Evaluating Pedagogical Training Needs of Science Teachers for Effective Teaching: A Rural-Urban Comparison

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Abstract

The study was designed to identify the pedagogical training needs (PTNs) of science teachers (STs) for effective teaching (ET) and to compare the differences in their PTNs between rural and urban settings. This study employed a descriptive design and utilized a survey method. The study included students from public secondary schools in Rahim Yar Khan district. Three hundred and twenty (320) STs were selected using a multi-stage random sampling process. Data was collected using a 5-point Likert scale. The data were analyzed with mean, SD, and t-tests. The study found that most respondents require pedagogical training for ET, and there are considerable differences in perceptions between rural and urban STs.

Keywords: Science Teachers, Pedagogical Training Needs, Effective Teaching.

Introduction

One of the numerous issues facing Pakistan's educational system and school administration is the lack of pedagogical competence among teachers, which implies that the quality of teachers in public schools has been compromised (Akram et al., 2022; Zaidi et al., 2023; Mumtaz et al., 2024). Providing quality education (QE) to all citizens is the basic objective of an educational system (Zaidi et al., 2023; Mohiman et al., 2024; Hassan et al., 2024). QE largely depends on quality teachers (Anjum et al., 2022; Zaidi et al., 2023) with effective teaching (ET) to make learning effective and gain targeted educational objectives.

ET includes a teacher's expertise, instructional strategies, and dedication to student learning. Morrison et al. (2019) described ET as the delivery of lessons to students at diverse levels by educational objectives. ET in science entails a variety of strategies, methods, and approaches designed to help students grasp scientific concepts, principles, and processes. Pedagogically skilled teachers may not only explain complex topics but also instil in their students a love of learning, which leads to higher academic accomplishment and long-term success.

A comprehensive understanding of pedagogical needs is necessary to enhance pedagogical competence, particularly in the field of science education. By attending to these needs, science

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teachers (STs) can improve their pedagogical skills and, in turn, increase the efficacy of their instruction. Additionally, improving teaching methods can enhance student understanding and engagement, thereby creating a more dynamic and effective learning environment. The ultimate goal is to ensure that STs have access to the best methods and materials to inspire and instruct the next generation of students.

High-quality science education is essential for developing critical thinking skills, problem-solving abilities, and a profound understanding of the world around us. However, the current state of education highlights an apparent deficiency in ensuring continual and efficient enhancement of STs' skills. The primary objective of this investigation is to identify the unique pedagogical needs of STs and to compare their perspectives in rural and urban areas, thereby addressing this pressing issue.

Literature Review

"A review of literature may only be a clear overview of the sources, in an organizational pattern, and its function is to estimate and summarize the previous writings linked to the current topic" (Ahmad, 2024, p. 3). Following is the literature review of the present research study.

Effective Teaching

Effective teaching is a multifaceted art form that requires a distinct blend of knowledge, competence, and enthusiasm. Hawthorne (2022) identified key characteristics for ET, i.e., creating a positive learning environment, motivating the students, building positive relationships with students, managing the class, having strong communication skills, having subject knowledge, being passionate about the subject and students' progress; provision of high-quality learning opportunities to students; and teacher's reflection.

Pedagogical Competence

Pedagogical competence (PC) is often described as the essential professional skills required for an individual to carry out particular responsibilities within the education sector (Zaidi et al., 2023; Fatima et al., 2024; Rasheed et al., 2024). It demands the ability to develop, implement, and assess teaching strategies that cater to diverse student needs while fostering a conducive learning atmosphere. Idris et al. (2023) described PC as consisting of the fundamental abilities and attributes required by educators to proficiently guide learning processes and engage students in meaningful educational experiences. This encompasses a mastery of the subject, the execution of curricular frameworks, the development of engaging learning tasks, and adept communication with students.

Pedagogical Needs of Science Teachers

Effective science education significantly depends on the pedagogical skills possessed by science educators. To foster an engaging and educational learning atmosphere, educators must possess a wide range of abilities that encompass not only scientific expertise but also effective teaching strategies. The study investigated eight crucial pedagogical needs, including teacher leadership, depth of knowledge in the subject matter, student learning, lesson planning, instructional strategies, efficient classroom management, technology use, and evaluation.

Teacher leadership is crucial for fostering a collaborative learning environment and promoting instructional development (Simpson, 2021; Naz et al., 2023). Effective science teachers demonstrate leadership by mentoring their peers, contributing to curriculum development, and

adopting innovative teaching practices (Ramzan et al., 2023; Heredia et al., 2024; Hassan et al., 2024). Teacher leadership training enables STs to apply inquiry-based methods linked to state standards, developing cooperation, self-awareness, and confidence, which ultimately drives change and innovation in their classrooms (Weatherhead, 2024; Naz et al., 2024; Saleem et al., 2024).

A solid understanding of the subject matter is essential for effective science instruction. Research indicates that educators who possess in-depth subject-matter expertise can better explain ideas, employ a variety of representations, and successfully correct misconceptions (Lee, 2013; Mafa-Theledi, 2024; Saleem et al., 2024; Shehbaz et al., 2025). Research indicates that professional development programs centred on subject matter knowledge significantly enhance teachers' ability to deliver engaging science lessons (You et al., 2024).

Knowledge of students' learning improves teachers' pedagogical skills by allowing them to fine-tune instructional tactics that promote critical thinking, problem-solving, and teamwork. This understanding is critical for effective teaching and increasing 21st-century learning outcomes in students (Sophie et al., 2024).

Effective lesson planning enhances teacher clarity and classroom management by enabling educators to logically organise content and develop clear instructional strategies, such as aligning lessons with objectives, incorporating hands-on activities, and selecting assessment strategies to increase student engagement (Juma, 2024). Effective science teaching strategies include inquiry-based learning, student-centred approaches, instructional videos, practical work, and active learning strategies, which enhance student engagement, understanding, and achievement (Ntuli et al., 2022; Park et al., 2022).

Efficient classroom management entails establishing clear rules and routines, fostering a positive learning environment, and employing proactive discipline strategies, whereas professional development in classroom management is critical for providing teachers with the skills needed to create structured and productive learning environments (Babadjanova, 2020; Matthew, 2022; Yadav, 2022; Zafar et al., 2023).

The use of technology in science education enhances student engagement, conceptual understanding, and inquiry-based learning while also emphasising the importance of teacher training in technological skills to effectively utilise these tools (Gusho et al., 2023; Rahmat et al., 2023). Practical assessment and evaluation are critical for tracking student progress, informing instructional decisions, and improving educational outcomes. Modern methodologies provide flexibility, technology integration, and inclusivity, whereas traditional methods emphasize summative assessments and academic knowledge (Meylani, 2024; Saleem et al., 2024).

Research Questions

1. What are science teachers' (STs) perceptions about their pedagogical training needs (PTN) for effective teaching (ET)?
2. Is there a difference in how male and female science teachers perceive their pedagogical training needs for effective teaching (ET)?
3. Is there a difference in how male and female science teachers perceive 'Teacher Leadership' as their pedagogical training needs for ET?
4. Is there a difference in how male and female science teachers perceive 'Subject Matter Knowledge' as their pedagogical training needs for ET?
5. Is there a difference in how male and female science teachers perceive 'Student learning' as their pedagogical training needs for ET?

6. Is there a difference in how male and female science teachers perceive 'Lesson Planning' as their pedagogical training needs for ET?
7. Is there a difference in how male and female science teachers perceive 'Instructional Strategy' as their pedagogical training needs for ET?
8. Is there a difference in how male and female science teachers perceive 'Classroom Management' as their pedagogical training needs for ET?
9. Is there a difference in how male and female science teachers perceive 'Technology' as their pedagogical training needs for ET?
10. Is there a difference in how male and female science teachers perceive 'Evaluation' as their pedagogical training needs for ET?

Methodology

"The research methodology is the procedure which the researchers use to gather data for resolving problems of investigation" (Ahmad et al., 2022, p.524). The research study was a descriptive type. For this study, the researcher employed the survey approach. All secondary school science teachers in the public sector were the population for the research study. Multi-stage sampling was applied to obtain quantitative data. A simple random technique was applied, with STs in Rahim Yar Khan district serving as the population of interest. Quantitative data were collected from STs. For data collection purposes, Rahim Yar Khan District was divided into four tehsils: Liaqat Pur (LQR), Khan Pur (KPR), Sadiqabad (SDK), and Rahim Yar Khan (RYK). Then, each tehsil was divided into urban and rural areas, and subsequently, male and female secondary schools were selected from these areas. Three hundred and twenty (320) science teachers (Eighty from each tehsil) were selected as the sample.

Research Instrument and Data Analysis

A research instrument is a tool used to collect, measure, and analyse data related to a specific subject. Research instruments can be tests, surveys, scales, questionnaires, or even checklists (Rao et al., 2023; Sadaf et al., 2024). The researcher utilized the self-developed questionnaire. The questionnaire was on a 5-point Likert scale. The statements were divided into eight constructs, namely teacher leadership needs, subject matter knowledge needs, students' learning needs, lesson planning needs, instructional strategy needs, classroom management needs, technology needs, and evaluation needs. The quantitative data were analyzed through SPSS version 27. To analyze the data, Inferential statistics of an independent sample t-test were applied to determine the differences in respondents' perceptions.

Results

RQ1. What are science teachers' (STs) perceptions about their pedagogical training needs (PTN) for effective teaching (ET)?

Table 1: STs' perspectives on their pedagogical training needs

Sr.#	Pedagogical training needs	N	Mean	SD	Qualitative Description
1	Pedagogical training needs	320	4.04	0.375	High

The analysis in Table 1 reveals STs' perspectives on their pedagogical training needs for ET. The results showed that most respondents showed a 'high' level need, with a mean score of 4.04, which falls within the range of (3.41-4.20).

RQ2. Is there a difference in how rural and urban science teachers perceive their pedagogical training needs for effective teaching (ET)?

Table 2: Differences in rural and urban STs' perspectives about their pedagogical training needs for effective teaching (ET)

Locality	N	Mean	SD	Levene's Test	df	MD	t-value	Sig	Cohen's d
Rural	160	4.12	0.329	0.004	304	0.141	3.413	<.001	0.382
Urban	160	3.97	0.406						

The analysis in Table 2 reveals that a significant difference exists in the rural and urban STs about their pedagogical training needs (p<.001<.05) for ET. This shows that rural STs need more pedagogical training toward ET as compared to urban STs.

RQ3. Is there a difference in how rural and urban science teachers perceive 'Teacher Leadership' as their pedagogical training needs for ET?

Table 3: Differences in rural and urban STs' perspectives about 'Teacher Leadership' as their pedagogical training needs

Locality	N	Mean	SD	Levene's Test	df	MD	t-value	Sig	Cohen's d
Rural	160	4.18	0.654	0.911	318	0.129	1.730	0.085	0.193
Urban	160	4.05	0.680						

The analysis in Table 3 reveals that there is no significant difference in the rural and urban STs' pedagogical training needs (p=.085>.05) for ET. This shows that rural and urban respondents both need 'teacher leadership' as pedagogical training needs toward ET.

RQ4: Is there a difference in how rural and urban science teachers perceive 'Subject matter knowledge' as their pedagogical training needs for effective teaching (ET)?

Table 4: Differences in rural and urban STs' perspectives about 'Subject Matter Knowledge' as their pedagogical training needs

Locality	N	Mean	SD	Levene's Test	df	MD	t-value	Sig	Cohen's d
Rural	160	4.24	0.503	<.001	285	0.286	4.143	<.001	0.400
Urban	160	3.96	0.714						

The analysis in Table 4 reveals that a significant difference in the rural and urban STs' perspectives about 'subject matter knowledge' as their pedagogical training needs (p<.001<.05) for ET. This shows that rural STs need more pedagogical training on 'subject matter knowledge' toward ET as compared to urban STs.

RQ5: Is there a difference in how rural and urban science teachers perceive 'Students' Learning' as their pedagogical training needs for effective teaching (ET)?

Table 5: Differences in rural and urban STs' perspectives about 'Students' Learning' as their pedagogical training needs

Locality	N	Mean	SD	Levene's Test	df	MD	t-value	Sig	Cohen's d
Rural	160	4.07	0.636	0.051	318	.080	1.020	0.309	0.114
Urban	160	3.99	0.761						

The analysis in Table 5 reveals that there is no significant difference in the rural and urban STs' about their pedagogical training needs (p=.309>.05) for ET. This shows that rural and urban respondents both need 'students' learning' as pedagogical training needs toward ET.

RQ6: Is there a difference in how rural and urban science teachers perceive 'Lesson Planning' as their pedagogical training needs for effective teaching (ET)?

Table 6: Differences in rural and urban STs' perspectives about 'Lesson Planning' as their pedagogical training needs

Locality	N	Mean	SD	Levene's Test	df	MD	t-value	Sig	Cohen's d
Rural	160	4.18	0.571	0.404	318	.062	1.013	0.312	.113
Urban	160	4.12	0.531						

The analysis in Table 6 reveals that there is no significant difference in the rural and urban STs' about their pedagogical training needs (p=.312>.05) for ET. This shows that rural and urban respondents both need 'lesson planning' as pedagogical training needs toward ET.

RQ7: Is there a difference in how rural and urban science teachers perceive 'Instructional Strategy' as their pedagogical training needs for effective teaching (ET)?

Table 7: Differences in rural and urban STs' perspectives about 'Instructional Strategy' as their pedagogical training needs

Locality	N	Mean	SD	Levene's Test	df	MD	t-value	Sig	Cohen's d
Rural	160	4.13	0.605	0.002	297	0.150	1.904	0.058	0.213
Urban	160	3.98	0.791						

The analysis in Table 7 reveals that there is no significant difference in the rural and urban STs' perspectives on 'instructional strategy' as their pedagogical training needs (p=.058>.05) for ET. This shows that rural and urban respondents both need 'instructional strategy' as pedagogical training needs toward ET.

RQ8: Is there a difference in how rural and urban science teachers perceive 'Classroom Management' as their pedagogical training needs for effective teaching (ET)?

Table 8: Differences in rural and urban STs' perspectives about 'Classroom Management' as their pedagogical training needs

Locality	N	Mean	SD	Levene's Test	df	MD	t-value	Sig	Cohen's d
Rural	160	3.97	0.632	0.005	305	0.110	1.393	0.165	0.156
Urban	160	3.86	0.778						

The analysis in Table 8 reveals that there is no significant difference in the rural and urban STs' perspectives about 'classroom management as their pedagogical training needs (p=<.165<.05) for ET. This shows that rural and urban respondents both need 'classroom management' as pedagogical training needs toward ET.

RQ9: Is there a difference in how rural and urban science teachers perceive 'Technology' as their pedagogical training needs for effective teaching (ET)?

Table 9: Differences in rural and urban STs' perspectives about 'Technology' as their pedagogical training needs

Locality	N	Mean	SD	Levene's Test	df	MD	t-value	Sig	Cohen's d
Rural	160	4.10	0.618	0.023	304	0.256	3.295	0.001	0.368
Urban	160	3.85	0.765						

The analysis in Table 9 reveals that there is a significant difference in the rural and urban STs' perspectives on 'technology' as their pedagogical training needs (p=.001>.05) for ET. This shows that rural STs need more pedagogical training on 'technology' toward ET as compared to urban STs.

RQ10: Is there a difference in how rural and urban science teachers perceive 'Evaluation' as their pedagogical training needs for effective teaching (ET)?

Table 10: Differences in rural and urban STs' perspectives about 'Evaluation' as their pedagogical training needs

Locality	N	Mean	SD	Levene's Test	df	MD	t-value	Sig	Cohen's d
Rural	160	4.04	0.632	0.712	318	0.054	0.778	0.437	0.087
Urban	160	3.98	0.612						

The analysis in Table 10 reveals that there is no significant difference in the rural and urban STs' perspectives about 'evaluation' as their pedagogical training needs (p=.437<.05) for ET. This shows that rural and urban respondents both need 'evaluation' as pedagogical training needs toward ET.

Discussion

Effective science instruction encompasses a diverse array of strategies, methodologies, and techniques aimed at aiding students in understanding scientific concepts, principles, and processes. The effectiveness of science education is largely dependent on the pedagogical expertise that STs possess. This study investigated the pedagogical training requirements of STs in district Rahim

Yar Khan, Pakistan, focusing on aspects such as teacher leadership, in-depth subject matter knowledge, student-focused educational methodologies, lesson planning, instructional techniques, effective classroom management, technology integration, and evaluation.

The results indicated that both rural and urban STs recognized the necessity for pedagogical training to enhance their teaching effectiveness. A substantial body of literature outlines the areas where pedagogical training is needed (Akhter, 2023; Mai & Mahizer, 2017; Safriana et al., 2023). The analysis revealed a notable difference in perceptions based on rural versus urban contexts. Numerous prior studies have documented variations in teachers' perceptions when comparing rural and urban settings (Baird et al., 1994; Lavanya et al., 2024; Mohan et al., 2017). The rural STs exhibited a considerably greater overall demand for pedagogical training than their urban counterparts. Geographic disparities were particularly pronounced in areas like subject matter expertise and technology utilization, where rural STs prioritized seeking additional training. Furthermore, no significant disparities were found in the areas of teacher leadership, student-centered learning, lesson planning, instructional strategies, classroom management, and evaluation needs, suggesting a shared acknowledgement of these domains as vital for professional development.

Conclusion

The research sought to explore the perceptions of STs regarding their PTNs and the contrasts between their viewpoints on rural and urban contexts within district of Rahim Yar Khan. A significant number of STs recognized the importance of ongoing pedagogical training in essential areas, such as teacher leadership, subject matter expertise, student-centered teaching methods, lesson design, instructional techniques, classroom management, and assessment, reflecting a collective acknowledgment of these skills as fundamental to delivering high-quality science education. Nevertheless, significant regional disparities were identified, with rural STs showing a markedly greater demand for training in subject matter knowledge and assessment. In contrast, the consistency in training priorities concerning teacher leadership, students' learning, lesson design, instructional techniques, effective classroom management, and assessment illustrates a shared training foundation for both rural and urban STs. These findings highlight the critical role of pedagogical teacher training programs. Stakeholders can equip both rural and urban STs to thrive as leaders, innovators, facilitators of student learning, and experts in subject matter knowledge, lesson design, instructional techniques, classroom management, assessment, and technology utilization. Ultimately, such initiatives will enhance the quality of science education, foster student engagement, and promote a more equitable and vibrant educational environment

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