ACADEMIA International Journal for Social Sciences
Volume 4, Issue 4, 2025 ISSN-L (Online): 3006-6638

Effect of Teacher's Pedagogical Competence on Students' Academic Achievement in Science Subjects at Secondary Level

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Received: 08-09-2025 **Revised:** 04-10-2025 **Accepted:** 17-10-2025 **Published:** 01-11-2025

ABSTRACT

This research investigates the effect of pedagogical competence on students' academic achievement in science subjects at the secondary level in Lahore, Punjab. Employing a quantitative causal comparative study design. The study employed a self-developed questionnaire to gather data on teachers' pedagogical competence, with responses collected from 250 teachers across 60 public schools in Lahore district, selected through simple random sampling. The correlation was conducted between teachers' pedagogical competence and students' marks that were obtained in science subjects in 9th class Lahore Board exam. The average marks for each class were derived from the teachers who participated in the pedagogical competence questionnaire. Utilizing SPSS version 25, the collected data underwent analysis. The findings revealed a statistically significant correlation between teachers' pedagogical competence and students' academic achievement in science subjects. Pearson's correlation showed r = 0.631 for pedagogical competence and students achievement in physics, r = 0.677 for chemistry, r = 0.539 for biology and r = 0.617 for overall these three science subjects and pedagogical competence. The regression analysis, a key statistical tool, demonstrated that pedagogical competence accounted for 39.9% of the variance in students' achievement in physics, 45.8% in chemistry and 28.9% in biology, moreover pedagogical competence accounted for 38% of the variance in students' academic achievement collectively in all 3 science subjects. The study underscores the pivotal role of teachers' pedagogical competence in shaping students' achievement in science subjects. As educational stakeholders strive to improve science subjects' outcomes, the insights from this research contribute valuable evidence supporting the importance of enhancing pedagogical competence among secondary level science teachers in Lahore, Punjab.

Keywords: *pedagogical competence, students' academic achievement, science subjects, secondary level*

INTRODUCTION

Education is a vital force for socio-economic growth, and its effectiveness is shaped by various elements such as curriculum design, student learning, governance, financial support, and assessment practices. Yet, scholars emphasize that the teacher is the most influential of these factors, as overall educational quality is directly linked to teacher competence (Sultana, Yousuf, Din, & Rehman, 2011). Pedagogical competence, as a core aspect of a teacher's professional competence, encompasses their beliefs, teaching methods, instructional practices, and attitudes, all of which play a crucial role in enhancing educational processes and students' academic achievement. It reflects a teacher's ability to handle professional challenges, support overall well-being, and influence students' learning, motivation, and achievement (Channa & Sahito, 2022). Elements such as classroom management and instructional skills also require teachers to interpret and adapt instructional policies in ways that positively affect student learning

outcomes (Kporyi & Arko, 2021). Channa and Sahito (2022) as well as Astuty (2015) emphasized that pedagogical competence significantly influences students' academic achievement. Pedagogical competence involves understanding students, planning and implementing instruction, assessing learning outcomes, and helping students realize their potential (Mahmud et al., 2019; Ngozi & Oyemade, 2021). Teachers' attitudes and behaviors significantly influence students' engagement and learning, making it their responsibility to actively involve students in achieving learning goals (Martina et al., 2020; Ho et al., 2023). Mastery of multiple learning theories allows teachers to select optimal strategies to support student development, preventing boredom and disengagement (Semarang & Pati, 2020). Additionally, teaching requires professional knowledge, creativity, self-reflection, and the effective use of ICT, all underpinned by pedagogical competence (Sabagh, 2021; Purnama et al., 2021).

Kusumayasa (2022) investigated pedagogical competence and reported that both teachers and students held favorable perceptions of teachers' abilities in mastering learning theories and teaching principles, understanding students' characteristics, communicating effectively, fostering students' potential, and conducting assessments. If a teacher lacks pedagogical competence, it negatively affects both the teaching–learning process and students' academic achievement. Fatmawada et al. (2020) highlighted a positive relationship between teachers' pedagogical competence and students' academic achievement. They further noted that applying pedagogical skills in teaching and understanding students, supported by the principal's supervision, can enhance student achievement. Student achievement, defined as academic progress attained through learning and evaluation, is influenced by internal factors such as cognitive abilities and interests, and external factors including curriculum, learning environment, and teacher effectiveness (Hapsari & Prasetio, 2017; Omran & Saleh, 2019; Djamarah et al., 2017). In Pakistan, the quality of secondary-level science education is a concern, with students often struggling to achieve satisfactory outcomes (Abdullah & Bhatti, 2018; Faize, n.d.). Teachers' pedagogical competence is a critical factor that can influence student performance, yet research exploring this relationship in the Pakistani context remains limited (W. M. Channa & Sahito, 2022; Fauth et al., 2019a; Javed, n.d.; Kporyi & Arko, 2021a; Pandey & Kumar, n.d.).

Declining student interest in science further underscores the importance of effective teaching practices, as competent teachers can enhance engagement, motivation, and understanding through tailored instructional strategies (Decano et al., 2021; Fauth et al., 2019b; Aker & Ellis, 2019; Steidtmann et al., 2023; Yang et al., 2017). Teachers with high pedagogical competence are better equipped to address diverse learning needs, utilize various instructional methods, and improve student achievement in science subjects (Anderhag et al., 2014; Hallez, n.d.; Istiqomah et al., 2019; Kporyi & Arko, 2021b). Although previous studies have established the significant role of teachers' pedagogical competence in enhancing student achievement (Channa & Sahito, 2022; Astuty, 2015; Fatmawada et al., 2020), much of this research has been conducted in broader educational contexts or at higher education levels, with limited attention to secondary school science subjects. Moreover, existing literature often focuses on general perceptions of pedagogical competence rather than its subject-specific impact. Very few studies have comparatively investigated how teachers' pedagogical competence influences students' academic achievement in science subjects across secondary schools in Pakistan. This creates a gap that the present study aims to address by examining the effect of teachers' pedagogical competence on science achievement at the secondary level, while also highlighting sectoral differences between public and private institutions.

Objectives of the study

The study aims to:

1. Determine the level of pedagogical competence among science teachers at the secondary level.

2. Examine the relationship between teachers' pedagogical competence and students' academic achievement in science subjects.
3. Compare the effect of teachers' pedagogical competence on students' academic achievement in public and private secondary schools.

Research Question

Based on the objectives, the following research questions were formulated:

1. What is the level of pedagogical competence among science teachers at the secondary level?
2. What is the relationship between teachers' pedagogical competence and students' academic achievement in science subjects?
3. Does teachers' pedagogical competence significantly affect students' academic achievement in science subjects at the secondary level?

LITERATURE REVIEW

Pedagogical Competence

Pedagogical competence has been widely recognized as one of the most significant aspects of teacher professionalism and is directly linked to the overall effectiveness of the teaching–learning process. It encompasses a teacher's ability to integrate knowledge, skills, attitudes, and values in a way that facilitates students' intellectual and personal growth. Scholars describe pedagogical competence as a multidimensional construct that includes mastery of learning theories, effective instructional practices, communication skills, classroom management, and the ability to adapt teaching strategies to meet the diverse needs of learners (Kusumayasa, 2022). In addition, it reflects the teacher's ability to handle professional challenges, respond to students' academic and emotional needs, and create a supportive classroom climate that fosters both motivation and achievement (Kporyi & Arko, 2021).

Pedagogical competence is not merely about delivering subject content but also about designing meaningful learning experiences. Teachers with strong pedagogical skills are able to interpret curriculum policies effectively, apply appropriate teaching methods, and engage students through interactive and student-centered approaches. According to Fatmawada et al. (2020), pedagogical competence extends to understanding learners' characteristics, encouraging their potential, and conducting valid assessments to monitor progress. Thus, it serves as a foundation for ensuring quality education, particularly in subjects like science, where conceptual understanding and problem-solving are critical.

Model of Pedagogical Competence

Pedagogical competence is a multifaceted construct that goes beyond the simple delivery of subject content. It encompasses a wide range of knowledge, skills, and attitudes that enable teachers to create effective learning environments and improve student outcomes. Scholars argue that pedagogical competence should be studied through its various dimensions, since each dimension contributes uniquely to the teaching–learning process and collectively determines the quality of education.

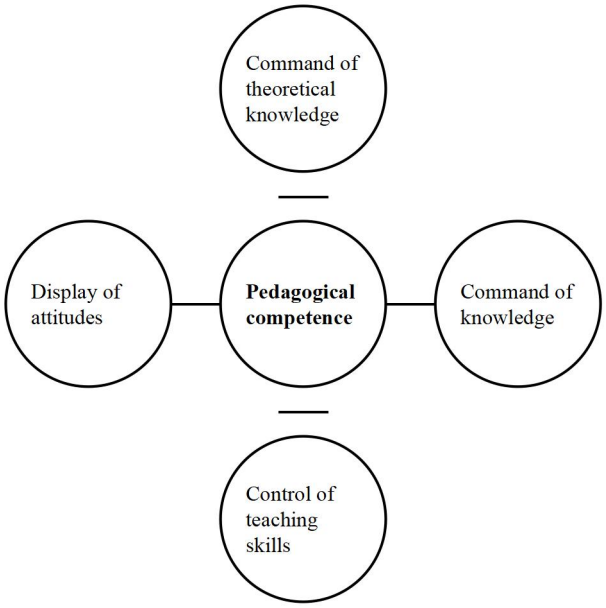

Figure 1: **Factors of pedagogical competence**

The effect of pedagogical competence on students' achievement in science subjects is a critical and multifaceted aspect of the education system. To be successful in achieving expected learning outcomes, a well-trained teacher must exhibit competence in four essential areas of teaching skills. These areas include commanding theoretical knowledge of learning and human behavior, demonstrating attitudes that promote learning and genuine human relationships, possessing in-depth information on the subject to be taught, and skillfully managing teaching techniques to encourage better student learning (Afalla & Fabelico, 2020).

Command of Theoretical Knowledge

This dimension emphasizes the teacher's understanding of educational theories, pedagogical principles, and learning psychology. It includes awareness of how students learn, classroom management theories, curriculum design, and assessment strategies. A teacher with strong theoretical knowledge can link classroom practices with established educational frameworks, ensuring that instruction is not random but scientifically grounded.

Command of Knowledge (Subject Matter Knowledge)

This refers to mastery of the subject content that is to be taught. Teachers must have deep and accurate knowledge of their discipline, including key concepts, facts, and methods of inquiry. Without adequate subject knowledge, teachers may provide misleading information or fail to answer students' questions effectively. Subject matter expertise allows teachers to explain concepts clearly, make connections across topics, and stimulate higher-order thinking.

Control of Teaching Skills

Teaching is not only about knowing the subject, but also about delivering it effectively. This dimension highlights the practical instructional skills teachers use in the classroom, such as lesson planning, questioning techniques, use of teaching aids, differentiated instruction, and classroom management. Competent teachers are able to adapt their methods according to students' needs, making learning more interactive, engaging, and productive.

Display of Attitudes

Teaching also requires professional values and ethical dispositions. This dimension includes the teacher's attitudes toward students, colleagues, and the profession. Respect, fairness, empathy, enthusiasm, patience, and responsibility all play a role in shaping students' motivation and classroom climate. A teacher's positive attitudes foster trust, encourage student participation, and create a supportive learning environment.

Pedagogical Competence and Science Subjects

Pedagogical competence is especially crucial in science subjects such as physics, chemistry, and biology, where the subject matter can be complex and difficult for students to understand. To be an effective science teacher, one must possess pedagogical competence, which includes understanding the learning needs of students, knowing how to design and deliver effective lessons, and being able to assess and evaluate student progress. This requires a deep understanding of the subject matter, as well as knowledge of current teaching methods and strategies (Guerriero & Guerriero, n.d.; Saggaf, Salam, & Wirawan, 2018). In physics, for example, pedagogical competence involves using analogies and real-world examples to help students understand abstract concepts, such as forces and motion. In chemistry, it involves using visual aids and demonstrations to help students grasp chemical reactions and bonding. In biology, it involves connecting concepts to students' prior knowledge and personal experiences to help them understand complex biological systems (Fauth et al., 2019; Luthfi, Supahar, & Puspita, 2022).

Pedagogical competence is about not only teaching content, but also about promoting critical thinking, problem solving, and scientific inquiry skills. Science teachers must be able to facilitate student-driven investigations and experiments, provide possibilities available to students to collaborate and communicate their findings, and encourage students to ask questions and explore beyond the classroom (Guerriero & Guerriero, n.d.; Hallez, n.d.). Overall, pedagogical competence is essential for effective science teaching. It allows teachers to engage and motivate students, provide meaningful learning experiences, and promote scientific literacy and understanding. With this competence, science teachers can inspire the next generation of scientists, engineers, and innovators (Council, 1997).

Students' Academic Achievement

Students' academic achievement is generally understood as the measurable outcomes of learning, often evaluated through tests, grades, and other performance indicators. However, in a broader sense, it also reflects students' ability to apply acquired knowledge, demonstrate critical thinking, and develop problem-solving skills that prepare them for higher education and life challenges. Academic success is influenced by various factors such as curriculum design, governance, financial resources, and assessment practices. Yet, the consensus among researchers remains that the teacher is the single most influential factor in shaping student learning outcomes (Sultana, Yousuf, Din, & Rehman, 2011).

In the context of science education, academic achievement holds particular importance because science subjects at the secondary level are considered key indicators of students' readiness for advanced studies and future careers in technology, medicine, and research. Effective teaching of science requires not only content expertise but also the pedagogical ability to make complex concepts understandable and engaging for students. As highlighted by Channa & Sahito (2022) and Astuty (2015), pedagogical competence plays a central role in enhancing students' academic performance, as it enables teachers to connect scientific knowledge with practical experiences, thereby making learning more meaningful and impactful.

Effect of Pedagogical Competence and Academic Achievement

Several empirical studies have demonstrated that pedagogical competence has a significant effect on students' academic achievement. Fatmawada et al. (2020) reported a positive relationship between teachers' pedagogical competence and student performance, noting that when teachers employ pedagogical skills effectively—supported by principals' supervision—students are more likely to achieve better academic results. Similarly, Kusumayasa (2022) found that both teachers and students had favorable perceptions of teachers' mastery of teaching principles, classroom management, and assessment, which directly contributed to improved learning outcomes. These findings align with international literature that consistently underscores the critical role of pedagogical competence in promoting students' motivation, engagement, and academic success.

Table 1: ***summary of the studies on the effect and relationship of pedagogical competence and students' achievement***

Author/Year	City	Focus of study	Methodology	Key findings
(Kporyi & Arko, 2021)	Ghana	Examine teachers' pedagogical competence for students' achievement	Descriptive survey research design	Weak positive link: classroom management & achievement.
(Tanjung, 2022)	Indonesia	Pedagogical competence of teachers in teaching English	Descriptive qualitative research	Good in curriculum & communication; weak in theory, activities, assessment
(Channa & Sahito, 2022)	Pakistan	Pedagogical competence & students' achievement in English	Qualitative case study	Teachers' competence directly affects students' performance
Lestari et al. (2024)	Indonesia	Pedagogical competence & student achievement in EFL context	Qualitative case study	Teachers' pedagogical competence substantially improves student achievement
Fabelico & Afalla (2023)	Philippines	Preservice teachers' pedagogical competence & achievement	Descriptive correlational study	Exceptional pedagogical competence; weak positive link with academic achievement; performance varied by specialization & school, not gender.
(Astuty, 2015)	Indonesia	Lecturer competencies student achievement	Descriptive study	Pedagogical competence most strongly influenced achievement; combined competencies also had positive effect
(Kusumayasa, 2022)	Negara	Perceptions of English teachers' pedagogical competence from both students and	Mixed-method study	Both students and teachers rated English teachers' pedagogical competence positively

		teachers		
(S, Maswati, & Krismiyati, 2020)	Indonesia	To examine the effect of teacher pedagogical competence on students' academic achievement.	Associative approach	Teacher pedagogical competence significantly improves student achievement.
(Sultana et al., 2011)	Pakistan	Indicators of good teaching, institutional policies, and professional development of teachers in higher education.	Survey study	Good teaching yields little reward beyond self-satisfaction; quality teaching requirements are lacking in universities.
(Nnamdi Edu Ph. D, 2025)	Nigeria	To examine the effect of teachers' pedagogical skills on students' academic performance in public senior secondary schools.	Descriptive survey design	Both teaching strategies and classroom management were positively linked to students' achievement; effects did not differ by gender
(Orakova et al., 2024)	Kazakhstan	Teachers' digital literacy, technological, and pedagogical competencies	Relational study	High pedagogical, moderate digital/tech; varied by gender/seniority; digital literacy predicted other competencies.
Ningtiyas & Jailani (2018)	Indonesia	Effect of trainings on mathematics teachers' pedagogical competence	Survey design	Trainings reduced knowledge but improved skills; teachers need relevant, continuous training aligned with their needs.
Samusevica & Striguna (2017)	Latvia	Teacher trainees' self-education, motivation, and independent learning as key to professional growth and pedagogical competence.	Theoretical analysis, questionnaires, interviews, student self-assessment, and self-reflection of study experiences	Independent learning and self-reflection drive pedagogical competence; motivation and self-directed effort enhance professional growth and lasting skills.

The reviewed studies collectively emphasize that teachers' pedagogical competence is shaped by a combination of professional knowledge, digital literacy, and self-education skills. While research from Indonesia, Lativa, Pakistan, Ghana and Philippines highlights the strong role of pedagogical competence in student achievement, other studies stress the growing importance of digital and technological skills in modern teaching. Across contexts, motivation, independent learning, and reflective practices emerge as critical drivers of professional growth. These findings suggest that teacher education programs must not only develop subject and pedagogical expertise but also actively foster digital competence and self-directed learning habits, ensuring teachers are prepared for 21st-century educational challenges.

METHODOLOGY

This study employed a causal-comparative research design with a quantitative approach to investigate the effect of pedagogical competence on students' achievement in science subjects at the secondary school level. The independent variable was teachers' pedagogical competence, while the dependent variable was students' academic achievement in physics, chemistry, and biology. The study population comprised secondary school science teachers from public schools in District Lahore, where a total of 415 secondary and higher secondary schools were registered under the School Information System (SIS). Using a multi-stage sampling technique, 60 schools were selected, and data were collected from 250 teachers. Teachers' pedagogical competence was assessed through a self-report questionnaire developed on the model proposed by Bonimar et al., which included four dimensions: theoretical knowledge, attitude, knowledge of topics, and teaching skills. The instrument contained 31 items and underwent pilot testing to ensure validity and reliability, with Cronbach's alpha values ranging from 0.770 to 0.810 across subscales and an overall reliability of 0.881. Students' achievement data were obtained from class teachers in the form of average marks in board examinations for physics, chemistry, and biology. Prior to analysis, data were cleaned by addressing missing values through mean imputation and detecting outliers using box plots. The cleaned dataset was analyzed using SPSS (version 25), employing descriptive statistics such as frequencies, means, and standard deviations, as well as inferential statistics, including correlation and regression analyses, to test the research questions. This methodological framework ensured a systematic and reliable process for examining the influence of pedagogical competence on student achievement in science subjects.

Table 2: ***Psychometric properties of the pedagogical competence scale***

Factor	Items	α
Theoretical knowledge	7	.810
Attitude	7	.799
Knowledge of topics	8	.783
Skills	9	.770
Pedagogical competence	31	.881

Analysis of the Study

Table 3: ***Demo-graphical data of the sample***

Characteristics		N	Percentage
Gender	Male	87	34.8%
	Female	163	65.2%
	Total	250	100%
Subject	Physics	99	39.6%
	Chemistry	77	30.8%
	Biology	74	29.6%
	Total	250	100%
Experience	1-3 years	93	37.2%
	4-6 years	71	28.4%
	7-10 years	55	22.0%
	More than 10 years	31	12.4%
	Total	250	100%
Status	Single	165	66.0%
	Married	85	34.0%
	Total	250	100%

Table 3 summarizes the demographic data of sample. The sample comprised of 250 teachers of science subjects. Out of these, 87 (34.8%) were male, and 163 (65.2%) were female. There were 99 (39.6%) physics teachers, 77 (30.8%) chemistry teachers and 74 (29.6%) biology teachers. The job experience was classified into four groups; 1 to 3 years, 4 to 6 years, 7 to 10 years and more than 10 years. 93 (37.2%) teachers were 1 to 3 years experienced, 71 (28.4%) teachers were 4 to 6 years experienced, 55 (22%) teachers were 7 to 10 years old and 31 (12.4%) teachers were more than 10 years experienced. A total of 165 (66%) were single while, 85 (34%) were married at the time of data collection.

Responses on the scale of teachers' pedagogical competence

Table 4: ***Summary of teachers' pedagogical competence***

	N	Minimum	Maximum	Mean	S.D
Theoretical Knowledge	250	14.00	35.00	26.2320	4.74682
Attitude	250	13.00	35.00	28.4160	4.62086
Knowledge of Topics	250	17.00	40.00	31.6640	5.42853
Skills	250	21.00	45.00	34.2800	5.88798
Pedagogical Competence	250	75.00	155.00	120.592	17.85330

Table 4 demonstrate the level of teachers' pedagogical competence. For Theoretical Knowledge, the minimum score observed is 14.00, with a maximum of 35.00, and a mean of 26.2320, accompanied by a standard deviation of 4.74682. Similarly, Attitude exhibits a range from 13.00 to 35.00, with a mean of 28.4160 and a standard deviation of 4.62086. Knowledge of Topics demonstrates a broader range, spanning from 17.00 to 40.00, with a mean of 31.6640 and a standard deviation of 5.42853. Skills, characterized by a minimum score of 21.00 and a maximum of 45.00, possess a mean value of 34.2800 and a standard deviation of 5.88798. The overall mean score is 120.590 and the standard deviation is 17.85330. The highest level of pedagogical competence is 155.00 and the lowest is 75.00. It can be inferred that the pedagogical competence of teachers is high.

Pedagogical competence and students' achievement

Table 4: ***Correlation between Pedagogical Competence and students' achievement in Physics, Chemistry, and Biology***

Factors	Physics	Chemistry	Biology
Theoretical knowledge	.543**	.625**	.397**
Attitude	.480**	.551**	.438**
Knowledge of topics	.572**	.557**	.478**
Skills	.582**	.632**	.487**
Pedagogical competence	.631**	.677**	.539**

Note: Values represent Pearson's r (**p < .01).

Table 4 presents the correlation between different components of pedagogical competence and students' achievement in Physics, Chemistry, and Biology. Across all subjects, the correlations are positive and statistically significant (**p < .01**), indicating that higher levels of teachers' theoretical knowledge, attitude, knowledge of topics, and skills are consistently associated with better student performance. Among the factors, skills and overall pedagogical competence show the strongest correlations in all three subjects, suggesting that these dimensions play a particularly important role in supporting students' achievement.

Teachers' pedagogical competence and students' achievement relationship:

Table 5: ***Effect of pedagogical competence on students' academic achievement in Physics***

Variables	R^2	*F*	*p*	*B*	*t*
Theoretical knowledge	.295	40.493	.000	.543	6.363
Attitude	.230	29.028	.000	.480	5.388
Knowledge of Topics	.327	47.095	.000	.572	6.863
Skills	.339	49.758	.000	.582	7.054
Pedagogical Competence	.399	64.372	.000	.631	8.020

Table 5 presents the regression analysis results for Physics. The findings reveal that all components of pedagogical competence significantly predicted students' academic achievement in Physics ($p < .001$). Among the individual factors, pedagogical competence as an overall construct emerged as the strongest predictor ($\beta = .631$), accounting for approximately 40% of the variance in student achievement ($R^2 = .399$). Skills also played a substantial role ($\beta = .582$, $R^2 = .339$), followed by knowledge of topics ($\beta = .572$, $R^2 = .327$), theoretical knowledge ($\beta = .543$, $R^2 = .295$), and attitude ($\beta = .480$, $R^2 = .230$). These results suggest that while each dimension of pedagogical competence contributes meaningfully, the holistic integration of competencies has the most profound effect on improving students' performance in Physics.

Table 6: ***Effect of pedagogical competence on students' academic achievement in Chemistry***

Variables	R^2	*F*	*p*	*B*	*t*
Theoretical knowledge	.391	48.103	.000	.625	6.936
Attitude	.304	32.724	.000	.551	5.720
Knowledge of Topics	.310	33.681	.000	.557	5.804
Skills	.400	49.948	.000	.632	7.607
Pedagogical Competence	.458	63.414	.000	.677	7.963

Table 6 displays the regression analysis results for Chemistry. All pedagogical competence factors were found to significantly predict students' academic achievement ($p < .001$). Among the predictors, overall pedagogical competence emerged as the strongest contributor ($\beta = .677$), explaining nearly 46% of the variance in achievement ($R^2 = .458$). Skills also had a substantial impact ($\beta = .632$, $R^2 = .400$), followed by theoretical knowledge ($\beta = .625$, $R^2 = .391$), knowledge of topics ($\beta = .557$, $R^2 = .310$), and attitude ($\beta = .551$, $R^2 = .304$). These findings suggest that while each competency positively influences Chemistry achievement, the comprehensive integration of pedagogical competence provides the most significant advantage, highlighting the central role of teachers' holistic competence in improving students' performance in Chemistry.

Table 7: ***Effect of pedagogical competence on students' academic achievement in Biology***

Variables	R^2	*F*	*p*	*β*	*t*
Theoretical knowledge	.158	13.476	.000	.397	3.671
Attitude	.192	17.093	.000	.438	4.143
Knowledge of Topics	.228	21.274	.000	.478	4.612
Skills	.237	22.370	.000	.487	4.730
Pedagogical Competence	.289	29.218	.000	.537	5.405

Table 7 presents the regression analysis results for Biology. All dimensions of pedagogical competence significantly predicted students' academic achievement ($p < .001$). Among the predictors, overall

pedagogical competence had the strongest effect (β = .537), explaining about 29% of the variance in Biology achievement (R^2 = .289). Skills (β = .487, R^2 = .237) and knowledge of topics (β = .478, R^2 = .228) also demonstrated meaningful contributions, followed by attitude (β = .438, R^2 = .192) and theoretical knowledge (β = .397, R^2 = .158). Compared to Physics and Chemistry, the predictive power of pedagogical competence in Biology was somewhat weaker, but still significant. These results indicate that while all components of pedagogical competence positively affect Biology achievement, teachers' overall pedagogical competence remains the most influential factor in enhancing students' performance.

DISCUSSION

This study examined the relationship between teachers' pedagogical competence and students' academic achievement in science subjects. The findings highlight patterns in teacher competence and student performance, aligning with previous studies (Abanador, 2019; W. Channa & Sahito, 2022; Fauth et al., 2019b; Istiqomah et al., 2019; Kporyi & Arko, 2021b; Mariane D. Gamayao & Jr Enrique E. Binas, 2021; Maswati et al., 2020), which reported a significant relationship between teacher competencies and student achievement. Pedagogical competence emerged as a key factor, enabling teachers to foster student learning through effective classroom management, strong communication, sound subject knowledge, and diverse teaching strategies (Ugbe & Agim, 2010). The results showed that teachers' pedagogical competence accounted for 39.9% of the variance in student achievement, indicating that 60.1% is influenced by other factors such as socio-economic status (Munir et al., 2023), parental involvement (Topor et al., 2010), student motivation and engagement (Aslam, 2021; Baranek, n.d.; Bin Abdulrahman et al., 2023), learning environment (Kate & Extension, 2023), and peer influence (Garrote, 2020). These findings support Hadi (2016), emphasizing that pedagogical competence involves effectively managing learning processes, employing active teaching strategies, and creating engaging learning experiences that enhance student motivation and outcomes. Pedagogical competence encompasses mastery of content, varied teaching methodologies, and the ability to design interactive learning programs (Sudrajat, 2012; Sardiman, 2004). Competent teachers can assess individual students' potential, implement tailored learning programs, and use diverse resources, including ICT, to optimize learning outcomes (Yulianti, 2012; Sudrajat, 2012). Prior studies confirm a direct link between higher teacher competence and improved student achievement (Rahman, 2014; Abanador, 2019). In this study, teachers' pedagogical competence was high (M = 120.590, SD = 17.85330), consistent with earlier research (Jones & Smith, 2017; Lee et al., 2018). Gender-based differences were observed in competence levels (Robinson, 2016; Wang et al., 2019), whereas subject specialization and experience did not significantly affect competence (Thompson, 2020; Martinez et al., 2018). In conclusion, the study reinforces that pedagogical competence significantly influences secondary-level science students' academic achievement. Competent teachers who employ effective strategies and adapt teaching to students' needs contribute to improved learning outcomes. These findings underscore the importance of comprehensive teacher training and professional development programs (Adams & Brown, 2016; Wilson & Garcia, 2020; Smith & Johnson, 2021; Lee & Martinez, 2019).

CONCLUSION

Pedagogical competence is an indispensable skill for professional educators, encompassing multiple facets of teaching and learning management. Effective teachers must understand individual student characteristics within diverse classroom and school contexts, as this understanding forms the foundation of competent instruction. Mastery of learning theories enables teachers to select appropriate teaching methodologies and design educational tools, such as syllabi and lesson plans, tailored to students' needs. Competence in developing learning activities ensures that instructional actions support, rather than hinder, students' physical, mental, and academic growth. Recognizing and nurturing each student's unique potential, establishing effective communication, and employing sound assessment techniques are essential

components of pedagogical competence. This study highlights the significant relationship between teachers' pedagogical competence and students' academic achievement in science subjects. It emphasizes that teaching effectiveness depends not only on what teachers know, but also on how they deliver that knowledge. The findings suggest that gender- and experience-related factors may influence pedagogical competence, and continuous professional development is critical to enhance teaching quality. Education stakeholders can leverage these insights to design targeted interventions, training programs, and policy initiatives aimed at improving teaching practices and student outcomes. Overall, this study provides a strong foundation for future research and initiatives to refine pedagogical approaches in science education, benefiting both teachers and students alike.

RECOMMENDATIONS

Recommendations have been formulated based on the findings and conclusions of this study:

Based on the findings presented in the study, here are three recommendations:

Pedagogical Training Programs

Develop and implement comprehensive pedagogical training programs for science teachers, focusing on enhancing theoretical knowledge, teaching skills, attitudes, and subject mastery. These programs should accommodate teachers with varying levels of experience, ensuring that both novice and experienced educators receive appropriate support and professional development. Interactive workshops, peer-learning sessions, and mentoring initiatives can be incorporated to foster collaboration and continuous improvement among teachers.

Gender-Specific Support Initiatives

Given the slight but notable differences in pedagogical competence between male and female teachers, gender-specific support initiatives are recommended. These could include mentorship programs, networking opportunities, and tailored professional development workshops that address the unique challenges and needs of each group. Such initiatives can promote gender equity and empower all teachers to enhance their teaching effectiveness.

Continuous Assessment and Feedback Mechanisms

Establish ongoing assessment and feedback systems to monitor and improve teachers' pedagogical competence over time. This can include regular classroom observations, evaluations of teaching practices, and structured feedback sessions with supervisors. Additionally, incorporating student feedback on teaching methods can provide valuable insights for improvement. By fostering a culture of continuous professional growth, schools can ensure that teachers remain effective, adaptable, and responsive to students' learning needs, ultimately enhancing academic outcomes.

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