
EFFECT OF VIRTUAL SIMULATIONS ON THE HIGHER ORDER THINKING SKILLS IN THE SUBJECT OF CHEMISTRY AT GRADE 9TH

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ABSTRACT

This study investigated the impact of virtual simulations on higher order thinking skills in ninth-grade chemistry to students. Quasi-experimental research design was used to investigate the impact of Virtual Simulations on Higher Order Thinking Skills in Chemistry at the ninth-grade level. In this study, it was looked at how virtual simulations affected higher order thinking skills (HOTS) in Chemistry at the ninth-grade level, as well as demographic variables in educational institutions. A specification table was created for the creation of test items included test questions that examined students' lower and higher order thinking skills (six items) Information (nine items) Understanding (Four items) Application (one item) Synthesis (three items) Evaluation for the purpose of measuring students' higher and lower order thinking abilities. Four research hypotheses were addressed in the study's findings. The students' higher order thinking skills (HOTS) in pre-test was not significantly high in experimental group and control group. The achievement means test score value of experimental group taught by virtual simulation method was $M=52.83$ which is exceed from control group which is taught by traditional method was Mean Value $M=25.33$. The average post-test score for the students in the experimental group was higher when compared to the results of the control group; According to the study, using virtual simulations in the classroom enhanced students' higher order thinking skills (HOTS), which could be useful for academic success in future.

KEYWORDS

Virtual Simulations, science students, higher order thinking skills, virtual learning

INTRODUCTION

Mostly students consider the chemistry as a difficult subject, feel burden and not take interest in this subject in classroom. Engagement in this subject is very necessarily, so try to achieve through virtual simulation classroom. Textbooks are the only supporting material, which is use by teacher in classroom and most of the content given from textbook based on lower level of learning, knowledge, comprehension and teacher using this material do not reach to the higher learning level skills analytical, evaluation and creative skills. In order to prepare high school students possessing higher level cognitive abilities, all students must be able to improve their higher order thinking skills; but unfortunately, lab applications are neglected brainstorming and simulation effect are not taught in Pakistani high schools, rote learning is in common practice at Secondary Level. As it is growing trend that all stakeholders focus on academic achievement in the form of Grades, rather than factual knowledge, conceptual understanding, skills in reasoning and analysis. Researchers felt that it is due to the lack of higher-level cognitive abilities. This study may discover how the effect of simulation in chemistry influences the higher order thinking skills (HOTS) of science students at Secondary level. Unfortunately, a major problem is lack of technology-based solutions such as use of virtual simulations are not used to facilitate in learning among learners. Students rely on memorized facts to explain chemical equilibrium and on a strict method to solve chemical equilibrium problems. At the secondary level, rote learning is common practice in Pakistani high schools. As a growing trend, all stakeholders are focusing on academic achievement in the form of grades rather than factual knowledge, conceptual understanding, reasoning and analytical skills (Ramirez & Ganaden, 2008).

Virtual Simulation provides an effective learning environment that can help students grasp information better. The purpose of this study is to examine the actual and perceived advantages of introducing virtual simulations into a construction materials and procedures course for undergraduates. The research covered the creation and application of a virtual simulation environment to assist with learning in the module on building supplies and techniques. The actual educational accomplishment of two groups was then compared: those who used the simulation and those who did not. The teaching group also required student self-worth, learning drive, and technology acceptability. Virtual simulation software is widely used in chemistry education to assist students in visualizing microscopic phenomena. Collision Theory is used in the learning of the topic rate of reaction to explain how the factors affect the rate of reaction. Students must visualize particle interactions and deduce how changes in factors such as temperature or concentration affect the rate of collisions between particles, resulting in changes in reaction rate. Little research has been conducted to assess the effectiveness of chemical modelling tools, such as simulation software, in improving student outcomes. Some scientists think that simulated environment are

advantageous for example, (Wagner, 2008). proposed that students interact with and solve ill-structured problems using computer-generated simulations as a learning guide. According to (Strangman et al., 2003). virtual reality simulation, can give students a one-of-a-kind experience while also letting them explore a variety of things, cyber space settings and phenomenon. They stated that some virtual simulation as virtual laboratories may assist students in having more in depth learning experiences (Reilly, 2008). In our context there is very limited work on virtual simulations based class room strategy and in our country no study was done to find the effect of virtual simulation on student higher order thinking skills, so that study will fill the gap and help educational institutions to implement it for active learning of students for better educations.

I have to choose purposefully the 9th grade and the subject of chemistry for my research purpose because in chemistry memorization is a common practice and visual lab tactics like simulations effect are not taught in Pakistan and the students of 9th grade do not use it too to gain extra knowledge by collecting material from net. To explain chemical equilibrium, the students rely on memorized facts and a rigid procedure to solve the chemical equilibrium problem. The use of virtual simulations strategy also improves student higher order thinking skills. Text and visual comprehension are assumed to be supported by the creation of mental models (Schnotz & Bannert, 2003). In learning studies, learners are commonly asked to develop mental models of causal systems using text and imagery, where knowing the system's spatial structure comes before understanding its functions (Hegarty & Just, 1993). According to (Larkin & Simon, 1987). Text is better suited to relaying abstract ideas than visuals are for expressing spatial information. However, mental models of spatial structures can be generated only from text, but this may result in inaccurate inferences about the system's spatial structure, resulting in a mental model that inadequately reflects the text's contents and obstructs comprehension (Schnotz & Bannert, 2003). Because a causal system picture has the same structure as a causal system mental model, having it in a book can help with mental model development (Hegarty & Just, 1993). To properly perceive text and images, students must first construct mental models of causal systems, from which spatial structure must be abstracted before understanding the system's functions (Hegarty & Just, 1993). A causal system picture, on the other hand, corresponds to the required structure of a mental model, making the addition of a picture to text useful for assisting mental model building.

The researchers assessed the effectiveness of using ball-and-stick models in teaching hydrocarbon structural equation identification and writing. Participation of a pre-service teacher was deemed critical in order to promote professional growth in instruction and material, as well as to adapt their teaching method employing models (Borko, 2004). Previous research has demonstrated that using tangible materials such

as models can improve students' knowledge and performance over time (Gabel & Sherwood, 1980). (Savec et al., 2006). discovered that models were beneficial in teaching structural formulae of organic compounds to both in-service and pre-service instructors. (Wu et al., 2001). developed the Chem model, which was found to improve the achievement of learners in IUPAC organic compound nomenclature. Similarly, (Kozma et al., 2000). Found that using representations can help students understand scientific topics. These studies illustrate the significance of models in teaching and learning chemical concepts, and they show that their use should be promoted across the curriculum (Savec et al., 2006). The present research aims to investigate the impact of students' contact with scientific animations and computerized simulations on spatial thinking and reasoning abilities. The study focused on looking at how students' awareness of the dynamic mechanisms at the submicroscopic level that regulate how frequently each phenomena occurs was impacted by their individual and group participation with professionally suggested chemical animations on mobile tablets. A list of research-based standards for choosing animations that can aid science learning is also included in the publication. Prior study has shown that in order to profit the most from picking up submicroscopic occurrences, learners must be adept in both spatial and logical thinking (Yarden, 2010).

A simulation recreates a scenario or occurrence using a mathematical or logical model. This allows the student to control the interactivity of the dynamic components of the phenomenon under investigation. Students can manage the teaching pace of a simulation when it uses minimal levels of interactivity. This permits them to comprehend one section before moving on to the next. The student can control the simulation's behavior through high-level interactivity. Thus, before being exposed to the outcome (dependent variable), For example, an acid-base system, students may provide data (independent variables) to design the system. Depending on the choices they made, the results can be shown as a mathematical or verbal statement, a static visualization, or an animated dynamic visualization. The goals of a simulation could be to: (a) assist students in correctly predicting the likelihood of various outcomes; (b) purposefully focus their attention on one aspect of reality while ignoring others; or (c) assist students in comprehending how a system works by changing the values for each variable and then "running the simulation." Students can forecast system activity and receive feedback on the system's performance by combining these three objectives. When provided with the appropriate instructional support, students can use a well-made simulation to understand scientific topics (Rieber, 2005).

LITERATURE REVIEW

As instruments for performing scientific research and interacting with members of the professional community, they give chemists a shared language for their collaborative investigation (Kozma et al., 2000). Students with limited spatial skills may even be

skeptical about the existence of some submicroscopic creatures and processes. Applying the visual-spatial tools supplied in computerized animations, on the other hand, enhances learners' reasoning skills, which has beneficial effects on their chemistry learning. Furthermore, mental models of submicroscopic things and events that are scientifically true interest an exceptional degree of spatial skill. In fact, study has demonstrated that animations can help learners construct scientifically recognized mental representations. As a result, accurate mental models are required for scientifically recognized thinking. According to the present study, animations have an important link between thinking, reasoning, and spatial abilities. As an outcome, the research emphasizes these factors in order to assess their impact on learning. Visual data reorganizations in digital animations enable students to piece together large volumes of spoken content, decreasing memory requirements (Cranford et al., 2014). Additionally, these animations show events step-by-step, which helps learners comprehend how the phenomenon happens (Akpnar, 2014). According to the findings, computerized cartoons can be sent via mobile devices, which are becoming more common in schools around the world. Furthermore, learners of all ages are drawn to mobile technology through smart phones and tablets. Using cell phones in science education has been shown to have positive impacts, such as increasing involvement (Ryu et al., 2015).

Moreover, Levy's, 2013 research showed that dynamic visualization boosts learners' reasoning ability. The research findings, on the other hand, could be explained by the fact that the reasoning test's computerized animations did not cover the categories of reasoning abilities and problems covered by the reasoning test. One participant, for example, stated that they had never encountered such queries previously. The qualitative findings of the study reveal that those who took part were unaware of the techniques required to respond to the logical thinking test questions. Although each participant answered each question effectively, the strategy they took was insufficient for the question at hand. For reasoning techniques like correlated reasoning, probabilistic reasoning, or proportionality reasoning, which demand more calculations than mental visualizations, there is no proof that computer-generated cartoons were employed in the study. As opposed to the Classroom Test of Scientific Reasoning, Levy's research focused on the effects on molecular reasoning, which was more directly related to the cognitive skills highlighted by computer animations.

Chemistry is one of the important subjects taught in secondary school and the student face multiple problems while learning it especially recalling the studied material. Abdullahi (2007) Commented that chemistry has primary importance in science studies in Pakistan being the prerequisite course for admission into physical and organic sciences programs. Different drawbacks have been observed in science education throughout the country, so the student found chemist as difficult and being

subjects. Different strategies and methodologies have been applied at higher secondary school level. (Congos & Dennis, 2011) have reported that McGraw-Hill's community college students got only 64% points at chemistry in an educational program. Such low grades show poor performance and lack of interest in their studies.

RESEARCH OBJECTIVES

1. To examine the effect of virtual simulations on the development of Higher Order thinking skills (Analysis, evaluation, creative) in chemistry at grade 9th.
2. To compare the difference between the levels of Higher Order Thinking Skill among the students taught through traditional methods and virtual simulations in the subject of chemistry at grade 9th.
3. To examine the gap between a student's pretest and posttest results in traditional and virtual simulations group in chemistry at grade 9th.

RESEARCH HYPOTHESES

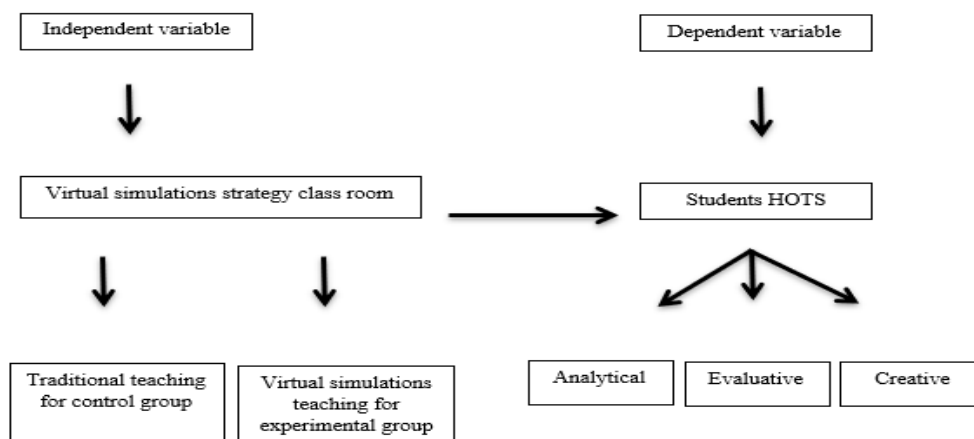
1. There is significant difference in the achievement scores of students taught by traditional and virtual simulations in pre-test and post-test in the subject of chemistry
2. There is significant difference in the mean test scores of students in traditional and virtual simulations group
3. There is significant effect of virtual simulations on the analysis abilities in chemistry at the secondary level students
4. There is significant effect of virtual simulations on the evaluative abilities in chemistry at the secondary level students
5. There is significant effect of virtual simulations on the creative abilities in chemistry at the secondary level students

RESEARCH METHODOLOGY

The study was quasi experimental in nature, with a pre-test post-test control group design based on intact classes used. Two intact 9th grade classes were engaged experimental and control group in each context as the suitable research design to conduct this study was quasi experimental design. Creswell (2019) defines a quasi-experimental design as "the development of a cause-and-effect relationship between an independent and dependent variable.

In this study there were two variable virtual simulation base learning was independent variable and higher order thinking skills, which was measured employing pretest and posttest procedure. This study contained two intact groups of 9th graders, each with 30 students: experimental and control groups. The context, classroom, surroundings, curriculum, and background of the teacher were all the same. There was no difference except that the experimental group received virtual simulation-based learning while the control group received traditional instruction. Four units 5, 6, 7 and 8 from

chemistry book of grade 9th were selected after discussion with school administration intervention was based on teaching through virtual base simulation technique comprising of 42 concepts of these units the researcher was 42 simulation videos covering all the concepts of these units.



Conceptual Framework

The population of the study was made up of all 9th grade students from FG Public Schools throughout the province of Punjab. The environmental study can be conducted on small units and can be generalized to the whole Population (Creswell, 2019). A school situated in Bahawalpur city was selected because it experimental research and it could be done in any F.G Public School of Punjab because all the federal school of the Punjab have same syllabus educational facilities and back ground of the students. Due to above reasons, selection of area and school was made on convenience of researcher as it has no significant effect on results of experimental study moreover the researchers were performing her duties in F.G Institution of District Bahawalpur and it was convenient to conduct this research near the workplace. After selections of school intact section of grade 9th were selected. The participants have almost same socio-economic background. The whole classes were selected as the intact group for the study as per decision of the school administration.

Sampling

Quasai experimental design was used and intact groups were taken.

Table 1: Details of Sample

Sr. No	Category of example	Sampling type
1.	School	Purposive sampling

2.	Student	Intact Classes
3.	Sample Size	Sixty students

Instrumentation

Chemistry Higher Order Thinking Skill (HOTS) Test was developed to examine the pretest- posttest mean score difference of the students

1. Multiple Choice Questions (MCQs).
2. Short Answers, where student were supposed to answer briefly.
3. Essay type question.

The Chemistry Higher Order Thinking Skill (HOTS) included 12 MCQs and 11 short Question, four essay type question the 27- item test covered the specific cognitive process involved analyzing, evaluating and creating. To measure the effect of virtual simulation base learning on higher order thinking skills of the students and its three elements analyses, evaluate and synthesis. The concept basis self-made before and post-test were built from the federal board's 9th grade chemistry. In pre-test, test items were developed from the first four units and in post-test, test items were developed from last four units. There were multiple choice question (MCQ's) short questions answer and essay type questions to measure the lower and higher order thinking skills of students.

DATA ANALYSIS AND RESULTS

Demographical analysis

Table 2: Gender

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Male	106	42.40	42.40	42.40
	Female	144	57.60	57.60	100
	Total	250	100	100	

Table 2 shows the total number of respondents in this study is 250, of which 106 (42.40%) respondents are male and 144 (57.60%) are female. In this study, female respondents are greater than males.

Table 3: Professional Qualification

		Frequency	Percent	Valid percent	Cumulative percent
Valid	Professionally Qualified	138	55.20	55.20	55.20
	Professionally Unqualified	112	44.80	44.80	100
	Total	250	100	100	

Table 3 reveals the total number of respondents is 250, of which 138 (55.20%) respondents are professionally qualified and 112 (44.80%) respondents are professionally unqualified as having no professional qualification.

Table 4: Teaching experience

		Frequency	Percent	Valid percent	Cumulative percent
	Less than 10 years	185	74	74	74
Valid	Above 10 years	65	26	26	100
	Total	250	100	100	

According to Table 4, from 250 total respondents, 185 (74%) respondents have experience of less than 10 years of teaching, and 65 (26%) respondents have more than 10 years of teaching experience.

Table 5: Reliability Test

Cronbach's Alpha	N of items
.852	22

The reliability of survey results is demonstrated by Cronbach's alpha coefficient in Table 5. The result is more than .852, and the data from the selected sample are trustworthy.

Correlation Analysis

Table 6: Correlation Table

	Professionally Qualified	Professionally Unqualified	Females	Males	1 to 10 years of experience	above 10 years of experience
Professionally Qualified	1					
Professionally Unqualified	0.34**	1				
Females	0.42**	0.23**	1			
Males	0.51**	0.41**		1		
1 to 10 years of experience	0.56**	0.38**	0.29**	0.56**	1	
above 10 years of experience	0.36**	0.31**	0.61**	0.48**	0.43**	1

years of experience

Table 6 shows the correlation analysis reveals the following key relationships between teacher demographics and their attitudes toward e-learning in private secondary schools in Pakistan:

Professionally Qualified Teachers

A moderate correlation (0.34) with professionally unqualified teachers suggests some overlap in attitudes. A strong correlation (0.56) with teachers having 1 to 10 years of experience indicates professionally qualified teachers are more likely to have fewer years of experience. There is a moderate correlation (0.42) with female teachers and a slightly stronger correlation (0.51) with male teachers, implying professional qualifications align more with male teachers.

Professionally Unqualified Teachers

A moderate correlation (0.38) with teachers having 1 to 10 years of experience suggests that less experienced teachers are more likely to be unqualified. A weaker correlation (0.31) with those having over 10 years of experience indicates that unqualified teachers are less common among those with longer tenure. There is a moderate correlation (0.41) with male teachers and a weaker correlation (0.23) with female teachers, showing that unqualified teachers are more likely to be male.

Gender

Female teachers show a strong correlation (0.61) with those having over 10 years of experience, indicating a higher likelihood of experienced female teachers. Male teachers have moderate correlations with both experience groups: 0.56 (1 to 10 years) and 0.48 (above 10 years), showing a more balanced distribution across experience levels. These findings suggest that professional qualifications, gender, and experience are key factors influencing teachers' attitudes toward e-learning.

Descriptive Analysis

Table 7 Sample mean, standard deviation, and correlation in variables with a confidence level of 95% (N= 250).

	Variable	n	M	SD	1	2	3	4	5	6
1	Professionally Qualified	138	0.55	0.14	1					
2	Professionally Unqualified	112	0.44	0.86	.56	1				
3	Female	106	0.42	0.17	.82	.52	1			
4	Male	144	0.57	0.19	.65	.84	.30	1		
5	1 to 10 years	185	0.74	0.15	.90	.78	.84	.72	1	

6	More than 10 years	65	0.26	0.13	.44	.62	.19	.72	.33	1
7										.59

The mean value of .55 shows that 55% of respondents are qualified with professional education. The standard deviation of 0.14 shows that 14 % of respondents deviate from the qualification. Thus included ± 1 SD in 0.14. The average respondents were 13% to 114% respondents have a professional qualification. The mean value for unqualified respondents is .44, which means 44% of respondents have no professional qualification. The 0.86 standard deviation value shows that 86% of respondents have no professional qualification. By ± 1 SD, 86% to 186% of respondents have no professional qualification. The mean value for female respondents is .42, which means 42% of respondents are females. The 0.17 standard deviation value shows that 17% of respondents are females. By ± 1 SD, 16% to 117% of respondents are females. The mean value for male respondents is .57, which means 57% of respondents are males. The 0.19 standard deviation value shows that 19% of respondents are males. By ± 1 SD, 18% to 119% of respondents are males. The mean value of 0.74 shows that 74% of respondents have below 10 years of experience. The standard deviation of 0.15 shows that 15 % of respondents variate. Thus, including ± 1 SD, the average respondents were 13% to 114% of respondents who have below 10 years of experience. The mean value of 0.65 shows that 65% of respondents have more than 10 years of experience. The standard deviation of 0.26 shows that 26 % of respondents variate. Thus, including ± 1 SD, the average respondents were 15% to 126% of respondents have more than 10 years of experience. $P > .05$, $p > .01$ with a 95 % confidence level. There is a strong positive correlation between the variables. The significance above 0.05 shows a strong positive interrelation between variables. The inter-correlation within variables is above .5, which shows a strong positive relationship among them.

Regression analysis

Table 8: Regression effect

Effect	Estimate	SE	95% CI		p
			LL	UL	
Fixed effects					
qualified	.63	0.02	5.56	6.11	0.06
unqualified	.74	0.05	5.09	5.77	0.09
females	.71	0.03	5.53	6.18	0.07
Males	.54	0.04	5.10	5.80	0.08
1 to 10 years of experience	.52	0.04	5.36	6.03	0.08
above 10 years of	.70	0.02	5.40	5.91	0.06

experience					
Random effects					
Within-group variance	.62	0.001	5.4	5.96	<.001
Between-group variance	.53	0.003	5.5	5.98	<.001

The fixed and random effect within variables is as above results of standard error (SE), estimation, lower and upper confidence interval with 95% confidence level and significance p-value greater than .001($p > .001$) show a strong positive relationship between and with a group of variables.

DISCUSSION

This study explores the attitudes of Pakistani private school teachers toward e-learning, examining the impact of gender, qualifications, and teaching experience. Both male and female teachers show a generally positive attitude, with little gender difference. Teachers with professional qualifications (B.Ed., M.Ed.) are more favorable toward e-learning, likely due to formal training in educational technology. Experience is positively correlated with acceptance of e-learning, challenging assumptions that younger teachers are more tech-savvy. Seasoned educators adapt well due to broader pedagogical knowledge. Barriers like limited infrastructure, lack of training, and time constraints may hinder adoption. Addressing these through professional development and resource allocation can improve implementation. Teachers' positive attitudes likely enhance student engagement and learning outcomes by creating more dynamic, personalized learning environments. Policymakers should focus on continuous training, reliable infrastructure, and blended learning models to support teachers and maximize the benefits of e-learning.

In Pakistani private schools, the attitudes of teachers toward e-learning are examined in this study. For their children to compete with the educational standards of wealthy nations, parents must spend large tuition costs. Therefore, I explore in this study if private school instructors' perspectives on online education. Is there a connection between a teacher's gender, credentials, and teaching experience and how they feel about using e-learning? Numerous aspects of the subject are explained via descriptive research. The characteristics of the analysis unit are characterized via descriptive research. The categorization, conceptualization, and development of the hypotheses used to evaluate relationships constitute the study's explanatory component. The total number of respondents in this study is 250, of which 106 (42.40%) respondents are male and 144 (57.60%) are female. 138 (55.20%) respondents 'are qualified with professional education as B.Ed. and M.Ed., and 112 (44.80%) respondents are

unqualified as no professional qualification graduate. 98 (39.50) respondents have experience of 1 to 5 years in teaching, 87(34.50%) respondents have 6 to 10 years' experience, and 65(26%) respondents have more than 10 years' experience. The correlation value of .571 demonstrates that there is a much stronger association than is generally the case between teachers' attitudes about using e-learning and their experience. It is generally agreed upon to use the Durbin Watson average, which is 1, as a standard value for comprehensive regression analysis. The alternate hypothesis must be accepted, and the null hypothesis must be rejected because the significance value is 0.000. This leads to the conclusion that online learning is usually favored by teachers of both sexes. A teacher's attitude toward adopting e-learning is influenced by their professional background, amount of knowledge, and skill set.

RECOMMENDATIONS

Based on research on teachers' attitudes toward e-learning in Pakistani private schools, here are a few recommendations:

Schools should offer regular training programs focused on e-learning tools and digital pedagogy, especially for teachers without formal qualifications in education (B.Ed., M.Ed.).

Schools must invest in reliable internet access and provide necessary digital devices to facilitate the adoption of e-learning, especially in under-resourced areas.

Introduce blended learning models that combine traditional teaching with online components to allow teachers to gradually integrate e-learning into their practices.

Utilize the experience of senior teachers by involving them in peer mentoring programs to help less experienced teachers adapt to e-learning tools.

Implement regular assessments of e-learning effectiveness and gather feedback from both teachers and students to continuously improve the learning environment.

These recommendations aim to foster a supportive environment for the adoption and effective use of e-learning in Pakistani private schools.

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