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Technological Challenges: A Case of Secondary-Level Mathematics Teachers' Integrating ICT in Mathematics Classrooms

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Abstract

In Nepal, the integration of Information and Communication Technology (ICT) into mathematics teaching and learning has become a topic of growing interest and importance in the field of mathematics education. Nevertheless, the effective and efficient integration of technology into the classroom environment remains a significant challenge for mathematics teachers. Therefore, this study examines the technological challenges faced by mathematics teachers and the key factors that have the greatest impact on integrating ICT into teaching and learning activities in mathematics classrooms. An online survey design was used in the quantitative research. A structural online survey questionnaire was distributed through Viber, WhatsApp, and Messenger to 135 public and 150 private secondary-level mathematics teachers in Kathmandu Metropolitan City during the academic year 2023–2024. The overall response from mathematics teachers was only 197 (59.23%). The response data was downloaded into Excel and cleaned. Means, standard deviations, and multiple linear regression were used to analyze the cleaned data using the JAMOVI software. The data clearly show that there are no challenges in the use of ICT, professional development, and pedagogical issues. However, technological limitations present challenges from teachers' perspectives. Additionally, technological limitations, professional development, and pedagogical issues have significant correlations and positive impacts on the use of ICT, with pedagogical issues emerging as the most influential factor. This means that teachers are qualified to integrate ICT into their teaching and learning activities. However, there were technological limitations in mathematics classrooms. Therefore, inadequate access to hardware, lack of technical support, and unreliable Internet connectivity are necessary for mathematics teachers to effectively incorporate ICT into their teaching and learning activities. Furthermore, further research should use a larger sample size to validate these results in diverse educational contexts in Nepal.

Keywords: ICT integration, mathematics education, technological challenges, Pedagogical issues, and secondary-level teachers

Introduction

In the 21st century, information and communication technology (ICT) is becoming an essential part of human life. It has been widely applied in many fields of human life, including the natural and medical sciences, business, entertainment, research, and language learning. In recent years, the use of ICT in the teaching and learning process appears to have increased rapidly. There is an increasing demand for ICT use in education to develop the knowledge and skills that students need for the 21st century. It is essential and significant role in teaching and

learning mathematics. (Buabeng-Andoh, 2012). It improves students' learning and has an impact on the mathematics taught. There are numerous benefits of use of ICT in teaching and learning mathematics. According to Khan et al. (2012), information and communication technology (ICT) has the power to completely change the way that education is delivered. It can also enhance the responsibilities that teachers and students play in the learning process and create a collaborative learning environment. But, there are several challenges that make it very difficult to use ICT in teaching and learning mathematics in secondary-level schools.

Challenges in Use of ICT in Mathematics Classroom

The development of information and communication technology (ICT) has significantly changed the teaching and learning processes of mathematics education. Therefore, mathematics teachers are faced with inhibiting challenges to the use of ICT (Hudson & Porter, 2010b). As a result, numerous studies have been carried out with a focus on ICT integration in the teaching of mathematics at the secondary level. There are two types of challenges, which are external and internal, to integrating ICT in the mathematics classroom faced by mathematics teachers (Chai et al., 2010; Drent & Meelissen, 2008; Ertmer & Ottenbreit-Leftwich, 2010; Wachira & Keengwe, 2011). The internal challenges refer to an individual's attitudes toward teaching and learning activities. These could be more challenge to overcome because teacher may not be aware of them (ertmer et all 2010). Even though it can be challenging to overcome these barriers, teachers still have a responsibility because of the significance of incorporating technology. However, external challenges that are easier to measure and address include things like professional development, time, support, and resource access that are outside of a teacher's control (Tosuntaş et al., 2019).

Internal Challenges to Use of ICT

Several studies have demonstrated that teachers face various technological challenges when integrating ICT into classrooms. Jones (2004) found that teachers often struggled due to a lack of confidence, limited awareness of mathematical software, incapacity, or insufficient knowledge and skill to use ICT, unfavorable attitudes toward ICT. These were the main challenges in integrating ICT in mathematics classrooms. Additionally, the main challenges teachers face when using ICT in their lesson plans include anxiety (Balanskat et al., 2006a), fear of failure (Beggs, 2000), and a lack of confidence (Jones, 2004). Teachers who confidently use ICT believe that it improves their teaching methods and are ready to use it more in the future (Cox et al., 1999). One significant factor that may challenge teachers' confidence in using ICT in the classroom is their lack of expertise or competency in using ICT in teaching and learning in classrooms (Jones, 2004). Research has also indicated that a lack of technological competency presents teachers with the same challenges in developed and developing countries (Newhouse, 2002). Thus, the government should focus on teacher training, and support to minimize teacher uncertainty and fears about the successful implementation of technology and improve the quality of mathematics education at the secondary level.

External Challenges to Use of ICT

External challenges to use ICT are a lack of available technology, insufficient administrative support, and inadequate professional development (Ertmer et al. 1999). Administrative support has an impact on teachers' ICT usage (Hanny et al.2021). Some of the issues preventing the adoption of ICT use in the classroom are curriculum, time constraints, and

a lack of technological support (Hanny et al., 2021). Several researchers found that mathematics teachers face various challenges in their professional development regarding the use of ICT. These challenges include the lack of ICT materials, insufficient training opportunities, institutional support for integrating ICT in classroom, increased the workload, lack of quality digital learning materials, inadequate access to ICT tools, lack of time for the integration, poor funding, and poor fit curriculum (Snoeyink, R., & Ertmer, P. A. 2002). Research shown that these programs have not sufficiently modelled the use of ICT in their teaching courses or included best practices for ICT integration into a single technology course (Brown and Warschauer 2006). To overcome these challenges, it will be necessary to provide more resources, support, and training to teachers in order to break down challenges that stand in the way of effective technology integration in mathematics education.

Overall, studies on the use of ICT in education have identified several global challenges to its use in classrooms, some of which have already been addressed in this section. The following challenges are the most frequently mentioned in the literature: lack of confidence, limited awareness of mathematical software, incapacity, or insufficient knowledge and skill to use ICT, unfavorable attitudes toward ICT, anxiety, fear of failure, lack of technological competency, a lack of available technology, insufficient administrative support, and inadequate professional development, time constraints, a lack of technological support, lack of ICT materials, insufficient training opportunities, institutional support, increased workload, lack of quality digital learning materials, inadequate access to ICT tools, lack of time for integration, poor funding, and poor curriculum fit. However, no study has examined the challenges and effects of these challenges on the use of ICT in mathematics classrooms in Kathmandu city by collecting accurate and trustworthy data on secondary-level mathematics teachers in both public and private schools. Consequently, the purpose of this study was to identify the technological challenges and significant factors affecting the integration of ICT by mathematics teachers in classrooms. Consequently, after reviewing the literature, the researcher has the following questions in mind:

- What are the current technological challenges that secondary level mathematics teachers in Nepal face when using ICT into their classrooms?
- What significant factors affect the integration of ICT by mathematics teachers?

Objectives of the Study

- To examine the challenges faced by mathematics teachers in integrating ICT into their teaching and learning activities at secondary-level mathematics classrooms.
- To investigate the key factors that have the greatest effects on integrating ICT by mathematics teachers in the mathematics classrooms.

Methodology

This research employed a quantitative framework with an online structured survey research design. This was the most effective design because it was easy to collect information from teachers in their natural setting on their attitudes toward ICT use. The population of this study consisted of all mathematics teachers employed in Kathmandu Metropolitan City's public and private secondary schools during the academic year 2023–2024 who have taught both compulsory and optional mathematics because they are the main facilitators of ICT integration

into the mathematics teaching and learning process in classrooms. The Kathmandu district's Education Development and Coordinate Unit shows that, there are 576 secondary schools in the Kathmandu Metropolitan Area. These schools were divided into public and private schools, with 76 publics and 500 private secondary schools. In the first stage, list all mathematics teachers from each stratum who taught both compulsory and optional courses. In the second phase, the online structural survey questionnaire was distributed through Viber, WhatsApp, and Messenger to 135 public and 150 private school's mathematics teachers. However, only 73 private and 124 public teachers answered the online survey, yielding a 69.12% response rate. A total of 114 mathematics teachers from public schools and 69 mathematics teachers from private schools in Kathmandu Metropolitan City made up the final sample size for this study after the data was cleansed. $N \geq 104 + k$ is the formula for determining sample size, where k is the number of independent variables. Regression analysis requires a minimum sample size of $N = 104 + 3 = 107$ for a model with three independent variables (Green, 1991). Therefore, the total sample size of $N = 183$ for this research is sufficient and satisfies the representativeness criterion. The structural online survey questionnaire was used as the primary tool for data collection. It has three sections: demographics, use of ICT, and factors influencing ICT use. The ICT use (dependent variable) section is generated with seven closed-end items to measure the use of ICT by mathematics teachers, and the third section addresses the factors that impact the use of ICT. It comprised three independent variables: technological limitations, professional development, and pedagogical issues. It consisted of 21 items to measure factors believed to impact ICT use. A five-point Likert scale was used to measure the independent and dependent variables. In behavioral science, the most common method to evaluate internal consistency is the Cronbach alpha (Cohen et al., 2007). The test's reliability coefficient was 0.856, and normalcy was examined. The researcher spent a month collecting information from the sample school's math teachers. Descriptive statistics included mean and standard deviations for the first objective, and inferential statistics included multiple linear regression for the second objective. The data were interpreted and analyzed using JAMOVI version 2.3.28 software.

Results and Discussion

Teachers' Challenges of ICT Use in Teaching Mathematics

Table 1

Teachers' Challenges of ICT Use in Teaching Mathematics

SN.	Items	Mean	SD	Decision
1	I am confident in my abilities to use ICT into mathematics teaching.	4.05	0.728	Not Challenge
2	ICT-based teaching and learning activities help the students' conceptual understanding of mathematical concepts.	3.64	0.926	Not Challenge
3	The use of ICT tools makes the mathematics classroom more dynamic and student-centered.	3.48	0.982	Not Challenge
4	ICT tools help to visualize and explore mathematical concepts.	3.04	1.010	Not Challenge
5	ICT tools improve students' participation and engagement in mathematics classes.	4.11	0.988	Not Challenge
6	I use ICT tools for my daily tasks and activities.	4.34	0.849	Not Challenge
7	There is adequate time to integrate ICT into teaching and learning activities in mathematics classroom.	3.81	0.870	Not Challenge
	Overall Mean and SD	**3.78**	**0.91**	

The data presented in Table 1 was analyzed to identify teachers' challenges regarding the use of ICT in mathematics classrooms. The items revealed no challenges, indicating that I am confident in my ability to use ICT (M = 4.05, SD = 0.728), ICT-based teaching and learning activities help the students' conceptual understanding of mathematical concepts (M = 3.64, SD = 0.926), the use of ICT tools makes the mathematics classroom more dynamic and student-centered (M = 3.48, SD = 0.982), ICT tools help to visualize and explore mathematical concepts (M = 3.04, SD= 1.01), ICT tools improve students' participation and engagement in mathematics classes (M = 4.11, SD= 0.988), use ICT tools for may daily tasks and activities (M = 4.34, SD= 0.849), and There is adequate time to integrate ICT into teaching and learning activities in mathematics classroom (M = 3.81, SD= 0.870). The mean level of the challenge items ranged from 3.04 to 4.34, while the overall mean is 3.78 and the standard deviation is 0.91, which indicates that there are no challenges about ICT use from the teachers' perspective.

The overall results presented in Table 1 demonstrate that secondary-level mathematics teachers at the Kathmandu Metropolitan City in Nepal have no challenges regarding ICT use in mathematics classrooms from teachers' perspectives. This means that teachers can effectively use ICT in mathematics classrooms. The results of this study are inconsistent with those of Hudson and Porter (2010), Jones (2004), Beggs (2000), Balanskat et al. (2006b), and Suryani (2010). Thus,

teachers have no challenges when using ICT in their classrooms; it improves their teaching and learning activities and empowers students' conceptual understanding of mathematical content. In addition, teachers should have a positive attitude toward ICT use in their classrooms.

Table 2

Teachers' Challenges of Technological Limitation in Mathematics Classrooms

SN.	Items	Mean	SD	Decision
1	**Teachers have easy access to ICT hardware (e.g. Computers, tablets, overhead projector) in mathematics classroom.**	2.75	1.080	Challenge
2	Reliable and high-speed internet connectivity in the classroom.	2.76	0.993	Challenge
3	Accessibility of important educational applications and software for teaching mathematics.	2.74	0.993	Challenge
4	**There is a committed technical team to support the technical problems in the classroom.**	2.54	1.230	Challenge
5	Students can learn mathematics with equal access to ICT tools and resources.	2.31	1.090	Challenge
6	There are many different ICT tools in my math classroom.	2.24	1.120	Challenge
	Overall Mean and SD	**2.56**	**1.080**	

The information presented in Table 2 was analyzed to identify the teachers' challenges regarding technological limitations in mathematics classrooms. The items identified challenges such as **easy access to ICT hardware** (M = 2.75, SD= 1.08), reliable and high-speed internet connectivity (M = 2.76, SD = 0.993), accessibility of important educational applications and software (M = 2.74, SD= 0.993), **a committed technical team to support the technical problems** (M = 2.54, SD= 1.23), students can learn mathematics with equal access to ICT tools and resources (M = 2.31, SD= 1.09), and there are many different ICT tools in my math classroom (M = 2.24, SD= 1.12). The mean level of the challenge items ranged from 2.24 to 2.76, while the overall mean was 2.56, and the standard deviation was 1.08, which indicates challenges regarding technological limitations from the teachers' perspective.

The overall results presented in Table 2 demonstrate that secondary-level mathematics teachers at the Kathmandu Metropolitan City in Nepal face challenges regarding technological limitations in ICT use in mathematics classrooms from teachers' perspectives. This indicates insufficient teaching ICT materials in schools and mathematics classrooms. The results of this study are consistent with those of Jones (2004), Agyei and Voogt (2011), Tondeur et al. (2011), Ertmer et al. (2012), Hudson and Porter (2010a), and Snoeyink and Ertmer (2001).Thus, teachers have technological limitations when using ICT in their classrooms; it has challenges to improving teaching and learning activities and empower students' conceptual understanding of mathematical content without technology. Therefore, school administrations and local governments should

provide ICT resources and motivate teachers to develop ICT skills and continue to use it in their teaching and learning activities in mathematics classrooms.

Table 3

Teachers' Challenges of Professional Development in Teaching Mathematics

SN.	Items	Mean	SD	Decision
1	I have received formal professional training in ICT.	2.40	1.14	Challenge
2	The training provided a clear idea for beginners to integrate ICT tools.	3.08	1.20	Not Challenge
3	The training materials and resources were highly beneficial in enhancing ICT-based teaching in mathematics.	3.23	1.13	Not Challenge
4	The training provided me aligns with my career goals and needs.	3.14	1.14	Not Challenge
5	The training improved my technical skills and knowledge.	3.26	1.18	Not Challenge
6	Participating in professional development training sessions has enhanced my confidence in effectively integrating ICT into math classes.	3.42	1.13	Not Challenge
7	The trainers in the ICT training are knowledgeable and skillful.	3.38	1.07	Not Challenge
	Overall Mean and SD	**3.13**	**1.14**	

The information presented in Table 3 was analyzed to identify the teachers' challenges regarding the professional development in teaching mathematics. The items were found no challenge that have training provided a clear idea for beginners to integrate ICT tools (M = 3.08, SD= 1.20), training materials and resources were highly beneficial in enhancing ICT-based teaching in mathematics (M = 3.23, SD = 1.13), training provided me aligns with my career goals and needs (M = 3.14, SD= 1.14), training improved my technical skills and knowledge (M = 3.26, SD= 1.18), Participating in professional development training sessions has enhanced my confidence in effectively integrating ICT into math classes (M = 3.42, SD= 1.13), and trainers in the ICT training are knowledgeable and skillful (M = 3.38, SD= 1.07), but received formal professional training in ICT classroom (M = 2.40, SD= 1.14) has challenge. The mean level of the challenge items ranged from 2.40 to 3.38, while the overall mean was 3.13, and the standard

deviation was 1.14, which indicates no challenges regarding professional development from the teachers' perspective.

Table 4

Teachers' Challenges of Pedagogical Issues in Teaching Mathematics

SN	Items	Mean	SD	Decision
1	I teach mathematics with effective use of ICT tools.	2.76	0.936	Challenge
2	I use digital resources to provide context for mathematical concepts.	3.78	0.836	Not Challenge
3	I have infrastructure-related problems when utilizing ICT, such as slow internet, outdated devices.	3.82	0.849	Not Challenge
4	I motivate students to use online tools to independently investigate mathematical concepts.	3.93	0.668	Not Challenge
5	I encourage collaborative learning using internet resources.	3.27	0.838	Not Challenge
6	I use ICT to monitor my students' progress through formative assessment using online games and quizzes.	3.81	0.747	Not Challenge
7	I use online platforms to give students feedback on time.	4.04	0.690	Not Challenge
8	I use ICT to evaluate students' achievement in every lesson.	2.11	0.957	Not Challenge
	Overall Mean and SD	3.44	0.815	

The information presented in Table 4 was analyzed to identify the teachers' challenges regarding the pedagogical issues in mathematics classrooms. The items were found no challenge that have use digital resources to provide context for mathematical concepts ICT (M = 3.78, SD= 0.836), infrastructure-related problems when utilizing ICT, such as slow internet, outdated devices (M = 3.82, SD = 0.849), motivate students to use online tools to independently investigate mathematical concepts (M = 3.93, SD= 0.668), encourage collaborative learning using internet resources (M = 3.27, SD= 0.838), use ICT to monitor my students' progress through formative assessment using online games and quizzes (M = 3.81, SD= 0.747), and use online platforms to give students feedback on time (M =4.04, SD= 0.690). Although, I teach mathematics with effective use of ICT tools (M = 2.76, SD= 0.936), and I use ICT to evaluate students' achievement

in every lesson (M = 2.11, SD= 0.957) have challenges. The mean level of the challenge items ranged from 2.11 to 4.04, while the total mean was 3.44, and the standard deviation was 0.815, which indicates no challenges regarding pedagogical issues from the teachers' perspective.

Effect of Independent Variables on ICT Use

The calculated R, R-square significance, and F-value for the secondary-level mathematics teachers' in Kathmandu Metropolitan City are given in Table 5.

Table 5

A Summary of the Regression Analysis of Independent Variables

							Overall Model Test			
Model	**R**	**R Square**	**Adjusted R Square**	**AIC**	**BIC**	**RMSE**	**F**	**Df1**	**Df2**	**Sig. F Change**
1	0.519	0.269	0.257	243	259	0.457	22.0	3	179	<0.001

a. Predictors: (Constant), Technological Limitations, Professional Development, Pedagogical Issues

The results presented in Table 5 indicated a high positive correlation between the use of ICT (the dependent variable) and various factors affecting it, namely technological limitations, professional development, and pedagogical issues (independent variables), among mathematics teachers (Cohen et al., 2007), with $R = 0.52$. The calculated value of $F\ (3, 179) = 22.0$, p value < 0. 001 (α), and adjusted R^2= 0.257 (Table **5**). This indicates a significant and positive impact on ICT use by these predictor variables (Technological Limitations, Professional Development, and Pedagogical Issues). In summary, independent factors account for 27% of the variation in the use of ICT among secondary-level mathematics teachers in our model, which is statistically significant for strong model fit (Chatterjee & Hadi, 2012; Cohen et al., 2007).

In Table 7, the analysis further reveals significant correlations between the independent variables (Technological Limitations, Professional Development, and Pedagogical Issues) and the use of ICT. Specifically, the correlation between technological limitations and use of ICT was statistically significant, $r\ (179) = 0.170$, $t\ (179) = 3.66$, $p < 0.001$, at a 95% confidence interval *[0.114, 0.380]*, indicating that for each unit increase in technological limitations, the use of ICT by secondary-level mathematics teachers increased by 0.247. Similarly, the correlation between professional development and use of ICT was statistically significant, $r\ (179) = 0.144$, $t\ (179) = 3.69$, $p < 0.001$, at a 95% confidence interval *[0.114, 0.378]*, indicating that for each unit increase in professional development, the use of ICT increased by 0.246.

Table 6

Significant Level in Regression Analysis (Omnibus ANOVA Test)

Model	Sum of Squares	df	Mean Square	F	Sig
Technological Limitations	2.86	1	2.856	13.4	<0.001
Professional Development	2.90	1	2.900	13.6	<0.001
Pedagogical Issues	3.11	1	3.111	14.6	<0.001
Residuals	38.18	179	0.213		

Note. Type 3 sum of Squares

Furthermore, the correlation between pedagogical issues and use of ICT was statistically significant, $r\ (179) = 0.315$, $t\ (179) = 3.82$, $p < 0.001$, at a 95% confidence interval $[0.122, 0.384]$, indicating that for each unit increase in pedagogical issues, the use of ICT increased by 0.253. As a result, these independent variables have positive and a significant impact on ICT use, with pedagogical issues emerging as the most influential factor (Table 7).

Table 7

Effect of Independent Variables on ICT Use

	Unstandardized Coefficients				Standardized Coefficients	95% Confidence Interval for B	
Predictor	B	Std. Error	t	Sig	Beta	Lower Bound	Upper Bound
Intercept	1.672	0.2861	5.85	<0.001			
Technological Limitations	0.170	0.0465	3.66	<0.001	0.247	0.114	0.380
Professional Development	0.144	0.0390	3.69	<0.001	0.246	0.114	0.378
Pedagogical Issues	0.315	0.0824	3.82	<0.001	0.253	0.122	0.384

Conclusion

In conclusion, this study aimed to clarify the technological challenges and influential factors affecting the integration of ICT by secondary-level mathematics teachers into mathematics classrooms in Kathmandu Metropolitan City. The findings of this study demonstrate that the use of ICT is positively correlated with technological limits, professional development, and pedagogical issues, with pedagogical issues emerging as the most significant factor. However, from teachers' perspectives, there are challenges with technological limitations. This means teachers' confidence in their ICT abilities and recognition of its educational benefits, but hardware, software, or infrastructure, such as outdated computers, slow internet connectivity, or inadequate digital resources, can obstruct teachers' ability to effectively use ICT to support students' learning and pose a challenge for them to achieve their teaching objectives. This study provides valuable insights for policymakers, teachers, and stakeholders in developing targeted strategies to improve mathematics education through ICT integration by addressing challenges and leveraging influential factors. Therefore, comprehensive support and training should be provided to enable mathematics teachers to effectively incorporate ICT into their teaching and learning activities. This study is limited to a small number of participants and was conducted in Kathmandu Metropolitan City; thus, the findings cannot be generalized. Therefore, further study and exploration should be used a larger sample size to validate these results in diverse educational contexts in Nepal.

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