



# Mathematics Teachers' Self-Reported Practices of Formative Assessments in Teaching Mathematics Online


Krishna Prasad Adhikari, Tribhuvan University, Nepal

 <https://orcid.org/0000-0002-4530-2147>

Dirgha Raj Joshi, Tribhuvan University, Nepal\*


 <https://orcid.org/0000-0002-1437-6661>

Shashidhar Belbase, College of Education, United Arab Emirates University, UAE

 <https://orcid.org/0000-0003-3722-756X>

Lekhnath Sharma, Tribhuvan University, Nepal

Bishnu Khanal, Tribhuvan University, Nepal

 <https://orcid.org/0000-0002-3304-7695>

## ABSTRACT

The current study examined the mathematics teachers' awareness toward and practices of different forms of assessments (of, for, and as learning) in teaching mathematics online during the pandemic. A cross-sectional online survey design was applied among 450 high school mathematics teachers in Nepal. Mean, standard deviation, Mann-Whitney and Kruskal Wallis tests, and structural equation modeling (SEM) were major statistical techniques used in the research. The findings of the study indicated that the level of formative assessment practices in mathematics teaching was found to be high during online classes. Age, gender, teaching experience, time for online classes, and mode of the online learning environment (OLE) are determinant factors associated with the assessment component and strategy, assessment of learning, for learning, and as learning. Assessment strategy and its components are significant predictors of the assessment for and as learning, whereas the assessment component is a significant predictor of the assessment of learning.

## KEYWORDS

Assessment as Learning, Assessment Components, Assessment for Learning, Assessment of Learning, Assessment Strategy

## INTRODUCTION

Students' mathematics learning and assessment are indispensable parts of curriculum despite issues with treating learning and assessment as separate entities, and have ongoing debates on the issues of fairness, reliability, and validity. Mathematics assessment can have some biases toward

DOI: 10.4018/IJOPCD.324603

\*Corresponding Author

This article published as an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>) which permits unrestricted use, distribution, and production in any medium, provided the author of the original work and original publication source are properly credited.

a group of students, resulting in good or bad achievements. There is a view that there is no single universal approach or tool that can assess what an individual has learned in mathematics. In this context, assessment has been used for promoting learning and certifying students' qualification. The differential usage shows multiple purposes of assessment with different meanings and types in day-to-day classroom practices. While assessment is considered a core component of pedagogy, it should be properly integrated into teaching and learning activities (Cornard & Openo, 2018) and used to promote learning in different ways (Black et al., 2006; Dann, 2014). Assessment is the "systematic collection of information about student learning using time, knowledge, expertise, and resources available to inform decisions that affect student learning" (Walvoored, 2010, p. 2), engage students in tasks integrated into the whole learning process (Dochy, 2009; Macdonald, 2004). However, it should be supported by feedback mechanism to identify the gap between actual and desired performance (Shute, 2008; Van et al., 2012), guide the teaching and support students' learning (Joughin, 2009a).

In the Nepali context, assessment of learning is mostly done with paper-and-pen and fixed-hour written examinations. Assessment for learning is not a priority, rather most mathematics teachers use tests or exams as summative assessments of the students to provide grades. Assessment has not been a tool for learning mathematics. As a result, students' performance in mathematics is low in Nepal (ERO, 2015, 2020). The situation was even further deteriorated during the COVID-19 pandemic due to closure of face-to-face classes.

The outbreak of the COVID-19 pandemic forced educational institutions shift the conventional system of education to distance and online modes. Educational institutions in Nepal and other places faced problems due to a need for adequate infrastructure, human resources, and internet connectivity (Pal et al., 2021). The center-based proctored examinations for assessing student learning was not possible due to physical and social distance with public health concerns. Therefore, schools and higher education institutions introduced online assessments in the country (CDC, 2019; MoE, 2020). For school education, the Curriculum Development Center (CDC) developed guidelines that for assessment introducing some formative assessment tools, like student participation, attendance, homework, project work, and other practical activities to assess students' learning achievements (CDC, 2019). However, the mathematics teachers were not trained to construct and apply formative assessment tools. This raised a question about whether the new practice of formative assessment tools improve students' learning and achievement. The formative assessment practices adopted at the schools need evidences from research to address public concerns in terms of its impacts on students' learning of mathematics. In this context, this study aimed to examine teachers' formative assessment practices in school-level mathematics in an online mode of instruction during the COVID-19 pandemic. The objective was to examine formative assessment practices and the effectiveness of different assessment strategies, such as assessment of, for, and as learning for the student. More specifically, this study answered the following research questions:

1. What assessment strategies are used by mathematics teachers to assess students' learning in an online mode of instruction?
2. What formative assessment components are used by mathematics teachers in the assessment process during online instruction?
3. How do the assessment strategies and components affect the three assessment approaches, namely assessment of learning, assessment for learning, and assessment as learning?

## Assessment Approaches

Many scholars agree that 'assessment may have a significant effect on learning of mathematics or other discipline (Boud & Falchikov, 2007). Assessment may have a very most powerful impact on students' learning by playing very important role on students' learning (Boud et al., 1999; Maclellan, 2001; McArthur, 2016; Taras, 2008). Generally, assessment has three approaches: assessment of

learning, assessment for learning, and assessment as learning (Earl, 2013a). These approaches, also called learning-oriented assessment, evolved from summative and formative assessment ideas (Zeng et al., 2018). Assessment of learning is typically done at the end of the teaching-learning activities in summative format to certify student's performance (Earl, 2013b; Harlen, 2007). Assessment for learning is the shift of assessment from summative to formative (Wiliam, 2011) in which teachers collect a range of data from students' work so that it can be used to improve the next stage of learning (Earl, 2013). Its primary aim is to modify the teaching-learning activities to improve students' understanding (Elmahdi et al., 2018). It enables students to receive feedback on their tasks and proceeds with their subsequent study (Carless, 2017), and it enables teachers to rethink and refine their teaching. The third approach to assessment is assessment as learning. Its primary focus is to develop students' metacognitive skills to be their best assessment of the learning process (Earl & Katz, 2013). More importantly, the essence of assessment as learning is to make students active, engaged, and critical of their learning (Earl & Katz, 2013). Assessment should be used to improve learning outcomes (Wiliam, 2011). Ideas in assessment as learning suggest that teachers focus on how learners interpret and understand feedback rather than giving focused and directive feedback (Dann, 2014). Assessment as learning promotes cognitive and emotional engagement in learning, enhances self-efficacy motivation, integrates agentic engagement, and promotes self-regulated learning behavior (Fletcher, 2016). All these three approaches have their importance in the teaching and learning process. Joughin (2009) explains that the three predominant functions of assessment are supporting the learning process, evaluating students' performance according to curriculum standards, and preparing the students for their future profession. Assessment as and for learning is crucial for developing problem-solving, critical thinking, innovation and creativity, learning to learn, and metacognitive skills in learners (Aldon & Panero, 2020; Hoogland & Tout, 2018; Ukobizaba et al., 2021). On the other hand, assessment of learning is also vital to provide essential information certification of qualification about the learners to the other stakeholders and job recruitment agencies (Dufaux, 2012; Harlen, 2007). However, assessment for and as learning is much more important for quality education to produce graduates who can best fit the changing context of employment and solve the problem of existing society (Li, 2018; Ukobizaba et al., 2021).

In reality, assessment monitors the students' learning and provides opportunities for teachers and students to reflect on and improve their teaching and learning activities (Cornard & Openo, 2018). The essence of assessment relies on teachers' and students' use of the information generated through assessment to improve teaching and learning. Assessment could define individuals' life chances and direction as well (Coats, 2018). An essential question now is how effectively the three assessment approaches are used in different modes of education.

## **Assessment in an Online Environment**

Both conventional and online modes of education need the proper utilization of assessment systems for better education. It is a common understanding that the assessment system as a sub-system of a more extensive education system, is considered one of the crucial qualifiers of education quality (Clarke, 2017). Transparency of assessment is observed in the conventional system, for there is a scheduled external examination with an internal assessment provision. Now that the system is new to the community, people are concerned about the types of tools used, and the quality of the assessment systems in the online education model. Therefore, assessment in online mode needs to specify scientific tools and procedures to make it more transparent and convincing using different tools. Some researchers (Adesemowo et al., 2016; Feldman, 2021; Lin & Wang, 2017; Veenman & van Cleef, 2019) justified online assessment as equally effective as the conventional testing system. For example, assessing students' activities through a discussion forum is a highly transparent evaluation where teachers have access to every posting by the students from the beginning (Lafuente Martínez et al., 2015). Appropriately designed online assessments can minimize the teachers' workload and maximize the engagement and performance of students (Adesemowo et al., 2016). Online assessment

instruments are preferable for metacognitive skills in mathematics (Veenman & van Cleef, 2019). Different models of web-based dynamic assessment can improve learning achievement and help to minimize misconceptions about the subject matter (Lin & Wang, 2017). Technology is an excellent asset for adopting innovative approaches for better learning opportunities (Feldman, 2021).

According to Benson (2003), different assessment techniques are used to assess learning in online environment, such as selected response assessments, constructed response assessments, virtual discussions, concept mapping, e-portfolio assessment, writing, field experiences, individual and group projects, informal student feedback, peer assessment and self-assessment. In this context, assessment should play a crucial role in developing students into effective online workers (Macdonald, 2003). Online students need to control their own learning through reflection, articulation, discovery learning and self and peer assessment (Australian National Training Authority, 2002).

Despite the positive impact of technology on students assessment, assessment in the online environment, in the context of Nepal, has several challenges, such as a lack of teachers' technical knowledge, infrastructural deficiencies, a lack of awareness of online teaching platforms, and cheating and plagiarism issues in assessment (Joshi et al., 2020). However, technology can minimize the challenges and change the assessment posture alone (Aldon & Panero, 2020; Farrell & Rushby, 2016). For instance, dynamic and video game-based assessments with learner-centered teaching methods like problem-based and cooperative learning styles strengthen the mathematical skills of students (Ukobizaba et al., 2021). Video lectures and assignments in online courses are more effective for students' engagement, and students were delighted with the online courses. Elaborated lectures summaries, clear assignments, constructive feedback, and communication are aspects of satisfying and motivating students (Soffer et al., 2017).

The primary focus of online assessment is to provide immediate feedback to the students, improve performance, reduce burden, minimize the cost, and promote higher-order thinking; however, poor infrastructure and a lack of student competency in technology are the challenges behind it (Alruwais et al., 2018). Online formative assessment significantly affects students' learning achievement ( $p < 0.01$ , Cohens'  $d = 0.877$ ), data also suggests that some students quickly recognize the value of the formative assessment (Petrović et al., 2017). Accessibility, affordability, flexibility, learning pedagogy, life-long learning, and policy are good arguments for online learning and assessment (Dhawan, 2020). For an effective online assessment, a teacher should be competent in using different forms of assessment online with a deeper understanding of the value of formative assessments (McVey, 2016). The teacher should design assessment activities to improve online teaching and learning by using student learning information/data (Vonderwell & Boboc, 2013). The findings of the research (St-Onge et al., 2021) suggest that educators are convinced about the quality practices of e-assessment. The institution should provide appropriate affordance to the teacher. Using technology properly can influence participation, feedback mechanisms, and grading accuracy (Robertson et al., 2019). However, the search for the best structure and strategies to support the learning of diverse students in a different setting in an online mode (Kim et al., 2021) should be done continuously. It is necessary to develop alternative assessment approaches to minimize the problems of cheating and plagiarism (Adedoyin & Soykan, 2020).

Formative assessment is a continuous cycle of activities or events (Harlen, 2007). The primary focus of online assessment is to promote formative assessment strategies (Alruwais et al., 2018). Formative assessment could provide more information about students' understanding and misconceptions, and the scores from an online formative assessment are the strongest predictor of student performance (Bulut, et al. 2023). The instructor could have sufficient time to reflect on the information, give appropriate feedback, and modify teaching-learning activities (Schroeder & Dorn, 2016). Formative assessment connects learning to the background and values of the learners. In particular, embedded formative assessment allow the instructor to regulate feedback and interventions to attain the learning objectives, self-regulation of learning, and the transformation of learners (Marquis, 2021). The appropriately designed formative assessment efficiently improves the students' performance (Petrović et al., 2017). Moreover, formative assessment strategies mainly help to develop

assessment skills in teachers, and peer assessment and success criteria have a significant positive impact on the development of metacognitive skills in the teachers (Wafubwa & Csíkos, 2021).

Lu and Law (2012) examined the experiences of students on online peer assessment, where the number of grade- giving and -receiving activities was done. The result shows that the students' performance as assessors of feedback that can identify problems and give suggestions was a significant predictor of the assessors' performance. This process also improves the assessment skills of assessors (Seifert & Feliks, 2019). Moreover, peer feedback can activate crucial cognitive processes than peer grading. Students can be benefited from what the teachers follow for online self- and peer-assessment (Seifert & Feliks, 2019). Voluntary (Liu et al., 2019) and anonymous peer evaluation is more effective and can minimize the inhibition in evaluating peer works (Liu et al., 2019; Seifert & Feliks, 2019). Self-assessment can enhance learners' self-efficacy to construct meaning and promote metacognition (Taras, 2002). Similarly, teachers with higher self-efficacy beliefs can enhance formative assessment practices (Yan, et al., 2022). It was also found that learners' intentions, success criteria, and peer assessment strategies significantly predicted teachers' evaluation skills (Wafubwa & Csíkos, 2021).

The approaches we are adopting in formative assessment should be conceptualized as part of a comprehensive system where all the assessment components work together to facilitate learning (Bennett, 2011). The formative assessment should focus on more than confirmative assessment procedures. Instead, it should cover the divergent possibilities inherent in formative assessment (Torrance, 2012). For that mutually supportive approach towards assessment, designing criteria, and the innovative task, it could be helpful (Gamage et al., 2020). Formative assessment is about planning for learning, improving learning, enhancing learning, and framing the strategies for future steps in learning (Moeed, 2015). Regular formative assessment can be effective for students to monitor their own progress, encourage further study, and increase a student's perceived level of learning and understanding (McCallum & Milner, 2020). These indicators help students become independent learners as well.

## **METHODOLOGY**

### **Study Setting**

The study was carried out during the COVID-19 pandemic without any financial support. Hence, an online cross-sectional online survey was employed among the mathematics teachers at secondary levels in Nepal. Educational institutions were physically closed during the pandemic period, which lasted around one and a half years at different times. This study is based on the fact that the mathematics teachers conducted their teaching and learning activities online.

### **Sample and Sampling Technique**

The sampling frame for the study was determined based on the mathematics teachers who participated in different technology-based trainings, workshops, and seminars organized by the Council of Mathematics Education. Those teachers who participated in the training and conducted their mathematics teaching and learning activities online were considered the sampling frame. In total, 1333 mathematics teachers were found, excluding repeated cases, and hence this number was considered the population of the study. Because of the COVID-19 pandemic, data collection was not feasible in a face-to-face mode; hence, an online form was developed and shared with all (1333) teachers through their email; hence, a list-based sampling technique was adopted (Fricker, 2017). Altogether, 483 teachers submitted their responses, and 450 teachers were selected for the study after excluding the incomplete responses. With a 95% confidence interval and a 5% margin of error in this population, the appropriate sample size is 298 (SurveyMonkey, 2021). However, the respondent of this study is 450 (33.76%) out of the total population. Hence, the sample is the most representative and sufficient to generalize to the entire population of digitally trained teachers.

## Research Instrument

A self-constructed instrument was used for data collection. The instrument consisted of 12 items measured on a three-point Likert scale: never, sometimes, and always. The nine items were categorized under two dimensions: assessment strategy and assignment practices. In contrast, three items, for example, assessment as, of, and for learning, were not separated under any categories. The items of the assessment approach were constructed based on different theoretical literature such as Earl and Katz (2013), Earl (2013a, 2013b), and Harlen (2007) and also approved by confirmatory factor analysis. Harlen (2007) discussed on the formative and summative types of assessment and mostly focus on how to use formative assessment components on assessment of learning. The assessment strategies that focus on self- monitoring and self-evaluation (self-assessment, peer-evaluation, project works, presentation, feedback mechanism) have been adapted in this study from Earl and Katz (2013). The formative assessment components such as homework, project work, attendance, and presentation are discussed by Earl and Katz (2013) and Earl (2013a, 2013b). The face validity was ensured by sharing the tool with education and mathematics education-related experts before piloting. The reliability of the tool was ensured by piloting among 60 samples, of which 15 were female and 35 were male, from the same population, and Cronbach alpha reliability was calculated and found to be 0.81. Convergent validity was calculated by the average variance extracted (AVE) being below 0.50. However, composite reliability was found to be greater than 0.06; hence, convergent validity (Fornell & Larcker, 1981; Huang et al., 2013) was considered in this research. Heterotrait-Monotrait (HTMT) ratio of correlations was calculated and found to be less than 0.90, indicating that the discriminant validity was established (Henseler et al., 2015).

## Description of Variables

### *Socio-Demographic Characteristics and ICT-Related Variables*

Socio-demographic characteristics and ICT-related variables were considered independent variables. Gender, qualification, types of institutions, and teaching experiences were considered socio-demographic characteristics. Whereas gender has two categories, male (9.6%) and female (90.4%), qualification is separated into two categories: holding a bachelor's (23.8%) and a master's (76.2%) degree because a bachelor's is a minimum qualification for teaching grades 9–10 and a master's is a minimum qualification for teaching grades 11–12. Similarly, the types of institutions have two categories as private (25.8%) and public (74.2%) whereas public represents the government and private represents affiliated but not supported by the government. Additionally, the experience has two categories: less than ten years (46.7%) and greater than or equal to ten years (53.3%) of teaching experience. The time of online classes, the learning management system (LMS) tool, and the mode of an open learning environment were considered ICT-related variables. The time of online classes has two categories: before less than one year (38%) and after more than or equal to one year (62%), whereas before less than one year represents the time of practice of taking online classes before one year and before more than or equal to one year represents the practice of taking online classes after more than a year. LMS tools have three categories: Google Classroom (53.3%), others (24.7%), and non (22%), indicating that the tools are used by mathematics teachers while taking online classes.

Table 1. Validity and reliability

Factors	CR	AVE	HTMT Analysis	
			AS	AC
Assessment Strategy	0.75	0.37		
Assessment Components	0.67	0.34	0.84	

Similarly, the mode of OLE has two categories: fully online (55.6%) and partially online (44.4%), whereas fully online represents the mathematics teachers who offered online classes at 80–100% and partially online represents a hybrid or blended (less than 80% inline classes) mode of instruction.

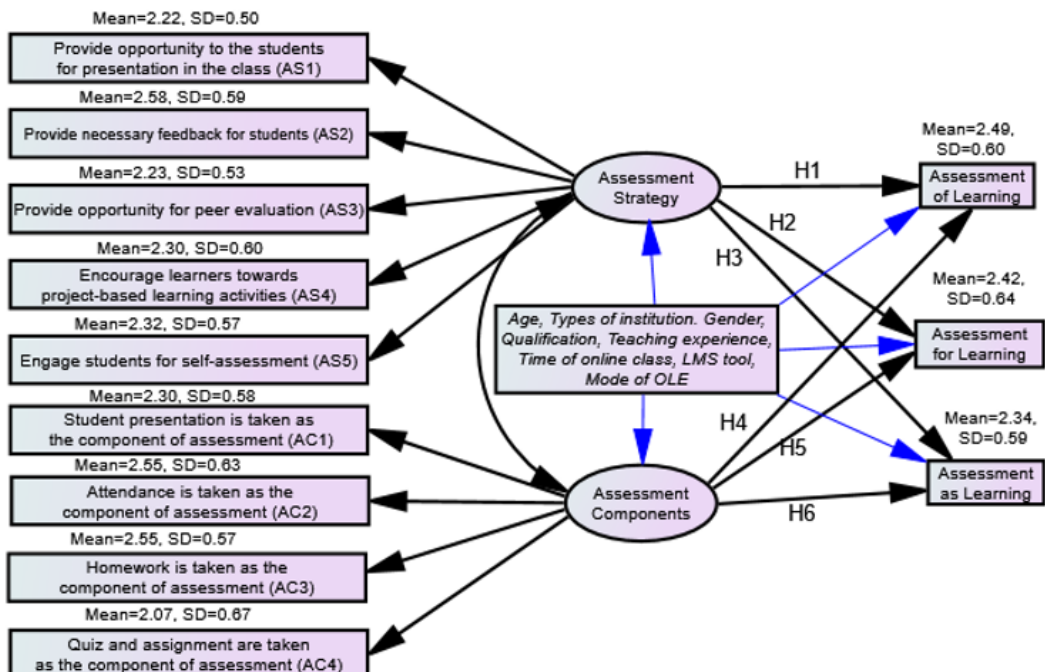
### Assessment-Related Variables

Provide an opportunity to the students for presentation in the class (AS1), provide the necessary feedback for students (AS2), provide an opportunity for peer evaluation (AS3), encourage learners towards project-based learning activities (AS4), and engage students in self-assessment (AS5) were considered under assessment strategies. In contrast, student presentations (AC1), attendance (AC2), homework (AC3), and quizzes and assignments (AC4) are taken as components of assessment. All of these variables were considered independent variables, and the formative assessment techniques as assessment of learning (AA1), assessment for learning (AA2), and assessment as learning (AA3) are considered dependent variables. The details of the variables are presented in the conceptual framework (Figure 1).

### Data Analysis Techniques

Frequency, mean and standard deviation (SD) were used to show the actual status of the practices of the online assessment system for different purposes. The status was determined in two categories as high (mean  $\geq 1.5$ ) and low (mean  $< 1.5$ ). The dependent variables, such as assessment strategy and components related items and assessment as, for, and of learning were measured in the three-point rating scale, which is non-parametric data hence Mann Whitney U for two independent samples (Verma & Abdel-Salam, 2019) and Kruskal Wallis H test for more than two independent samples (Cohen et al., 2007) were used to test the significant results based on different socio-demographic variables. The result of mean ranks and mean were similar in each group category; hence, the mean

Figure 1. Conceptual framework (the black arrow represents the testing of effect, and blue arrow represents the testing of significant results)



score is reported instead of mean rank value while using U and H tests. Structural equation modeling (SEM) was also applied to find the effect of assessment strategies and practices on assessment for, of, and as learning.

## RESULTS

Figure 1 shows that the status of using different assessment strategies was higher with mean=2.33 and SD=0.39, followed by using different components of formative assessment practices (Mean=2.37, SD=0.42). Teachers are using different strategies and components of assessment with the purpose of: assessment of (Mean=2.49, SD=0.60), for (Mean=2.42, SD=0.64), and as (Mean=2.34, SD=0.49) learning. Based on the item-wise analysis in the assessment strategy, provide the necessary feedback for students (Mean=2.58, SD=0.59) who have the highest and provide an opportunity to the students for presentation in the class (Mean=2.22, SD=0.50) who have the lowest mean score. In contrast, homework is taken as the most important component of assessment (Mean=2.55, SD=0.57) has the highest. Quizzes and assignments, taken as the component of assessment (Mean=2.07, SD=0.67) have the lowest mean score under the assessment component as comparisons to other items; however, the practice of assessment in all items is found to be high (Mean  $\geq 1.5$ ).

Table 2 shows that age, gender, time of online class, and mode of OLE have significant results on the assessment of learning ( $p \leq 0.05$ ) where the types of institution, qualifications, teaching experience, and LMS tools used in online classes have insignificant results in the independent variable categories of age <35 years, female, time of online class  $\geq 1$  year, and full-time online classes offered, respectively. In the assignment for learning, significant results were measured based on age, gender, teaching experience, time for the online class, and mode of OLE, and the mean score was found to be high in >35-year-old females, <10 years of experience, a short time for the online class  $\geq 1$  year, and a full-time online class offered, respectively. Assessment as learning has significant results concerning age, gender, teaching experience, and time for an online class in the categories of <35 years, females, <10 years of teaching experience, and full-time online classes offered, respectively. The assessment strategy has significant results based on time for online classes only in favor  $\geq 1$  year. In contrast, the assessment component has significant results concerning age, gender, time of online classes, LMS tools, and mode of OLE in favor of age <35 years, female, time of online class  $\geq 1$  year, use of Google Classroom, and full-time online classes offered, respectively. Insignificant results were found in each variable concerning types of institutions and qualifications.

### *Model Fit Indices in SEM*

The causal structural equations (Mirete et al., 2020) was adopted in this research. The sample size is 450, and the observed variables are 12; hence, the sample size is sufficient for SEM analysis (MacCallum et al., 1996). The significant value of the chi-square is considered in the models (Bentler & Bonett, 1980) because of appropriate fit of remaining indicators as root mean square error of approximation (RMSEA) is 0.07 (<0.08), goodness-of-fit statistic (GFI) is 0.94 ( $\geq 0.90$ ), adjusted goodness-of-fit statistic (AGFI) is 0.90 ( $\geq 0.90$ ), standardized root mean square residual (SRMR) is 0.05 (<0.08), normed-fit index (NFI) is 0.91 ( $\geq 0.90$ ), comparative fit index (CFI) is 0.93 ( $\geq 0.90$ ), and Tucker-Lewis index (TLI) is 0.91 ( $\geq 0.90$ ), and incremental fit index (IFI) is 0.93 ( $\geq 0.90$ ) are good fit (Bentler & Bonett, 1980; Byrne, 1989; Hooper et al., 2008; Hu & Bentler, 1999; MacCallum et al., 1996; Sarker & Chakraborty, 2021) in the model.

Figure 2 shows the effect of assessment strategies (AS) and assessment components (AC) on approaches to assessment. The model explains 65%, 63%, and 50% of the variance on assessment of learning, for learning and as learning, respectively. AS has a significant positive effect on assessment for learning (beta=0.31) and assessment as learning (beta=0.44). Additionally, AS has a significant



**Table 2. Results of inferential statistics (n=450)**

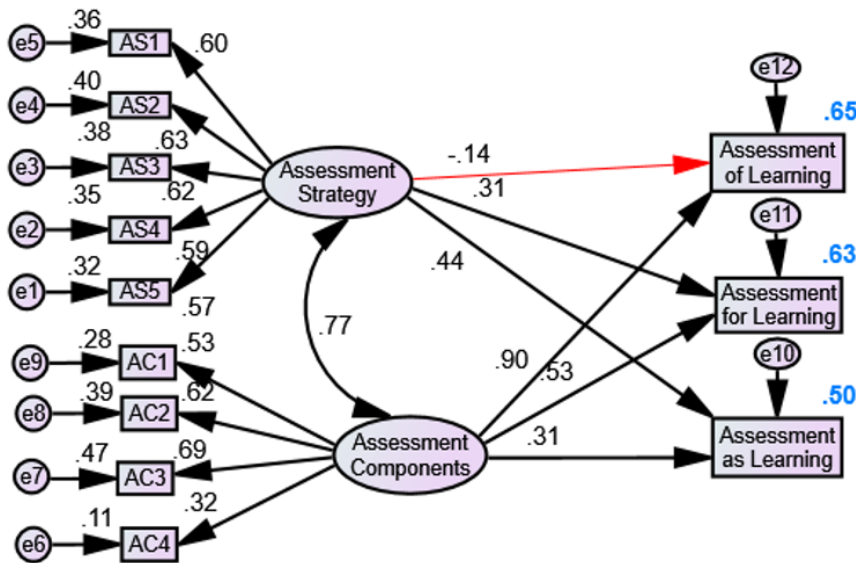
Variables	Frequency	AOL		AFL		AAL		AS		AC	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
<b>Age</b>	p-value	0.03*		0.01*		0.00*		0.10		0.05*	
< 35 years	46.0	2.57	0.53	2.49	0.63	2.44	0.60	2.36	0.33	2.42	0.41
≥ 35 years	54.0	2.42	0.64	2.35	0.64	2.26	0.57	2.30	0.37	2.34	0.41
<b>Types of institution</b>	p-value	0.09		0.22		0.65		0.57		0.17	
Private	25.8	2.57	0.58	2.47	0.67	2.31	0.64	2.31	0.36	2.42	0.40
Public	74.2	2.46	0.60	2.40	0.63	2.35	0.58	2.33	0.35	2.36	0.41
<b>Gender</b>	p-value	0.01*		0.01*		0.01*		0.32		0.02*	
Female	9.6	2.72	0.50	2.65	0.53	2.56	0.55	2.39	0.35	2.51	0.35
Male	90.4	2.47	0.60	2.39	0.64	2.32	0.59	2.32	0.35	2.36	0.41
<b>Qualification</b>	p-value	0.77		0.93		0.26		0.08		0.35	
Up to bachelor	23.8	2.48	0.60	2.40	0.70	2.39	0.61	2.38	0.37	2.41	0.44
Masters and above	76.2	2.50	0.60	2.42	0.62	2.33	0.59	2.31	0.35	2.37	0.40
<b>Teaching experience</b>	p-value	0.13		0.02*		0.00*		0.21		0.21	
< 10 years	46.7	2.54	0.56	2.48	0.64	2.44	0.59	2.35	0.34	2.40	0.41
≥ 10 years	53.3	2.45	0.62	2.36	0.63	2.26	0.58	2.31	0.37	2.35	0.41
<b>Time for online classes</b>	p-value	0.00*		0.00*		0.01*		0.04*		0.00*	
Before < 1 years	38.0	2.37	0.64	2.30	0.65	2.25	0.57	2.28	0.36	2.27	0.42
Before ≥ 1 years	62.0	2.57	0.56	2.48	0.62	2.40	0.60	2.36	0.35	2.44	0.39
<b>LMS tool</b>	p-value	0.19		0.37		0.09		0.08		0.00*	
Gool classroom	53.3	2.53	0.58	2.45	0.64	2.40	0.56	2.37	0.39	2.44	0.39
Others	24.7	2.48	0.63	2.41	0.71	2.27	0.62	2.32	0.38	2.29	0.45
Non	22.0	2.40	0.60	2.34	0.56	2.28	0.62	2.27	0.37	2.28	0.42
<b>Mode of OLE</b>	p-value	0.01*		0.00*		0.10		0.28		0.04*	
Fully online	55.6	2.56	0.55	2.50	0.60	2.39	0.57	2.34	0.35	2.41	0.41
Partially online	44.4	2.40	0.64	2.32	0.67	2.29	0.61	2.31	0.36	2.33	0.41

**Table 3. Model fit indices summary**

Calculated Value	$\chi^2$	CMIN/DF	GFI	AGFI	NFI	IFI	TLI	CFI	RMSEA	SRMR
Model 1	0.00	3.26	0.94	0.90	0.91	0.93	0.91	0.93	0.07	0.05
Acceptable value	>0.05	<0.05	0.9	0.9	0.9	0.9	0.9	0.9	<0.08	<0.08
Acceptability	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

positive effect on the assessment of learning (beta=0.90), assessment for learning (beta=0.53), and assessment as learning (beta=0.31). However, the AS is the main predictor of the assessment as learning, and AC is the main predictor of the assessment of learning and the assessment for learning because of the highest beta value. The constructs AS1 to AS5 are significant predictors of AS, whereas

Figure 2. Results of structural equation modeling (black arrow represents significant and red arrow represents insignificant results)



AS2 is the main determinant of AS, having the highest beta value ( $\beta=0.63$ ). Similarly, all AC1 to AC4 are found to be significant to AC, but AC3 was found to be the primary predictor based on the highest beta value ( $\beta=0.69$ ), and AC4 ( $\beta=0.32$ ) has a less significant role in determining AC. Concerning items, AC3 has the highest contribution to determining assessment components ( $\lambda=0.69$ ) and the least contribution in reference to AC4 ( $\lambda=0.32$ ). Similarly, AS2 has the highest contribution to determining assessment strategy ( $\lambda=0.63$ ) and the least contribution to AS5 ( $\lambda=0.57$ ).

Table 4 shows the contribution of each item to each latent variable. The factor weight on the assessment approach found to be high in AA2 (0.249) and AA1 (0.16) indicates that when the measured variables AA2 and AA1 go up by 1 unit, the predicted value for the latent variable AA goes up by 0.249 and 0.161 units, respectively. Similarly, the contributions of AC3 and AC2 have a more significant role in determining AC, and AS1 and AS3 have a more significant role in determining the AS. However, none of the observed variables negatively contribute to all measured latent variables.

## DISCUSSION

The study results show that the strategy of giving timely and necessary feedback is highly practiced by mathematics teachers, which is useful for improving learning (Adesemowo et al., 2016; Fyfe et al., 2014). However, the nature and quality of the feedback matter more to improve mathematics learning (Debusse & Lawley, 2016). The strategy of having participating students evaluate their peers' work was better in the online mode of instruction. This outcome would help students develop confidence

Table 4. Factor score weights of each item with all latent variables

Variables	AA3	AA2	AA1	AC3	AC1	AC2	AC4	AS1	AS2	AS3	AS4	AS5
Assessment Approaches	.148	.249	.161	.075	.041	.056	.017	.045	.040	.046	.035	.036
Assessment Components	.070	.119	.077	.203	.111	.150	.047	.032	.028	.032	.025	.025
Assessment Strategy	.049	.082	.053	.036	.020	.027	.008	.132	.117	.134	.103	.105

in the learning content (Ismaeel, 2020). More specifically, the anonymous peer assessment seems effective in upgrading the learning value of peer assessment, providing critical feedback, and enhancing the self-perception of social effects. However, instructional context and assessment goals should be considered when implementing anonymity in assessment. Self-assessment as an assessment for learning, also known as a sustainable assessment, is also practiced online (Li, 2018). The provision of self-assessment helps to promote the evaluation skills of teachers and students (Seifert & Feliks, 2019). The findings also show that the mathematics teachers of Nepal have made good progress in the evolution of formative assessment practices in the online mode of instruction during the pandemic, and the digital skills training programs have been seen as effective in increasing awareness of working in the digital space (Elzainy et al., 2020).

This study also observes the practices of formative assessment strategies and using assessment components based on different demographic variables. The result shows that the assessment practices were found to be better for females than males, indicating that the females are more careful on the adoption of assessment practice. This result indicates that females have a more adaptive and transforming character when it comes to adopting new technology. A similar finding was reported by Zhou and Xu (2007) concerning the use of technology in learner-centered pedagogical approaches and differences concerning formative assessment in Ghana (Asamoah et al., 2019) however these studies are limited to senior high schools and university levels and are not limited to mathematics teachers.

On the other hand, this study focuses on the online mode of instruction during the Covid-19 pandemic. Simultaneously, the result also reflects that the male teachers need additional efforts and supervision from institution-related supervisors to monitor their assessment priorities and practice for their improvement. Teachers under 35 years of age have better assessment practice, which causes new teachers to integrate technology into their instructional practices easily. This result is also consistent with the findings of the studies related to the role of the age factor in the adoption of technology in instructional activities (Abdelaziz, 2013; Hu et al., 2020); hence special training and awareness should be designed and implemented for the teachers having age  $\geq 35$  years by diagnosing their level, interest, and demands. Also, the young teachers are sound in using digital technology, as younger generations use it frequently in their daily lives, which may cause them to get acquainted quickly. Regarding the duration of online classes, the level of assessment practice was found to be higher among those taking online classes for more than one year, which may cause them to developed practices and become habituated to using different assessment practices in their instructional activities (Hu et al., 2020). Those offering fully online classes have better results in assessment practices, which may cause them to have good practices and known online instructional designs; however, feedback mechanism and grading accuracy are challenging features in e-assessment (Robertson et al., 2019). Most teachers use Google Classroom as an LMS tool and have better formative assessment practices in the assessment component; hence it should be applied to mathematics instruction because it is a free tool with user-friendly features. Better infrastructure availability and increased awareness of online teaching platforms (Zhang et al., 2021) may also have led to good assessment practices.

Assessment strategy and component have a significant positive effect on assessment for learning and assessment as learning; hence, instructors should focus on enhancing the activities to provide an opportunity to the students (William, 2011) for presentation and peer evaluation in the class, necessary feedback for students, encouraging learners towards project-based learning and self-assessment, and considering student presentation, attendance, quizzes, and homework as components of assessment. Additionally, the assessment component has a significant positive effect on the assessment of learning; hence for its enhancement, student presentation, attendance, quizzes, and homework should consider a part of the evaluation system. However, the assessment component has a negative contribution to the assessment of learning, but the result is insignificant. Hence, instructors should focus on assessment components to enhance the assessment of learning (Ismaeel, 2020). Learners in this age are habited to using technology; hence, dynamic and game-based assessment should be priorities for learning mathematical content (Ukobizaba et al., 2021), and teachers should give regular feedback

to motivate students (Soffer et al., 2017). The new learning method may have fascinated the students and made teaching and learning more attractive and interesting than conventional teaching practices. Also, the teachers getting the opportunity to practice different teaching methods may have increased their efficiency by working harder than previously, ultimately improving the teaching and learning (Nikou & Economides, 2019). A significant positive correlation was measured between assessment strategy and components, indicating that the increment of one of these variables positively enhances the results of another. Homework is taken as the assessment component, which is the main predictor of the assessment component. However, there is no space for regularities of homework completion in the final and terminal examination system and the class upgrading system in Nepal; hence, separate scores should allocate for homework activities in all evaluation and class upgrading systems. Providing necessary feedback to the student is the main predictor of the assessment strategy; hence, proper feedback should be prioritized during online learning (Van Der Kleij et al., 2012). Besides these results, the quiz and assignment are taken as the component of assessment and have less contribution to assessment component as opposed to the findings of the study (Akimov & Malin, 2020), which may explain why there is no provision to include quiz-type items in the terminal and final examination of mathematics at secondary level of Nepal. Hence, the finding also suggests that related stakeholders mention such items in different tests. Compared to other items, the engaged students for self-assessment have a lower contribution to assessment strategies. However, self and peer-assessment (Seifert & Feliks, 2019) promotes learning (Wafubwa & Csíkos, 2021).

## **IMPLICATIONS**

E-assessment seems to have many advantages: it helps to reduce the workload and misconceptions (Lin & Wang, 2017), maximizes the engagement and performance of students (Adesemowo et al., 2016), and motivates learning (Feldman, 2021). However, it is necessary to develop technical knowledge and infrastructures to combat the issues of cheating and plagiarism in assessment (Adedoyin & Soykan, 2020; Joshi et al., 2020). For an effective online assessment, there should be institutional and governmental efforts to increase accessibility, affordability, and flexibility with appropriate policies in place (Dhawan, 2020) so that teachers are motivated for its effectiveness (St-Onge et al., 2021). The teachers included in this study had technology-based trainings, workshops, and seminars organized by the Council for Mathematics Teachers and other professional groups and institutions in Nepal. Hence, such provisions boosted teachers' confidence and encouraged and motivated them to practice teaching and learning activities online and conducting assessments with a variety of online tools (e.g., assignments, quizzes, and tasks). Compared to all the measured assessment practices, it was found that student presentation in the class and quizzes and assignments should have been used or supported by the teachers. Hence, teachers should prioritize allowing the students to present their project works and setting up different content-related online quizzes for assessment. There can be various reasons for the lower participation of students in the online mode of presenting of their works. Some of these reasons could be lack of training and awareness (Meccawy et al., 2021), monotonous lecture delivery practices, lack of discussion among students while teaching and learning, and minimal student involvement in teaching and learning. The results in practice may be poorer than others because there were no provisions for these questions in the terminal and final examination at the school level in Nepal. Furthermore, the students were more habitual with summative examinations than formative assessments (Khan & Jawaidd, 2018), and sudden transition might also have taken time for the students to get used to it. Therefore, the findings suggest that mathematics teachers more rigorously develop formative assessment methods, implement them with more student participation, and use them as an integral tool in teaching-learning activities. Assessment should be used to improve the learning situation rather than focusing on certifying the students (Baird et al., 2017).

## CONCLUSION

In conclusion, this novel study shows that the level of practice of assessment in mathematics teaching was found to be high during online classes in all assessment-related activities. Age, gender, teaching experience, time for online classes, and mode of OLE are determinant factors associated with the assessment component and strategy, assessment of learning, for learning, and as learning. Assessment strategy and component are significant predictors of the assessment for and as learning, whereas the assessment component is a significant predictor of the assessment of learning. The results obtained here may have implications for understanding the level of assessment practice in mathematics teaching at secondary schools in Nepal during the pandemic period. The findings may lead to a better understanding of the contribution of age, gender, qualification, types of institution, online class taking time, and LMS tools used in online classes on assessment-related components. The findings of this work have significance in terms of the effect of assessment support and strategy in assessment for learning, as learning, and of learning. We discussed the implications of our results concerning assessment practices in the context of mathematics teaching at secondary levels in Nepal. However, in summary, this work only offers minimal aspects of teachers' perceptions of assessment practice in mathematics teaching during the pandemic period. Despite this, the study is limited to a survey design among digitally trained mathematics teachers of Nepal only; hence, further study can be conducted among all mathematics and other teachers following different research designs to identify the assessment practices on different subjects carried out by all teachers during the pandemic period. Hence, the result of this study will be generalized in the context of digitally trained mathematics teachers in Nepal during the pandemic in the online teaching context. In the methodological approach, the study has yet to follow factor analysis for determining tool standardization by statistical techniques. However, the other processes are statistically verified. Further study is needed to uncover the details of the phenomena that need to be covered in this research. More studies are needed to address this issue concerning the higher educational institutions in Nepal.

## REFERENCES

- Abdelaziz, E. A. M. (2013). Exploring the relationship between teaching staff age and their attitude towards information and communications technologies (ICT). *International Journal of Instruction*, 6(1), 1694–609. <https://files.eric.ed.gov/fulltext/EJ1085387.pdf>
- Adedoyin, O. B., & Soykan, E. (2020). Covid-19 pandemic and online learning: The challenges and opportunities. In *Interactive Learning Environments*. Routledge. doi:10.1080/10494820.2020.1813180
- Adesemowo, A. K., Johannes, H., Goldstone, S., & Terblanche, K. (2016). The experience of introducing secure e-assessment in a South African university first-year foundational ICT networking course. *Africa Education Review*, 13(1), 67–86. doi:10.1080/18146627.2016.1186922
- Aldon, G., & Panero, M. (2020). Can digital technology change the way mathematics skills are assessed? *ZDM Mathematics Education*, 52(7), 1333–1348. doi:10.1007/s11858-020-01172-8
- Alruwais, N., Wills, G., & Wald, M. (2018). Advantages and challenges of using e-assessment. *International Journal of Information and Education Technology (IJJET)*, 8(1), 34–37. doi:10.18178/ijet.2018.8.1.1008
- Asamoah, D., Songnalle, S., Sundeme, B., & Derkye, C. (2019). Gender difference in formative assessment knowledge of senior high school teachers in the upper west region of Ghana. *Journal of Education and Practice*, 10(6), 8–13. doi:10.7176/JEP/10-6-08
- Australian National Training Authority. (2002). Assessment & online teaching. *Australian Flexible Learning Quick Guide Series*. <http://www.flexiblelearning.net.au/guides/assessment.pdf>
- Bennett, R. E. (2011). Formative assessment: A critical review. *Assessment in Education: Principles, Policy & Practice*, 18(1), 5–25. doi:10.1080/0969594X.2010.513678
- Benson, A. D. (2003). Assessing participant learning in online environments. *Facilitating Learning in Online Environments: New Directions for Adult and Continuing Education*, 100, 69–78.
- Bentler, P. M., & Bonett, D. G. (1980). Significance tests and goodness of fit in the analysis of covariance structures. *Psychological Bulletin*, 88(3), 588–606. doi:10.1037/0033-2909.88.3.588
- Black, P., McCormick, R., James, M., & Pedder, D. (2006). Learning how to learn and assessment for learning: A theoretical inquiry. *Research Papers in Education*, 21(2), 119–132. doi:10.1080/02671520600615612
- Boud, D., Cohen, R., & Sampson, J. (1999). Peer learning and assessment. *Assessment & Evaluation in Higher Education*, 24(4), 413–426. doi:10.1080/0260293990240405
- Boud, D., & Falchikov, N. (2007). *Rethinking assessment in higher education*. Kogan Page. doi:10.4324/9780203964309
- Bulut, O., Gorgun, G., Yildirim-Erbasli, S. N., Wongvorachan, T., Daniels, L. M., Gao, Y., Lai, K. W., & Shin, J. (2023). Standing on the shoulders of giants: Online formative assessments as the foundation for predictive learning analytics models. *British Journal of Educational Technology*, 54(1), 19–39. doi:10.1111/bjet.13276
- Byrne, B. M. (1989). A primer of LISREL: Basic applications and programming for confirmatory factor analytic models. Springer-Verlag. doi:10.1007/978-1-4613-8885-2
- Carless, D. (2017). Scaling up assessment for learning: Progress and prospects. In D. Carless, S. M. Bridges, C. K. Y. Chan, & R. Glofcheski (Eds.), *Scaling up Assessment for Learning in Higher Education* (pp. 3–17). Springer. doi:10.1007/978-981-10-3045-1\_1
- CDC. (2019). *Secondary education curriculum 2077 class 11 and 12*. <https://tinyurl.com/32dv927w>
- Clarke, P. (2017). *Making use of assessments for creating stronger education systems and improving teaching and learning*. <https://unesdoc.unesco.org/ark:/48223/pf0000259564>
- Coats, H. (2018). Research and governance architectures to develop the field of learning outcomes assessment. In O. Zlatkin-Troitschanskaia, M. Toepper, H. A. Pant, C. Lautenbach, & C. Kuhn (Eds.), *Assessment of learning outcomes in higher education Cross-National comparisons and perspectives* (pp. 3–18). Springer. doi:10.1007/978-3-319-74338-7\_1

- Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education* (6th ed.). Taylor & Francis. doi:10.4324/9780203029053
- Cornard, D., & Openo, J. (2018). *Assessment strategies for online learning: Engagement and authenticity*. AU Press.
- Dann, R. (2014). Assessment as learning: Blurring the boundaries of assessment and learning for theory, policy and practice. *Assessment in Education: Principles, Policy & Practice*, 21(2), 149–166. doi:10.1080/0969594X.2014.898128
- Debusse, J. C. W., & Lawley, M. (2016). Benefits and drawbacks of computer-based assessment and feedback systems: Student and educator perspectives. *British Journal of Educational Technology*, 47(2), 294–301. doi:10.1111/bjet.12232
- Dhawan, S. (2020). Online learning: A panacea in the time of COVID-19 crisis. *Journal of Educational Technology Systems*, 49(1), 5–22. doi:10.1177/0047239520934018
- Dochy, F. (2009). The edumetric quality of new modes of assessment: Some issues and prospects. In G. Joughin (Ed.), *Assessment, Learning and Judgement in Higher Education* (pp. 1–30). Springer. doi:10.1007/978-1-4020-8905-3\_6
- Dufaux, S. (2012). Assessment for qualification and certification in upper secondary education. A Review of Country Practices and Research Evidence. In *OECD Education Working Papers* (Issue 83). OECD.
- Earl, L. (2013a). *Assessment as learning*. Sage Publishing. <http://uk.sagepub.com/en-gb/eur/book/assessment-learning-1>
- Earl, L. (2013b). *Assessment as learning using classroom assessment to maximize student learning* (Second). Sage (Atlanta, Ga.).
- Earl, L., & Katz, S. (2013). Getting to the core of learning: Using assessment for self-monitoring and self-regulation. In M. Mok (Ed.), *Self-Directed Learning Oriented Assessments in the Asia-Pacific* (pp. 123–137). Springer Netherlands. doi:10.1007/978-94-007-4507-0\_7
- Elmahdi, I., Al-Hattami, A., & Fawzi, H. (2018). Using technology for formative assessment to improve students' learning. *The Turkish Online Journal of Educational Technology*, 17(2), 182–188.
- Elzainy, A., El Sadik, A., & Al Abdulmonem, W. (2020). Experience of e-learning and online assessment during the COVID-19 pandemic at the College of Medicine, Qassim University. *Journal of Taibah University Medical Sciences*, 15(6), 456–462. doi:10.1016/j.jtumed.2020.09.005 PMID:33106752
- ERO. (2015). Report on national assessment of student achievement, 2013 (Grade 8: Mathematics, Nepali and Science). National Assessment Report.
- ERO. (2020). *Main report of National Assessment of Student Achievement (NASA) 2019*. ERO.
- Farrell, T., & Rushby, N. (2016). Assessment and learning technologies: An overview. *British Journal of Educational Technology*, 47(1), 106–120. doi:10.1111/bjet.12348
- Feldman, P. (2021). Digital transformation in education: From vision to practice during the pandemic. *Languages at Work. Competent Multilinguals and the Pedagogical Challenges of COVID*, 19(19), 39–45. doi:10.14705/rpnet.2021.49.1216
- Fletcher, A. K. (2016). Exceeding expectations: Scaffolding agentic engagement through assessment as learning. *Educational Research*, 58(4), 400–419. doi:10.1080/00131881.2016.1235909
- Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, 18(1), 39–50. doi:10.1177/002224378101800104
- Fricker, R. D. (2017). Sampling methods for online surveys. In J. Burger (Ed.), *The SAGE handbook of online research methods* (2nd ed., pp. 162–183). SAGE Publication. doi:10.4135/9781473957992.n10
- Fyfe, G., Fyfe, S., Meyer, J., Ziman, M., Sanders, K., & Hill, J. (2014). Students reflecting on test performance and feedback: An on-line approach. *Assessment & Evaluation in Higher Education*, 39(2), 179–194. doi:10.1080/02602938.2013.801063

- Gamage, K. A. A., de Silva, E. K., & Gunawardhana, N. (2020). Online delivery and assessment during COVID-19: Safeguarding academic integrity. *Education Sciences*, 10(11), 1–24. doi:10.3390/educsci10110301
- Harlen, W. (2007). *Assessment of learning*. Sage Publication Inc. doi:10.4135/9781446214695
- Henseler, J., Ringle, C. M., & Sarstedt, M. (2015). A new criterion for assessing discriminant validity in variance-based structural equation modeling. *Journal of the Academy of Marketing Science*, 43(1), 115–135. doi:10.1007/s11747-014-0403-8
- Hoogland, K., & Tout, D. (2018). Computer-based assessment of mathematics into the twenty-first century: Pressures and tensions. *ZDM Mathematics Education*, 50(4), 675–686. doi:10.1007/s11858-018-0944-2
- Hooper, D., Coughlan, J., & Mullen, M. R. (2008). Structural equation modelling: Guidelines for determining model fit. *Electronic Journal of Business Research Methods*, 6(1), 53–60. <https://arrow.tudublin.ie/buschmanart/2/>
- Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling*, 6(1), 1–55. doi:10.1080/10705519909540118
- Hu, S., Laxman, K., & Lee, K. (2020). Exploring factors affecting academics' adoption of emerging mobile technologies-an extended UTAUT perspective. *Education and Information Technologies*, 25(5), 4615–4635. Advance online publication. doi:10.1007/s10639-020-10171-x
- Huang, C.-C., Wang, Y.-M., Wu, T.-W., & Wang, P.-A. (2013). An empirical analysis of the antecedents and performance consequences of using the moodle platform. *International Journal of Information and Education Technology (IJJET)*, 3(2), 217–221. doi:10.7763/IJJET.2013.V3.267
- Ismaeel, D. A. (2020). Alternative web-based assessment and academic self-efficacy of pre-service student teachers. *International Journal of Web-Based Learning and Teaching Technologies*, 15(4), 66–81. doi:10.4018/IJWLTT.20201001.oa1
- Joshi, A., Vinay, M., & Bhaskar, P. (2020). Impact of coronavirus pandemic on the Indian education sector: Perspectives of teachers on online teaching and assessments. *Interactive Technology and Smart Education*, 18(2), 205–226. doi:10.1108/ITSE-06-2020-0087
- Joughin, G. (2009). Introduction: Refocusing assessment. In G. Joughin (Ed.), *Assessment, Learning and Judgement in Higher Education* (pp. 1–11). Springer Netherlands. doi:10.1007/978-1-4020-8905-3\_1
- Khan, R. A., & Jawaid, M. (2018). Technology enhanced assessment (TEA) in COVID 19 pandemic. *Pakistan Journal of Medical Sciences*, 34(1). Advance online publication. doi:10.12669/pjms.341.14354 PMID:32582325
- Kim, Y. A., Rezende, L., Eadie, E., Maximillian, J., Southard, K., Elfring, L., Blowers, P., & Talanquer, V. (2021). Responsive teaching in online learning environments: Using an instructional team to promote formative assessment and sense of community. *Journal of College Science Teaching*, 50(4), 17–24. <https://www.nsta.org/journal-college-science-teaching/journal-college-science-teaching-marchapril-2021/responsive>
- Kleij, F. M., Eggen, T. J. H. M., Timmers, C. F., & Veldkamp, B. P. (2012). Effects of feedback in a computer-based assessment for learning. *Computers & Education*, 58(1), 263–272. doi:10.1016/j.compedu.2011.07.020
- Lafuente, M. M., Álvarez, V. I. M., & Remesal, O. A. (2015). Making learning more visible through e-assessment: Implications for feedback. *Journal of Computing in Higher Education*, 27(1), 10–27. doi:10.1007/s12528-015-9091-8
- Li, X. (2018). Self-assessment as 'assessment as learning' in translator and interpreter education: Validity and washback. *The Interpreter and Translator Trainer*, 12(1), 48–67. doi:10.1080/1750399X.2017.1418581
- Lin, C. Y., & Wang, T. H. (2017). Implementation of personalized e-assessment for remedial teaching in an e-learning environment. *Eurasia Journal of Mathematics, Science and Technology Education*, 13(4), 1045–1058. doi:10.12973/eurasia.2017.00657a
- Liu, J., Guo, X., Gao, R., Fram, P., Ling, Y., Zhang, H., & Wang, J. (2019). Students' learning outcomes and peer rating accuracy in compulsory and voluntary online peer assessment. *Assessment & Evaluation in Higher Education*, 44(6), 835–847. doi:10.1080/02602938.2018.1542659
- Lu, J., & Law, N. (2012). Online peer assessment: Effects of cognitive and affective feedback. *Instructional Science*, 40(2), 257–275. doi:10.1007/s11251-011-9177-2



- MacCallum, R. C., Browne, M. W., & Sugawara, H. M. (1996). Power analysis and determination of sample size for covariance structure modeling. *Psychological Methods*, 1(2), 130–149. doi:10.1037/1082-989X.1.2.130
- Macdonald, J. (2003). Assessing online collaborative learning: Process and product. *Computers & Education*, 40(4), 377–391. doi:10.1016/S0360-1315(02)00168-9
- Macdonald, J. (2004). Developing competent e-learners: The role of assessment. *Assessment & Evaluation in Higher Education*, 29(2), 215–226. doi:10.1080/0260293042000188483
- Maclellan, E. (2001). Assessment for Learning: The Differing Perceptions of Tutors and Students. *Assessment & Evaluation in Higher Education*, 26(4), 307–318. doi:10.1080/02602930120063466
- Marquis, T. L. (2021). Formative assessment and scaffolding online learning. *New Directions for Adult and Continuing Education*, 2021(169), 51–60. doi:10.1002/ace.20413
- McArthur, J. (2016). Assessment for social justice: The role of assessment in achieving social justice. *Assessment & Evaluation in Higher Education*, 41(7), 967–981. doi:10.1080/02602938.2015.1053429
- McCallum, S., & Milner, M. M. (2020). The effectiveness of formative assessment: Student views and staff reflections. *Assessment & Evaluation in Higher Education*, 46(1), 1–16. doi:10.1080/02602938.2020.1754761
- McVey, M. (2016). Preservice teachers' perception of assessment strategies in online teaching. *Journal of Digital Learning in Teacher Education*, 32(4), 119–127. doi:10.1080/21532974.2016.1205460
- Meccawy, Z., Meccawy, M., & Alsobhi, A. (2021). Assessment in 'survival mode': Student and faculty perceptions of online assessment practices in HE during Covid-19 pandemic. *International Journal for Educational Integrity*, 17(1), 1–24. doi:10.1007/s40979-021-00083-9
- Mirete, A. B., Maquilón, J. J., Mirete, L., & Rodríguez, R. A. (2020). Digital competence and university teachers' conceptions about teaching. A structural causal model. *Sustainability (Basel)*, 12(12), 1–13. doi:10.3390/su12124842
- MoE. (2020). *Student Learning Facilitation Guidelines-2020*. <https://moe.gov.np/article/1502/Notice.html>
- Moeed, A. (2015). Theorizing formative assessment: Time for a change in thinking. *The Educational Forum*, 79(2), 180–189. doi:10.1080/00131725.2014.1002593
- Nikou, S. A., & Economides, A. A. (2019). A comparative study between a computer-based and a mobile-based assessment: Usability and user experience. *Interactive Technology and Smart Education*, 16(4), 381–391. doi:10.1108/ITSE-01-2019-0003
- Pal, K. B., Basnet, B. B., Pant, R. R., Bishwakarma, K., Kafle, K., Dhimi, N., Sharma, M. L., Thapa, L. B., Bhattarai, B., & Bhatta, Y. R. (2021). Education system of Nepal: Impacts and future perspectives of COVID-19 pandemic. *Heliyon*, 7(9), e08014. Advance online publication. doi:10.1016/j.heliyon.2021.e08014 PMID:34568606
- Petrović, J., Pale, P., & Jeren, B. (2017). Online formative assessments in a digital signal processing course: Effects of feedback type and content difficulty on students learning achievements. *Education and Information Technologies*, 22(6), 3047–3061. doi:10.1007/s10639-016-9571-0
- Robertson, S. N., Humphrey, S. M., & Steele, J. P. (2019). Using technology tools for formative assessments. *The Journal of Educators Online*, 16(2). Advance online publication. doi:10.9743/JEO.2019.16.2.11
- Sarker, B., & Chakraborty, S. (2021). Structural equation modeling-based performance estimation and parametric analysis of wire electrical discharge machining processes. *Sadhana - Academy Proceedings in Engineering Sciences*, 46(1), 1–14. doi:10.1007/s12046-020-01546-4
- Schroeder, L. B., & Dorn, B. (2016). Enabling and integrating online formative assessment in a flipped calculus course. *International Journal of Lifelong Education*, 26(6), 585–602. doi:10.1080/10511970.2015.1050619
- Seifert, T., & Feliks, O. (2019). Online self-assessment and peer-assessment as a tool to enhance student-teachers' assessment skills. *Assessment & Evaluation in Higher Education*, 44(2), 169–185. doi:10.1080/02602938.2018.1487023

Shute, V. J. (2008). Focus on formative feedback. *Review of Educational Research*, 78(1), 153–189. doi:10.3102/0034654307313795

Soffer, T., Kahan, T., & Livne, E. (2017). E-assessment of online academic courses via students' activities and perceptions. *Studies in Educational Evaluation*, 54, 83–93. doi:10.1016/j.stueduc.2016.10.001

St-Onge, C., Ouellet, K., Lakhal, S., Dubé, T., & Marceau, M. (2021). COVID-19 as the tipping point for integrating e-assessment in higher education practices. *British Journal of Educational Technology*, (September), 1–18. doi:10.1111/bjet.13169 PMID:34898680

SurveyMonkey. (2021). *Sample Size Calculator: Understanding Sample Sizes*. Author.

Taras, M. (2002). Using assessment for learning and learning from assessment. *Assessment & Evaluation in Higher Education*, 27(6), 501–510. doi:10.1080/0260293022000020273

Taras, M. (2008). Assessment for Learning: Sectarian Divisions of Terminology and Concepts. *Journal of Further and Higher Education*, 32(4), 389–397. doi:10.1080/03098770802395892

Torrance, H. (2012). Formative assessment at the crossroads: Conformative, deformative and transformative assessment. *Oxford Review of Education*, 38(3), 323–342. doi:10.1080/03054985.2012.689693

Ukobizaba, F., Nizeyimana, G., & Mukuka, A. (2021). Assessment strategies for enhancing students' mathematical problem-solving skills: A review of literature. *Eurasia Journal of Mathematics, Science and Technology Education*, 17(3), 1945. doi:10.29333/ejmste/9728

Van Der Kleij, F. M., Eggen, T. J. H. M., Timmers, C. F., & Veldkamp, B. P. (2012). Effects of feedback in a computer-based assessment for learning. *Computers & Education*, 58(1), 263–272. doi:10.1016/j.compedu.2011.07.020

Veenman, M. V. J., & van Cleef, D. (2019). Measuring metacognitive skills for mathematics: Students' self-reports versus on-line assessment methods. *ZDM Mathematics Education*, 51(4), 691–701. doi:10.1007/s11858-018-1006-5

Verma, J. P., & Abdel-Salam, A. S. G. (2019). Testing statistical assumptions in research. In *Testing Statistical Assumptions in Research*. Wiley., doi:10.1002/9781119528388

Vonderwell, S. K., & Boboc, M. (2013). Promoting formative assessment in online teaching and learning. *TechTrends*, 57(4), 22–27. doi:10.1007/s11528-013-0673-x

Wafubwa, R. N., & Csíkos, C. (2021). Formative assessment as a predictor of mathematics teachers' levels of metacognitive regulation. *International Journal of Instruction*, 14(1), 983–998. doi:10.29333/iji.2021.14158a

Walvoord, B. E. (2010). *Assessment clear and simple: A practical guide for institution, departments, and general education*. Jossey-Bass.

Wiliam, D. (2011). What is assessment for learning? *Studies in Educational Evaluation*, 37(1), 3–14. doi:10.1016/j.stueduc.2011.03.001 PMID:22114905

Yan, Z., Chiu, M. M., & Cheng, E. C. K. (2022). Predicting teachers' formative assessment practices: Teacher personal and contextual factors. *Teaching and Teacher Education*, 114, 103718. doi:10.1016/j.tate.2022.103718

Zeng, W., Huang, F., Yu, L., & Chen, S. (2018). Towards a learning-oriented assessment to improve students' learning—A critical review of literature. *Educational Assessment, Evaluation and Accountability*, 30(3), 211–250. doi:10.1007/s11092-018-9281-9

Zhang, C., Yan, X., & Wang, J. (2021). EFL teachers' online assessment practices during the COVID-19 pandemic: Changes and mediating factors. *The Asia-Pacific Education Researcher*, 30(6), 499–507. doi:10.1007/s40299-021-00589-3

Zhou, G., & Xu, J. (2007). Adoption of educational technology: How does gender matter? *International Journal on Teaching and Learning in Higher Education*, 19(2), 140–153. [http://www.isetl.org/ijtlhe/pdf/IJTLHE19\(2\).pdf#page=40](http://www.isetl.org/ijtlhe/pdf/IJTLHE19(2).pdf#page=40)

*Krishna Prasad Adhikari is a faculty of the Central Department of Education, Tribhuvan University Nepal and a Ph.D. scholar at Tribhuvan University, Nepal. He completed his MPhil. in Mathematics Education from Tribhuvan University, Nepal in 2019. His research interest includes Mathematics Learning, Integration of Educational Technology in Education, Mixed Method Research, and other issues related to digital pedagogy. He has been working as a facilitator in digital pedagogy, mathematics teaching-related software and application, quantitative data analysis tools (SPSS), referencing tools (Mendeley, Zotero, EndNote), qualitative data analysis tools (Atlas.ti, MindMapple), academic/scientific writing) and other teaching-learning-related software and applications.*

*Dirgha Raj Joshi is a faculty of Mahendra Ratna Campus Tahachal, Tribhuvan University Nepal. Dr. Joshi completed his Ph.D. in Education from Banaras Hindu University India and earned M.Ed. in Mathematics Education from Tribhuvan University. His research interest includes Educational Technology, ICT in Education, applied mathematics, quantitative research, structural equation modeling, machine learning, and other issues related to digital pedagogy. He has been working as a facilitator in digital pedagogy, mathematics teaching-related software and application, quantitative data analysis tools (SPSS, JASP), Structural Equation Modeling (AMOS), referencing tools (Mendeley, Zotero, EndNote), qualitative data analysis tools (Atlas.ti), academic/scientific writing and other teaching-learning-related software and applications.*

*Shashidhar Belbase is an assistant professor in the Department of Curriculum and Instruction in the College of Education, United Arab Emirates University since August 2019. Dr. Belbase earned his Ph.D. in Education (Mathematics Education) from the University of Wyoming in May 2015. He has a long experience of teaching middle and high school mathematics and science in Nepal before teaching at Higher Education Institutions (Tribhuvan University and Kathmandu University). His research interest ranges from teacher and student beliefs about teaching-learning mathematics with technology, interdisciplinary STEM/STEAM education, and other cross-cutting issues of education and environment. Dr. Belbase is interested in collaborative research and scholarly activities across the departments and disciplines both locally and globally. Dr. Belbase serves as an editorial board member and peer reviewer for several reputed journals.*

*Lekhnath Sharma is a professor of Mathematics Education at Tribhuvan University Nepal. He is a former vice-chancellor of Nepal Open University. He has good expertise in research, writing, and publication.*

*Bishnu Khanal is an Associate Professor in the Department of Mathematics Education in the Mahendra Ratna Campus, Tribhuvan University, Kathmandu, Nepal. Currently, Dr. Khanal is an Assistant Dean at the Faculty of Education, Tribhuvan University. Dr. Khanal earned his Ph.D. in Education (Mathematics Education) from the Tribhuvan University in October 2015. He also earned M.Phil. in Education and M.Ed. in Mathematics Education from Tribhuvan University. His research interest includes learning strategies and styles, teaching styles and strategies, teaching approaches, assessment of student achievement and integration of ICT in teaching and learning mathematics and other cross-cutting issues regarding education.*