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IDENTIFYING THE CHALLENGES IN TEACHING PRACTICES IN SCIENCE EDUCATION

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Abstract
This study explores the key challenges in teaching practices within university-level science education, emphasizing the complex relationship between teachers' content knowledge and classroom implementation. Despite widespread support for inquiry-based and constructivist reforms aimed at fostering critical thinking and problem-solving skills, the transition from traditional teaching methods remains slow. Challenges include misconceptions about inquiry-based learning, the influence of teachers' beliefs and values, and systemic barriers such as limited resources, professional development, and institutional support. Faculty also face difficulties adapting to digital technologies and balancing multiple roles, compounded by concerns about academic integrity in the era of AI. Through a quantitative survey of 100 university science educators, this research identifies critical obstacles related to pedagogy, classroom management, and future readiness. The findings highlight the urgent need for targeted faculty training, collaborative practices, and flexible teaching models. Incorporating emerging technologies thoughtfully can offer new pathways to enhance science education and align it with evolving educational demands.
Keywords: science education, teaching practices, inquiry-based learning, higher education, and challenges

Introduction

For decades, the relationship between teachers' knowledge and their classroom practices has been a central focus in educational research, particularly within science education. It is widely acknowledged that a teacher's mastery of subject matter significantly impacts their effectiveness, shaping how they deliver content and engage students. However, emerging research reveals this relationship to be far more complex than a simple, linear translation of knowledge into practice. Instead, teaching involves a nuanced interplay of tacit understanding, personal beliefs, and values that profoundly influence instructional decisions (Lakin & Wellington, 1994; Waters-Adams, 2000).

Contemporary educational reforms in science emphasize a move away from traditional, didactic teaching toward inquiry-based and constructivist approaches. These reforms aim to cultivate students' critical thinking, problem-solving skills, and independent learning (AAAS, 1994; NRC, 1996). Yet, despite broad support for these changes, implementation has been gradual, with ongoing challenges in ensuring teachers possess both deep content knowledge and the pedagogical expertise necessary to foster higher-order cognitive skills (Barak & Shakhman, 2008).

Successfully addressing these challenges demands not only innovative teaching strategies but also a deeper understanding of the factors shaping teacher practice, such as reflective capacity and adaptability to new instructional methods (Leou, 2006; Zohar, 2006). This paper, therefore, investigates the major challenges in university-level science education, focusing on the complex process of translating educational reforms into effective classroom practice.

Theoretical Contribution

This study contributes to the theoretical discourse on science education by situating its findings within the framework of Critical Pedagogy, particularly as conceptualized by Paulo Freire. Critical Pedagogy challenges traditional hierarchies in education and advocates for teaching that is transformative, dialogic, and rooted in social justice (Freire, 1970/2000). In this view, education is not merely the transfer of content knowledge but a political and ethical act aimed at empowering learners and encouraging critical reflection on the structures shaping their lives and learning environments.

The challenges identified in this study—such as the persistence of traditional, didactic methods, limited professional autonomy, and technological barriers—reflect the institutional and ideological constraints that Freire critiqued. The enduring reliance on the "banking model" of education, where teachers deposit knowledge into passive students, continues to undermine the development of critical consciousness and dialogic engagement (Freire, 2000). Teachers' struggles with balancing instructional roles, managing digital platforms, and addressing systemic inequalities illustrate how power and control are embedded within educational structures (Giroux, 2011).

Furthermore, the findings highlight the need to critically assess how emerging technologies, including artificial intelligence, are reshaping pedagogical relationships. While these tools offer opportunities, they may also reinforce surveillance, standardization, and the depersonalization of learning (Selwyn, 2016). From a critical pedagogical lens, integrating technology should not simply focus on efficiency or content delivery, but rather on how it can foster participatory, emancipatory, and inclusive learning environments.

This research advances the theoretical understanding of science education by advocating for a pedagogy that is critically reflective, socially engaged, and oriented toward transformative practice. It emphasizes the importance of equipping educators not only with technical skills but also with the critical consciousness (conscientização) necessary to resist oppressive structures and reimagine science education as a space for dialogue, equity, and empowerment (Freire, 2000; Kincheloe, 2008).

Review of the Related Literature

The challenges in teaching practices within science education at the university level have been widely debated, particularly since the release of the National Science Education Standards (National Academy of Sciences, 1995). A central issue in this debate is how science should be taught, with many advocating for an inquiry-based approach that promotes science as a process of discovery. This model encourages students to engage with scientific principles through investigation. However, scholars like Chinn & Malhotra (2003) and Roth (1995) have raised concerns about this approach, arguing that it confuses the distinction between learning science and doing science. While scientific inquiry generates new knowledge, science education should help students understand established knowledge. Consequently, inquiry-based teaching often leads to misapplication, creating a "category error" that conflates acquiring scientific knowledge with the process of discovery.

A major issue in implementing inquiry-based science education is the lack of a universally accepted definition of teaching science through inquiry. Educators often reduce inquiry-based teaching to hands-on activities, which Osborne (2014) criticizes as “cookbook” laboratory exercises that emphasize following instructions rather than understanding scientific principles. This undermines the intended purpose of inquiry-based learning. Moreover, practical constraints such as limited time, inadequate resources, and insufficient professional development opportunities (Roth & Garnier, 2006) further hinder effective application. Addressing these challenges requires a shift from disconnected activities to an approach that promotes meaningful engagement with core scientific concepts.

This aligns with the goals outlined in the Framework for K-12 Science Education and the Next Generation Science Standards, which emphasize deeper content understanding and scientific inquiry processes (Kloser, 2014). Kloser also argues for adaptable and contextual teaching practices, emphasizing the importance of professional development frameworks that integrate core teaching methods into real classroom settings. Teacher beliefs significantly shape how teaching practices are implemented. Calderhead (1996), Fang (1996), and Mansour (2009) note that teacher beliefs, influenced by ideologies and personal experiences, affect instructional methods and priorities. This becomes crucial when balancing inquiry-based learning with traditional science curricula. External pressures like standardized testing often push teachers to prioritize content coverage over innovative methods, limiting opportunities for student-centered inquiry (Haney, Czerniak, & Lumpe, 1996). Windschitl & Calabrese Barton (2016) call for a cultural shift in science education that emphasizes collaboration over individual teaching. By fostering partnerships between educators and researchers, universities can create infrastructures that support ambitious science teaching.

These collaborations can help bridge the gap between inquiry-based and content-focused teaching, enabling educators to balance both effectively. An additional aspect of science education is the role of epistemic practices, which reflect the values and methods of scientific inquiry. Kelly & Licona (2018) emphasize that students should not only learn scientific content but also understand how scientific knowledge is constructed, communicated, and evaluated. This holistic approach can contribute to greater scientific literacy and equip students to engage with scientific issues meaningfully. Looking ahead, artificial intelligence (AI) presents both challenges and opportunities. On the one hand, AI poses risks such as potential misuse for academic dishonesty (Hernandez, 2021). On the other hand, it offers innovative possibilities, such as automating routine tasks, allowing educators to focus on higher-order instructional activities like mentoring and designing complex assessments (Jensen & Liu, 2021). AI’s role in science education mirrors broader trends in higher education, where flexible, adaptable models, like hybrid learning, are becoming essential in an unpredictable educational landscape (Clark, 2022).

These models not only enrich the student experience but also foster international collaborations, enabling global exchanges of knowledge and best practices (Emms, Laczik, & Dabbous, 2022). Early assumptions of a simple, linear connection between teaching practices and outcomes have been challenged by studies highlighting the dialectical nature of practice and the influence of tacit knowledge, beliefs, and values on teaching behavior (Lakin & Wellington, 1994; Laplante, 1997; Waters-Adams & Nias, 2003). This shift underscores the importance of both explicit and implicit knowledge in teacher practice.

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Today, fostering intellectual competencies like independent learning, problem-solving, and critical thinking is a key focus in science education. Educational reforms advocate for moving away from traditional methods toward constructivist-oriented instruction. Schraw, Crippen, and Hartley (2006) stress the need for promoting metacognition and self-regulation through inquiry-based learning, collaborative support, and problem-solving strategies. However, despite general agreement on these goals, implementation at the school level remains slow, with many classrooms still relying on traditional methods, such as content delivery and rote problem-solving. To promote higher-order thinking, teachers must possess both deep subject knowledge and pedagogical skills that foster cognitive processes in the classroom (Brickhouse, 1990; Bybee, 1993; Fullan, 1993).

Inquiry-based science education (IBSE) is widely promoted as a means of developing competencies such as decision-making, critical thinking, and adaptability. Hiang (2005) and Aksela et al. (2010) note that inquiry encourages active engagement with scientific concepts, fostering conceptual change through hands-on experiences. However, transitioning from traditional to inquiry-based methods requires careful measurement to ensure effective implementation and meaningful learning outcomes (Shamsudin et al., 2013). Research has shown that students often retain misconceptions despite being exposed to correct information, underscoring the need for strategies that actively engage learners in conceptual conflict and reflection (Driver et al., 1985; Osborne & Freyburg, 1985). Recent reforms stress the importance of understanding scientific concepts deeply rather than memorizing facts. Conceptual understanding involves knowing how scientific ideas interrelate and applying them to new phenomena (NRC, 1996). Engaging students with science requires teachers who understand student misconceptions and use this knowledge to guide instruction, helping students build scientifically accurate understandings of the world (Driver, Guesne, & Tiberghien, 1985). Effective strategies, such as the learning cycle, analogies, and language use, have proven successful in confronting and changing students' misconceptions (Karplus & Thier, 1967; Lawson et al., 1989; Fellows, 1994).

Additionally, studies explore the effectiveness of various teaching strategies, such as inquiry-based learning, teacher-directed instruction, and adaptive teaching, on student outcomes. While inquiry-based learning yields mixed results depending on the discipline, teacher-directed instruction consistently correlates with improved science outcomes. Adaptive teaching and feedback are also recognized for fostering personalized learning and enhancing student engagement in science (Waldrop, 2015). In the broader context of higher education, research underscores its growing significance in economic development, social equity, and knowledge creation. Universities are increasingly seen as key drivers of societal progress. Despite this attention, research in higher education can sometimes be fragmented, lacking integration with broader comparative frameworks. Topics like access, equity, governance, and market-driven education dominate the research agenda, yet greater cohesion is needed to address these challenges within higher education systems.

In conclusion, the challenges in science education teaching practices at the university level are complex, involving the misapplication of inquiry-based learning, the impact of teacher beliefs, and systemic constraints within educational systems. Moving forward, refining teaching practices, providing robust professional development opportunities, and fostering collaborative environments will be essential to support innovative science education. Emerging technologies, such as AI, offer new possibilities for flexible, student-centered learning models that could reshape the future of science education.

Statement of the Problem

The study aimed to explore the challenges in teaching practices in science education at the university level.

Objectives of the Study

1. To identify the challenges facing the future of higher education.
2. To explore the challenges in teaching practices at the university level.
3. To identify the challenges of classroom teaching management at the university level.

Research questions

- What are the challenges facing the future of higher education?
- What are the challenges in teaching practices at the university level?
- What are the challenges of classroom teaching management at the university level?

Methodology:

Research Design:

This study employed a quantitative descriptive research design to systematically examine the challenges facing science education teaching practices at the university level. The design enabled the collection of numerical data to identify patterns, trends, and levels of agreement among university faculty regarding pedagogical, systemic, and technological barriers.

Theoretical Framework:

The study was underpinned by the theoretical lens of Critical Pedagogy (Freire, 2000), which frames education as a political, ethical, and dialogic act. The framework guided the construction of the instrument and interpretation of results, particularly focusing on faculty agency, structural constraints, and institutional practices.

Population and Sampling:

The target population included university faculty members—Professors, Associate Professors, and Heads of Departments—from multiple departments within public and private universities in Punjab, Pakistan. A stratified purposive sampling technique was used to select 100 participants to ensure representation across disciplines and institutional types.

Instrumentation:

A structured questionnaire using a five-point Likert scale was developed based on an extensive review of relevant literature. The instrument included 25 items divided into three categories:

- Challenges Facing the Future of Higher Education
- Challenges in Teaching Practices at the University Level
- Challenges of Classroom Teaching Management

Each item ranged from 1 (Strongly Disagree) to 5 (Strongly Agree). The instrument underwent expert validation and a pilot test, achieving a Cronbach's Alpha of 0.89, indicating high internal reliability.

Data Collection:

The questionnaire was administered in person to ensure maximum participation and accuracy. Participants provided informed consent, and responses were collected anonymously.

Data Analysis:

Quantitative data were analyzed using SPSS v26. The analysis included:

Descriptive statistics: Mean and standard deviation were computed for each item.

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Inferential statistics:
Independent samples t-tests were used to examine differences based on faculty gender and experience. One-way ANOVA was applied to test differences across institutional types. Multiple linear regression was conducted to identify predictors of perceived teaching challenges. A significance level of $p < .05$ was adopted for all inferential tests.
Ethical Considerations: All procedures followed ethical research guidelines. Consent was obtained from all participants, and data confidentiality was strictly maintained. The study was approved by institutional authorities overseeing research ethics.
Findings:

- Education Systemic barriers hindering access received the highest agreement (Mean = 3.83), indicating strong concern over structural inequalities in higher education.
- Tuition as a major financial barrier was also highly agreed upon (Mean = 3.76), showing that affordability remains a significant issue.
- The need for institutions to adapt to globalization (Mean = 3.62) and the impact of technology on traditional teaching (Mean = 3.58) were acknowledged but with slightly less intensity.
- The strongest consensus (Mean = 4.12) was on the need for faculty training in LMS and digital tools, emphasizing technical competency as critical.
- Significant concerns exist about AI tools potentially undermining academic integrity (Mean = 3.77) and the time demands of online/hybrid teaching formats (Mean = 3.74).
- Respondents moderately agreed on the importance of ongoing professional development (Mean = 3.72) and integrating mental health resources in courses (Mean = 3.67).
- The highest agreement (Mean = 4.15) highlighted the difficulty faculty face balancing multiple roles in online environments, pointing to workload issues.
- Strong agreement also emerged on the need for flexible teaching models for diverse learners (Mean = 3.90) and the negative impact of limited inter-university collaboration on sharing best practices (Mean = 3.91).
- The importance of institutional support for instructional design was recognized (Mean = 3.82).
- While concerns about the impact of adjunct faculty on classroom instruction were lower (Mean = 3.46), they still indicated moderate agreement.

Overall, respondents consistently perceive these challenges as highly relevant to the future of higher education. These findings underscore the need for institutional support and capacity building in modern teaching practices. The results highlight a clear need for systemic reforms in faculty support, collaboration, and pedagogical flexibility.
Discussion
The relationship between teachers' knowledge and their classroom practices has long been a central focus in educational research, particularly within science education. It is broadly accepted that a teacher's subject matter knowledge significantly shapes their effectiveness, influencing how they present content and interact with students. However, recent research reveals this relationship to be more complex than previously assumed. Early views that knowledge straightforwardly translates into practice have been challenged by findings emphasizing the nuanced interplay of tacit knowledge, beliefs, and values in shaping teaching behavior (Lakin & Wellington, 1994; Waters-Adams, 2000).

Contemporary educational reforms in science emphasize a shift from traditional, lecture-based instruction toward inquiry-based and constructivist methodologies designed to promote critical thinking, problem-solving, and learner autonomy (AAAS, 1994; NRC, 1996). Despite widespread endorsement of these reforms, their implementation has been slow. Science education still grapples with challenges, notably the demand for teachers to possess both deep disciplinary expertise and pedagogical skills necessary to cultivate higher-order cognitive skills in students (Barak & Shakhman, 2008). Overcoming these challenges necessitates innovative teaching strategies coupled with enhanced reflective practices and adaptability among educators to new instructional approaches (Leou, 2006; Zohar, 2006).

This study, therefore, investigates the key challenges faced in university-level science teaching, focusing on the complexities involved in translating educational reforms into effective classroom practices.

Conclusions

The challenges facing science education at the university level are multifaceted, involving conceptual misunderstandings of inquiry-based learning, the impact of teacher beliefs, and systemic constraints such as resource limitations and policy pressures. Advancing science education requires refining pedagogical practices, expanding professional development, and fostering collaborative academic environments. Emerging technologies like AI provide opportunities to support flexible, student-centered learning models that could transform the future landscape of science education.

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Appendix A:
Five-Point Likert Scale Questionnaire
Response Options:
1 = Strongly Disagree
2 = Disagree
3 = Neutral
4 = Agree
5 = Strongly Agree

Section 1: Challenges Facing the Future of Higher Education

Sr. No.	Statement	1	2	3	4	5
1	The increasing use of technology in higher education poses significant challenges to traditional teaching methods.	15	7	8	45	25
2	Universities need to adapt to meet the demands of a globalized educational environment.	12	10	6	48	24
3	The financial burden of tuition is a major barrier for students seeking higher education.	11	5	8	49	27
4	Systemic barriers, such as those faced by underrepresented groups, hinder access to higher education.	9	5	6	54	26

Section 2: Challenges in Teaching Practices in Education

Sr. No.	Statement	1	2	3	4	5
1	Faculty members struggle with the time demands of transitioning courses to online or hybrid formats.	11	7	9	43	30
2	Ongoing professional development is necessary for faculty to keep pace with educational technologies.	13	6	11	36	34
3	AI tools in education can undermine academic integrity and the quality of student assessments.	15	5	8	32	40
4	Faculty need training to use learning management systems (LMS) and other digital tools effectively.	5	2	1	60	32
5	Mental health resources should be integrated into course designs to support student success.	3	18	6	55	18

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Section 3: Challenges of Classroom Teaching Management

Sr. No.	Statement	1	2	3	4	5
1	The increasing reliance on adjunct faculty compromises the quality of classroom instruction.	11	17	2	55	15
2	Faculty members struggle to balance their roles as instructors and content creators in online learning environments.	5	5	5	40	45
3	Institutional support for instructional design is essential for effective teaching practices.	12	9	3	37	39
4	The lack of collaboration among universities limits the sharing of best practices in teaching.	11	8	4	33	44
5	Flexibility in teaching models is necessary to address the diverse needs of students in higher education.	9	4	3	56	28