*Neuropsychology, 10*(5), 623-639. https://doi.org/10.1080/01688638808402800

Fries, L., Son, J., Givvin, K., & Stigler, J. (2020). Practicing connections: a framework to guide instructional design for developing understanding in complex domains. *Educational Psychology Review, 33,* 739-762. https://doi.org/10.1007/s10648-020-09561-x.

Inan, F., &Bolliger, D. (2024).Online instructors' pedagogical beliefs and choice of student learning activities. *Educational Technology Research and Development, 72,* 727-746. https://doi.org/10.1007/s11423-023-10331-2

Lee, J., Y., Sagastui, J., Mischo, C., Masters, A. S., Peters, S., Wolstein, K., Golinkoff, R. M., & Hirsh-Pasek, K. (2024). Understanding cross-cultural differences in pedagogical beliefs: a comparison among south Korean, Spanish, and German early childhood teachers. *Teaching and Teacher Education, 148*, 104704.https://doi.org/10.1016/j.tate.2024.104704

Lee, J. C., Zhang, Z., Song, H., & Huang, X. (2013). Effects of epistemological and pedagogical beliefs on the instructional practices of teachers: Chinese perspectives. *Australian Journal of Teacher Education, 38*(12), 120-146. http://ro.ecu.edu.au/ajte/vol38/iss12/8

Lowell, V., &Urena-Rodríguez, L. (2023).A framework for examining relationships and classifying instructional strategies, methods and techniques. *SAGE, Open*, 13.https://doi.org/10.1177/21582440231202911

Mckeen, H. (2019). The impact of grade level flexible grouping on math achievement scores. *Georgia Educational Researcher, 16*(1), Article 5. https://doi.org/10.20429/GER.2019.160105.

Muhtarom, M., Juniati, D., &Siswono, T. (2019).Examiningprospective teachers' belief and Pedagogical content knowledge towards teaching practice in mathematics class: a case study.*Journal of Mathematics Education*. https://doi.org/10.22342/JME.10.2.7326.185-202

O'Connor, K. (2020). "Constructivism, curriculum and the knowledge question: tensions and challenges for higher education" *Studies in Higher Education, 47*(2), 412-422. https://doi.org/10.1080/03075079.2020.1750585

Samuelowicz, K. Bain, J. D. (2001). Revisiting academics' beliefs about teaching and learning. *Higher Education, 41*(3), 299-325. https://doi.org/10.1023/A:1004130031247

Sendurur, E. (2018). The pedagogical beliefs and instructional design practices: pre-service IT teachers' case. *Eurasian Journal of Educational Research, 75*, 59-80. DOI:10.14689/ejer.2018.75.4

Shah, R. (2019). Effective constructivist teaching& learning in the classroom. *Shanlax International Journal of Education, 7*(4), 1-13. https://doi.org/10.34293/education.v7i4.600.

Snider, V., & Roehl, R. (2007). Teachers' beliefs about pedagogy and related issues. *Psychology in the Schools, 44,* 873-886.https://doi.org/10.1002/PITS.20272

Spada, N., 7 Lightbown, P. (2008). Form-focused instruction: isolated or integrated? *TESOL Quarterly, 42,* 181-207. https://doi.org/10.1002/J.1545-7249.2008.tb00115.X.

Stegeager, N., Traulsen, S., Guerra, A., Telleus, P., & Du, X. (2024). Do good intentions lead to expected outcomes? Professional learning amongst early career academics in a problem-based program. *Education Sciences, 14*(2), 205. https://doi.org/10.3390/edusci14020205.

Sulaiman, T., Mahomed, A., Rahman, A., & Hassan, m. (2022). Examining the influence of the pedagogical beliefs on the learning management system usage among university lecturers in the Kurdistan region of Iraq, *Heliyon, 8*.https://doi.org/10.1016/j.heliyon.2022.e09687.

Watson, A. (2015). The problem of grammar teaching: a case study of the relationship between a teachers' beliefs and Pedagogical practice. *Language and Education, 29*, 332-346. https://doi.org/10.1080/09500782.2015.1016955

Yang, X., Kaiser, G., Konig, J., &Blomeke, S. (2020). Relationship between pre-service mathematics teachers' knowledge, beliefs and instructional practices in China.*ZDM, 52*, 281-294. https://doi.org/10.1007/s11858-020-01145-x

Yilmaz, H., &Sahin, S. (2011). Pre-service teachers' epistemological beliefs and conceptions of teaching. *Australian Journal of Teacher Education, 36*(1), 1-16. https://doi.ro.ecu.edu.au/ajte/vol36/iss1/6

Yousaf, A., Kazmi, M., &Habib, R. (2021). Exploring the relationship between instructional practice and pedagogic beliefs of university teachers. *VFAST Transaction on Education and Social Sciences, 9*(3), 122-132. https://vfast.org/journals/index.php/VTESS/article/view/657

Zhang, J., Ge, Y., Du, J., &Hu, Z. (2025). The investigation of EFL teachers' cognitive emotion, regulation, pedagogical beliefs, pedagogical practices, and their engagement across the curriculum. *ActaPsychologia, 252*, 104673.https://doi.org/10.1016/j.actpsy.2024.104673