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Role of Information and Communication Technologies (ICT) Integration in Improving Teaching and Learning Environment

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Abstract
This study investigates the integration of ICT in teaching and learning environments within Gilgit-Baltistan, Northern Pakistan. It focuses on the impact of ICT on students' learning abilities, teachers' support, and the effectiveness of Learning Management Systems. The study also explores how ICT integration improves teaching efficiency and instructional practices. Using structured questionnaires, data were collected from 272 teachers across four districts of GB, Pakistan i.e., Gilgit, Hunza, Ghizer, and Nagar. The data included teachers' demographics, technology usage, online teaching experiences, and perceptions of ICT in education. Statistical analysis was performed using SPSS to identify trends and significant differences.
The findings indicate a positive correlation between ICT integration and improved teaching, and learning environment (TLE), with an average response significantly above neutral (p-value < 0.000). District-wise comparisons show that teachers in Ghizer reported higher student learning abilities (SLA) improvements than those in Gilgit, with a significant difference of 0.241 (p-value = 0.057). Additionally, 43% of respondents strongly agreed that ICT boosts students' motivation to learn independently. Teachers' support in using ICT for teaching showed no significant differences across districts. Significant differences were found between Ghizer and Gilgit regarding LMS (mean difference = 0.249, p-value = 0.023), highlighting varied perceptions of LMS effectiveness. ICT integration significantly improves teaching and learning environments in the GB province, enhancing students' learning abilities and teaching efficiency. However, variability in LMS effectiveness and ongoing support and training needs highlight areas for improvement to elevate ICT's role in education further.

Keywords: ICT, COVID-19, Learning Management system, and teaching and learning environment

1. Introduction

The use of Information and Communication Technologies (ICT) in education became crucial during the COVID-19 and the post-pandemic world, to keep learning going despite disturbances from around the world (Dube, 2020). Online learning platforms, like Zoom, Microsoft Teams, and Google Meet, are instrumental in enabling interactive education and discussions between teachers and students by providing virtual classrooms, video conferencing, and collaboration tools (Benty *et al.*, 2020). Digital resources such as interactive courses, multimedia presentations, and e-books are created by educators and content developers for use in education(Qekaj-Thaqi & Thaqi, 2021), where students might use laptops, tablets, or smartphones to access from home (Paschal & Mkulu, 2020). Virtual learning management systems (LMS), with their capacity to upload materials, create quizzes, and monitor student progress, have become indispensable for managing course materials, assignments, evaluations, and grades (Turnbull *et al.*, 2020; Salas-Rueda *et al.*, 2022). The recorded lectures may be available on demand at the LMS, where students are given a plethora of possibilities for a self-paced learning environment with their study speed (Paschal & Mkulu, 2020).
Many researchers and IT practitioners strongly suggested virtual assessment and examination systems to maintain academic integrity and transparency ((Aidoo *et al.*, 2022; Butler-Henderson & Crawford, 2020; Özden, 2004; Shen *et al.*, 2006; Simamora et al., 2020). Virtual laboratories for science and engineering courses are becoming important tools for students to perform experiments and learn basic and useful skills from anywhere and anytime (Kolil & Achuthan, 2023; Reginald, 2023). Online collaboration technologies such as Google Docs and Microsoft Office 365 allow students to collaborate on group projects together, no matter where they are placed in the world (Nungu *et al.*, 2023). These tools allowed for real-time communication, project management, and remote teamwork(Hargis & Wilcox, 2008; Tarun, 2019). These tools promoted personalized learning experiences and allowed teachers to keep an eye on each student's progress and adjust their classes to meet their needs (Paschal & Mkulu, 2020). The webinars and virtual guest lectures from experts around the world will enhance the teaching and learning process for students to a diversity of viewpoints and expertise (Nungu *et al.*, 2023).

Numerous tools and techniques are available for teachers, students, and parents to stay connected to address any questions or concerns during online learning (Ramírez-Donoso *et al.*, 2023). At the same time, ICT plays a crucial role to enhance in teachers' digital skills and professional development (Ahmad *et al.*, 2020). During the pandemic, ICT became an essential tool to manage educational crises, at the same time it also clearly identified the future direction of ICT deployment in traditional educational settings in the post-pandemic world. This also proved ***Blessings in Disguise,*** as many educational institutes in the remote regions had no other option to continue their teaching and research endeavors. The utilization of ICT in education has emphasized the opportunity for enhancing overall learning outcomes and creating more flexible, comprehensive learning environments. It determines how ICT may alter teaching and learning approaches and increase their adaptability to various demands and settings. Adaptation of emerging technologies is a crucial step for maintaining continuity and good standards in education even in non-emergency situations, as the pandemic experience has demonstrated. As a result, there is a growing acknowledgment of the need for educational institutions to maintain and enhance digital skills in order to improve future teaching and learning opportunities.

In this research, the teachers' perceptions about ICT integration for students; learning abilities, teaching, and LMS effectiveness were assessed based on a structured questionnaire survey.

2. Literature Review

2.1.ICT in Education

The use of ICT in teaching, learning, and educational administration has produced several benefits that have transformed education and given instructors and students access to a dynamic learning environment (Cabellos et al., 2024; Lawrence & Tar, 2018; Turnbull et al., 2020). This tactic raises student engagement by pushing them to actively interact as both independent and collaborative learners(Kumar, 2024). It improves the teaching and learning experience by providing interactive data, multimedia tools, and simulations that take into account various learning preferences and styles(Rukajat *et al.*, 2024). Students have a variety of online resources at their disposal which include databases, learning websites, open educational materials, and online libraries, students can study a wide range of subject areas (Fitzgerald *et al.*, 2023; Khan, 2024; Walton, 2023). This encourages individualized education (Arhin *et al.*, 2024).

Professional software tools play a critical role in improving learning outcomes by helping students understand complex subjects through adaptive learning strategies tailored to their individual learning styles. The tools evaluate learning patterns and adapt instructional materials to meet the individual needs of students (Abdulrahaman *et al.*, 2020; Mohamed, 2023). Interactive elements, such as multimedia resources, simulations, and quizzes, can clarify complex subjects and foster higher knowledge, according to (Krusche *et al.*, 2020; Shi *et al.*, 2022; Yang & Baldwin, 2020; Aljawarneh, 2020). By providing students with alternative assistance when they run into problems and continuing until mastery is achieved, these technologies improve the effectiveness of learning(Winget & Persky, 2022). Additionally, these technologies highlight students' strengths and provide additional resources as needed, and also provide prompt feedback to clear up misunderstandings and reinforce proper learning behavior (Ali et al., 2022; Chen *et al.*, 2020; Renzulli & Reis, 2021). In addition, ICT integration guarantees equitable access to learning materials in a variety of geographic locations, which helps rural and isolated communities (Budnyk *et al.*, 2021; Dube, 2020). ICT not only improves instruction and student learning but also makes data management, information sharing, and efficient communication possible, thereby revolutionizing administrative work and educational governance(Matasci, 2020; Paudel, 2021).

ICT integration in education does, however, come with a number of difficulties and challenges (Toquero, 2020). While it can be a major obstacle, building a dependable technology infrastructure with hardware, software, support systems, and internet access is necessary(Cheng, 2020; Lunenburg & Ornstein, 2021). Lack of access to ICT resources and the subsequent digital divide have resulted in socioeconomic differences. This becomes more challenging in areas with limited exposure like remote mountain communities (Helsper, 2021; Lythreatis et al., 2022).

Sustaining ICT integration necessitates sufficient and fair funding for the purchase of gear, software, and technical assistance (Ma, 2021). The attitudes, perceptions, and beliefs of teachers can be major obstacles to their readiness to incorporate ICT into classroom activities (Amtallah, 2020; Jamil, 2021; Raygan & Moradkhani, 2022). It is always difficult to integrate technology with efficient teaching methods to meet the challenges of tight deadlines, little institutional support, and a lot of labor (Mohebi, 2021; Perienen, 2020).

2.2. Teacher Professional Development

To effectively integrate ICT into their practices, instructors must improve their knowledge, abilities, and methods of instruction through professional development (Fernández-Batanero *et al.*, 2022; Sancar *et al.*, 2021). Development requires an ongoing learning culture(Mlambo et al., 2021). To this end, teachers can stay current on new pedagogical approaches, subject matter expertise, and technological advancements through online courses, conferences, workshops, and seminars advancement*(Haatainen & Aksela, 2021; Nilson & Goodson, 2021; Rahmawati et al., 2020; Saiyad et al.*, 2020).

Tailored training initiatives are imperative to tackle the distinct requirements and obstacles encountered by educators, encompassing classroom administration, evaluation techniques, special education tactics, project-based learning methodologies, and technological integration. Teachers can share and trade materials, ideas, and cutting-edge teaching methods both within and between schools by using collaborative platforms(Wu, 2022; Zhang et al., 2022). Teachers who receive training in technology integration are better able to use instructional resources, which improves student learning in general (Peled & Perzon, 2022).

Additionally, by encouraging self-evaluation and ongoing development, these resources and platforms help educators practice reflectively(Petrarca & Samaha, 2022; Zou *et al.*, 2023). Teachers should be encouraged to continue their professional development by receiving certifications, financial rewards, and other forms of recognition for their achievements(Kuja *et al.*,

2022). According to (Hennessy et al., 2022; Smith & Gillespie, 2023), administrative assistance is essential for setting up professional development training, supplying the required resources, and fostering a climate that promotes progress(Hongchao, 2024). By emphasizing these elements, educational institutions can support teachers' professional development, enabling them to take on new tasks, apply creative solutions, and eventually enhance student results(O. K. Kilag et al., 2023; Nguyen & Habók, 2023).

2.3. Research Objectives

The major aim of this research objective such as to assess ICT integration in the effectiveness of teaching and learning systems in the selected districts of Gilgit Baltistan, Northern Pakistan. The impact of ICT integration in teaching and learning systems is further analyzed in the following:

- Student learning abilities (SLA)
- Teachers support in learning and teaching (TSLT)
- Teaching and Learning Environment (TLE)
- Learning Management System (LMS)

3. Methodology

3.1.Study Area

The Gilgit Baltistan (GB) region of Pakistan is located in the North most of the country, with ethnic linguistic, and religious diversity. The population of the region is about 1.6 million spread over an area of 72,971 km2 (28,174 sq mi). The region is home to diverse cultures, rich history, and unparalleled natural beauty, making it a unique place in the country for adventurers, trekkers, and nature enthusiasts alike. The terrain of the region is mostly mountainous with difficult access to remotely located valleys. The poor socioeconomic condition of the region makes it challenging for accessible, affordable quality education. GB has 10 districts, six in the Gilgit sub-region and four in Baltistan sub-region. The location of the region and selected districts is shown in Figure 1.

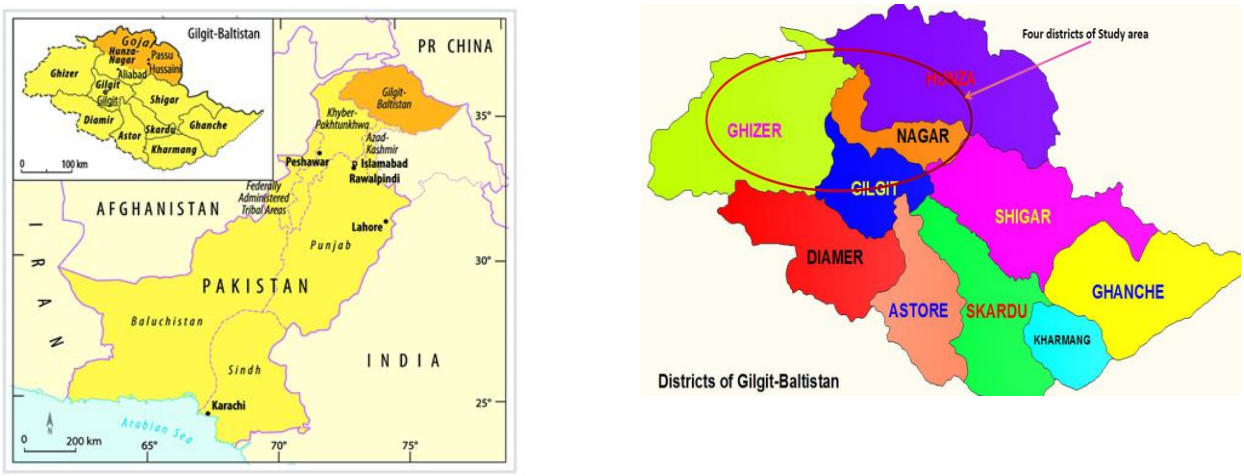


Figure 1. Location map of Gilgit Baltistan and Study area.

3.2. Data collection

Questionnaires were used to collect data from the school-teachers (Lefever *et al.*, 2007). The questionnaire consisted of questions related to the teachers' demographics, technology usage, experience with online teaching, utilization of LMS, and perceptions about technology-enabled teacher training and development (LeDune & Chametzky, 2024). The data collected from the questionnaires were analyzed using Statistical Package for Social Sciences (SPSS 21) to identify patterns and trends in the responses (Sadriddinovich, 2024).

3.3. Sampling procedure

Four districts of Gilgit-Baltistan i.e. Gilgit, Hunza, Ghizer, and were selected for the study Nagar (shown in Figure 1). These areas were chosen based on their representation of different types of schools and their locations in various districts of Gilgit-Baltistan. The inclusion of government, private, and Aga Khan Education Services Program (AKESP) schools provides a diverse range of schools and stakeholders to assess the effectiveness of technology-enabled teacher training and development programs. Additionally, focusing on schools in mountainous areas addresses the unique challenges faced by schools in these remote locations. The overall sample size was 300 teachers, at different schools of GB, 272 respondents participated in the survey, comprising of 90.6% response rate, 68.4% were female and 31.6% were male participants. This shows a representative sample.

3.4. Scales and Measurements

A quantitative technique incorporating structural questionnaires was adopted and the survey tools were distributed among the teachers of four districts of Gilgit-Baltistan (GB). The structured questionnaire was adopted from (Schoonenboom, 2023). Primary and secondary data were also collected for the study(O. K. T. Kilag, T. P. Evangelista, et al., 2023). Primary data was

collected by the school-to-school survey in the study area in the established procedure (Alkalash & Alkalash, 2024). Secondary data was collected through articles and research papers as adopted by. The survey tools study was divided into two sections (A and B). The first part of section A addresses the demographic information of respondents such as age, gender, district, and Institutions (Details regarding age, and gender is shown in Table 1). The second part of section A addresses the teachers' ICT use and competency (e.g. ICT training/certificate, skills to use the computer, use of LMS, and types of LMS used for teaching and learning). Section B is aimed at collecting data regarding the integration of ICT for the effectiveness of teaching and learning environments (TLEs), teachers' support of learning, and students' learning abilities (SLA) using a learning management system (LMS). The research objective is further divided into four sub-objectives such as student learning abilities (SLA), teachers' support in learning and teaching (TSLT), Teaching and Learning environment (TLE), and Learning Management System (LMS). To identify these objectives, the respondents were asked to indicate their agreement for each statement ranging from 5 strongly agree to 1 strongly disagree, and for some questions, they were asked to answer Yes or No.

Table1. Participants characteristics (respondents age, gender, and District).

	Age of Respondents	less than 20		20 to 30		31 to 40		41 to 50		Above 50		Total	
District	Gender	N	%	N	%	N	%	N	%	N	%	N	%
Gilgit	Male	0	0	8	3	9	3	5	2	4	1	26	10
	Female	0	0	27	10	40	15	11	4	3	1	81	30
Hunza	Male	0	0	6	2	6	2	3	1	0	0	15	6
	Female	2	1	28	10	14	5	3	1	0	0	47	17
Ghizer	Male	0	0	8	3	15	6	11	4	1	0	35	13
	Female	0	0	20	7	22	8	10	4	1	0	53	19
Nagar	Male	0	0	2	1	6	2	0	0	2	1	10	4
	Female	0	0	3	1	2	1	0	0	0	0	5	2
Total	Male	0	0	24	9	36	13	19	7	7	3	86	32
	Female	2	1	78	29	78	29	24	9	4	1	186	68

Some other questions were also asked from the respondents regarding ICT training, skills to use computers, use of LMS for teaching and learning, and a few more questions across the four districts. Table 2 shows the details.

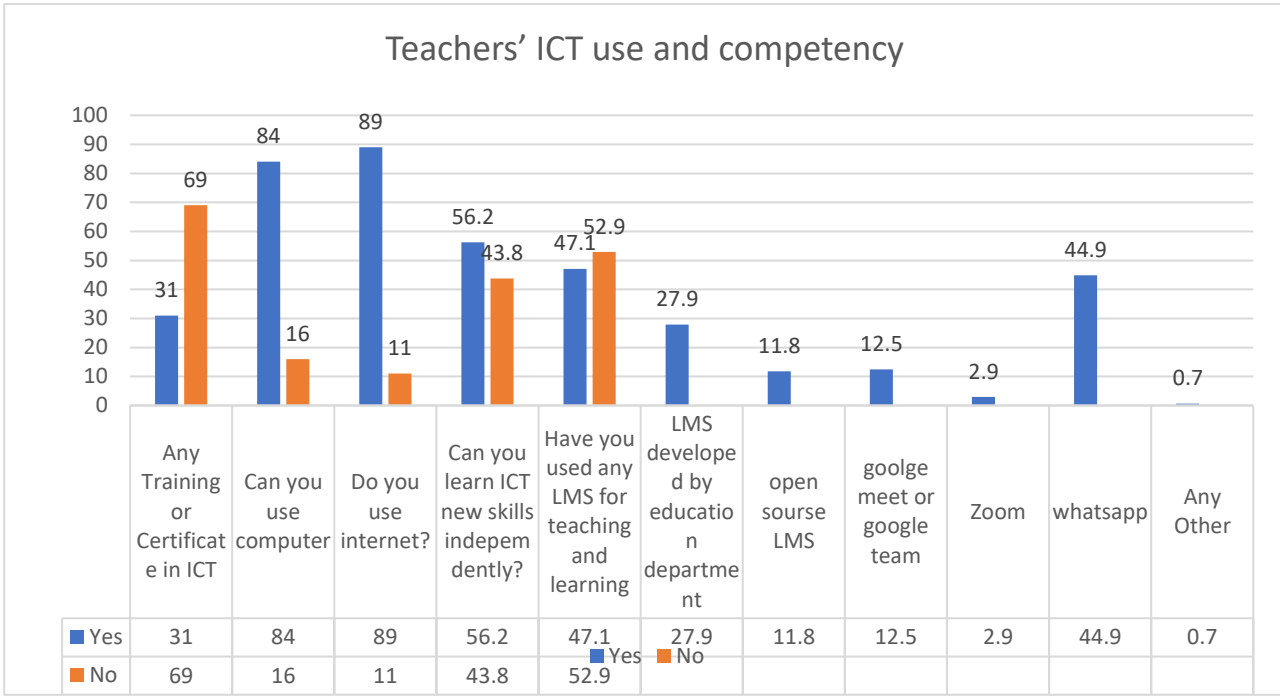
Table2. Response on teachers' ICT use and competency

Items	District of Respondents										
	Yes/ No	Gilgit		Hunza		Ghizer		Nagar		Total	
		N	%	N	%	N	%	N	%	N	%
Any Training or Certificate in ICT	Yes	31	11.4	26	9.6	24	8.8	3	1.1	84	31
	No	76	27.9	36	13.2	64	23.5	12	4.4	188	69
Can you use computer	Yes	83	30.5	57	21.0	75	27.6	13	4.8	228	84
	No	24	8.8	5	1.8	13	4.8	2	0.7	44	16
Do you have your own computer at home	Yes	83	30.5	53	19.5	73	26.8	11	4.0	220	81
	No	24	8.8	9	3.3	15	5.5	4	1.5	52	19
Do you use internet?	Yes	93	34.2	58	21.3	79	29.0	12	4.4	242	89
	No	14	5.1	4	1.5	9	3.3	3	1.1	30	11
Do you have knowledge how to use ICT tools and resources in classroom	Yes	83	30.5	53	19.5	52	19.1	11	4.0	199	73.2
	No	24	8.8	9	3.3	36	13.2	4	1.5	73	26.8
Can you create effective digital resources for classes using ICT	Yes	68	25.0	49	18.0	46	16.9	10	3.7	173	63.6
	No	39	14.3	13	4.8	42	15.4	5	1.8	99	36.4
Do you promote ICT resources within your school for learning and teaching	Yes	74	27.2	53	19.5	54	19.9	10	3.7	191	70.2
	No	33	12.1	9	3.3	34	12.5	5	1.8	81	29.8
Can you learn ICT new skills independently?	Yes	57	21.0	47	17.3	39	14.3	10	3.7	153	56.3
	No	50	18.4	15	5.5	49	18.0	5	1.8	119	43.8
Have you used any LMS for teaching and learning	Yes	50	18.4	44	16.2	28	10.3	6	2.2	128	47.1
	No	57	21.0	18	6.6	60	22.1	9	3.3	144	52.9
Which type of LMS avail and use											
LMS developed by the Organization		17	6.3	8	2.9	11	4.0	2	0.7	38	14.0
open source LMS		8	2.9	2	0.7	5	1.8	1	0.4	16	5.9
Google Meet or Google Team		1	0.4	11	4.0	2	0.7	3	1.1	17	6.3
Zoom		0	0.0	4	1.5	0	0.0	0	0.0	4	1.5
WhatsApp		22	8.1	20	7.4	16	5.9	3	1.1	61	22.4
Any Other		1	0.4	1	0.4	0	0.0	0	0.0	2	0.7

4. Results and Discussion

The Statistical Package of the Social Sciences (SPSS 21.0) was utilized to analyze the data. For Sections A and B, descriptive statistics like mean, standard deviation, and percentage as well as inferential statistics like independent t-test were used. The association between independent and dependent variables, including age, gender, district, ICT for teaching and learning, ICT certificate training, student learning capacities, teacher support for teaching, and the use of LMS in the teaching and learning environment, was examined using the t-test.

Part A provides information on the demographics of the respondents, including age distribution and gender (32% male, 68% female): under 20 (1% female, 0% male), 20-30 (29% female, 9% male), 31-40 (29% female, 13% male), and 41-50+ (10% each). ICT training (Yes 31%, No 69%), computer skills (Yes 84%, No 16%), LMS use (Yes 47.1%, No 52.9%), and the kinds of LMS utilized, such as WhatsApp (44.9%) and organization developed LMS (27.9%), are among the ICT use and proficiency of teachers. The development of digital content (Yes, 63.4%), independent learning (Yes, 56.3%), and internet use (Yes, 89%) are additional competencies. Table 1 and 2 and Figure 2 provide details broken down by district.



	Any Training or Certificate in ICT	Can you use computer	Do you use internet?	Can you learn ICT new skills indepemdently?	Have you used any LMS for teaching and learning	LMS developed by education department	open sourse LMS	goolge meet or google team	Zoom	whatsapp	Any Other
Yes	31	84	89	56.2	47.1	27.9	11.8	12.5	2.9	44.9	0.7
No	69	16	11	43.8	52.9						

Figure 2. Teachers' ICT use and competency

For the Likert scale questions, the raw score for each index has been normalized to 1 to 5, to compare it with other scores for each index. The scores 5 and 4 represent the responses for highly agree and agree, 3 score represent neutral response, while 2 and 1 score represent the responses for strongly Disagree and Disagree, respectively. In this connection, we used to test a tailed t-test for testing the null hypothesis index score =3 against the alternative hypothesis of greater than three.

The main objective is to collect and analyze data regarding the integration of ICT in the effectiveness of teaching and learning environments (TLEs), teachers' support of learning and teaching (TSLT), and students' learning abilities (SLA) using a learning management system (LMS).

The results for all indices when tested for mean comparison to 3 or greater, supported to acceptance the alternative hypothesis as the p-value is 0.000 revealing the key importance of ICT in teaching and learning in Gilgit-Baltistan (GB). The average response is significantly higher than 3 revealing the key roles of ICT in enhancing students' learning abilities, supporting teachers in their learning and teaching practices, in building a teaching and learning environment (TLE) in classroom teaching in the school of GB(shown in table 3). It also signifies the critical importance of the Learning Management System (LMS) in teaching and learning across schools of GB. Further, the analysis has been done on gender and LMS users wise.

Table 3. Descriptive Statistics and T-test Score for effective integration of ICT in TLEs, TSLT, SLA, and LMS

Indices	Average	Standard Error	Standard Deviation
SLA	3.929***	0.053	0.879
TSLT	3.903***	0.047	0.774
TLEN	3.935***	0.047	0.774
LMSY	3.510***	0.046	0.765

In the gender-wise analysis, the sample consists of 86 males and 186 females. The average response for each difference index is provided in Table 4. The t-test has been conducted for the mean-difference for the null hypothesis of no significant difference for response male to female. Based on the higher p-value than 0.05, we accept the null hypothesis and conclude that gender wise responses, there is no significant differences in the response for the SLA, TSTL, TLE and LMS.

Table 4. Indices two-sample t-test: Gender-Wise Comparison

	Count	SLA	TSTL	TLEN	LMS
MALE	86	3.894	3.904	3.907	3.503
FEMALE	186	3.945	3.903	3.948	3.513
Difference (Male-female)		-0.445	0.008	-0.406	-0.010
T-test		-0.445	0.008	-0.406	-0.101
P-value		0.657	0.993	0.685	0.920

In addition to this, in the sample 128 teachers were currently using the LMS system in their respective schools such as LMS developed by schools, Google Meet and Google Team, open source LMS, WhatsApp, Zoom, and others. We compare the average response by using a t-test for two samples mean and based on a higher p-value for each index, we can conclude the insignificant differences between the responses of LMS user's teacher's vs non-users. Detailed results are provided in Table 5.

Table 5. Indices: Two sample t-test: LMS usage by teachers

	Count	SLA	TSTL	TLEN	LMS
LMS Users	128	3.932	3.862	3.924	3.499
LMS non-users	144	3.926	3.940	3.944	3.520
Mean (1-0)		0.006	-0.827	-0.020	-0.021
t-stat		0.059	-0.827	-0.212	-0.230
P-value		0.953	0.409	0.832	0.818

4.1.Sub-objective 1, Student learning abilities (SLA)

The average scores for each district Ghizer, Hunza, Nagar, and Gilgit, are 4.058, 3.954, 3.857, and 3.817, which is above 3, as presented in Table 6. This is reflected across each district; ICT is deemed important to enhance the learning abilities of students. The average score for the index for SLA across each district is the same except for comparing the district of Ghizer vs Gilgit. The p-value of 0.05 reflects it is statistically significant at a 95-confidence level, hence, we can conclude the difference between the average score of Ghizer to Gilgit is 0.241 which is statistically significant reflecting the opinion of teachers of Ghizer districts considering the role of ICT support SLA comparatively more when compared to Gilgit-District teacher's responses.

Table 6. District wise comparison of Students' Learning Abilities

	Average		Difference	t	P>|t|
Gilgit	3.817	Hunza vs Gilgit	0.137	0.98	0.329
Hunza	3.954	Ghizer vs Gilgit	0.241**	1.91	0.057
Ghizer	4.058	Nagar vs Gilgit	0.04	0.17	0.869
Nagar	3.857	Ghizer vs Hunza	0.105	0.72	0.473
		Nagar vs Hunza	-0.097	-0.38	0.702
		Nagar vs Ghizer	-0.201	-0.82	0.412

According to Figure 3, 43% of respondents strongly agreed that ICT boosts students' motivation to learn independently (SLA1), compared to 35% who agreed, 12% who were unsure, and 10% who disagreed. Of those who agreed, 46% disagreed, 7% were unsure, and 36% strongly agreed with the statement "accessing quality information" (SLA2). With respect to ICT as a useful tool for all abilities (SLA3), 22% agreed, 15% were unsure, and 11% opposed, with 52% strongly agreeing. Regarding raising motivation in learning activities (SLA4), 49% agreed, 11% were doubtful, and 8% disagreed, with 32% strongly agreeing. Finally, 44% of respondents agreed, 17% were unsure, and 9% disagreed that ICT improves interpersonal and critical thinking skills (SLA6). Of those, 30% strongly agreed.

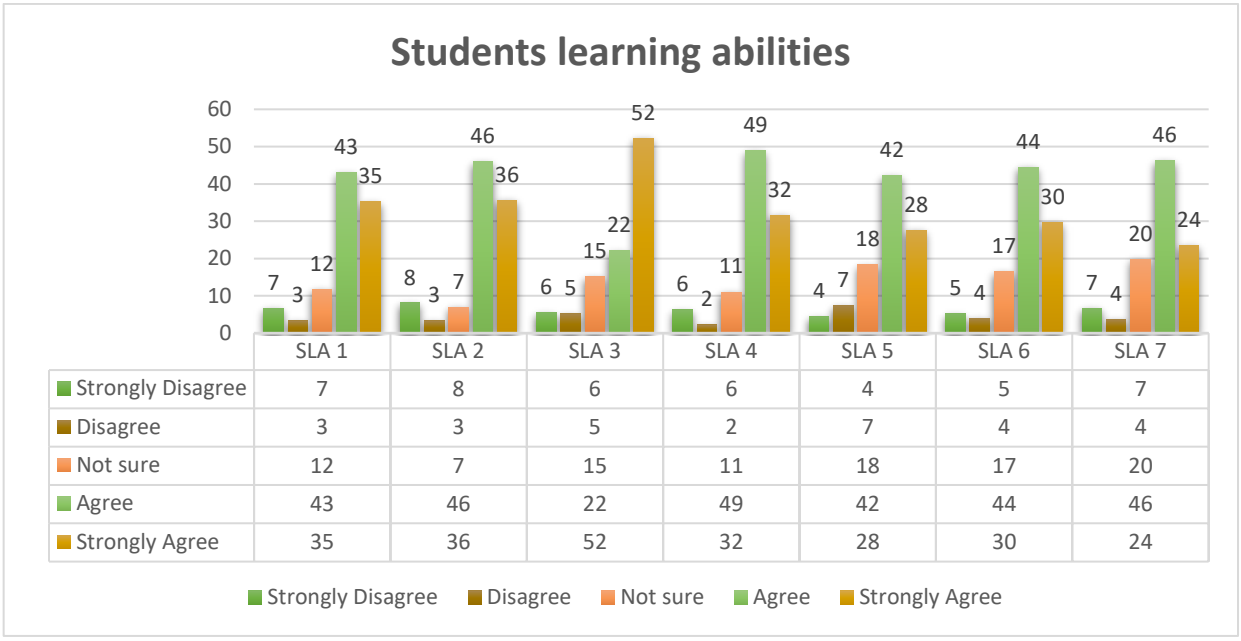


Figure 3. Student learning abilities

A significant portion of respondents strongly agree or agree that ICT positively impacts various aspects of student learning and engagement. However, there remains no respondent who is either unsure or disagrees, indicating some variability in perceptions of ICT's effectiveness.

4.2. Sub-objective 2. Teachers support in learning and teaching (TSLT)

The comparison of district-wise mean for the index TSLT reveals insignificant mean differences across four districts of GB. Detailed results are provided in Table 7. The null hypothesis was tested for mean-difference is zero against the alternative. The results of the test supported the acceptance null hypothesis for each district.

Table 7. District-wise comparison on Teachers' Support in learning and teaching (TSLT)

	Average		**Difference**	**t**	**P>|t|**
Gilgit	3.890	Hunza vs Gilgit	-0.027	-0.220	0.826
Hunza	3.863	Ghizer vs Gilgit	0.049	0.440	0.664
Ghizer	3.939	Nagar vs Gilgit	0.068	0.320	0.751
Nagar	3.958	Ghizer vs Hunza	0.076	0.590	0.556
		Nagar vs Hunza	0.095	0.430	0.670
		Nagar vs Ghizer	0.019	0.090	0.929

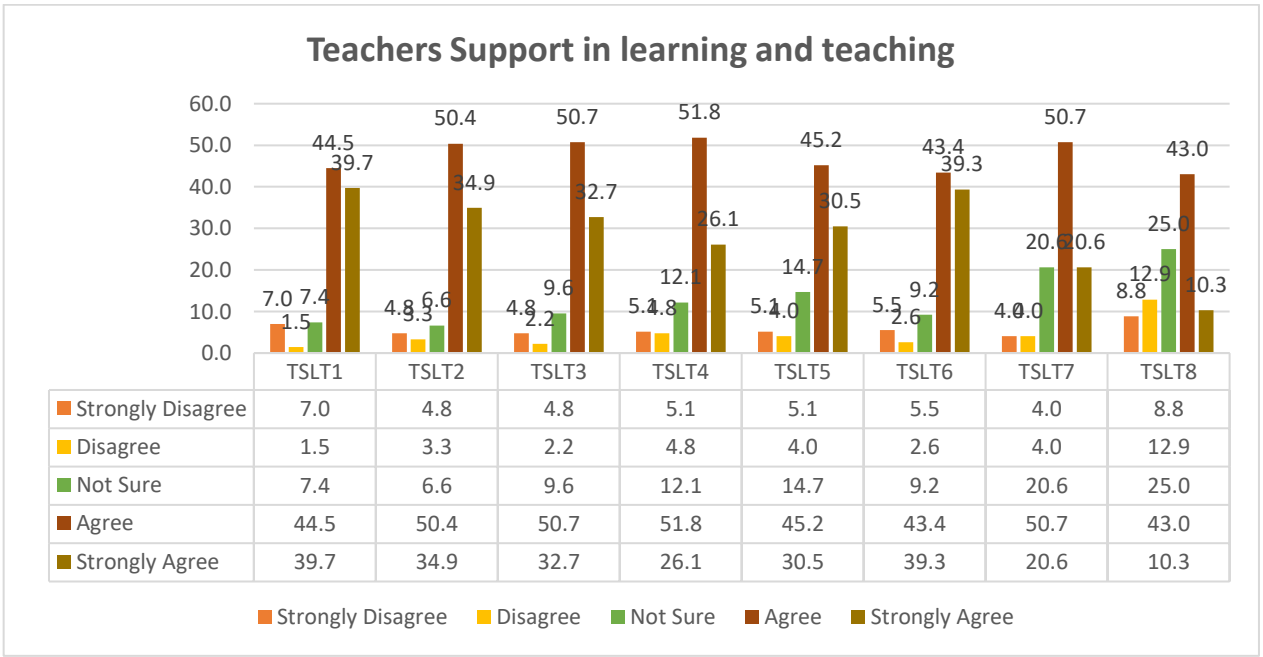


Figure 4. Teachers' Support in learning and teaching

A significant positive perception is indicated by Figure 4, which reveals that 84.2% of respondents agree or strongly agree that ICT changes teachers' teaching approaches. There isn't much opposition, as only 8.5% disagree. Also, 85.3% of respondents think ICT improves communication abilities, compared to 6.6% who are unsure and 5.5% who disagree. While 8.2% are doubtful and 9.7% disagree, about 83.4% of respondents think that ICT is an effective teaching tool. Teachers need to use ICT more effectively, according to 76.7% of respondents, however, 12.1% are undecided and 11.2% disagree. ICT also relieves teaching strain, according to 78.5% of respondents; 14.7% are unclear and 6.8% disagree. 82.7% of respondents believe that ICT makes courses more entertaining, while 5.6% are unclear and 6.1% disagree. Last but not least, while 68.0% of respondents believe they are technically proficient when using ICT, 12.9% are unsure and 11.7% disagree, emphasizing the necessity for further training. Majority of respondents agree on most elements, indicating that the data generally reflects a good assessment of ICT's role in promoting teaching and learning. To fully utilize ICT's potential in education, however, areas of doubt and dispute emphasize the necessity for continual support and training.

4.3. Sub-objective 3. Teaching and Learning Environment (TLE)

The district-wise mean comparison test for the index of TLE also revealed insignificant mean differences across the districts of Gilgit, Hunza, Ghizer, and Nagar. The p-values are higher than 0.05 supporting to accept the null hypothesis of no mean difference across the districts (Detail in Table 8 and Figure 5).

Table 8. District-wise comparison of Teaching and Learning Environment (TLE)

	Average		Difference	t	P>|t|
Gilgit	3.894	Hunza vs Gilgit	0.095	0.124	0.443
Hunza	3.989	Ghizer vs Gilgit	0.019	0.112	0.866
Ghizer	3.913	Nagar vs Gilgit	0.239	0.214	0.264
Nagar	4.133	Ghizer vs Hunza	-0.076	0.129	0.553
		Nagar vs Hunza	0.144	0.223	0.519
		Nagar vs Ghizer	0.220	0.217	0.310

Just 7% of respondents disagree, with the majority (80.6%) agreeing or strongly agreeing that ICT fosters collaborative learning between teachers and students. Of those who are unsure or disagree, 10.3% disagree, and 75.8% agree or strongly agree that after-school instruction should be participatory. 79.0% of respondents agree or strongly agree, 15.4% are undecided, and 5.5% disagree with the idea of a learner-centered workplace. 78.0% of respondents believe that ICT is useful for organizing educational activities and resolving issues outside of the classroom, with 15.4% remaining uncertain and 6.6% disagreeing. Furthermore, 78.3% of respondents feel that ICT boosts confidence and job prospects, with some potential for lowering confusion and disagreement, and 81.6% think that it improves course material and exhibits expertise.

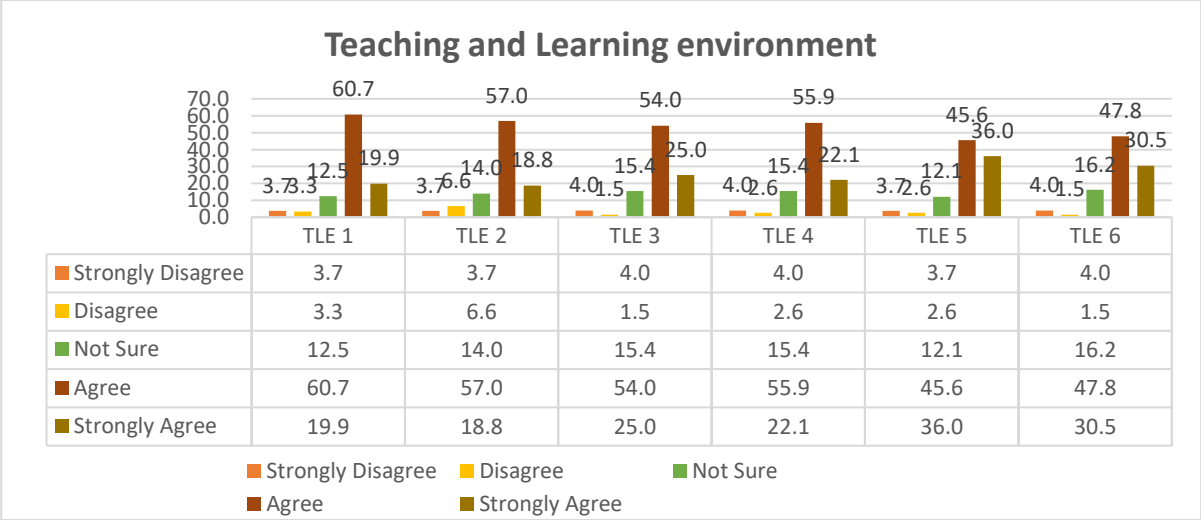


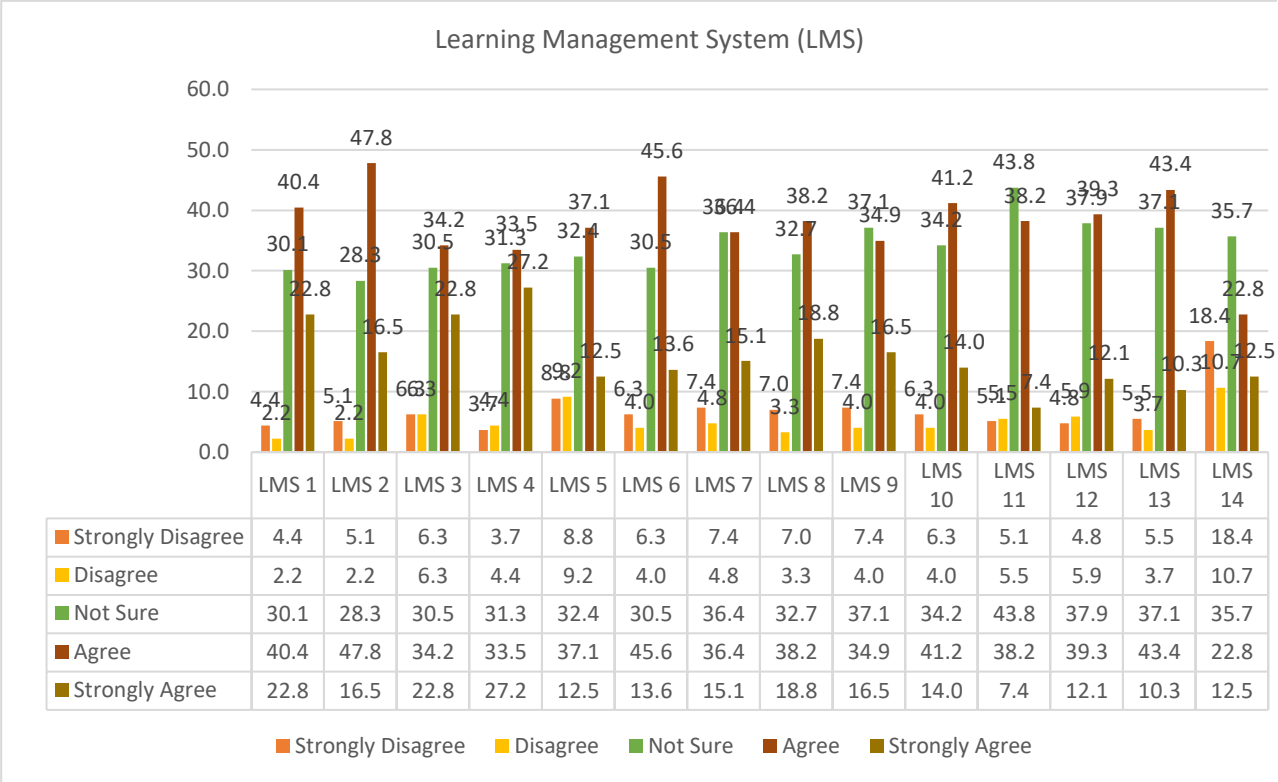
Figure 5. Teaching and Learning Environment

4.4. Sub-objective 4. Learning Management System (LMS)

The district-level analysis for indices of LMS revealed the significant mean difference between districts Ghizer and Gilgit. The mean score difference between Gilgit to Ghizer is 0.249, which is statistically significant and higher. Therefore, we can conclude that teacher response regarding LMS in the Gilgit district is significantly higher than Ghizer (details given in Table 9 and Figure 6). This can be attributed to the fact that Gilgit is relatively conveniently located, being the capital city of the region, where better connectivity and capacity-building opportunities are available.

Table 9. Normalized Index of Learning Management System (LMS): District-wise comparison

	Average		Difference	t	P>|t|
Gilgit	3.580	Hunza vs Gilgit	0.029	0.121	0.809
Hunza	3.609	Ghizer vs Gilgit	-0.249**	0.109	0.023
Ghizer	3.331	Nagar vs Gilgit	0.072	0.209	0.730
Nagar	3.652	Ghizer vs Hunza	-0.278	0.126	0.028
		Nagar vs Hunza	0.043	0.218	0.844
		Nagar vs Ghizer	0.321	0.212	0.131



	LMS 1	LMS 2	LMS 3	LMS 4	LMS 5	LMS 6	LMS 7	LMS 8	LMS 9	LMS 10	LMS 11	LMS 12	LMS 13	LMS 14
Strongly Disagree	4.4	5.1	6.3	3.7	8.8	6.3	7.4	7.0	7.4	6.3	5.1	4.8	5.5	18.4
Disagree	2.2	2.2	6.3	4.4	9.2	4.0	4.8	3.3	4.0	4.0	5.5	5.9	3.7	10.7
Not Sure	30.1	28.3	30.5	31.3	32.4	30.5	36.4	32.7	37.1	34.2	43.8	37.9	37.1	35.7
Agree	40.4	47.8	34.2	33.5	37.1	45.6	36.4	38.2	34.9	41.2	38.2	39.3	43.4	22.8
Strongly Agree	22.8	16.5	22.8	27.2	12.5	13.6	15.1	18.8	16.5	14.0	7.4	12.1	10.3	12.5

Figure 6. Learning Management System (LMS)

Strong positive perceptions of these LMS aspects are evident in the highest agreement levels found in statements like "I need to undergo training to be familiar with the administrative tools of LMS" (60.7%), "The school administration office supports the use of LMS" (74.2%), and "Using the Learning Management System (LMS) enables me to accomplish my tasks better" (64.3%). The statement "My institution holds training for students and teachers on LMS" (48.3%) has the lowest level of agreement, indicating ambiguity or discontent. There is a need for more precise communication regarding the advantages of learning management systems (LMS), as seen by the high levels of ambiguity found in statements like "Uploading and downloading materials is easy in LMS" (40.8%), "LMS enhances face-to-face teaching" (38.3%), and "I would recommend LMS to my colleagues" (38.8%). Higher levels of disagreement are also highlighted in the following statements: "LMS makes collaboration with students more interesting" (14.8%) and "The school administration office supports the use of LMS" (13.2%), highlighting potential areas where the LMS may fall short of user expectations. By addressing these issues, LMS at educational institutions may operate more effectively and satisfy users more.

This research study provides significant insight into how ICT supports students in teaching and learning (Hakimi *et al.*, 2024; Hayani et al., 2024). The study shows that the implementation of LMS in teaching and learning can enhance the learning abilities of students which is in line with earlier studies (Akhmedova & Rahmatova, 2024; Sari et al., 2024). The results also reveal how teachers can improve their digital and develop their professional skills by using emerging technologies(Fowler & Leonard, 2024). The integration of ICT in Teaching and Learning Environments shows a favorable correlation between ICT incorporation and efficacy of teaching and learning settings in the rural remote areas of GB(Sosa et al., 2024). The respondents, regardless of their district, age, and gender, consistently acknowledged the importance of ICT in boosting the learning capacity of students, helping instructors in their activities, and fostering beneficial teaching and learning environments(O. K. T. Kilag, G. B. Segarra, *et al.*, 2023). Most of the participants stated that LMS enhances students' engagement and learning efficiency in the classroom, which is a critical component in this setting (Faroji et al., 2024).

At the district wise survey there is a minor difference in opinions regarding ICT integration in teaching and learning environments, for example the respondents of District Ghizer had a higher understanding of the role of ICT in enhancing pupils learning skills as compared to District Gilgit(Hayani *et al.*, 2024). These differences show the necessity of taking local circumstances and requirements when integrating ICT in teaching and learning environments. ICT helps the students in various learning related aspects such as increased learning interest, provide easier access to trustworthy information and

enhancing critical thinking skills(Girinzio *et al.*, 2023; Stephen, 2024; Timotheou et al., 2023). As the majority of respondents agreed with above mentioned statements, a significant number of respondents expressed skepticism or disagreement, highlighting the need for further research and clarification on the role of ICT in teaching and learning(Cabellos et al., 2024).
The vast majority of teachers acknowledged the importance of ICT on transforming teaching practices and fostering a communicative environment(Parveen *et al.*, 2024). However, concerns were raised about the extra effort required and the degree to which ICT lessens the actual burden of teaching. So, these findings highlight the importance of providing ongoing support and training to fully leverage the benefits of ICT in teaching methodologies. The respondents(teachers) agreed on the importance of ICT in promoting collaborative learning, creating engaging learning environment, boosting confidence and provide paths career opportunities(Alenezi *et al.*, 2023; Uy *et al.*, 2024).
The proper utilization of ICT can be even more successfully to build dynamic teaching and learning environment by addressing the unknown issues related to integration(Klusmann *et al.*, 2023). There are divergent views on the number of aspects of LMS integration in teaching and learning(Simon *et al.*, 2024). There were some problems with things like training and student involvement, but most people agreed that tasks were completed well, and the administrative help was good(Hongchao, 2024). The results showed that we need to focus on fixing user complaints and making the learning management system (LMS) work better in schools(Morze et al., 2024).

5. Conclusions

The study was conducted across four districts of Gilgit-Baltistan such as Gilgit, Hunza, Ghizer, and Nagar, and showed substantial insights into the integration and impact of technology-enabled teacher training and development programs. Data collected from 272 respondents, with a high response rate of 90.6%, indicated that 68.4% were female and 31.6% were male participants. Analysis using SPSS emphasized key patterns and trends. The following conclusions are drawn from the results:

i. ICT training was prevalent among 31% of teachers, while 84% reported computer proficiency and 47.1% used LMS for teaching. The study highlighted the positive impact of ICT on student learning abilities (SLA), teaching and learning environments (TLE), and teacher support in learning and teaching (TSLT), with average scores significantly higher than the neutral score of 3 (p-value < 0.000).
ii. Gender-wise, no significant differences were found in responses regarding SLA, TSLT, TLE, and LMS usage, indicating a steady observation across male and female teachers. District-wise comparisons showed a statistically significant higher average SLA score in Ghizer (4.058) compared to Gilgit (3.817), reflecting a stronger perceived impact of ICT on student learning in Ghizer.
iii. The use of LMS revealed a significant difference between Gilgit and Ghizer, with Gilgit reporting a higher average score (3.580 vs. 3.331, p-value < 0.05). Teachers recognized the role of ICT in enhancing collaborative learning, enhancing motivation, and improving communication skills, although there were areas of uncertainty and disagreement, particularly regarding the ease of LMS use and institutional support for LMS.
iv. Overall, the results show a comprehensive positive insight into ICT's role in improving educational outcomes in Gilgit-Baltistan, Pakistan. However, the study also highlights the need for ongoing training and support to address the indiscretion in ICT competency and to fully influence the potential of LMS and other digital resources in education.

6. Recommendations

The use of ICT tools in teaching and learning has become a new normal, hence comprehensive training of the teachers is required in all districts of Gilgit Baltistan. At the same time to improve equality and access to ICT in remote, the Government of GB needs to heavily invest in the establishment of ICT Labs, improving power supply and connectivity in the region.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study

Author Contributions: Conceptualization, SR and AS; methodology, SR and GJ; software, SK and GS; validation, SB, AS and SK; formal analysis, SR and SK; investigation, SR; resources, AH; data curation, GJ and GS; writing—original draft preparation, SR; writing—review and editing, AS; supervision, SR; All authors have read and agreed to the published version of the manuscript

Data Availability Statement: The data is available within the Manuscript.

Conflicts of Interest: The authors declare no conflicts of interest

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