MATHEMATICS TEACHING RESEARCH JOURNAL
Spring 2023
Vol 15 no 2

A Case Study on Effectiveness of Online Teaching and Learning Mathematics: Teacher's Perspective

Rajendra Kunwar[1], Jagat Krishna Pokhrel[2], Baikuntha Khanal[3], Hari Prasad Sapkota[4]

[1]Mahendra Ratna Multiple Campus, Ilam, Nepal, [2]Sanothimi Campus, Bhaktapur, Nepal,

[3]Mahendra Ratna Campus, Kathmandu, Nepal, [4]Mahendra Ratna Multiple Campus, Ilam, Nepal

rajendrailam@gmail.com, jagatpokhrel.tu@gmail.com, khanalbaikuntha1@gmail.com,

hpsapkota11@gmail.com

Abstract: *The study on the effectiveness of teaching and learning mathematics online focused on teachers' perspectives on the experiences they face in real-life situations in the Nepalese context. This study examines the effectiveness of online mathematics teaching and learning in higher education during the COVID-19 pandemic. It is based on a qualitative exploratory case study design. The results of the study are based on the holistic views of eight persistently selected university mathematics teachers. It examines the effectiveness of teaching mathematics online covering four areas; teacher preparation and technological competence, the issue concerning students, access to resources, and the nature of mathematics. Teachers' technical competence and preparation for online lessons were rated as satisfactory. Similarly, student-related issues were found to be uncooperative and dependent on teacher guidance during online learning. Likewise, students were found to benefit according to their access to resources. Urban students have an advantage in online learning over remote students. Similarly, the results suggest that online math classes were perceived as difficult due to the nature of mathematics. Thus, the study concludes that higher-level online mathematics education has several determinants that make online mathematics education effective compared to face-to-face classroom instruction.*

Keywords: Nature of mathematics, Online teaching and learning, Teacher's perspective, Technological competency

INTRODUCTION

The teaching and learning process is considered to be started at the establishment of human civilization. In the early days, the Gurukul system of teaching was popular in Nepal. Gurukul is an educational system in which one is educated under the full guidance of a guru or teacher. The main aim of the Gurukul education system was to transform ethics, discipline, cultural values, and behaviors concerning religion through the teachers' role models. Religious and spiritual knowledge and real-life practice were the main parts of the study (Paudel, 2021). Gradually, changes have been made in the overall education system concerning the need and interests of the nation and its

citizen. In the present context, the process of teaching and learning has been accelerated due to the prevailing context, innovations in subject matter, and modern technology (Kunwar et al., 2022). It is a difficult job in an open inquiry environment the teacher requires a variety of proficiency skills (Milin Sipus et al., 2022).

The emergent use of information communication technology (ICT) has also transformed the whole education system. It has been changing society gradually from analogous systems to digital technology (Martin, 2020). It is also connecting globally and leading to transform the entire system, and the process of digitalization has also been inspiring to transform everything in the world (Schwab & Davis, 2018). The digital revolution has made human life easier, faster, and more independent (Bello et al., 2021), however, it has also been separating people from physical contact and characterizing them as more mechanical or instrumental (Khanal et al., 2022; Kunwar et al., 2022). This digital evolution has been compelling people to disconnect from the real world into the virtual world. Online teaching and learning refer to interactive activities for instance student-teacher interaction, student-student interaction, student-content interaction, and student-technology interaction to provide meaningful learning experiences for students through the online system (Turley & Graham, 2019). It is a pedagogical modification in knowledge transformation with the help of digital technology.

In the area of education, the advancement of technology has been seen reflected in the execution of ICT (Hernández et al., 2016), which directly affects the plans of training and instructional processes in the different stages of education (Moreno-Guerrero et al., 2020). All such innovations lead to new and better learning experiences, by means of creating new spaces in which they perform teaching practices (Li et al., 2019). Society is moving toward the utilization of technology in their daily life (Garzón et al., 2020). The use of technology in society has transformed into a new phase in the life of all human beings (Khanal et al., 2022). Various aspects of human activity for instance work, society, and education have been changed due to infrastructural development and technological support (López-Belmonte et al., 2020; Moreno-Guerrero et al., 2021).

In the case of mathematics teaching and learning, it requires sufficient interaction and feedback. Mathematics education intends to promote activities related to meaningful teaching and learning, inspiring students through advancing the regeneration of intended mathematical concepts (Milin Sipus et al., 2022). Online learning also ensures interaction by means of technological tools like human-computer interaction, different forums, PowerPoint, blogs, online discussion groups, podcasts, media, live chat, and visual communication (Beldarrain, 2006). However, such technological tools cannot be enough to make sure for the process of effective learning and interaction to teach mathematics online (MacLaren, 2014). This suggests the maximum utilization of student-teacher interaction to reduce the feeling of loneliness in online teaching and learning and assist them to exhibit the stepwise solving process of mathematics problems in a digital setting (Karal et al., 2015). In mathematics learning, there is no constant interaction, it is accounted as a crucial tool to understand the immediate learning environment and characterize the various facts,

whether technical, scientific, and/or social, that takes place in today's world (Williamson, 2018). The language of mathematics permits to clarify with detail and accuracy the phenomena that occur (Kartal & Caglayan, 2018) in the usual events of life, which makes it possible to change all these facts into logical information and knowledge (Yagci & Uluoz, 2018). It implies that mathematics can be considered an instrumental subject because it assigns the foundations for knowledge acquisition in other fields of education such as sociology or political science that are very important (Lewis et al., 2017). Likewise, mathematics allows for the development of the student's creativity, intelligence, entrepreneurship, autonomy, or the enhancement of self-esteem and extends to the social and environmental aspects (Paechter et al., 2017).

The use of digital technology in teaching is not a new event in higher education (Kopp et al., 2019). The academicians seem positive to adopt digital technology for making them competitive in the prevailing context, however, they are lethargic to adopt digital technology in practice (Flavell et al., 2019). The proper use of digital technology can enhance student motivation and self-efficacy (Zhang et al., 2021). Students' interest and awareness of digital technology can highly contribute to the effectiveness of online learning (Dhawan, 2020). The effective use of online learning also depends upon contextual factors such as the willingness of the learner, infrastructural development, access to digital devices, and the learning environment (Adhikari et al., 2022; Khanal et al., 2022). In the present context, several underdeveloped and developing countries are facing problems concerning utilizing online classes due to limited ICT-related infrastructural development, internet connection, and human resources (Adhikart et al., 2022; Pham & Nguyen, 2020). Similarly, the students are also facing problems due to limited learning space in their homes and a disturbed learning environment for online classes (Khanal et al., 2022; Zhang et al., 2021). Therefore, such managerial aspects, learning environment, and access to learning resources are creating problems in implementing effective online classes (Adarkwah, 2021; KC, 2020).

Most of the students in higher education in Nepal are still unfamiliar with online learning. In the meantime, the transformation of teaching and learning such as a change in approaches, assumptions, methodology, and overall practice to another method, system, and perspective generally hampers many students and teachers in their teaching and learning process (Devkota, 2021; KC, 2020). Teaching online at the university level requires more preparation technically and pedagogically with necessary online resources for both students and teachers (Khanal et al., 2022; Mishra et al., 2020). In teaching and learning mathematics, different software related to mathematics can help to teach and learn effectively but the training about using such software has not been given sufficiently to both teachers and students (Adhikari et al., 2022; Khanal et al., 2022). In addition, the non-availability of regular high-speed internet, electricity, a well-managed classroom, and sufficient e-learning materials that facilitate students and teachers to interact with each other during class also pose a major problem (Devkota, 2021; Khanal et al., 2022). The inaccessibility of the proper resources to the students has also been increasing the education gap (Adhikari et al., 2022; Kunwar et al., 2022). The students should be attentive to every mathematical

fact to develop new mathematical ideas for constructing new knowledge. Thus, the students should be regular, attentive, interactive, and motivated, however, the unstable electricity and an internet connection also have been causing the absence of the student in the online class.

LITERATURE REVIEW

In the Nepalese context, online teaching and learning can be considered a new experience. The rapid progression of technology helps to expand and offer online learning around the world and also makes it popular. Online learning is fully technology-based learning, so the growth of online learning depends on the development of technology. The use of online teaching and learning depends on accessibility, advancement in communication technologies, and other resources (KC, 2020; Mishra et al., 2020). The teacher should be completely familiar with how to use different software and online application for effective content delivery (Adhikari et al., 2022; Kunwar et al., 2022). It is one kind of pedagogical transformation in education. Thus, it forced us to rethink and redesign the total education system. Online teaching and learning has become a global avenue to assist students learning in a time of schools closing due to the COVID-19 pandemic. In Nepal, generally, schools and colleges are using different online web applications such as Zoom, Google Meet, Microsoft Teams, Skype, Viber, Messenger, WhatsApp, etc. to deliver the subject matter at a closer time of schools and colleges (Khanal et al., 2022). The proper situation for delivering online teaching and learning has not been prepared to this date in terms of the technological system, knowledge, and infrastructural development (KC, 2020). However, the repeated onsets of the COVID-19 pandemic compel the educational authority to adopt online teaching and learning forcefully. Thus, the full effort could not have been implemented for the effective delivery of the classes due to various causes such as poor physical infrastructures, different resources, and pedagogical viewpoints (Devekota, 2021; Kunwar et al., 2020). Likewise, student background, practices, teachers' traditional teaching habits, and school location have made it more challenging to implement online teaching and learning (Devekota, 2021; KC, 2020). Consequently, Devkota (2021) further states that the students who stay in the urban region and have well access to digital assets and internet services have more advantages in comparison to their rural colleagues and this condition has been generating a matter of inequality in the subject of quality, uniformity, equality, and validity. On the other hand, both the teachers and the learners are also low motivated and anxious to active participation in teaching and learning due to the fear and terror of the current COVID-19 pandemic situation.

Thus, online teaching and learning became a forced pedagogical shift from the conventional method to the modern approach due to the emergency of COVID-19 (Kunwar et al., 2022). It also forced the educational institution to provide teacher training for its implementation and to the government for the infrastructure development, connectivity of electricity, and extension of internet facility to get access for each learner in the country. In the diversified geopolitical condition of Nepal, there is no equal access to stable connectivity (Devkota, 2021; KC, 2020). Access to resources has a greater impact on virtual teaching and learning in higher education in

Nepal (Adhikari et al., 2022; Khana et al., 2022; Kunwar et al., 2020). In the same way, the unstable electricity and internet facilities hamper both the students and the teacher from their regular and active participation in learning (Adhikari et al., 2022; Kunwar et al., 2022). The facility of internet and electricity are mostly centered in rural areas (Devkota, 2021). Such disparity affects not only the implementation of online education but also impacts the widening of the education gap.

A survey report conducted in Indrawati Rural Municipality among school students and parents revealed that less than 10% of the students had access to the internet in their homes (Baral, 2022; KC, 2020). This scenario probably represents the existing condition of internet access in most of the rural areas of the country and access to digital devices as well (Dawadi et al., 2020; Laudari et al., 2021). An economic survey report of Nepal conducted in 2020 showed that 8366 schools have computers among the 29,707 public schools (MoF, 2020). Also, it is found that 12% of the public schools out of 29,707 found to be capable to offer information technology-based teaching with internet connectivity (Baral, 2022). The government of Nepal has already launched the National ICT policy 2015 focusing on developing ICT literacy through integrating ICT in classroom activities (MoCIT, 2015), and it was also emphasized in the school sector development plan 2016-2023 (MoE, 2016) to integrate and implement the current technologies into classroom practice (Joshi et al., 2021). However, the lack of infrastructural development, connectivity, and ICT-based teacher training, the proper implementation of ICT in the classroom has not been found satisfactory level (Rana et al., 2020). As reported by Adarkwah, (2021), people's feelings toward online learning, technological skills, and personal skills can hamper effective online learning. In the context of mathematics teaching, these constraints may or may not impact mathematics online classes however, student participation is a key influencing factor for their achievement in an online setting (Ayouni et al., 2021).

In Nepal, most urban private schools have been adopting the online teaching and learning approach as an excellent transitional remedy for the teaching and learning crisis produced by the pandemic (Khanal, 2020). Some of the urban public schools also have been implementing online as an alternative approach. All the universities have also provisioned an online teaching and learning system to deliver their courses (KC, 2020). Thus, most of the academic institutions in Nepal have started to teach an online mode to make it viable by replacing it as an alternative method to conventional teaching and learning approaches (Khanal et al., 2022; Paudyal, 2020). The immediate closedown of schools and colleges has enforced and also obliged the education institutions to think, manage, and organized a different process of education delivery and reforming pedagogy (Adhakari et al., 2022; Pokhrel & Chhetri, 2021). However, the sudden incident influenced each education policymaker, school principal, and teacher to rethink and look for an alternative to the face-to-face mode of instruction for assurance of children's education rights and enforced them to move fast toward the online mode of instruction (OECD, 2020). Almost educational institutions in Nepal have shifted forcefully into the online mode of teaching however

it was new practice and experience for many of the teachers and students (Adhikari et al., 2022; KC, 2020; Kunwar et al., 2022; Paudel, 2021).

On this backdrop, the article investigates the effectiveness of online teaching and learning mathematics at the bachelor's level concerning teachers' perspectives they face while implementing online teaching and learning during the time of the COVID-19 crisis. The study is mainly concerned with the lived experiences of teachers teaching online and face to face, their students' responses about the effectiveness of content delivery, and the transformation of learning through the online classroom. Specifically, it explores the self-assessment of the teacher about the effectiveness of online mathematics teaching, adopting technology into the online classroom, and their students' participation, progress, and responses. Considering the above prevailing context in mind, it provides insight into the real ground of online instruction at the university level in the crisis times of COVID-19. This research intends to identify the teachers' perspectives regarding teaching mathematics through the online mode in Nepal. The study is based on the following research questions:

i) What are the problems encountered by mathematics teachers in teaching mathematics online?

ii) What are the experiences of the teacher about implementing an online mode of teaching mathematics?

METHOD

This study is based on the teacher's perspective on the effectiveness of online mathematics teaching and learning. The study is centered on the descriptive research method with a qualitative research approach. It is based on a qualitative exploratory case study design depending on the responses of the mathematics teachers teaching mathematics classes at the bachelor level.

Participants

In this study research, purposive sampling was used to describe and interpret the teacher's perspective on the effectiveness of online teaching and learning mathematics at the bachelor level during the COVID-19 pandemic. In this study, eight mathematics teachers teaching at the bachelor level in the faculty of education, and humanities and social sciences, in Mahendra Ratna Multiple Campus Ilam, Mahendra Ratna Campus, Kathmandu and Sanothimi campus, Bhaktapur were chosen as the participants. One teacher of the management faculty who teaches statistics was chosen as the participant. Similarly, two mathematics teachers from the humanities and social sciences faculty and the remaining eight mathematics teachers from the faculty of education were chosen as the participants for the study.

The participants belonging to this study were based in the urban area of Ilam Municipality, Province 1, Kathmandu Metropolitan city and Bhaktapur, Bagmati Province. Also, there is a linkage between the participant and the background of the college students with whom the

participants deliver online teaching and interact with them. So the geophysical background of the student is directly linked with the feeling and perspectives of the participant. In this study, the participant interacts with the majority of students that come from the rural areas of Ilam and other neighboring districts. In recent years, a very low number of students are found to be admitted with majoring in mathematics in the overall college and universities in Nepal. This study is limited by the small sample size of mathematics teachers teaching at the bachelor level.

Participant	Teaching experience	Age	Workload	No. of Student
A	3 Yrs.	28 Yrs.	12 periods per week	11
B	16 Yrs.	37 Yrs.	24 periods per week	13
C	28 Yrs.	58 Yrs.	27 periods per week	10
D	18 Yrs.	40 Yrs.	24 periods per week	12
E	25 Yrs.	51 Yrs.	15 periods per week	14
F	22 Yrs.	48 Yrs.	12 periods per week	21
G	24 Yrs.	52 yrs.	12 periods per week	21
H	27 Yrs.	57 Yrs.	12 periods per week	24

Table 1: Participants Details

Instrument

In this study, the investigator used the in-depth interview as the instrument to explore the data about the case of the specific phenomenon. Since the study is based on a descriptive qualitative case study design, the teacher's perspective regarding online mathematics teaching and learning activities was explored by employing an in-depth interview. Thus, the data were based on the interviews of the teacher concerning their classroom experiences, students' participation, access to time and resources, and completion of class work of the students, etc. focusing on the holistic experiences of the mathematics teacher and what they face in the situation. The participants were interviewed based on the research questions regarding the effectiveness of online teaching and learning mathematics individually.

Data Analysis

The study uses the different stages of obtaining qualitative descriptive data before formulating the results as transcribing, initial coding, analyzing codes, identifying themes, and data presentation. The views of the participants regarding mathematics teaching online after transforming into consistent themes have been analyzed using some particular statements. Such self-reported views of the teacher about their classroom practice or online instruction can reflect the actual situation regarding the problems of teaching mathematics online in higher education. Thus, the actual

problems of online teaching mathematics were analyzed thematically on the basis of four themes. The process of analysis was rooted in the eight different participants' experiences, feelings, observations, and opinions about the actual practices and their differences in views on meaningful learning. It was especially focused on describing teachers' observations, perceptions, and self-practices in the classroom context. The details of the problems regarding mathematics teaching online are presented in Figure 1 as the thematic framework of the study.

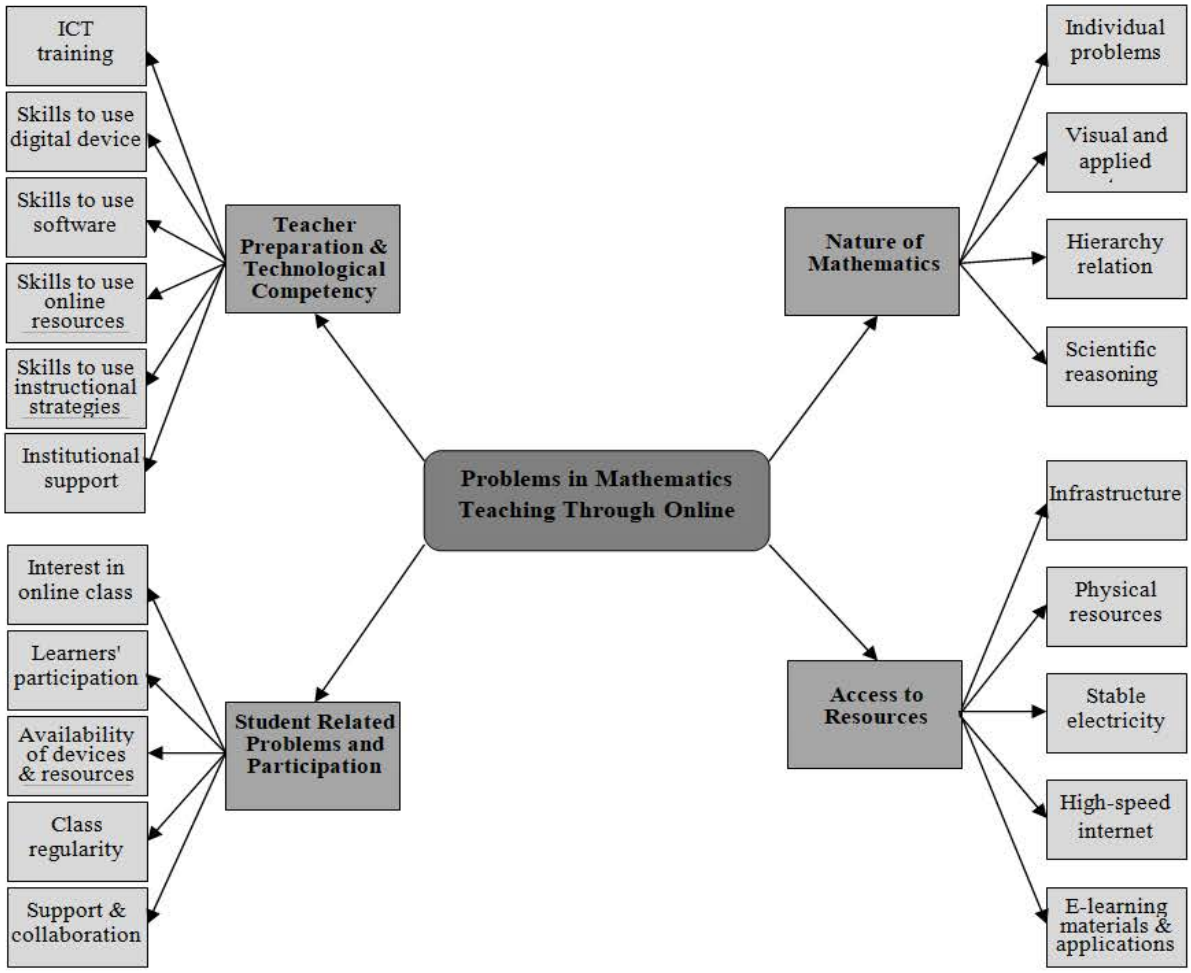

Figure 1: Thematic Framework

RESULTS

The results of the study are mainly based on the teachers' knowledge about their students' mathematics learning activities during online classes in three different faculties; humanity and social sciences, management and education such as student motivation level, collaboration and cooperation, student performance, class activity, class work, and the completed mathematical

tasks. The study mainly focuses on four main thematic areas based on various sub-themes. The results of the four thematic areas are discussed in separate headings.

Theme 1: Teacher Preparation and Technological Competency

Theme one illustrates how effectively the teachers prepared the lesson and implemented it by combining technological tools. This theme mainly focuses on the effectiveness of teacher preparedness and skill in delivering lessons in both synchronous and asynchronous formats. Teacher preparation and technological competency are the most essential aspects of the teacher for the effective execution of online teaching-learning. Teacher preparation for an online class is more time-consuming and skillful work in its place in a physical classroom setting. The teacher should have sufficient knowledge and skills regarding the use of new technologies and plan for instruction in innovative ways to carry on students engaged. Only expertise in the subject matter does not mean effective teaching, it requires professional knowledge for delivering content efficiently using technology. Mathematics teachers must have extensive expertise in teaching mathematics content and language to bring mathematics ideas live in online teaching (Khanal et al., 2022). Similarly, online lessons require teachers to have technical knowledge with content knowledge and educational content knowledge (Chand et al., 2020). The teacher's creativity with good communication skills is also an essential part of online teaching that can help the student to retain information and engage them more effectively. An online class allows live virtual instruction, online assignments, project work, and virtual activities that permit them to learn new things.

In this context, three participants shared their views: *"We all teachers do have not the same level of technological competency to use appropriate mathematical software as well as a basic skill of handling online class*es *while delivering subject matter. We are facing several difficulties regarding technical knowledge due to the absence of prior knowledge and skills in this field."* But the online teachers need to be perfect to handle online tools and technology so that they can help their students when they asked. Thus, the teacher should be up-to-date in both knowledge and skills regarding the use of the latest technology.

Likewise, concerning the skill-related topic that is based on different drawing, construction, and conceptual understanding, two participants viewed: *"Some topics that required more conceptual understanding and skill related topic like construction, it takes more time to teach through online class and also very difficult to make a clear concept about the topic than the physical class*." In virtual classes, the teacher should more dynamic and expert in the subject matter and way of interaction too. In such conditions, the teacher can perform the class in exciting ways to keep students engaged with skill-related problems. Sometimes they should go beyond the subject matter to support the students individually according to their needs, interest, and background.

In addition, at the beginning stages of the virtual class, the teacher should spend more time preparing different teaching resources. They should also engage in the teaching lesson, providing

support to the students, reviewing and clarifying the students' confusion about the contents. Since the use of online teaching is newly applied, thus the teachers are fully engaged to prepare their lessons.

In this regard, four participants expressed about over workload: *"The duration of 50 minutes physically single in a room and the over workload due to preparing resources and only virtual interaction sometimes makes very tedious while delivering the lesson."* An effective virtual class requires more preparation time, and dedication to build up the necessary skills for each teacher. An online teaching journey is a more patient and time-consuming task for each educator to get success in teaching.

On the other hand, most of the students studying at this level are from diverse locations. Particularly, in remote areas, there is not enough connection to electricity and the internet which also hamper both the students and the teacher to implement virtual teaching and learning. Even in urban areas, there is no stable electricity and internet connection.

The sudden change of delivering classroom learning from physical face-to-face to online mode of teaching has created big challenges for both students and teachers due to various causes such as access to devices, the internet, appropriate physical learning space, and the learner's habit of learning. Regarding unstable network connection and electricity, three participants said: *"It is more challenging. ……sometimes only the teachers are crying alone on their computers or smartphones. Their students have already disconnected due to either caused by electricity or internet connection."*

Online teaching at the university level needs more technical as well as pedagogical preparation to use effectively different online educational resources and applications. It is also necessary to make students able to do online activities, project work, and provide more opportunities to learn beyond the class activities. In this regard, six participants shared their views regarding low habituation, resources, and infrastructure: "…..*some students could not find themselves engaged in such tasks rather than making notes from the teacher's discussion and presentation. They found less engagement in virtual class rather than the physical class."* The learning environment shifted from classroom to home learning environment creates another concern for students. Due to no access to electricity or the internet and disrupted learning environments by noise and other disturbances, students' active participation in online learning can be hampered. Also, the habituation of physical classroom learning habits can cause feeling uneasy to adopt a new learning situation.

Theme 2: Student Related Problems and their Participation

Theme two depicts students' participation in online class learning in terms of attending class regularly, timely engagement in learning activities, and participation in discussion. There were several other student-related issues, such as Internet connectivity, digital devices, and resources

that also affected learner participation. Likewise, learners' readiness to learn, interest in online class participation, and support from the institution and parents are the necessary aspects of online teaching and learning. Online teaching and learning also require student collaboration such as peer collaboration, and student-teacher collaboration which makes student-centered learning (Chand et al., 2020). Concerning students' participation in online classes regularly and punctually, the participants expressed bitter experiences. Some student does not join the online class at a sharp time due to different causes like unstable electricity, the internet, or their interest. High levels of motivation of the student toward learning mathematics create more engagement opportunities in learning and hence help to improve students' skills and outcomes. Similarly, the unavailability of basic online resources and the appropriate personal learning space for the student at their home also make hamper attending timely and regular online learning activities.

In this regard, three participants shared their views: *"Some of the students mostly join late in the learning platform 'Microsoft Teams' and also irregular. These students generally do not participate actively in the learning process. Some students like to of their video and sound too, and we cannot observe their learning activity."*

The causes of interruption and irregularities can also depend upon the student's attitudes, skills related to the use of technology, and other external barriers. Students feeling toward online learning, loneliness, and limited access or no access to resources due to living in rural areas can also hinder them to participate actively in the online learning platform. In the issue related to students' active participation in the teaching-learning process in the online class, three participants expressed their views as such: *"The student who is irregular and always joins late in the learning platform has the same answer and always tries to escape from the teacher. Such students always lack discussion, class work, and doing exercise"*. Particularly, students from remote areas mostly do not present at online classes timely and regularly and the teacher cannot see physically what they are doing. Sometimes the teacher should wait for them a long time to ask and teach something related to the lesson.

In the same way, two participants expressed their views in different ways regarding the student's active participation in an online class: *"....self-directed and motivated students always take active participation in virtual class also, but the poor and lazy students try to avoid the class frequently". Even, they do not respond to the chat written by the teacher."*

The habituation of the traditional teaching style can have an impact on teaching and learning mathematics in online classes. In the physical class, students usually copy the problem solved by the teacher, and the teacher also uses the talk and chalk method. The student can feel difficulty in an online class to contact and interact with their teachers to seek help in the difficult learning concept and topics due to their habituation in the traditional physical face-to-face class. In this regard, three participants viewed: "…*the poor students often look passive or less engaged in learning mathematics. They mostly depend on their teachers or they put all of their focus on their*

teacher's activity and instruction. They like to listen to their teacher; they often do not like to collaborate in the learning activity."

They often like to express their queries orally. Most of the students do not communicate actively in an online class. The cause may be poor communication skills through technology or causes of low-speed internet and other obstacles. However, such obstacles led to challenges in interacting, communicating, and engaging for effective online classes.

Theme 3: Access to Resources

The third theme, access to resources mainly comprises four different aspects. 1) Access to physical resources such as a separate well-managed online classroom, and digital resources (personal laptop, Smartphone, and writing pad). 2) Access to stable electricity. 3) Access to stable high-speed internet. 4) Access to different e-teaching and learning materials and applications 5) Access to training for operating devices and different programs. Such access to resources can make the delivery of online teaching-learning easy and effective for both students and teachers.

In this regard, seven participants viewed personal digital resources: *"Most of the students do not have their laptop for the online class, and they use their Smartphone. They can listen to every activity properly but face difficulty in seeing figures, charts, and other small lettered presentations due to small screen."*

Some of the students located in remote areas have limited digital devices and also do not have access to stable electricity and internet facility.

In this concern, six participants shared the same experiences about access to electricity and internet facility: *"Very few classes have been conducted, joining with all the students throughout the class time. Otherwise, mostly, someone else has faced the problem of electricity, internet, low-speed internet, or internet connection problem. Such incident has been happening, sometimes only students are found discussing in the online class and the teacher could not join….."*

Generally, urban students have better access to digital devices and the internet. Most of the students in mathematics class are from remote areas, and they are from varied geographical locations.

On the topic, of student class absentees due to geophysical situations and other disturbances, four participants remarked: *"The incidental absence of the students in the online class also hampers the other students because the absent student asks about the previous lesson, and it is also necessary for the teacher to clear the previous class. So it takes more time to complete the current lesson."*

A large number of students from remote areas have been studying higher education. Some of the students still have out of reach to telephone and electricity.

In this regard, two participants argued: *"Sometimes, the internet does not work properly for 2-3 days and could not conduct the class. Particularly, in summer, the problem of unstable electricity creates more problems in online teaching and learning."*

In mathematics teaching and learning, access to different e-teaching and learning materials and the relevant software plays a significant role. However, due to the geographical location, it is also difficult to find timely such materials.

In this regard, four participants shared their views: *"...such e-learning material has a significant role in teaching and learning mathematics for the students who stay in the remote areas and the students of urban areas as well, however, we could not able to provide them such relevant resources and applications."*

Thus, it is comparatively more difficult for students from remote areas terms of getting resources and acquiring skills for using the online application than urban students.

Theme 4: Nature of Mathematics

The specific nature of mathematics comprises diverse disciplines and deals with the logical analysis of inferences, events, truth, and observations using different mathematical procedures and models. It is used to explore natural phenomena, human behavior, and complete social systems. It is considered a much more difficult task to work alone and self-study to grasp the mathematical concept. The nature of mathematics requires a high level of symbolic and schematic representation in mathematics education (Chand et al., 2020). Also, online education requires gestures and multimodal communication. Thus, it is necessary extra skills in handling mathematics classes for the teacher to create a proper learning environment when teaching online. The nature of mathematics is hierarchical and each topic is related to another. Each individual student also has difficulties with different concepts and problems related to mathematics. So well, conceptual knowledge of the subject matter is needed before moving to another topic. Also, mathematics has a visual nature and it is described as visual art. Hence, it is difficult to create a proper learning environment and address such nature of mathematics in remote teaching. Mathematics can learn effectively through group work and collaboration with face-to-face engagement due to its logical and skill-related nature. In this study, the theme, the nature of mathematics has been discussed on the student's individual problems regarding learning mathematics, the visual and applied nature of mathematics, hierarchical relation, and scientific reasoning.

Online learning has flexible characteristics, there is no need for a fixed time and schedule for teaching (Hassan & Mirza, 2020). In this concern, two participants expressed their views regarding the nature of mathematics. "…..*due to the abstract nature of mathematics, it is very difficult to make concentrate the students for learning mathematics. The teacher cannot pay equal attention to the students which distracts the weak and passive learner, and they lag behind day by day and only the active learner gets more chances and benefits from learning mathematics*." Most students

feel that learning mathematics a harder to work on individually, however, it is considered easier in group work.

On the other hand, the nature of mathematics is visual (Ní Fhloinn & Fitzmaurice, 2021). So they need to see as well as hear their learner properly to ensure when teaching and learning online. Direct one-to-one relation is necessary for effective learning of mathematics due to its abstract and applied nature. In this regard, two participants claimed that "*mathematics combines different models, theorems and applications to establish relations and solve different practical problems in different fields of education which necessitates one-to-one relations between the learner and the instructor. However, it is very difficult to establish one-to-one relationships with weak students in online classes. They usually do not ask questions or discuss the topic, and they only like to be a passive listener. It may be caused by the unavailability of proper learning space at their home."*

In mathematics, the development of some ideas is considered a fundamental aspect of the discipline and is regarded as very crucial. Equally, it is also difficult to create a learning environment to develop such ideas and knowledge by just talking in front of the laptop screen. Each and every topic of mathematics exist a hierarchical relation, the new topic can learn only after getting the complete knowledge and skill of the preceding one. In this regard, three participants argued: *Each topic of mathematics is so interconnected that no topic can be taught after getting the proper understanding of the previous one. Due to the irregularity of the students in the online class and the student's individual differences, it is very difficult to move to a new topic or very difficult to deal effectively with each next topic, especially for weak students. The continuation of the problem of hierarchical knowledge of mathematics has been increasing the gap between weak and smart students and de-motivating learning mathematics for weak students.*

Mathematics is a subject of scientific reasoning. Clear knowledge, skills, and ideas are needed for each mathematical term that enables the learner to think logically as well as critically. Scientific reasoning comprises different skills such as inquiry, experimentation, evaluation of the evidence, argumentation, and implication. Such skills help in the formation of concepts and theories regarding mathematics. It is also a capacity to understand and generation of scientific knowledge that is required in learning mathematics. In this concern, two participants argued that "*the study of mathematics underpins the use of inductive reasoning and axiomatic method, it begins with specific facts, symbols and particular applications following the universal laws. Individual students need logical thinking and scientific understanding that comes from interaction, logical argument, and cognitive resources while solving the problem. However, it is very difficult to manage such situations in an online class."* Thus, due to the nature of mathematics, each student should enable to understand and be familiar with each concept, statement, and procedure before solving such problems. However, most of the students have difficulties in solving such problems due to the absence of scientific reasoning skills.

DISCUSSION

The study has been carried out employing the explorative case study research design. So the evidence explored by the participants also supports the objective of the study and overall understanding of the situation. In this section, the results obtained from in-depth interviews are discussed on the basis of major themes and initial codes related to the teachers' perspectives.

The results based on the theme 'teacher preparation and technological competency' their expressions show that the unequal technological competency and basic skills of the teacher in handling the online class have been affecting effective online class delivery. As claimed by Panthi and Belbase (2017) empowering or disempowering the students in the classroom learning mainly depends on the teacher's pedagogical skill through their actions. Thus, it seems to improve the teachers' teaching skills to enhance effective online class delivery. Also, it may be the cause of the poor experience in using such technological tools in teaching mathematics (Adhikari et al., 2022; Rana, Greenwood & Fox-Turnbull, 2019). This may be the cause of creating low motivation in the students toward online teaching. However, teaching online possesses enough technological skills to access a range of technological tools and resources, teaching and learning capabilities, and limitations of the tools and technical potentiality for effective class delivery (Albrahim, 2020; Khanal et al., 2022). Similarly, the topics related to skills and conceptual understandings were found difficult to deliver effectively in class due to the absence of proper skills and time limitations (Khanal et al., 2022). Lack of such skill not only makes discomfort for the teacher but also creates low motivation for the students towards learning mathematics. This finding is consistent with the finding of Kunwar et al. (2022). So each teacher needs to be familiar with the use of software and different mathematical applications. Teachers are habitual to use a learning platform, Microsoft Teams but are not perfect to use different mathematical software to teach mathematics (Kunwar et al., 2022). Also, as concluded by Joshi et al., (2020) university-level teachers have less practice in online teaching. The majority of the participants' views correspond to over workload due to preparing materials and multiple roles and responsibilities. Conversely, the over workload of the teacher affects the delivery of quality education focusing on the needs of learners (Pacaol, 2021). This saying also shows that the teachers are also feeling bored and are not curious about their job. In such a situation, the teacher cannot entertain delivery spontaneously and cannot deliver the subject matter effectively.

The participants' responses regarding unstable network connections and electricity, it has also been creating a major problem to conduct the online class. According to Devkota (2021), different students from rural areas of Nepal are still experiencing disconnection from higher education due to not having the required physical infrastructure of electricity and internet access. Thus, the unavailability of high-speed internet and electricity has also been creating problems in the effective delivery of online classes (Adhikari et al., 2022; Dawadi et al., 2020; Baral, 2022; Khanal et al., 2022; Laudari et al., 2021). Therefore, it is necessary to focus on infrastructural development and extension to remote areas with a high-speed and stable internet connection to address the problem.

The results obtained from the theme 'student participation in online class have been discussed focusing on regularity, punctuality, engagement in-class activities, and participation in discussion. Mathematics education is an interesting, relevant, and applicable subject (Milin Sipus et al., 2022). So the participation of the student in the virtual class is considered most important because it reinforces the teacher for effective teaching and also enables the students to acquire more knowledge and skills through the discussion between teacher and students, more engagement in the classroom, and sharing the idea among them. So, the students should be observed regularly, whether they are interacting with each other during the class or not. However, the result is found opposite. Student interaction in online classes was found comparatively low. This finding is similar to the finding of Khanal et al. (2022) and Mamolo (2022) that students do not take part actively in online classes while teaching abstract mathematical concepts.

In the case of the students' punctuality and regularity, it is found that some of the students do not take part actively, i.e. some join late, try to escape to participate in class discussion, and do not take part in class work an online class. Therefore, encouragement to the student is needed to create a conducive learning environment that stimulates the student to be actively involved in the classroom (Bringula et al., 2021). According to Milin Sipus et al., (2022), the teacher creates numerous creative moments by generating opportunities and challenges to make their learner able to face the situation and to support the productive exchange of mathematical ideas. Similarly, it is difficult to increase cognitive as well as behavioral participation in virtual classes in comparison to the face-to-face real classroom setting (Kunwar et al., 2022). In terms of student punctuality and regularity, similar results are observed by Yusuf and Al-Banawi (2013) and Bringula et al. (2021) that there are some obstacles in the process of online learning, such as less motivation, delayed feedback, sometimes not available of the teacher or student in class and isolation feeling due to lack of physical face-to-face class. Novljan & Pavlin (2022) argued that the student can acquire new knowledge and skills outside the physical class too. It indicates that students can be taught effectively by creating an inspiring learning environment in an online class.

The habituation of the teacher in traditional teaching and learning has found an impact on both students and teachers in online teaching. Traditionally with teacher-centered learning habits, students were also found to be passive and dependent on their teacher (Poudel, 2021). They were also found to prefer the traditional teacher-centered method to collaborative learning. It may be the postback effect of traditional learning. Similarly, teachers were also found the same (Kunwar et al., 2022). This may be caused by low levels of technical skills and a lack of collaboration among themselves both the students and teachers regarding online teaching and learning. According to Sun et al., (2017), habit is the human characteristic that acts to make easy our cognitive load while making the decision. So it will come spontaneously while performing the behavior.

The results of the theme 'accesses to resources' have been discussed in different four aspects: access to physical resources, stable electricity and stable high-speed internet, and different e-teaching learning materials and applications. The result shows that every student has no personal computer,

and they use their Smartphone in online classes. So, they can listen to the teacher in the class but do not take part actively in the learning process (Kunwar et al., 2022). On the other hand, access to electricity, internet facility, geophysical situation, and other disturbances have been found to create problems of irregularity and absence for both student and teacher which cause to hamper the effectiveness of delivering the online class (Devkota, 2021; Poudel, 2021). This also confirms the result of (Adhikari et al., 2022; Khanal et al., 2022). Thus, online teaching was found more time-consuming due to frequent revising of the lesson for an absent student who could not attend the class by unstable electricity or the internet. On the other hand, it is a very tedious process due to unnecessary hurdles like unstable internet and power supply (Kunwar et al., 2022). The students in urban areas who have better access to resources are getting more benefits; conversely, the students in remote areas who have low or no access to resources are losing their opportunities. This result also conforms to the results of Devlota (2021) and Adhikari et al., (2022) that the students who stay in an urban location and have access to the internet, electricity, and resources have benefitted more than the rural students. The inaccessibility of such resources to students has been increasing their gap in education ((Kunwar et al., 2022; Poudel, 2021). Therefore, as suggested by Lin et al, (2021), more attention should be given to the learners in online learning to address their needs and enhance the value of overall learning (Lin et al., 2021). It was also found that students have been facing difficulty to study at their home due to the improper learning environment such as small spaces, noise, and distractions (Baticulon et al., 2021). Thus, it is a great consideration about selecting the best method of teaching mathematics online that can support successfully and bridge the gap between the learners.

In the theme nature of mathematics, individual problems of the students in learning mathematics, the visual and applied nature of mathematics, hierarchy, and scientific reasoning were discussed. It was found that online learning has been creating a gap between learners. Also, it was found very difficult to make the concentration on the weak learner due to the abstract nature of mathematics. This result is similar to the result of Ní Fhloinn & Fitzmaurice (2021) that teaching mathematics remotely is much harder and also difficult to address the weak student. The nature of mathematics is visual and can be taught effectively through creating one-to-one relations with the students. The result showed that it was very difficult to treat individually the student in an online class in comparison to a physical class. This result also confirms the results of Ní Fhloinn & Fitzmaurice (2021). They claimed that students do not learn mathematics effectively only through self-study, but they need individual support in each step while solving problems. Each topic of mathematics exists in a hierarchical relationship, and no one can learn the next topic without acquiring the knowledge and skills of the previous topic. In this regard, it was found that irregularity in the class due to various causes like electricity, unstable internet, and the student's motivation toward learning online class has been disturbing learning mathematics effectively and the student absenteeism in a single class has been affecting the next class or topic due to hierarchical nature of mathematics (Ní Fhloinn & Fitzmaurice, 2021). This result also aligns with the results of Khanal et al., 2022: Devkota, 2021). Also, the scientific reasoning which is applied in mathematics

learning is found difficult to develop in the learners through online learning. Because, scientific reasoning can be developed through interaction, observation, and logical argument in the group which is difficult in online mode. This result also aligns with the results of Ní Fhloinn & Fitzmaurice (2021).

CONCLUSION

The pandemic situation emerged by COVID-19 has caused the closure of educational institutions and shifted the physical face-to-face teaching-learning into virtual classes. In this situation, there are two options, either close the institution or implement online teaching and learning. It was a sudden change in pedagogy or a force paradigm shift in teaching and learning (Kunwar et al., 2022). It is a more complex task to manage and conduct effectively in the current pandemic situation. This paper has attempted to find out the effectiveness of online teaching and learning mathematics in higher education. This study has explored the results through the mathematics teachers' viewpoint that what they exactly face in the situation.

The study extracts the conclusion from the four thematic areas of teacher preparation and technological competency, student-related problems and their participation, access to resources, and the nature of mathematics. Since the change in pedagogy is sudden then, the condition of teacher preparation and technological competency in terms of ICT-related skill and knowledge was not found high. Student participation in online learning was also found less engaged in learning mathematics and mostly dependent on the teachers' activity and instruction. They were found more engaged in individual tasks, but with less effort in collaborative work. Similarly, there is greater variation in terms of access to resources between the students of remote areas and urban areas. Most urban students found benefited more due to the access to electricity, the internet, and other e-teaching and learning materials and mathematical applications than the students of remote areas. According to Albrahim (2020), online teaching entails trained and skillful teachers, especially in mathematics due to its nature. However, the study found a gap in technological knowledge and skills among the teachers for an online class in higher education in Nepal. The results, thus obtained, can be specified for the initial understanding due to incorporating the small size of the sample and the single dimension of the data. Thus, the result demands a more in-depth study involving a large sample size and multi-perspective for more generalizable results. Thus, the study concludes on the basis of the insights drawn out from the mathematics teacher teaching online mathematics at a higher level of mathematics has not been executed effectively in comparison to physical face-to-face classroom teaching.

Similarly, the study recommends that teachers need to have continuous professional training to acquire the proper knowledge and skill in using different mathematical software for effective virtual class delivery. Deliberate and consistent efforts should be made by the teachers to attract the students to the virtual class and to make them more active, engaged, and keep continuing their

participation and collaboration in the class and beyond. Infrastructural development and connectivity should be developed for stable electricity and the internet.

Conflict of Interest

It is declared that the authors have no conflict of interest.

References

[1] Adarkwah, M. A. (2021). I am not against online teaching, but what about us?: ICT in Ghana post COVID-19. *Education and Information Technologies*, *26*(2), 1665-1685. https://doi.org/10.1007/s10639-020-10331-z

[2] Adedoyin, O. B., & Soykan, E. (2020). Covid-19 pandemic and online learning: the challenges and opportunities. *Interactive Learning Environments, 28*(0), 1–13. https://doi.org/10.1080/10494820.2020.1813180

[3] Adhikari, K. P., Joshi, D. R., & Sharma, K. P. (2022). Factors Associated with the Challenges in Teaching Mathematics Online During COVID-19 Pandemic. *Contemporary Mathematics and Science Education, 3*(2), ep22014. https://doi.org/10.30935/conmaths/12225

[4] Albrahim, F. A. (2020). Online teaching skills and competencies. *The Turkish Online Journal of Educational Technology, 19* (1), 9-20. https://doi.org/10.26529/cepsj.895

[5] Baral, R. (2022). The Digital Divide in Online Learning: A Case Study of University Students in Nepal. *Prithvi Academic Journal, 5*(), 88-99. https://doi.org/10.3126/paj.v5i1.45043

[6] Beldarrain, Y. (2006). Distance Education Trends: Integrating new technologies to foster student interaction and collaboration. *Distance Education, 27*(2), 139-153.

[7] Booren, L. M., Downer, J. T., & Vitiello, V. E. (2012). Observations of Children's Interactions with Teachers, Peers, and Tasks across Preschool Classroom Activity Settings. *Early education and development*, *23*(4), 517–538. https://doi.org/10.1080/10409289.2010.548767

[8] Bringula, R., Reguyal, J. J., Tan, D. D., & Ulfa, S. (2021). Mathematics self-concept and challenges of learners in an online learning environment during COVID-19 pandemic. *Smart Learn. Environ, 8*(22), 1-23. https://doi.org/10.1186/s40561-021-00168-5

[9] Buelow, J. R., Barry, T., & Rich, L.E. (2018). Supporting learning engagement with online students. *Online Learning, 22*(4), 313-340. https://doi.org/10.24059/olj.v22i4.1384

[10] Chand, V.S., Deshmukh, K.S. & Shukla, A. (2020). Why does technology integration fail? Teacher beliefs and content developer assumptions in an Indian initiative. *Education Tech Research Dev 68*, 2753–2774. https://doi.org/10.1007/s11423-020-09760-x

[11] Dawadi, S, Giri, R., & Simkhada, P. (2020). *Impact of COVID-19 on the education sector in Nepal-challenges and coping strategies*. Sage Submissions. Preprint. https://doi.org/10.31124/advance.12344336.v1

[12] Devkota, K. R. (2021). Inequalities reinforced through online and distance education in the age of COVID-19: The case of higher education in Nepal. *International Review of Education, 67*, 145–165. https://doi.org/10.1007/s11159-021-09886-x

[13] Dhawan, S. (2020). Online learning: A panacea in the time of COVID-19 crisis. *Journal of Educational Technology Systems*, *49*(1), 5-22. https://doi.org/10.1177/0047239520934018

[14] Flavell, H., Harris, C., Price, C., Logan, E., & Peterson, S. (2019). Empowering academics to be adaptive with eLearning technologies: An exploratory case study. *Australasian Journal of Educational Technology*, *35*(1), 1-15. https://doi.org/10.14742/ AJET.2990

[15] Garzón, E., Sola, T., Ortega, J. L., Marín-Marín, J. A., & Gómez, G. (2020). Teacher training in lifelong learning: The importance of digital competence in the encouragement of teaching innovation. *Sustainability*, *12*(7), 2852. https://doi.org/10.3390/su12072852.

[16] Hassan, M. M., & Mirza, T. (2020). Perspective of students regarding online learning during the COVID-19 Pandemic. *Tathapi, 19*(35), 235-245.

[17] Hernández, R., Fernández, C., & Baptista, P. (2016). *Metodología de la Investigación*, 6th Ed.; MC Graw Hill Education: Mexico.

[18] Joshi, O., Chapagain, B., Kharel, G., Poudyal, N. C., Murray, B. D., & Mehmood, S. R. (2020). Benefits and challenges of online instruction in agriculture and natural resource education. *Interactive Learning Environments,* 1–12. https://doi.org/10.1080/10494820.2020.1725896.

[19] Karal, H., Kokoc , M., & Yalcin, Y.(2015). A case study on online mathematics teaching with pen-based technology: Experiences of two instructors. *Contemporary Educational Technology, 6*(4), 319-337.

[20] KC, T. (2020). Impact of covid-19 on university education, Nepal. *Tribhuvan University Journal 35*(2), 34-46. https://doi.org/10.3126/tuj.v35i2.36187

[21] Khanal, B., Joshi, D. R., Adhikari, K. p., & Bishowkarma, A. (2022). Factors associated with the challenges in teaching mathematics online during COVID-19 Pandemic. *International Journal of Education and Practice, 10I*(3), 237-254. https://doi.org/10.18488/61.v10i3.3097

[22] Khanal, P. (2020). Lived experience of online teaching during the COVID-19 pandemic: implications for curriculum and teaching. ***Interdisciplinary Research in Education, 5*(1), 89-102.** https://doi.org/10.3126/ire.v5i1&2.34738

[23] Konya, E., & Kovacs, Z. (2022). Management of problem solving in a classroom context. *Center for Educational Policy Studies Journal, 12*(1), 81-101.

[24] Kopp, M., Gröblinger, O., & Adams, S. (2019). Five common assumptions that prevent digital transformation at higher education institutions. *Inted2019 Proceedings*, *1*, 1448-1457. https://doi.org/10.21125/inted.2019.0445

[25] Kunwar, R., Poudel, K. K. & Shrestha, A. K. (2020). Online education as a new paradigm for teaching and learning in higher education in Nepal: Issues and challenges. *Global Scientific Journal, 8*(8), 208-219.

[26] Kunwar, R., Shrestha, A. K., & Phuyal, S. P. (2022). The impact of force paradigm shift in teaching and learning higher education in Nepal: A study on behavior perspective. *European Journal of Education and Pedagogy, 3*(2),12-17. https://doi.org/10.24018/ejedu.2022.3.2.270

[27] Laudari, S., Pradhan, S., & Lama, S. (2021). Remote teaching in Nepalese higher education during COVID-19 : Teachers' perspectives. *Higher Learning Research Communication*, *11*(2), 91-110. https://doi.org/10.18870/hlrc.v11i2.126

[28] Li, S., Yamaguchi, S., Sukhbaatar, J., & Takada, J. (2019). The influence of teachers' professional development activities on the factors promoting ict integration in primary schools in Mongolia. *Educ. Sci.*, *9*(2), 78-86. https://doi.org/10.3390/educsci9020078

[29] Lin, CL., Jin, Y. Q., Zhao, Q. et al.(2021). Factors influence students' switching behavior to online learning under COVID-19 Pandemic: A push–pull–mooring model perspective. *Asia-Pacific Edu Res 30*, 229–245. https://doi.org/10.1007/s40299-021-00570-0

[30] López-Belmonte, J., Marín-Marín, J. A., Soler-Costa, R., & Moreno-Guerrero, A. J. (2020). Arduino advances in web of science: A scientific mapping of literary production. *IEEE Access*, *8*, 128674-128682. https://doi.org/10.1109/ACCESS.2020.3008572.

[31] Maclaren, P. (2014). The new chalkboard: The role of digital pen technologies in tertiary mathematics teaching. *Teaching Mathematics and Its Applications, 33*(1), 16-26.

[32] Mamolo, L. A. (2022). Online learning and students' mathematics motivation, self-efficacy, and anxiety in the: New normal. *Education Research International, 9439634,* 1–10. https://doi.org/10.1155/2022/9439634

[33] Milin Sipus, Z., Basic, M., Doorman, M., Spalj, E., & Antolis, S. (2022). MERIA – Conflict lines: Experience with two innovative teaching materials. *Center for Educational Policicy Studies Journal, 12*(1),103-124. https://doi.org/10.26529/cepsj.987

[34] Mishra, L., Gupta, T., & Shree, A. (2020). *Online teaching-learning in higher education during lockdown period of COVID-19 Pandemic. International Journal of Educational Research Open,1(), 100012.* https://doi.org/10.1016/j.ijedro.2020.100012

[35] MoCIT. (2015). National information and communication technology policy 2015. *Ministry of Communication and Information Technology, Government of Nepal*. https://doit.gov.np/en/resources/1

[36] MoE. (2016). School sector development plan 2016-2023. *Ministry of Education, Nepal*. http://www.moe.gov.np/assets/uploads/files/ MOE_SSDP_Final_Document_Oct_2016.pdf

[37] MoF. (2020). Economic survey 2019/20. *Ministry of Finance*. https://www.mof.gov.np/uploads/document/file/Economic%20Survey%202019_20201125024153.pdf

[38] Moreno-Guerrero, A. J., López-Belmonte, J., Marín-Marín, J. A., & Soler-Costa, R. (2020). Scientific development of educational artificial intelligence in web of science. *Future Internet*, *12*(8), 124. https://doi.org/10.3390/fi12080124

[39] Ní Fhloinn, E., & Fitzmaurice, O. (2021). Challenges and opportunities: experiences of mathematics lecturers engaged in emergency remote teaching during the COVID-19 Pandemic. *Mathematics, 9,* 2303. https://doi.org/10.3390/math9182303

[40] Novljan, M., & Pavlin, J. (2022). Experiences of Slovenian in-service primary school teachers and students of grades 4 and 5 with outdoor lessons in the subject science and technology. *Center for Educational Policy Studies Journal, 12*(1), 189-215. https://doi.org/10.26529/cepsj.919

[41] OECD (2020). *Strengthening online learning when schools are closed: the role of families and teachers in supporting students during the covid-19 crisis*. http://www.oecd.org/termsandconditions

[42] Pacaol, N. (2021). Teacher's workload intensification: A qualitative case study of its implications on teaching quality. *International Online Journal of Education and Teaching (IOJET), 8*(1). 43-60.

[43] Paudel, P. (2021). Online education: Benefits, challenges and strategies during and after COVID-19 in higher education. *International Journal on Studies in Education, 3*(2), 70-85.

[44] Paudyal, G. R. (2020).Online classes as a paradigm shift in teaching and learning culture. *Prithvi Academic Journal*, Special Issue COVID-19 & Beyond, 52-60. https://doi.org/10.3126/paj.v3i1.31285

[45] Pham, T., & Nguyen, H. (2020). COVID-19: Challenges and opportunities for Vietnamese higher education. *Higher Education in Southeast Asia and Beyond*, *8*, 22-24. https://doi.org/10.2/JQUERY. MIN.JS

[46] Pokhrel, S., & Chhetri, R. (2021). A literature review on impact of covid-19 pandemic on teaching and learning. *Higher Education for the Future*, *8*(1), 133-141. https://doi.org/10.1177/2347631120983481

[47] Rana, K., Greenwood, J., & Fox-Turnbull, W. (2020). Implementation of Nepal's education policy in ICT: Examining current practice through an ecological model. *Electronic Journal of Information Systems in Developing Countries*, *86*(2). https://doi.org/10.1002/isd2.12118

[48] Schwab, K. & Davis, N. (2018). *Shaping the future of the fourth industrial revolution*. Currency, New York.

[49] Sun, Y., Liu, D., Chen, S., Wu, X., Shen, X. L., & Zhang, X. (2017). Understanding users' switching behavior of mobile instant messaging applications: An empirical study from the perspective of push-pull-mooring framework. *Computers in Human Behavior, 75*, 727–738

[50] Turley, C. & Graham, C. (2019). Interaction, student satisfaction, and teacher time investment in online high school courses. *Journal of Online Learning Research, 5*(2), 169-198.

[51] Yusuf, N., & Al-Banawi, N.(2013). The impact of changing technology: The case of e-learning. *Contemp. Issues Educ. Res, 6,* 173–180.

[52] Zhang, J., Chen, Z., Ma, J., & Liu, Z. (2021). Investigating the influencing factors of teachers' information and communications technology-integrated teaching behaviors toward "learner-centered" reform using structural equation modeling. *Sustainability (Switzerland)*, *13*(22), 12614. https://doi.org/10.3390/su132212614.