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

Teachers' Readiness And Challenges In Using Digital Tools For Chemistry Instruction In District Kohat

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Received: 04-11-2025 **Revised:** 21-11-2025 **Accepted:** 11-12-2025 **Published:** 23-12-2025

ABSTRACT

The adoption of digital learning in teaching chemistry can boost the students' engagement and conceptual learning, but it will heavily rely on the willingness of the teachers and the difficulty they encounter. The article examined the preparedness and issues of chemistry educators to employ digital tools in secondary and higher secondary educational institutions of District Kohat, Khyber Pakhtunkhwa, Pakistan. The quantitative descriptive-correlational research design was used. The study sample was the entire population of all chemistry teachers in the schools of the District of Kohat, all in the public sector, and a stratified random sample of 100 teachers was chosen. A structured questionnaire that measured readiness, use of digital tools and perceived challenges was used to collect data. Statistics descriptive, t-tests, ANOVA, correlation, and regression were carried out. The results showed that the teachers had an intermediate degree of preparedness, reported an increased confidence and attitude but lower scores in training and pedagogical integration. Professionals reported such challenges like lack of proper ICT infrastructure, scarce internet connections, and lack of professional development. The tools that were used most commonly were multimedia presentations and underused were simulations and virtual laboratories. The relationship between the preparedness of teachers and their use of digital tools was seen to have been positive, and problems impacted negatively on their use. On the basis of these findings, it is proposed that the education authorities should increase teacher training, ensure proper ICT infrastructure, and institutional support structures that will enable effective use of digital tools in instruction of chemistry. The research gives evidence-based findings on policy, professional growth of teachers, and technology-supported learning in resource-restricted environments.

Keywords: *The willingness of teachers, computer-based tools, teaching chemistry, difficulties, Khyber Pakhtunkhwa, Pakistan*

INTRODUCTION

The high rate of development of digital technologies has drastically changed the way education is done in different parts of the world with a focus on incorporating digital technology in order to promote learning

and teaching in the educational field. Simulation, virtual lab, multimedia, and Web-based assessment tools have become an important aspect in science teaching, especially in chemistry, which involves abstract and complicated concepts that seem to be less available and interesting to the student. The studies have shown that conceptual learning, motivation, and academic performance of students can be enhanced with the use of technology-based instruction when delivered properly (Crompton et al., 2023; Redecker, 2024).

Regardless of the identified opportunities of digital tools, the extent of their effective implementation is preconditioned by the willingness of teachers, comprising digital skills, pedagogical expertise, technological intentions, and previous training. The research indicates that the better a teacher is technologically and pedagogically equipped, the more likely they will consider the meaningful use of digital tools in the classroom (Koehler et al., 2023; Mishra and Koehler, 2024). On the other hand, the lack of proper preparation may hamper the successful application of technology leading to shallow or spotty implementation.

Digital tools come in handy especially in chemistry education because of the abstract nature of the subject coupled with the need to learn through experiments. Virtual laboratories and digital simulations can be used to address the shortage of access to laboratories, security protocols, and the lack of resources (Makransky and Petersen, 2023). Nevertheless, studies also emphasize the chronic problems of chemistry educators, such as the absence of professional growth, infrastructure, access to sufficiently stable internet, and time are among the challenges (Schmid et al., 2024).

In Pakistan, the policies of national and provincial education have been focusing on the implementation of Information and Communication Technology (ICT) in schools to enhance the quality of teaching and learning. However, the empirical literature shows that not all regions are the same in their implementation, with the schools of the public sector having more limitations than the private ones (Ahmad and Shah, 2024). Chemistry teachers in Khyber Pakhtunkhwa and especially in the District Kohat frequently operate in an environment where there are limited digital opportunities, conventional instructional methods, and institutional support is insufficient. Nevertheless, scanty empirical studies have considered the willingness of teachers and the barriers that teachers have encountered in the implementation of digital tools in the teaching of chemistry at the district level.

Thus, the proposed research undertaking attempts to address the research question of the willingness of chemistry teachers in District Kohat, as well as, the issues they face when employing digital tools to teach chemistry; in the view of making evidence-based contributions to the understanding of teacher professional development, formulation of policies, and successful use of technology in teaching science.

Statement of the Problem

Despite all the possible benefits of digital tools to the teaching of chemistry, and in particular, student engagement and comprehension, the successful implementation of such tools in the school system of the District Kohat, in the sphere of public schools, is not widespread. Low levels of digital skills, training opportunities, inadequate ICT environment, poor internet connectivity, and work overload are some of the challenges experienced by chemistry teachers. Moreover, the existing evidence on the issue is not empirical and context specific as the data are not available about the willingness of teachers to introduce digital tools and the type of difficulties they face in classroom application. This is the gap in research that limits informed decision-making by policymakers and educational administrators. Therefore, the willingness and difficulty of chemistry teachers in District Kohat to use digital tools in their instruction is urgent and requires study.

Research Objectives

The study aims to:

1. Assess the level of readiness of chemistry teachers to use digital tools for instruction in District Kohat.
2. Identify the types of digital tools used by chemistry teachers in their instructional practices.
3. Examine the challenges and barriers faced by chemistry teachers in integrating digital tools into chemistry instruction.
4. Analyze the relationship between teachers' readiness and their use of digital tools in chemistry teaching.
5. Suggest strategies and recommendations for improving teachers' digital readiness and effective technology integration in chemistry education.

Research Questions

The study seeks to answer the following research questions:

1. What is the level of readiness of chemistry teachers to use digital tools for instruction in District Kohat?
2. What types of digital tools are currently used by chemistry teachers in their classrooms?
3. What challenges do chemistry teachers face in integrating digital tools into chemistry instruction?
4. Is there a significant relationship between teachers' readiness and their use of digital tools in chemistry teaching?
5. What measures can be adopted to enhance teachers' readiness and overcome challenges in using digital tools for chemistry instruction in District Kohat?

Research Hypotheses

Based on the objectives of the study, the following null hypotheses are formulated for quantitative testing:

H_{o1}: There is no significant difference in the level of readiness of chemistry teachers to use digital tools based on gender in District Kohat.

H_{o2}: There is no significant difference in the level of readiness of chemistry teachers to use digital tools based on teaching experience in District Kohat.

H_{o3}: There is no significant relationship between chemistry teachers' readiness and their use of digital tools for instruction in District Kohat.

H_{o4}: There is no significant relationship between teachers' digital training and their readiness to use digital tools in chemistry instruction in District Kohat.

H_{05}: There is no significant effect of perceived challenges on the use of digital tools for chemistry instruction in District Kohat.

RESEARCH METHODOLOGY

Research Design

The research design that will be used in the study will be quantitative descriptive correlational research design. This design is suitable because it allows the researcher to characterize the existing degree of the readiness of chemistry teachers, find out the difficulties with using digital tools, and analyze relationships between the most significant variables without controlling the research setting.

Population of the Study

All teachers of chemistry at secondary and higher secondary level in the public sector schools of District Kohat, Khyber Pakhtunkhwan will form the population of the study. These are the teachers who are working under Elementary and Secondary Education Department and they are involved in imparting chemistry education based on the prescribed KP curriculum.

Sample and Sampling Technique

In District Kohat government secondary and higher secondary schools, the sample of about 80120 chemistry teachers will be selected. The sampling technique that will be used in the study will be a stratified random sampling method in order to provide a fair representation depending on:

- School level (secondary / higher secondary)
- Gender (male / female schools)

In each stratum, simple random sampling will be used to select the participants.

Research Instruments

A questionnaire will be used that was self-developed based on validated tools on technology use and readiness of teachers. It includes:

1. Demographics: Gender, experience, qualification, level of school.
2. Preparation: Digital literacy, pedagogical ability, attitudes, and preparation.
3. Digital Tools Utilization: Multimedia, simulations, virtual laboratories, Internet-based tests.
4. Challenges: Support, infrastructure, time, training and internet.

Everything is rated on a 5-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree).

Validity and Reliability of the Instrument

- Content validity will be covered by expert opinion, in the review, of three science education and educational technology specialists.
- Pilot testing will be done on a small sample of chemistry teachers not in the main sample.
- Cronbach alpha will be used to establish reliability whereby 0.70 or higher will be acceptable.

Data Collection Procedure

The District Education Office (DEO), Kohat, and school principals will be asked to give formal permission. The questionnaires will be distributed either in person or online in case possible. Participants will be informed of the cause of the study and their confidentiality will be maintained.

Data Analysis Techniques

The analysis of the data will be done by SPSS. The statistical methods that will be used include the following:

- Descriptive statistics (mean, standard deviation, frequency, percentage).
- Independent sample t-test
- One-way ANOVA
- Pearson correlation
- Regression analysis

Ethical Considerations

- The participation will be voluntary
- Informed consent will be taken among all the participants.
- Responses will be anonymous and confidential.
- Data will be utilized with the purpose of academic research.

RESULTS

This part will provide the findings of the quantitative data synthesis done to investigate the preparedness and difficulties of chemistry teachers in utilizing digital tools to teach in District Kohat. The analysis of data was performed with the help of descriptive and inferential statistics.

Descriptive Statistics of Teachers' Readiness

Table 1 presents the mean scores and standard deviations of chemistry teachers' readiness dimensions.

Table 1: Descriptive Statistics of Teachers' Readiness (N = 100)

Readiness Dimensions	**Mean**	**SD**
Digital Literacy and Technical Skills	3.42	0.71
Pedagogical Use of Digital Tools	3.36	0.68
Attitude and Confidence towards Technology	3.58	0.65
Training and Professional Development	3.12	0.74
Overall Teachers' Readiness	**3.37**	**0.69**

Interpretation:
The findings reveal that chemistry teachers in the **District of Kohat have moderate readiness**. The teachers also expressed comparatively more confidence and positive attitudes towards the digital tools, whereas training and professional development had lower mean scores.

Descriptive Statistics of Challenges Faced by Teachers

Table 2: Descriptive Statistics of Challenges in Using Digital Tools

Challenges	Mean	SD
Lack of ICT Infrastructure	4.10	0.82
Limited Internet Connectivity	4.02	0.79
Insufficient Training Opportunities	3.88	0.76
Time Constraints and Workload	3.75	0.73
Lack of Institutional Support	3.69	0.70

Interpretation:
Educators expressed that they face a great number of difficulties, especially with regard to infrastructure and internet connectivity, which demonstrates that there are barriers in the system that would ensure digital implementation in chemistry education.

Use of Digital Tools in Chemistry Instruction

Table 3: Frequency of Digital Tools Used by Chemistry Teachers

Digital Tools Used	Mean	SD
Multimedia Presentations	3.90	0.72
Simulations and Animations	3.35	0.69
Virtual Laboratories	2.88	0.77
Online Assessment Tools	3.05	0.74
Overall Use of Digital Tools	**3.30**	**0.73**

Interpretation:
The most commonly used digital tools were multimedia presentations, whereas virtual laboratories were less commonly used (possibly because of inaccessibility and training).

Gender-wise Comparison of Teachers' Readiness (H_{01})

Table 4: Independent Samples t-test for Gender Differences in Teachers' Readiness

Gender	N	Mean	SD	t-value	p-value
Male	55	3.39	0.67	0.48	0.63
Female	45	3.35	0.71		

Interpretation:
There was no meaningful difference between the willingness of male and female chemistry teachers to use digital tools ($p > .05$). **Hence, H_{01} was accepted.**

Teaching Experience and Teachers' Readiness (H_{02})

Table 5: One-Way ANOVA of Teachers' Readiness by Teaching Experience

Experience (Years)	N	Mean	SD
1–5 Years	30	3.52	0.66
6–10 Years	35	3.38	0.69
Above 10 Years	35	3.25	0.72

Source of Variance	SS	df	MS	F	p-value
Between Groups	0.78	2	0.39	1.92	0.15

Within Groups	19.5	97	0.20		

Interpretation:
The outputs of the ANOVA indicate that there is no statistically significant difference in readiness of teachers according to the teaching experience ($p > .05$). **Thus, H_{02} was accepted.**

Relationship between Teachers' Readiness and Use of Digital Tools (H_{03})

Table 6: Pearson Correlation between Teachers' Readiness and Use of Digital Tools

Variables	**R**	**p-value**
Teachers' Readiness × Use of Digital Tools	0.62	0.001

Interpretation:
There was a significant positive and statistically significant relationship between teacher preparedness and the use of digital tools in the teaching of chemistry ($r = 0.62$, $p < .01$). Therefore, **H_{03} was rejected.**

Effect of Challenges on Use of Digital Tools (H_{05})

Table 7: Regression Analysis of Challenges Predicting Use of Digital Tools

Predictor Variable	**β**	**T**	**p-value**
Challenges	-0.48	-5.21	0.001
Model Summary	**R**	**R^2**	**Adjusted R^2**
	0.48	0.23	0.22

Interpretation:
The presence of challenges had a significant negative and negative predictive value regarding application of digital tools in chemistry teaching (23/ -0.48, p = -0.30), with the challenges clarifying 23% of the variance. Hence, **H_{05} was rejected.**

DISCUSSION OF FINDINGS

The current research has analyzed the preparedness of the chemistry teachers and the obstacles encountered by them in teaching through the use of digital tools within the District of Kohat. The results have been discussed in terms of the available literature and the educational setting of Khyber Pakhtunkhwa.

Level of Readiness of Teachers to use Digital Tools

The findings showed that the readiness to use digital tools in instruction was on a moderate level of chemistry teachers in District Kohat. The attitude of teachers towards technology was relatively positive and confident but their willingness was limited by the lack of professional training and the ability to systematically integrate into the pedagogical process. The present research is consistent with the existing literature indicating that although educators tend to express the desire to use digital technologies, their level of practical preparation is not yet high enough due to the lack of appropriate training and resources (Schmid et al., 2024; Redecker, 2024).

The same outcome has been found in Pakistani context, where teachers tend to have positive perceptions of ICT but do not have the technical and pedagogical skills to successfully incorporate it to the classroom (Ahmad and Shah, 2024). The mean preparedness of the case in question suggests that the teachers of District Kohat are at the pre-proficient stage, as they are already driven enough to implement digital tools but are not well prepared enough to make their use efficient.

Difficulties and Favorable Results experienced by Chemistry Instructors when using digital tools

The results revealed that the chemistry teachers were experiencing extreme amounts of challenges especially when it comes to poor ICT infrastructure, poor internet connectivity, and lack of training opportunities. These obstacles were a major hindrance in the proper utilization of digital tools in the teaching of chemistry. The finding correlates with the studies of other countries and the country itself, which postulated infrastructure and access as significant barriers to technology integration in developing countries (Schmid et al., 2024; Makransky and Petersen, 2023).

Such issues are also compounded by the lack of digital resources and unreliable electricity availability in Pakistan, particularly in the schools of KP in the public sector (Ahmad and Shah, 2024). The mean scores of infrastructure-related issues in this research point to the systemic nature of the issue and the argument that teacher preparedness is not enough without the support at the institutional and policy level.

Digital Resources in the Teaching of Chemistry

It was determined in the study that multimedia presentations were most frequently used digital tools whereas more sophisticated tools like virtual laboratories and simulations were less commonly used. The trend can be related to results of previous studies that note that educators prefer technologies that are readily available and familiar instead of more advanced options that need specific training (Makransky and Petersen, 2023; Crompton et al., 2023).

Narcissistic utilization of virtual labs in District Kohat could be explained by the absence of awareness, technical skills, and licensed software. This result supports the thesis that successful technology-related integration of the field of chemistry involves not only access to resources but also professional growth, dedicated to subject-specific digital resources.

Differences in the Readiness of teachers Gender and Teaching Experience

These findings did not have any significant differences in readiness of teachers according to the gender or teaching experience. This observation implies that demographic factors do not necessarily affect the willingness to use digital tools, but institutional contextual factors, including the opportunity to receive training and institutional support, have a stronger impact. The same conclusions have been drawn in earlier research, which stated that demographic predictors have a low predictive potential in comparison with professional growth and access to resources (Redecker, 2024; Koehler et al., 2023).

In the case of District Kohat, it means that new and old teachers will be affected by the same structural issues, and there is the necessity to introduce capacity-building opportunities that are inclusive and equal.

Correlation between Preparedness and Usage of Digital tools by Teachers

There was also a positive close relationship between the readiness of teachers and the use of digital tools in teaching chemistry. This finding can be explained by the reliable theoretical frameworks, including the Technological Pedagogical Content Knowledge (TPACK), which highlights that the success of a technology integration is determined by the overlap of technological, pedagogical, and content knowledge (Mishra and Koehler, 2024).

The observation is in line with the previous research studies that showed that more prepared teachers were more likely to incorporate digital tools into their instructional activities more often and strategically

(Crompton et al., 2023). The finding underscores readiness as one of the determinants of successful integration of digital in chemistry classes.

Impact of Difficulties on the Application of Digital Tools

Regression analysis showed that perceived challenges played a major negative role in the use of digital tools to teach chemistry. This observation confirms the fact that infrastructural and institutional impediments may frustrate the intentions of teachers to integrate technology, whether they are ready or motivated to do so. The same has been concluded in earlier studies that were done in resource-constrained learning environments (Schmid et al., 2024; Ahmad and Shah, 2024).

The adverse effect of the challenges noticed in this paper presupposes that it is necessary to address the systemic barriers, i.e., to improve ICT infrastructure and ensure a long-term professional development to ensure digital tools are better employed in chemistry education in District Kohat.

General Conclusions of the Results

All in all, the results of this research support the point that effective implementation of digital technologies in chemistry teaching is a complex process that is conditioned by the readiness of the teacher, institutional facilitation, and situational issues. Whereas chemists teachers in Kohat demonstrate a good attitude and moderate readiness, structural obstacles do not allow using digital technologies effectively. These results are consistent with international and Pakistani literature and imply the necessity of efforts at the policy, institutional, and classroom levels.

RECOMMENDATIONS OF THE STUDY

1. The researchers discovered that the level of readiness among chemistry teachers of District Kohat is moderate with relatively low scores in training and pedagogical integration of digital tools. Thus, it is suggested that the Elementary and Secondary Education Department, KP, should arrange frequent, subject-based, professional development activities, the theme of which is pedagogical integration of digital tools in teaching chemistry.
2. Teachers indicated that there were high levels of challenges especially those revolving around poor ICT infrastructure and poor internet connectivity. Considering this observation, it is advisable that the relevant authorities make sure that basic ICT infrastructure is provided, internet connectivity is stable and electricity availability is continuously provided in government secondary and higher secondary school of the District Kohat.
3. Multimedia presentations were common, but more advanced digital tools, including simulations and virtual laboratories were not common. As a result, the schools are to be assisted with the access to chemistry-specific digital materials, such as simulations and virtual laboratories and their practical training to encourage their further use in the classroom.
4. Teachers did not show any significant differences in their readiness according to gender or teaching experience. Based on this, equitable capacity building should be aimed at achieving inclusive professional development programs to all teachers of chemistry, irrespective of gender and years of experience.
5. The readiness of the teachers and their use of digital tools to teach chemistry was found to be correlated with a strong positive relationship. Therefore, effective use of digital tools in chemistry classrooms should be enhanced by increasing the digital preparedness of teachers by means of continuous training and mentoring programs.

6. The perceived challenges impacted greatly on the use of digital tools negatively. Consequently, school heads and those in charge of educational policies must incorporate systematic support system, such as administrative facilitation and less work load, to reduce challenges to incorporation of digital tools.
7. The teachers expressed that they had positive attitudes towards digital tools and were not supported institutionally in the long term. As such, school administrations are suggested to foster a culture that is conducive to technology through fostering peer cooperation, offering technical support, and acknowledging new digital teaching methods.

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