Mathematics Teachers' Reflection on Essential Digital Skills and Techniques for Effective Online Mathematics Instruction

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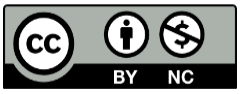
Published: December 2022

DOI:
https://doi.org/10.3126/ed.v32i1.61571



Journal
Education and Development

ISSN: 1816-7691 (Print)
3021-9558 (Online)

Website:
https://www.nepjol.info/index.php/ed

Published By
Research Centre for Educational Innovation and Development (CERID)
http://www.cerid.tu.edu.np

Abstract

Digital skills are necessary to integrate novel technologies in instructional practices of each subject including mathematics. The aim of this research was to explore the necessary skills for teaching mathematics and practical ways to teach mathematics online. The qualitative survey design was used among 277 mathematics teachers in Nepal through open questionnaires using Google Form. The list-based sampling strategy was used to collect the data. The results were analyzed by using word cloud and descriptive methods. The findings indicate that every mathematics teacher should have skills in using different tools like video conferencing, collaboration, subject-specific software, visualization, and LMS. Furthermore, an access to the internet, digital devices, and resources is necessary for all teachers and students in this age. Skill development, use of novel instructional activities, use of digital tools, resource management, and development, collaboration, and communication are the key areas of mathematics teachers for effective teaching online.

Keywords: collaboration, digital resources, digital skills, mathematics, software

Introduction

Technology has several benefits in instructional practices and other settings (Belbase et al., 2022; Joshi et al., 2019; Joshi, Adhikari, et al., 2022; Joshi, Khanal, et al., 2022; Joshi, Singh, et al., 2021; Joshi & Rawal, 2021; Joshi & Singh, 2020; Khanal et al., 2021; Neupane et al., 2020). Hence teachers' reflections were reported for effective mathematics learning online in this research. Reflection can be used to explore the depth of knowledge and enable to take a step back and review their entire learning process (Chang, 2019). Additionally, reflection can

To cite this article (APA):

Khanal, B., Joshi, D. R., & Sharma Chapai, K. P. (2022). Mathematics teachers' reflection on essential digital skills and techniques for effective online mathematics instruction. *Education and Development*, *32*(1), 79–92. https://doi.org/10.3126/ed.v32i1.61571

provide a framework for organizing learning facilitating ideas and theories to permeate practice. Further, it helps to foster ongoing thought and invention simultaneously (Helyer, 2015). Mathematics teachers' reflective thinking plays a major role in the achievement of objectives of mathematics education, solutions to issues in mathematics teaching, and the assessment of their classroom experiences (Aldahmash et al., 2021).

Global technology advancements and subsequent reform efforts have made a significant impact on educational systems (Ghory & Ghafory, 2021; Joshi, 2017). As a consequence technology is now highly prevalent in learning environments (Morozov & Kozlov, 2020). The rising level of technology application in every sector and changing status make it a compulsion to seek a solution to the issues in education and highlight online education as an alternative to the current practices (Adhikari et al., 2022; Khanal, Joshi, Adhikari, Khadka, et al., 2022). Many countries including Nepal announced the promotion of online and technology-based education during the COVID-19 pandemic (Dawadi et al., 2020; Belbase et al., 2022; Joshi, Adhikari, et al., 2022; Khadka et al., 2022). The government of Nepal, Ministry of Education, Science and Technology gave the direction to all the educational institutions to run their teaching and learning activities online. Almost all universities of Nepal made policies to run online classes and act with their policies. Universities and schools ran their classes through various digital tools such as Microsoft Teams, Zoom, Google Meet, What's App and others. The secondary schools having appropriate digital resources could be able to run their classes online. However, those schools having lack of digital resources were facing different troubles (Joshi & Rawal, 2021) like skillful human resources, internet access, digital resources, related infrastructure and others (Khanal, Joshi, Adhikari, Khadka, et al., 2022). Government of Nepal has begun to integrate technology into education through by ongoing policies the School Sector Development Plan (SSDP) 2016–2023 (MoE, 2016) and the Digital Nepal Framework (MoICT, 2019). However, it does not seem to have been implemented properly. The previous studies show that less access to electronic devices (Dawadi et al., 2020), less numbers of computers in community schools (MoF, 2020), lack of internet access at school and home (Ghimire, 2020), limited ICT infrastructure, and human resources (Joshi, Chitrakar, et al., 2021; Pham & Nguyen, 2020; Rana et al., 2020) are key issues of online learning in the context of Nepal. These glimpses were seen due to the lack of planning and preparation which added to the problem in online teaching. Despite these, problems were encountered during the pandemic while teaching mathematics such as monitoring and controlling unnecessary noise, internet access and tools used for taking online classes in mathematical content (Adhikari et al., 2022). Students' engagement during online learning is another issues faced by teachers (Chin et al., 2022). Hence, teachers need additional digital resources to

integrate various resources, as well as periodical trainings for their professional development in online techniques for teaching mathematics (Martínez et al., 2020).

The best predictor of student learning and preserving consistency in student learning is student involvement, which is a significant aspect in determining student achievement in an online environment (Ayouni et al., 2021). Both teachers and students should have access to technical support (Osman, 2005). Additionally, Schrum et al. (2005) recommend that students have access to an online orientation to become familiar with online course features like chat rooms, discussion forums, and working with PDFs and document files. In order to achieve high quality in online distance learning, online courses should incorporate a variety of content exploration and delivery techniques, such as synchronous and asynchronous learning activities (Joshi et al., 2019; Liu et al., 2010; Neupane et al., 2020), compressed videos, presentation slides, video lectures, website viewing, and multiple communication channels, such as e-mail, chat rooms, and webcam conversations (Balkin et al., 2005) and to get a successful learning process, interaction is essential (Arabia, 2008). By giving students real-time feedback and enabling the digitization of mathematical concepts, digital pen technology helps to improve the interaction between the components of an online learning environment (Karal et al., 2015). Effective instruction depends upon teachers' teaching role in the classroom with their ability to reflect in instructional activities (Feiman-Nemser, 2003). In this context, it is essential to explore mathematics teachers' self-reported reflection towards needful skills for effective teaching online.

Khanal, Joshi, Adhikari, and Khanal (2022) found that teaching mathematical content as Algebra, Statistics, Vector, Geometry, and Analysis online was problematic and suggested the requirement for support systems or training. Digital ink technology and related technologies are required in online mathematics courses in order to represent concepts, symbols, and solution process steps, provide adequate feedback, achieve a high degree of interactivity, and more effectively teach the course (Karal et al., 2015). Hence, the instructors needed proper training, pedagogical skills, and knowledge in how to use digital resources (Khanal, Joshi, Adhikari, Khadka, et al., 2022) in order to deliver effective instruction in online mathematics classes. Chin et al. (2022) found in their study that the majority of the teacher respondents desired to advance their technological skills. However, Cao et al. (2021) showed that the teachers believed student self-discipline played a significant role in effective online classes. In addition to resources, other factors like staff readiness, confidence, student accessibility and motivation play crucial roles in online learning (Wahab & Ali, 2020). Wahab and Ali (2020) further suggest that teacher and student should use technology and technological devices to enhance learning. The results of the analysis by Cao et al. (2021) pointed to the

need to increase the use of technology in classroom instruction, changing the way of interaction with students and rearranging instructional strategies in face-to-face classrooms. Human-computer interface (HCI) tools, PowerPoint, forums, blogs, podcasts, online discussion groups and media, live chat, live visual communication, and written chat tools are used to facilitate interaction and feedback in online distance learning (Beldarrain, 2006). However, technological tools are not sufficient to ensure interactivity and a successful learning process in online mathematics instruction (Maclaren, 2014). Hence, technology skills are necessary for the effective online learning. Among several challenges reflected in the literature, the researcher intended this research to share mathematics teachers' potential experience towards effective mathematics instruction online.

Recent studies have focused on online such as; factors associated with the challenges in teaching mathematics online (Adhikari et al., 2022), problems of mathematics teachers in teaching mathematical content online (Khanal, Joshi, Adhikari, & Khanal, 2022), teachers' perceptions on the effect of information and communication technologies (ICTs) (Joshi, 2021; Belbase et al., 2022; Joshi, Khanal, et al., 2022), teachers' perceptions toward student support in using information and communication technology in mathematics learning Joshi, Adhikari, et al., 2022). However, there is a lack of literature on teachers' reflections on necessary skills and ways to make effective mathematics classes through online teaching in the context of Nepal. The aim of this study, therefore, was to seek the necessary skills and ways of effective mathematics classes through online teaching. Hence, this study is guided by the following research questions.

1. What are the necessary skills for teaching mathematics online?
2. How can mathematics be taught online effectively?

Methodology

The qualitative survey method (Braun et al., 2021) with open-ended questions through Google Form was employed to collect written responses in the research. The instrument was shared among 1572 mathematics teachers of basic to university level through their email. Among them, 277 teachers replied in the items (Khanal, Joshi, Adhikari & Khanal, 2022). The data were collected through Google Forms by sharing tool among certain (1572) mathematics teachers whereas the list of mathematics teachers were collected through Society of Technology Friendly Teachers, Nepal and Nepal Council of Mathematics Education, hence list based sampling was employed in the research (Fricker, 2017; Schonlau et al., 2002). The results of the research were analyzed thematically including word cloud methods and interpreted descriptively. The nature of the items was open hence the results were interpreted by theme- wise coding. The codes were categorized into seven themes which are described in the following subheading.

Findings and Discussion

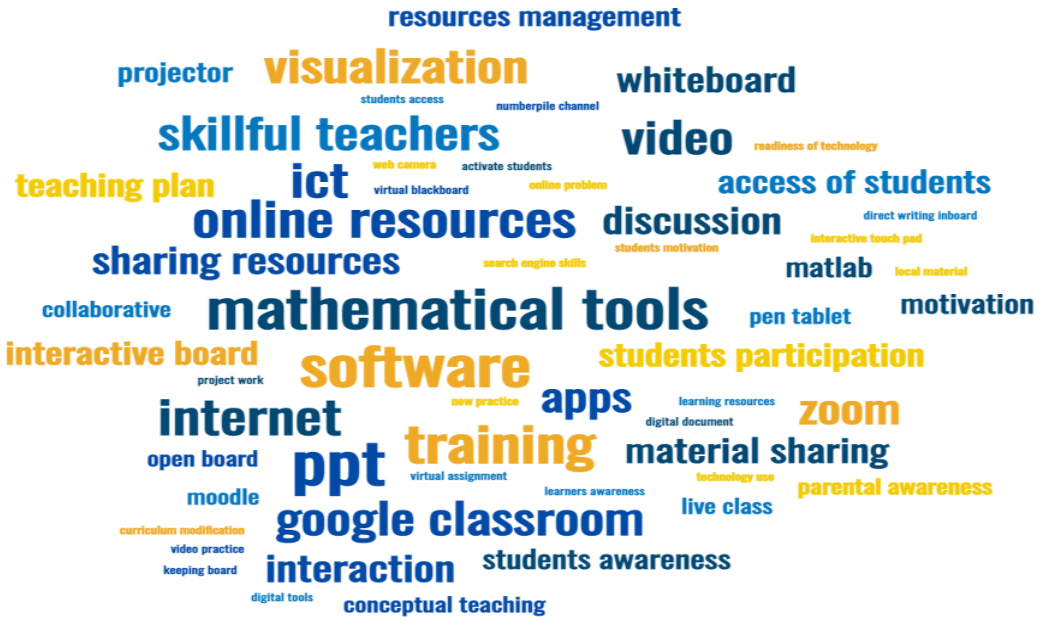
Necessary Skills for Teaching Mathematics Online

The teachers' perceptions towards necessary skills in teaching mathematics online were reported based on the answers of respondents in open questions. The participants reported that all of the teachers and learners should have access to digital resources (devices, internet and other digital materials). They also argued that teachers should have additional skills for the use of digital resources in their classroom practices. One of the respondents reported "The learning materials should be interactive. Learners' interests should be counted. Assessment tools should be developed and mathematical software should be used for manipulation and visualization for the difficult concept". By this arguments it can be said that teachers should have skills in using evaluation tools along with subject- related software however competency of mathematics teachers in using digital resources is poorer in the context of Nepal (Adhikari et al., 2022; Joshi & Rawal, 2021; Khanal, Joshi, Adhikari, & Khanal, 2022; Khanal, Joshi, Adhikari, Khadka, et al., 2022). Another respondent argued that online courses are different from the traditional classroom hence software and hardware-related trainings are necessary for teachers with technical support from the institution. Another respondent emphasized the use of text chat during the instruction encouragement of have students towards homework completion in time and teachers should have skills of providing quick feedback to the students and collaborating with students and teachers. Based on this argument, additional skills and practices of digital assessment and collaboration should be enhanced.

Another respondent reported that the engagement of students in group work, maintaining a collaborative environment, additional class times for discussions with the students, and students fallowing up are necessary for effective online classes. Moreover, the participants additionally agreed to use mathematics-related software for interactive learning environments whereas the findings of Joshi, Khanal, et al. (2022) also similar to learners engagement, Joshi and Rawal (2021) in the case of using digital resources and Khanal, Joshi, Adhikari, and Khanal (2022) and Khanal, Joshi, Adhikari, Khadka, et al. (2022) suggested to the use of different digital resources for mathematics instruction. Additionally, online training for students and teachers on the use of ICT tools is also necessary for effective teaching online whereas Joshi, Neupane, et al. (2021) preferred different digital resources for mathematics teachers in their instruction and Khanal et al. (2021) found that digital awareness has a positive significant effect on the performance of the students. Also, the respondents emphasized that the teachers should learn to use teaching digital materials, preparation of assignments and evaluations, development of rubrics for the evaluation, use learning management system (LMS) tools (like

Google Classroom and Moodle), and digital boards (like Jamboard and Microsoft Board) for effective teaching of mathematics. The details of the respondents towards the necessary skills are presented in Figure 1. Figure 1 shows that the different digital skills like software, online resources and mobile applications are important for mathematics teachers.

Figure 1 *Visual Representation of Necessary Skills in Word Cloud*



Ways of Effective Mathematics Teaching Online

The results were presented based on the theme of the respondents under seven categories (1) planning and skill development, (2) use of novel instructional activities, (3) access to resources, (4) use of digital tools, (5) resource development, (6) collaboration and communication, and (7) resource management. The detail descriptions of these themes are presented as follows:

Planning and Skill Development. Instructional planning for mathematics teaching online, training, awareness and motivation of students and parents towards online classes, and participation-related information were mentioned under planning and skill development. The thirty-five teachers suggested that planning and skill development of teachers and students are major techniques for effective mathematics instruction online. Under this category, the special suggestions were found as teaching with a teaching plan, providing training to the students and teachers, activating students to participate virtual classes, student motivation

towards online learning, focus on student's participation, increase student's awareness, students and teacher's motivation (Gabriel & Kaufield, 2008) and parental awareness towards online teaching. These findings are similar to the findings indicated by Khanal, Joshi, Adhikari, Khadka, et al. (2022). Hence, the instructors needed proper training, pedagogical skills, and knowledge of how to use digital resources (Khanal, Joshi, Adhikari, Khadka, et al., 2022) in order to deliver effective instruction in online math classes. Gabriel and Kaufield (2008) reported that online courses take more time than face to face courses hence students' and teachers' motivation should be increased.

Use of Novel Instructional Activities. The use of novel instructional practices represents conceptual teaching, use of collaboration and project work, readiness to use technology and visualization of mathematical content. The twenty-one teachers were excited to use novel instructional activities for effective mathematics online instruction. In this category, a teacher was convinced to focus on conceptual teaching and emphasize discussion, to adopt new ideas and project work, readiness to use technology and visualization of mathematical content. These findings play crucial roles in online learning that were similar to the findings identified by Wahab and Ali (2020) such as staff readiness, confidence, student accessibility and motivation.

Access of Resources. Access to resources represents the availability and accessibility of the internet, digital devices, subjective software, mobile applications, human resources and technical support. Twenty-nine teachers emphasized the availability of access internet and digital resources with students and teachers, skillful human resources, technical support, and search engine skills for effective teaching-learning environment in online learning. As stated findings are similar to Schrum et al. (2005) which recommend that students and instructors both have access to an online orientation to become familiar with online-course features like chat rooms, discussion forums, and working with PDFs and document files. However, In the context of Nepal, the expressed and emphasized resources and skills are not properly available which were cleared various research such as (Dawadi et al., 2020; MoF, 2020; Ghimire, 2020; Joshi, Chitrakar, et al., 2021; Pham & Nguyen, 2020; Rana et al., 2020).

Use of Digital Tools. The use of digital tools represents mathematics- related mobile apps, digital tools, mathematical tools, Mat lab, online resources, pen tablets, PPTs, software, technology use, number pile channel and ICT. Nearly one half of the respondent teachers were suggested to use digital tools for effective mathematics learning like mathematics mobile apps, digital tools, mathematical tools, MATLAB, online resources, pen tablet, PPTs, software, technology use, Numberphile channel and ICT. These results were similar to the finding identified

by Beldarrain (2006) which indicates that Human-computer interface (HCI) tools, PowerPoint, forums, blogs, podcasts, online discussion groups and media, live chat, live visual communication, and written chat tools are used to facilitate interaction and feedback in online distance learning (Joshi, Neupane, et al., 2021).

Resource Development. Curriculum modification, digital document development, Google Classroom, learning resources, Moodle, Zoom, Meet, video development and sharing available videos and virtual assignment creation. Twenty-seven respondent teachers focused on resource development for effective online instructions such as curriculum modification, digital document development, Google Classroom, learning resources, Moodle, Zoom, Meet, video development and sharing available videos and virtual assignment creation. In order to achieve high quality in online distance learning Liu et al., (2010) suggested online courses should incorporate a variety of content exploration and delivery techniques, such as synchronous and asynchronous learning activities.

Collaboration and Communication. Collaboration and communication make mathematics teaching online more and interactive. Twenty-nine respondent teachers suggested making collaborative and two way commission classes for effective instruction. Guthrie and McCracken (2010) suggested that designing communications should be done with attention. Balkin et al. (2005) suggested compressed videos, presentation slides, video lectures, website viewing, and multiple communication channels, such as e-mail, chat rooms, and webcam conversations are helpful for enhancing and successful online learning. Respondents also focused on live class, material sharing and sharing resources. Online environments can cause instructors to become socially isolated, missing out on valuable conversations, helpful criticism, and a feeling of community. Hence, Gabriel and Kaufield (2008) suggested creating communities of practice where instructors can exchange ideas and support one another in online teaching to help alleviate these possible worries.

Resource management. Use of writing board, interactive board, interactive touch pad, local material, open board, projector, virtual blackboard, web camera and whiteboard in teaching. Twenty-three respondent teachers suggested managing the resources for effective online teaching. They suggested using of writing board, interactive board, interactive touchpad, local material, open board, projector, virtual blackboard, web camera and whiteboard in teaching. Similar results found by Karal et al. (2020) and their research showed that for effective instruction in online mathematics courses digital ink technology and related technologies are required to represent concepts, symbols, and solution process steps, provide adequate feedback, achieve a high degree of interactivity, and more effectively teach the course.

Conclusion

The findings indicate that every teacher of mathematics should have skills in using different tools for different purposes like video conferencing, collaboration, visualization, LMS, technical skills, and digital resource-using skills during instruction online. Hence, concerned stakeholders should focus and additional programs for promoting such skills. The respondents also reported that access to digital devices and resources, and awareness of teachers, parents, and students are also mandatory for the proper use of digital resources in instructional activities hence government and other concerned stakeholders should be responsible for managing such resources at institutions and at home. Furthermore, the respondents reported that skill development, use of novel instructional activities, access to resources, use of digital tools, resource management and development, collaboration, and communication are key areas of mathematics teachers for the use of digital resources in their teaching hence teacher should promote and use such skills in their instructional activities for effective mathematics online. The findings of the research are important to educational institutions, policymakers, concerned organizations, and the Government for making new policies and developing new programs related to the findings of the research. The findings are also important for mathematics teachers to know and develop their digital skills for implementing technology in classroom instruction. However, the study was carried out among limited digitally literate mathematics teachers hence further study is needed among all mathematics and other subject teachers because digital skills are necessary for all teachers at this age. Moreover, the study was limited to qualitative research design hence further studies are needed by adopting other research designs. Furthermore, the research was limited to the mathematics teachers in Nepal hence further study is needed in diverse country contexts.

Acknowledgement

We express thanks to all participants of this research who voluntarily participated in the survey. This study was conducted by the first author and the manuscript was prepared based on partial data from a mini-research project (Grant number: 16-2078/079) supported by Mahendra Ratna Campus, Kathmandu, Tribhuvan University Nepal hence the researchers gratefully acknowledge this institution for the financial support.

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