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## **Mathematics Learning Achievement of School Students through Virtual and Face to Face Mode of Learning**

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### **Abstract**

The main objective of this paper is to examine the difference between mathematics learning achievement of school students through virtual and face to face mode of learning. This quasi-experimental study was conducted in two similar institutional schools of Birendranagar municipality Surkhet. All the students of grade nine from sample schools were the participants of this study, however the intervention and comparison groups were made similar on the basis of number, inclusiveness, grade of mathematics in Basic Level Examination, first-terminal examination and pre-test. Pre-test and post-test were conducted using the similar parallel sets of test items that were finalized by piloting and analyzing the items. SPSS-20 was used as the tool of data analysis. The result revealed that learners through virtual mode of learning performed better than traditional face to face mode of learning mathematics and the study suggests that virtual mode of learning can be an alternative learning approach in school level to increase the mathematics achievement.

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## **Introduction**

At the beginning of the 21<sup>st</sup> Century, technology is rapidly changing, and different organizations and learning institutions have started a blended learning approach. Developed countries in the world have practiced an integrated approach to learning since 2000. After the worldwide terror of Coronavirus (COVID-19), most of the developing countries started online mode of learning from school to university level. Virtual learning environment is an approach of delivering instruction that allows the teachers and students to interact and communicate without being in same place. It is a flexible approach that uses a variety of tools like video conferencing, learning management systems, and online

collaborative platforms. Siemens (2004) mentioned that the virtual learning occurs through network connection as individuals share their interests, knowledge, perspectives, expertise, and opinions through synchronous and asynchronous learning strategies. Similarly, Joseph and Ekemini (2014) state that the virtual learning environment is human-directed with the machine processing process, enabling learners to participate from a distance in both synchronous and asynchronous modes. The design of a virtual learning environment includes five aspects: knowledge (design of interactive digital content with pedagogical perspective), collaboration (student-student, student-teacher and teacher-teacher interaction), consulting (both synchronous and asynchronous), experimentation (simulation) and management (homework, evaluation and follow-up), all of this for technology to stimulate the required learning (Bravo & Alarcia, 2012).

Developed countries have transformed their education system due to new forms of technology, also the developing countries have tried to improve teaching-learning activities by integrating ICT. Brick and Wilson (2015) described that technological knowledge and ICT infrastructure have become essential to work between students and teachers in the physical classroom as well as in the online learning community. Beede et al. (2011) explained that online learning creates new ways for teachers and students to engage, interact, and contribute to learning. Virtual learning is a new practice in the Nepali education system, although open and distance learning through radio was launched in 1978 with the technical and financial support of USAID (Dahal, 2014). Tribhuvan University and Kathmandu University had provided online learning opportunities for the students of Bachelors and Masters' degree in some specific programs, however, Nepal Open University formally started Bachelors, Masters' and MPhil degree program in Nepal through virtual mode in different disciplines since 2017. The Government of Nepal has also provided distance learning options to the students of School Education Examination through radio and television to increase the success rate. In the period of crises of Covid-19, the Government of Nepal requested all the stakeholders to conduct virtual mode as an alternative way of teaching-learning activities from school to university level. Therefore, most of the schools of urban area and the universities of Nepal started virtual learning in the period of pandemic. The starting of virtual mode at the school level was not an easy job in the Nepali context, but it was an option to engage the learners for a long pandemic period.

Government of Nepal, Ministry of Information and Communication Technology has implemented the ICT policy 2015 to transform Nepal into an information and knowledge- based society through ICT following the mission of 'using ICT for sustainable development and poverty minimization'. On the basis of this policy, some of the strategies have been developed and implemented to encourage in applying ICT from school to university level, provide the training for teachers in ICT, encourage the researches in ICT, make ICT accessible to remote and inaccessible teachers, students and communities (Ministry of Information and Communication Technology [MoICT], 2015). Regarding the online learning policies of Nepal, Shrestha and Gnawali (2021) mentioned that an emergency action plan for school education, student learning facilitation guidelines, and a framework for school education were three important policies. Emergency Action Plan for School Education, 2020 (Ministry of Education, Science & Technology [MoEST], 2020a) was the first plan introduced by the government during the COVID-19 pandemic. This policy created five categories of student record systems. The categories were based on no access to any resources, access to radio, access to television, access to a computer, access to the internet and all resources. This categorization highlights the effort towards online learning. Similarly, the Student learning facilitation guideline 2020

has mentioned that there will be actions for developing and managing education portals, digital teaching materials, online technology and devices, and E-library (MoEST, 2020b). Furthermore, National Educational Policy 2076 made some provisions regarding ICT. It has devised several provisions under the policy in which it is mentioned that making teaching and learning ICT-friendly through developing technological infrastructure in schools and making ICT an integral part of education (MoEST, 2016).

### **Virtual Learning in Mathematics**

ICT-integrated pedagogy, as well as a practice-based mathematics curriculum, is the need of the 21<sup>st</sup> century to mitigate the challenges in mathematics learning. Integrating technology in lessons improves the learners' concepts and learning styles. The use of technology makes teachers more confident in teaching, and technological classrooms support the learners' learning (Bennison & Goos, 2010). New teaching-learning approaches containing modern technology are demanded by learners from school to university in the Nepalese context. During the period of COVID-19, most of the schools in urban areas started virtual classes in Nepal, and now it is not new to the students from school to university level.

Most of the students and mathematics teachers say, 'teaching mathematics through virtual mode is not effective.' Also, some of them believe that students cannot understand mathematics through online mode, and also, the teachers cannot teach effectively. In the context of Nepal, a few literature are available in the field of online learning in Mathematics. An experimental study was conducted in a virtual learning environment for engaged and interactive learning in higher education (Dhakal, 2019). The data collected with a survey questionnaire, achievement test, interview guidelines and Moodle database introduced that virtual learning environment contributed to meaningful mathematics learning at the university level. Also, the study revealed that virtual learning environments provided opportunities to engage in learning anytime and anywhere. Dhakal (2019) also recommended that VLE can be utilized in teaching higher mathematics courses with the critical judgment of the overall context. Similarly, Bhusal and Rimal (2020) emphasize the coordination of education governing authorities, electrical authority and telecommunication to make online classes more useful and accessible. Moreover, Kunwar et al. (2020) argue that most higher education institutions do not have enough preparation to support online pedagogy, online resources, digital library, learning requirements and competencies in the present context. In this regard, this study has aimed to compare the mathematics achievement of school students through face to face and virtual mode of learning.

#### **Hypothesis**

We developed the following hypothesis to obtain the goal of this study:

1. There is no significance difference between mathematics achievement of school students through virtual and face to face mode of learning.

### **Literatures**

#### **Theoretical Framework**

TPACK framework, described by Koehler and Mishra (2009) is the theoretical foundation of this study. The seven disjoint regions represent three knowledge domains; pedagogical content knowledge (PCK), technological pedagogical knowledge (TPK), technological content knowledge (TCK),

although the regions are disjoint, to understand the TPACK framework, one needs to know these seven regions in interactive ways. TPACK framework can be mentioned as below:

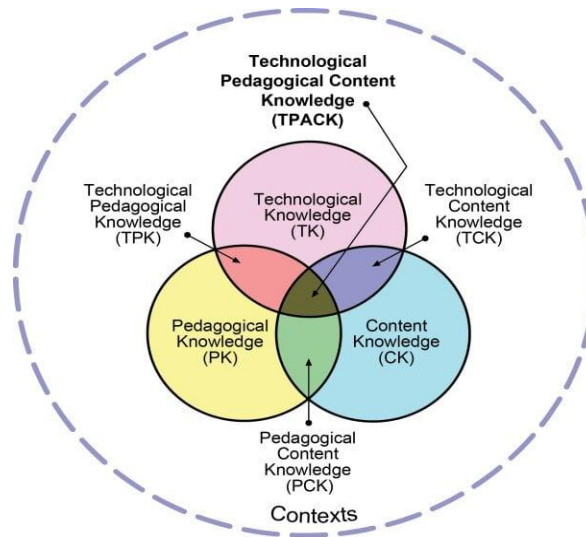


Figure 1. The TPACK Framework (Image from <http://tpack.org>)

Shulman (1986) has mentioned CK as the understanding of concepts, theories, practices, and approaches to the development of such knowledge. It means that CK is associated with knowing the subject matter to be learned or taught (Koehler & Mishra, 2009). It is obvious that if teachers do not have good knowledge of content, then students might develop misconceptions about the concepts taught by teachers. Therefore, for effective teaching, teachers need to be good at CK. Another component of TPACK is pedagogical knowledge. Pedagogical knowledge (PK) consists of knowledge of teaching methods, knowledge of learning theories, and knowledge of assessment approaches (Koehler & Mishra, 2009; Koehler et al., 2014). Thus, it is not limited to knowledge of teaching methods, but it also includes psychological aspects and approaches of evaluating students learning. In addition, it includes the skill of applying knowledge of these aspects in the classroom. The third component of the TPACK framework is technological knowledge (TK). Koehler et al. (2014) introduced TK as teachers' knowledge about technology that can be integrated into the curriculum. The term technology covers wide areas, from pencils and whiteboards to computers, the internet, and multimedia. However, TK in this framework is more associated with fluency in information technology in relation to its application in teaching learning (Koehler & Mishra, 2009). In this way, TK is the knowledge and skill of accomplishing tasks associated with teaching through the use of information technology.

### Empirical Literatures

In examining the impact of virtual manipulation in fraction learning at the school level, Mendiburo (2010) identified that students enjoyed virtual manipulation and completed more practical activities using virtual manipulation than physical manipulation. Also, regarding the efficacy of online

mathematics courses in California, Smith (2004) conducted a quantitative survey and found that the students who engaged in online mathematics courses obtained higher grades than their peers in the traditional classroom format. However, the rate of completion of students in online courses was lower than in general during the same period. Along the same line, Tucker et al. (2016) explored that an app can influence children's mathematical learning in various ways, including revealing, concealing and developing mathematical understanding. Regarding the perceptions toward virtual learning environment, Amrithesh and Jeayaram (2019) studied student's perceptions of virtual learning environment. It was a survey of 200 students from classes 8 to 12 who were learning math and science through virtual mode. The researchers concluded that 85% of students strongly agreed that VLE makes it easy for teachers to teach practical modules. And 70% of students strongly agreed that VLE has helped them to improve their mathematics and science scores. Also, the researchers focused that VLE helps the students to recollect the learning easily even after one month and helps them to understand a concept in a much better way as compared to traditional labs. In a quasi-experimental study by Moreno-Guerrero et al. (2020) at the high school level in Spain indicated that e-learning has a positive impact on students' mathematics learning, results as well and grades. The researchers concluded that e-learning in mathematics is effective in implementation for adult learners. Also, Castro et al. (2014) conducted experimental research on 300 children of the age group 7-10 years in Brazil and explored that virtual environment improved mathematics learning and it allowed the learners to integrate thoughts, feelings and actions in learning. The researchers also pointed out that the virtual environment motivated the learners and contributed to their intellectual development. Likewise, the experimental study entitled *The Effect of 3D Virtual Learning Environment on Secondary School third-grade Students' Attitudes toward Mathematics in Turkey* by Simsek (2016) revealed that there is a significant difference between the students' pre-experiment and post-experiment scores taken from the mathematics attitude scale. When the mean rank and rank sums of the difference scores are taken into account, this difference is in favour of the post-test score. According to these results, it can be stated that the Mathematics robot developed in the second life environment had an important effect on students' attitudes toward mathematics.

In an experiment on the influence of an app on the mathematics learning of school children in the USA, Tucker et al. (2016) explored that an app can influence children's mathematical learning in various ways, including revealing, concealing and developing mathematical understanding. However teachers should consider mathematical and technological distance. Correspondingly, Engelbrecht et al. (2020) focus on the use of digital technology to transform mathematics learning from the traditional push method from the research on South African students. The researchers also emphasize that technological development and communication that involves different computer platforms, e.g. LMS and social media, is a combination of icons, videos, regular writing, orality, images, graphs and video-clips that seems to bring a new consequence to mathematics learning.

In the context of Nepal, Parajuli (2016) investigated mobile learning practices among 161 undergraduates in Gorkha district. The survey questionnaire and semi-structured interview indicated that the majority of the students had a positive attitude towards mobile learning, although many of them were not satisfied with the effectiveness of their practices and the institutional support for using mobile devices for their learning practices. This study also recommended that the institutions and the teachers should provide appropriate guidance and support for using mobile devices to learn at a higher level. Similarly, Dhakal (2019) conducted an experimental study in the virtual learning environment for

engaged and interactive learning in higher education. The data collected with a survey questionnaire, achievement test, interview guidelines and Moodle database introduced that virtual learning environment contributed to meaningful mathematics learning. Also, the study revealed that virtual learning environments provided opportunities to engage in learning anytime and anywhere. He also recommended that VLE can be utilized in teaching higher mathematics courses with the critical judgment of the overall context. Most of the studies regarding virtual learning in the Nepalese context are based on quantitative surveys and qualitative studies, however, an experimental study is needed at the school level to examine the impact of virtual mode in mathematics learning.

## **Methodology**

### **Study Design**

This study has adopted quasi experimental research design. When the formation of randomized controlled group is not feasible and ethical, quasi-experiment is the best to examine cause and effect (Harris et al., 2006). Randomized controlled trial is considered to have a high level of credibility, although it is not always possible to randomize in the research of social sciences (Harris et al., 2006). White and Sabarwal (2014), state “Quasi experiment tests the causal hypothesis and identifies a comparison group that is as similar as possible to the intervention group in terms of baseline characteristics (pre-intervention)” (p. 1). In this study, randomization was not feasible due to the location of the students, their interest in the learning environment, the availability of electronic devices and the internet, as well as the other difficulties. It was not ethical to compel the learners to join virtual mode if they have neither computer nor smart smartphone in their home. On the other hand, the learners who are at a long distance from school and use the school bus to come and return cannot join virtual classes before or after school time. This study follows a non-equivalent group design, however, the groups were similar in number, average score and geographical area, as well as inclusive criteria.

### **Study Site, Population, Sample and Sampling**

This intervention was conducted in two similar schools in Birendranagar, Surkhet. Usha Bal Vatika Secondary School (UBVSS) and Children’s Paradise Secondary School(CPS) were selected purposively as the sample of this study. The intervention of 8 weeks (three days per week) was conducted to collect the required information. All the students of grade nine in the academic year 2079 of the sample schools were the participants of this study. There were 66 students in total as the participants in this intervention. We selected Children’s Paradise Secondary School (CPS) as the intervention school on the basis of the students’ interest and their home environment. There were altogether 33 students in grade 9 in the academic year 2079 in CPS. Similarly, we selected an equal number of students from Usha Bal Vatika Secondary School (UBVSS) as the comparison group. There were altogether 64 students in two sections. But, only 33 students from two sections of UBVSS were selected as the comparison group to make a similar with intervention group on the basis of BLE grade in mathematics and the score of pre-test. However, the classes were conducted equally in two sections in physical mode according to the daily routine of the school during intervention period. The groups were made similar on the basis of geographical area, number of teachers and students, physical infrastructure, educational environment, classroom environment, qualification, age group and teaching style of mathematics teachers.

### Tools and the Procedure of Data Collection

Mathematics Achievement Test (MAT) was the tool of data collection. Basic Level Examination (BLE) grade of mathematics was also observed to make the groups similar. Mathematics Achievement Test item was prepared on the basis of curriculum and specification grid prescribed by curriculum Development Centre (CDC), Nepal and finalized by piloting in different school and testing difficulty index and discrimination index. Same test item was used in both groups to conduct pre-test. After testing the significance difference between average achievements of two groups, the intervention of 8 weeks (24 teaching hours) was started. After completion the intervention, same test item (parallel to pre-test) was used to conduct post-test in intervention and comparison group with the help of mathematics teacher and the school administration. All the procedure of intervention was conducted in coordination and permission with mathematics teachers, students, guardians and the school administration.

### Procedure of Data Analysis and Interpretation

Collected data was analysed quantitatively by using SPSS Software. Mean, standard deviation and t-value were calculated and compared to test the null hypothesis. Independent sample t-test was used in testing hypothesis.

## Findings and Discussion

Both the intervention and comparison groups participated in the same achievement tests before and after the intervention. The test items were piloted and finalized on the basis of difficulty and discrimination indexes. Pre-test and post-test items contained altogether ten multiple-choice items, including knowledge, understanding and application level and six short questions from the knowledge level, two long questions from the application level and two very long questions from higher ability. Average Score, Standard Deviation and the Standard Error of Means of intervention and comparison group in pretest and posttest is mentioned as below:

**Table1**

*Average Score, Standard Deviation and Standard Error of Means of Intervention and Comparison Group in Pre-test and Post –test*

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pre-test (Int.)	7.90	33	4.39	.76
	Pre-test (Com.)	7.67	33	4.20	.73
Pair 2	Post-test (Int.)	23.09	33	10.89	1.89
	Post-test(Com)	17.88	33	8.66	1.50

Pair1 indicates the pair of intervention and comparison group in pre-test and pair 2 indicates the pair of intervention and comparison group in post-test. Table 1 indicates that the average scores of intervention and comparison groups in the pre-test are 7.90 and 7.67, and the difference between means is 0.23. This means there was no more difference in the pre-test, and the groups were similar. On the other hand, the average scores of intervention and comparison groups in the post-test were 23.09 and 17.88, and the difference between means was 5.21. This shows that the intervention group performed

better than the comparison group in the post-test. To examine whether the difference is significant or not, we used the paired sample t-test by SPSS 20 as follows:

**Table****2**

*Comparison between Intervention and Comparison Group with Respect to t-value*

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Pre-test (Int.) Pre-test (comp.)	.24	6.15	1.07	-1.93	2.42	.23	32	.82
Pair 2	Post-test (Int.) Post-test (comp.)	5.21	12.82	2.23	.67	9.76	2.3	32	.03

The table 2 specifies that p-value in the two-tailed case for 95% confidence level is 0.82, which is greater than  $\alpha$  value 0.05 in the case of pre-test ( $p = 0.82 > \alpha = 0.05$ ). So, the null hypothesis is accepted, and the difference between means was not significant in the pre-test. This means the groups were similar before starting the intervention.

In the case of the post-test, p-value in the two-tailed case for 95% confidence level is 0.03, which is smaller than  $\alpha$  value 0.05 ( $p = 0.03 < \alpha = 0.05$ ). So, the first null hypothesis, 'there is no significant difference between the average achievement of intervention and comparison group,' is rejected, and it concluded that the difference between the average *scores of* intervention and comparison group in the post-test was significant. This result shows that the learners who learned from virtual mode had better performance than the learners who learned from traditional face to face mode.

The finding of this study is similar to the finding of Hughes et al. (2007). In examining students' achievement and perception in virtual and traditional secondary mathematics classrooms, Hughes et al. (2007) found that online students consistently performed better than traditional students on algebraic understanding. They also found that online students felt a more supportive and motivated environment, and they could access quality mathematics content and skilled teaching. Hughes et al. (2007) also focused that increased access to virtual mathematics courses may provide more equitable and easy access to mathematics and increase mathematics literacy among children. In the same line, Heemskerk et al. (2014) examined the effect of interactive whiteboard (IWB) and virtual learning environment(VLE) combined on mathematics education. They further found that the mathematics performance of students in VLE was evaluated more positively, and VLE was useful for them. Also, the teachers and students were satisfied and benefited from the combined use of IWB and VLE. The researchers suggested that consistent use of VLE can increase the student's performance on mathematics.

In the context of Nepal, Dhakal and Sharma (2016) indicated that VLE provided an opportunity to learn, relearn and clarify mathematical concepts, and it can be the alternative way of learning to continue higher education in Nepal, however, the students were facing different problems. Likewise, the study by Subedi et al. (2022) on the effectiveness of online team-based learning for medical students at Gandaki Medical College found that online team-based learning was effective, and the

students were satisfied with online learning. Also, their study indicated that students had positive experiences, and they found the online sessions more interesting and better than traditional lectures.

It means that the researchers applied the TPACK framework (Koehler & Mishra, 2009; Koehler et al., 2014) to facilitate the learning through VLE mode. Principles of TPACK were followed from the planning of lessons to the implementation of plans. During teaching, the researcher fully prepared the content to be taught and modified her pedagogical approach by integrating technological tools such as Zoom whiteboard, Google Classroom, attractive PowerPoint, videos, polls, chat box, and Google Form and implementing in online classes to develop understanding and skills associated with the content. Thus, the virtual class was guided by the principle of the TPACK framework (Koehler & Mishra, 2009; Koehler et al., 2014), which in turn resulted in a higher achievement.

### Conclusion

This comparative analysis revealed that interactive virtual instruction incorporating tools such as real-time chat discussions, multimedia presentations, and digital manipulative produced higher learning outcomes than conventional teaching methods. This suggests that properly designed digital learning environments can not only match but potentially surpass traditional classrooms in effectiveness. The findings leads to the claim that virtual learning environment in mathematics can achieve parity with in-person instruction when two fundamental conditions are met: the instructional design prioritizes interactivity and engagement, and the learning ecosystem provides adequate technological and social support structures.

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