Linking Secondary School Students' Ratings of Teacher Effectiveness with Their Achievement in Biology

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ABSTRACT

The foremost aim of science education is to equip students with knowledge and understanding of scientific concepts. Teachers are considered to play a pivotal role in achieving this goal, because they have a direct interaction with students to deliver high-quality science instruction to foster students' academic success. This study examined the effect of various factors of teacher effectiveness on student academic achievement in Biology in public secondary schools in Lahore, Pakistan. Guided by Marzano's Causal Teacher Evaluation Model, the study investigated how teacher competencies—including subject matter knowledge, instructional planning, assessment, classroom environment, and communication—predicted academic success of Biology students. A quantitative correlational design was used to answer research questions. Cluster random sampling technique was used to select the sample size. The data were collected using School Teacher Effectiveness Questionnaire (STEQ) developed by Akram (2018) with overall reliability (α=.88) besides collecting Biology scores in BISE Lahore Exams 2024. The collected data from 3,450 students (boys and girls) were analyzed using Pearson correlation and regression. The results revealed a strong, positive, and significant relationship between teacher effectiveness and Biology achievement (r = .787, p < .01), explaining 61.9% of the variance in student achievement. Communication, Assessment practices, and subject expertise were the strongest predictors. These findings highlight the significance of teacher quality in science education and underscore the need for targeted professional development to improve teacher effectiveness. Thus, the study adds subject-specific insights to the limited research on teacher effectiveness in Pakistan and provides actionable recommendations for improving Biology instruction and outcomes.

Keywords: Teacher Effectiveness, Subject Matter Knowledge, Assessment, Communication, Instructional Planning, Classroom Environment, Academic Achievement

INTRODUCTION

In today's rapidly evolving world, science education has become increasingly vital. As a foundational branch of science, Biology helps students understand living systems, make informed health and environmental decisions, and engage meaningfully in scientific and technological advancements. However, the effectiveness of teachers plays a central role in enabling this learning. Effective Biology teachers not only possess subject knowledge but also motivate, engage, and support students in developing critical thinking and academic success (Akram, 2018; Liou, 2021; Stronge, 2006).

Students at secondary school level are at a pivotal stage in their cognitive development because according to Piaget's theory of cognitive development, students aged 12 to 15 fall within the formal operational

stage, where they begin to exhibit more advanced forms of thinking, such as abstract reasoning, logical problem-solving, and the ability to comprehend complex scientific ideas (Ahmad et al., 2024). At this stage subjects like biology, chemistry and physics are formally taught as separate or distinct subjects. So the role of teachers become fundamentally important because their effective teaching aided with innovative techniques and strategies will helps students in understanding the complex concepts of science subjects. Effective teaching also helps students comprehend abstract scientific knowledge and help build a strong foundation for future scientific learning, thereby impacting the future generation of scientists (Ahmed et al., 2020).

Secondary school marks the turning point in Pakistani education system as students start preparing for province level assessment that not only decide their future academic path but also reflects the quality of teaching they received. Such as BISE Lahore is responsible for assessing students located in Division Lahore. According to their data from 2024 a substantial number of students failed in biology, highlighting the need of identifying the factors that affect their academic achievements. Therefore, focusing students' needs at this level not only give early warning for targeted intervention but also give an opportunity to improve student learning outcomes before they enter into higher education system or vocational paths. Hence, this group gives a meaningful context to assess the role of teacher effectiveness in improving Biology achievement, with the definitive goal of enlightening policy makers and stakeholders.

Teacher effectiveness refers to which extent teachers are successful in accomplishing desired student learning outcomes using their professional characteristics include content delivery, instructional planning, assessment strategies, classroom learning environment, and communication skills (Darling-Hammond, 2017; Stronge et al., 2011). These characteristics are in line with the National Professional Standards for Teachers (NPST) in Pakistan, introduced with the help of UNESCO and USAID (Ministry of Education, 2009; Shaukat & Chowdhury, 2020).

Despite numerous modifications and policies, students' achievement in science subjects especially in the subject of Biology remains a persistent challenge in public schools of Pakistan. The evidence are evident because according to BISE Lahore results, rates of students failed in Biology are disturbingly high. In 2022, 36.01% of 9th-grade and 19.74% of 10th-grade students failed in Biology. In 2023, failure rates were 21.98% and 9.1% respectively, while in 2024, 20.94% of 9th graders failed the subject (BISE Lahore, 2024). These figures highlight a critical need to explore factors influencing student outcomes in Biology.

International research has consistently shown that teacher effectiveness significantly impacts student academic achievement, motivation, and engagement in science subjects (Ingersoll et al., 2011; Johnson et al., 2007; Kraft et al, 2018; Bardach et al., 2020). However, in Pakistan, limited empirical work has investigated teacher effectiveness within specific science disciplines. Most research treats science as a single domain, potentially obscuring subject-specific insights. Given classroom challenges such as large student-teacher ratios and varying instructional quality, context-specific and subject-focused studies are essential.

This study aimed to examine the relationship between teacher effectiveness and student academic achievement in biology among secondary school students in Lahore. Drawing on Marzano's Causal Teacher Evaluation Model, the research offers subject-specific, data-driven insights for policymakers, educators, and school leaders. By identifying the specific competencies that influence Biology achievement, the study aim to inform teacher training, instructional strategies, and education policy to ultimately improve science learning outcomes and support national STEM goals (Lee & Mun, 2023; Glynn et al., 2011).

Components of Teacher Effectiveness

Teacher effectiveness is not a singular trait but a multidimensional construct comprised of several interrelated instructional competencies. Each of these components contributes uniquely to shaping students' academic success, particularly in science education where conceptual understanding, inquiry, and communication are vital. The current study focused on five core dimensions of teacher effectiveness presented by National Professional Standards for Teachers in Pakistan and highlight their significance in enhancing student learning outcomes.

Subject Matter Knowledge

Subject matter knowledge is the foundation of effective teaching, especially in content-heavy subjects like Biology, Chemistry, and Physics. It is the fundamental quality of teachers because depth of concept clarification of teachers allows them to deliver scientific concepts confidently, answer students' queries accurately, and correct their misunderstandings and misconceptions effectively. Research over the time has consistently shown that teachers with deep content and subject matter knowledge have students who perform significantly better in science assessments. Whereas inadequate subject knowledge leads to confusion among learners as they cannot fully comprehend the concepts and content (Cicek & Taspinar, 2021; Gess-Newsome et al., 2019; Owusu-Fordjour et al., 2022). Thus, guaranteeing that subject specific teachers possess mastery of their discipline's content is imperative for developing conceptual clarity and deeper student engagement in learning activities.

Instructional Planning

Instructional planning and strategies of teacher enables them to sequence content in a meaningful way by aligning learning activities and pedagogies with learning outcomes. Teachers with well-planned lessons plans have their time properly manage, room for flexibility during instructions, and coherence in content delivery. Moreover, teachers who plan lessons with clear aims, objectives, and content appropriate learning activities can help students acquire deeper comprehension of learning material. Previous studies showed that teachers who integrate multiple instructional techniques into their lesson planning can positively and significantly enhance and improve science students' achievement and engagement in learning activities. This is because it allows teachers to target particular learning outcomes and adjust their instruction according to the needs and mind level of their students (Akram, 2019; Jaafar et al., 2024; Samdani, 2021). Thus in science classrooms especially, where topics are linked with prior knowledge, advance effective planning ensures that foundational concepts and content are grasped before moving on to the more complex ideas and concepts.

Assessment Practice

Assessment techniques are not only used to grade and evaluate students but also used to significantly guide teaching instructions and improve student learning outcomes. Effective assessment approaches assist in identifying learning misconceptions and gaps, measure students' progress over time, and offer timely feedback to both learners and instructors. Effective teachers practice various forms of assessments in classrooms not just to assign grades/marks, but also to direct students on the path to improvement by informing students about areas needing improvement, contributing to deeper learning and better performance (Babinčáková et al., 2020; Bouriah, 2021; Ray et al., 2022; Zhou, 2023). In science education when teachers integrate diverse and meaningful assessment approaches such as quizzes, lab work, and presentations they can detect misconceptions early and adjust their teaching instruction accordingly, leading to better and improved academic outcomes (Berry & Van Driel, 2013).

Effective Communication

Subjects like biology, clear verbal instructions are imperative for thoroughly understanding relevant content and concepts. Effective communication act as a bridge between teachers' intent and students' understanding of their teachers' intent. Because when teachers effectively communicate abstract ideas, give comprehensive instructions, and encourage students to actively engage in learning activities it significantly improve student learning engagement and success in education. Teachers who possess effective communication skills can better explain complex scientific concepts, give relevant examples, and adapt their verbal language and tone according to the needs, mind level, and cognitive skills of students. Many researches also support this stance that communication skills are one of the strongest predictor of academic success and improved achievement in science (Saldivar et al., 2022; Khan et al., 2021). Moreover, communication does not involves only delivering content but also include listening, questioning, and encouraging students' interaction. Because when students understand what is taught and feel their voices are heard, they are more likely to stay engaged and perform better academically (Kasim & Joseph, 2022).

Learning Environment

Fostering academic success is the main goal of education institutions and for this purpose a positive and structured learning environment is imperative. When classrooms are supportive, structured, and concentrated, students feel more secure and motivated to participate in learning activities. An organized learning environment nurtures safety, respect, and collaboration, all of which are crucial for student engagement and success in academics. So, when teachers maintain discipline, encourage questioning, show respect for students' ideas, and create conditions that support intellectual comprehension students overall learning outcomes and achievement improved. Students when felt respected, valued, and encouraged to ask questions possess higher motivation and academic success. Because, classroom climate has been significantly and positively correlated with academic achievement, particularly in subjects where active participation, demonstration, and experimentation are essential and encouraged (Mikeska et al., 2017; Li et al., 2021; Stronge et al., 2011).

In conclusion, previous studies consistently highlighted that factors undertaken as factors of overall teacher effectiveness play vital role in enhancing student academic achievement. Teachers with strong subject matter knowledge are better equipped to simplify complex biological processes, adapt their instructional approaches to meet varied learner needs, and foster deeper conceptual comprehension. Likewise, effective communication skills of teachers engage students in learning activities more confidently, thus lessen confusion and increase motivation among students. In addition, regular and effect assessments directs instructional planning and provide feedback, allowing both instructors and learners to observe their progress and address misunderstandings on time. Furthermore, a supportive and well-managed classroom learning environment improves students' readiness to participate, ask questions, and collaborate in classroom activities. Therefore, investing in teacher professional development focusing on improving their communication skills, assessment literacy, and classroom management skills is essential for upholding academic success in Biology at the secondary school level.

LITERATURE REVIEW

Effective teaching remains a central driver of student academic achievement, particularly in science education, where conceptual understanding, inquiry skills, and real-world application are vital (Stronge et al., 2011; Saldivar et al., 2022). Teacher effectiveness refers to the extent to which teachers frequently demonstrate high performance on quality standards like instructional strategies and their planning,

knowledge of subject related content, assessment techniques, strong communication, and classroom management skills and how these competencies of teachers influence students' academic performance (Akram, 2018; Berry & Van Driel, 2013). Most of the previous researches addresses general teaching effectiveness, but a growing number of researchers stress the need for studying subject-specific strategies, especially in subjects like Biology that require both factual accuracy and scientific thinking.

Various researches in international context continues to provide evidence that subject specific teaching skills such as content knowledge, instructional practices, pedagogical content knowledge play a key role in improving and enhancing student academic achievement in biology. Such as Gess-Newsome et al. (2019) reported that U.S. high schoolers academic achievement significantly improved when their teachers demonstrated stronger understanding of the subject matter. These results highlighted that combining content expertise with effective pedagogical training can leads to more effective teaching. Owusu-Fordjour et al. (2022) also found that pedagogical content knowledge had a significant effect on teachers' ability to create conducive learning environment which in turn improved student learning outcomes.

Various other factors such as teachers' efficacy, optimistic teaching attitude, and overall teaching competence all had been consistently correlated with increased student biology outcomes (Bizimana, 2023; Dr. Rajesh, 2023). Research studies further reported that student focused teaching strategies for example guided, and open inquiry, and generative learning approaches all produced better biology outcomes in comparison to conventional teaching methods (Owolade et al., 2022; Onanuga, 2020). Additionally, other teacher-related factors like formal qualifications and years of professional experience had also been found to significantly affect student success in Biology (Eno, 2022), highlighting the significance of targeted teacher training and continuous professional development.

Research studies on other components such as role of teacher communication had also highlighted the importance of how Biology is taught. Berry and Van Driel (2013) reported that in Australia and Netherlands, teachers clearly and explicitly explained biological concepts and addressed student misconceptions had a significant effect on student academic achievement. In Greece, Mastrokoukou et al. (2022) observed that effective classroom environment where student-centered teaching strategies were applied had higher levels of satisfaction and academic performance among students. Collectively these studies highlighted that successful biology teaching depends not only on the delivery of its content but also on engaging students in this process using clear communication and student centered activities.

In another study Saldivar et al. (2022) found that among science educators in the Philippines subject expertise and clear communication were the leading predictors of teacher effectiveness in Biology. Similarly in Indonesia, Jaafar et al. (2024) found that innovative instructional strategies such as multimedia-driven instructional planning significantly improved motivation and engagement levels among biology students, underscoring the importance of innovative and resource-sensitive approaches.

In Pakistan, evidence on improved academic achievement in specific science subjects are limited. Whereas fewer studies had address the relationship between teacher related factors and student achievement in general subject such as Hassan and Akbar (2020), in a study of 800 students in Kasur, found that teaching methods such as lecture method, discussion method, question answer method, and demonstration method all collectively improved science scores ($r^2 = .656$, $p < .01$). Khan et al. (2021) similarly showed that teachers' subject knowledge ($r^2 = .846$) and communication skills ($r^2 = .722$) strongly predicted student academic achievement. While these findings align with global research, most Pakistani studies still approach science education as a general category, potentially overlooking key variations in teaching needs across Biology, Chemistry, and Physics.

Therefore, this study aims to fill that gap by focusing exclusively on the subject Biology. By examining how various factors of teacher effectiveness impact students' performance in Biology, this study provides subject-focused, context-specific evidence that can better inform relevant stakeholders to organize professional development programs, classroom management practices, and policy reform in Pakistan's public education system.

Theoretical framework

The current study was grounded in Marzano's Causal Teacher Evaluation Model (2011). It is a comprehensive framework that evaluates effectiveness, classroom behaviors and instructional planning of teachers through observation. This framework have four major domains of teacher quality: (1) classroom strategies and behaviors, (2) planning and preparation, (3) reflecting on teaching, and (4) collegiality and professionalism. When applied to current study, Marzano's model highlighted that effective teaching goes beyond content delivery and teachers must promote inquiry-based learning, communicate complex ideas effectively, manage varied classroom needs, and assess student learning regularly. The dimensions especially subject expertise, planning, assessment, environment, and communication form the basis of teacher effectiveness in this study.

Conceptual Framework
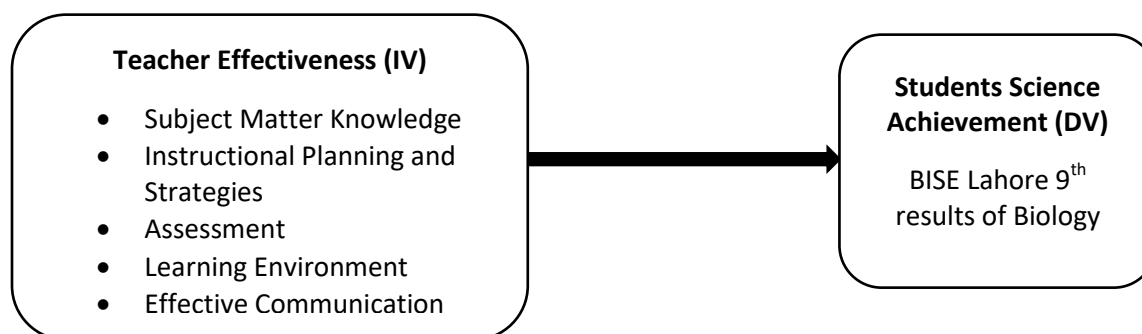
This study conceptualized teacher effectiveness as a multidimensional construct including subject matter knowledge, instructional planning, and assessment practices, learning environment, and communication skills. The teacher effectiveness was considered as an independent variables in the study, while student academic achievement in Biology as the dependent variable. According to this framework teachers who exhibit these behaviors more in classrooms across these areas are more likely to raise higher academic outcomes among their students.

Research Objectives

1. To examine the perception of secondary school students about their Biology teachers' effectiveness.

2. To determine the relationship between Biology teacher effectiveness and students' academic achievement in Biology.

3. To measure the effect of teacher effectiveness (instructional planning, subject knowledge, communication, classroom management) on student academic achievement in Biology.

Research Question

1. What do secondary school students perceive the effectiveness of their Biology teachers?

2. What is the relationship between Biology teacher effectiveness and student academic achievement in Biology?

3. What is the effect of teacher effectiveness on students' academic achievement in Biology?

RESEARCH METHODOLOGY

This study was grounded in the positivist paradigm, which emphasizes objective measurement and statistical analysis to examine empirical relationships. A quantitative correlational research design was adopted to explore the relationship between perceived teacher effectiveness and student academic achievement in Biology. The population of the study was consisted of 10th grade students enrolled in public secondary schools in Lahore, Pakistan. A total of 3,450 students from 42 public schools were selected as a sample using a cluster random sampling technique.

Data about student perception of their teacher effectiveness were collected using School Teacher Effectiveness Questionnaire (STEQ) developed by Akram (2018) based on Pakistan's National Professional Standards for Teachers. This 26-item instrument used a 5-point Likert scale (1 = Never to 5 = Always). The items assessed five dimensions: subject knowledge, instructional planning, assessment, learning environment, and communication. The instrument demonstrated high internal consistency with a Cronbach's alpha of 0.93. To collect Academic Achievement Data student achievement scores was obtained from official Biology exam scores (out of 60), obtained from school records under the BISE Lahore system. Informed consent and permission was obtained from school principals or head teachers on behalf of their students prior to data collection. Moreover students' anonymity and data confidentiality were ensured throughout the data collection process.

The collected data were analyzed using SPSS Version 26. Descriptive statistics (mean, standard deviation) were used to summarize students' perceptions. Inferential analyses included Pearson correlation were calculated to examine the relationship between teacher effectiveness and Biology achievement. Simple and multiple linear regression were employed to assess the predictive power of overall teacher effectiveness and its factors on student academic achievement in biology. Statistical significance was set at $p < .05$.

RESULTS AND INTERPRETATIONS

The data collected by the researchers were later organized, summarized and analyzed using appropriate statistical techniques. For this purpose descriptive (Mean and SD) and inferential (Pearson r and Regression) statistical analysis were used.

Table 1: *Gender wise Distribution of Students*

Gender	Frequency	Percentage
Male	1,715	49.71%
Female	1,735	50.29%
Total	3,450	100%

Table 1 shows the gender-wise distribution of the sample. Out of the 3,450 secondary school students surveyed, 1,735 (50.29%) were female and 1,715 (49.71%) were male, indicating an almost equal gender representation.

Research Question 1

What do secondary school students perceive the effectiveness of their Biology teachers?

Table 2: *Descriptive Statistics of Students' perception about their Biology Teachers' Effectiveness*

Factors	Mean	S.D.
Subject Matter Knowledge	3.24	.860
Instructional Planning	3.34	.831
Assessment	3.36	.874
Learning Environment	3.41	.882
Effective Communication	3.40	.839
Overall	3.35	.642

The Table 2 presents the values of mean and standard deviation of students' perception about their biology teachers' effectiveness. The results revealed moderately positive response across all factors. The overall mean score (M = 3.35, SD = 0.642) suggests that students generally perceived their teachers *often* performed their roles as moderately effective. Among the five domains, the learning environment received the highest rating (M = 3.41, SD=.882), indicating that teachers were perceived as successful in creating a respectful, supportive, and well-managed classroom.

Research Question 2

What is the relationship between Biology teacher effectiveness and student academic achievement in Biology?

Table 3: *Relationship between perceived Teacher Effectiveness and Students' Academic Achievement in Biology*

Variables	SMK	IP	ASSESS	LE	EC	BTE
SMK	1					
IP	.638**	1				
ASSESS	.543**	.579**	1			
LE	.382**	.396**	.554**	1		
EC	.340**	.315**	.427**	.546**	1	
BTE	.755**	.758**	.811**	.764**	.711**	1
SAAB	.661**	.653**	.709**	.662**	.643**	.787**

**. Correlation is significant at the 0.01 level (2-tailed).

SMK = Subject Matter Knowledge, IP = Instructional Planning, Assess = Assessment, LE = Learning Environment, EC = Effective Communication, BTE = Biology Teacher Effectiveness (overall), SAAB = Students' Academic Achievement in Biology

The Table 3 presents the results of Pearson r analysis between teacher effectiveness and student academic achievement in biology. It revealed a strong, positive, and statistically significant relationship between Biology teacher effectiveness and student academic achievement in Biology ($r = .787$, $p < .01$). This suggested that students who perceived their teachers as effective tended to achieve higher scores in Biology. The strength of this correlation indicated a substantial relationship between the two variables. The results of this analysis also indicated that factors related to teacher effectiveness such as subject knowledge, instructional planning, assessment, classroom environment, and communication all played a significant role in shaping student outcomes in Biology.

Research Question 3

What is the effect of teacher effectiveness on students' academic achievement in Biology?

Table 4: *Effect of Biology Teacher Effectiveness (BTE) on Students' Academic Achievement in Biology (SAAB)*

Sr. No	Model	B	SE	*B*	*T*	*P*
1	SAAB (constant)	-16.987	.471		-34.174	.000
2	BTE	15.112	.135	.787	104.702	.000

Note: $r = .787^a$, $r^2 = .619$, $p < .05$

BTE = Biology Teachers' Effectiveness, SAAB = Students' Academic Achievement in Biology

The above Table 4 shows the results of simple linear regression conducted to examine the effect of Biology teacher effectiveness (BTE) on student academic achievement in Biology (SAAB). The model was statistically significant, (F (1, 3473) = 11,179.33, $p < .001$) indicating that BTE was a significant predictor of SAAB. The regression equation accounted for 61.9% of the variance in Biology achievement, $r = .787$, $r^2 = .619$, suggesting a large effect size. The unstandardized regression coefficient showed that for each one-unit increase in perceived teacher effectiveness, student Biology scores increased by 15.112 points ($B = 15.112$, $SE = 0.135$, $\beta = .787$, $t = 104.702$, $p < .001$). The negative constant ($B = -16.987$) indicated the predicted Biology score when teacher effectiveness is zero, though it holds limited practical interpretation. Overall, the results strongly support the hypothesis that teacher effectiveness significantly influenced student academic achievement in Biology.

Table 5: *Effect of different factors of Biology Teachers' Effectiveness on Students' Academic Achievement in Biology (SAAB)*

No	Model	B	SE	B	t	p
1	SAAB (constant)	-16.815	.491		-34.071	.000
2	Subject Matter Knowledge	3.127	.153	.231	20.982	.000
3	Instructional Planning	2.771	.155	.197	17.445	.000
4	Assessment	3.096	.154	.227	19.972	.000
5	Learning Environment	2.740	.143	.215	19.651	.000
6	Effective Communication	3.445	.128	.285	29.102	.000

Note: r = .878[a], r^2 = .771, $p < .05$

SAAB = Student Academic Achievement in Biology

The above Table 5 presents the values of regression analysis. The model had a strong fit, with r = .878, indicating that the predictors collectively explained a significant portion of the variance in students' academic achievement. The $r^2 = .771$ suggests that 77.1% of the variance in SAAB (students' academic scores) was accounted for by the different components of BTE (predictors). All predictors showed significant positive relationships with students' academic scores, as indicated by the t-values and p-values (all p < .05). among all factors Effective Communication (B = 3.445, β = .285, t = 29.102, p < .000) had the strongest positive effect on academic achievement of students in biology, suggesting that better communication by the teacher was associated with higher student achievement.

CONCLUSION

This study examined the effect of teacher effectiveness on student academic achievement in Biology among secondary school students in Lahore. The findings revealed that students generally perceived their Biology teachers as moderately effective, with the highest ratings in classroom environment and communication. A significant and positive relationship was found between perceived teacher effectiveness and Biology achievement, with teacher effectiveness accounting for nearly 77% of the variance in student performance. Effective communication, Assessment and Subject Matter Knowledge

were the strongest predictors of student academic achievement in biology. These results highlight the crucial role of overall teacher effectiveness in shaping students' academic outcomes in Biology and signifying the need for targeted and specific professional development programs that will strengthen not only teacher's pedagogical skills but also their expertise in subject specific content. Thus current study contributed to the existing literature by proposing subject-specific evidences within Pakistani context and emphasized the significance of evaluating and assessing effectiveness of teachers.

DISCUSSION

The findings of this study highlighted the significant impact of teacher effectiveness on students' academic achievement in Biology at the secondary school level. Students perceived their Biology teachers as moderately effective overall, with the highest ratings in creating a positive learning environment and demonstrating effective communication. These affective and interpersonal aspects of teaching appear to be highly valued by students which contribute to increased classroom engagement and motivation, which are known to facilitate academic success (Hernandez et al., 2017; Bardach et al., 2020).

The strong, positive, and significant correlation between teacher effectiveness and Biology achievement ($r = .787$) is consistent with the results of previous research studies that had also established a close link between teacher characteristics and student academic performance in science subjects (Gess-Newsome et al., 2019; Owusu-Fordjour et al., 2022). The results of regression analysis also demonstrated that biology teacher effectiveness significantly predicted student academic achievement, with $r^2=.619$, representing that nearly 62% of the variance in biology achievement can be explained by perceptions of students about their teachers' effectiveness.

The findings of this study were also supported by the results of Khan et al. (2021) and Hassan and Akbar (2020) studies, who found that the most important factors of teacher effectiveness include effective communication skills, assessment techniques, and subject related knowledge. From these results it can be inferred that teaching proficiencies like transformation of comprehensive content matter and application of assessment techniques to give timely feedback are directly linked to the academic success of students in Biology. It can be recommended from these results that teacher training programs need to be adapt to bring a balance between pedagogy and content knowledge.

These evidences add to the limited body of literature in Pakistani context where the researchers examined the teacher effectiveness within specific science disciplines rather than studying it as a general subject. This specific focus on biology as a separate subject provided more comprehension about how subject-focused teaching skills and competencies effect students' success. The exploration of this area was mainly important given the constantly high failure rates in biology according to BISE Lahore over the recent years, which further validate the urgency of improving instructional quality.

Overall, these findings emphasized that to improve student academic achievement in biology in public schools one requires more than curriculum reform or assessment changes. To make this happen a strategic investment is required in planning and evaluating teacher effectiveness through structured models or frameworks. Improving teacher quality in specific subjects offer one of the most impactful and sustainable approach for improving science achievement in Pakistan's secondary education system.

RECOMMENDATION AND SUGGESTIONS

In the light of the study results, following are some of the recommendations and future calls for researchers presented by the researchers:

- Schools administrations should organize teacher training programs with major focus on improving various dimension of teacher effectiveness, to ensure that teachers possess the knowledge and skills require to deliver content successfully.

- School administrations should implement structured evaluation models and frameworks, such as Marzano's Teacher Evaluation Model, to thoroughly evaluate and then strengthen teacher performance across all key instructional domains.

- Continuous professional development should be sustained and targeted, allowing Biology teachers to remain updated with both pedagogical techniques and developments in their subject area.

- Teachers should be encouraged to adopt data-informed and evidence-based instructional strategies that are aligned with student learning needs and classroom assessment outcomes.

- Future research should explore similar relationships using longitudinal designs to gain more comprehensive understanding of teacher effectiveness, measure its effect in other science subjects, incorporate triangulation of data, and consider other geographical locations to identify variation in results.

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