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Learner-Centered Instruction: Teachers' Practice in Online Class of Mathematics During Covid-19 Pandemic in Nepal

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Learner-centered instruction is very important concept in virtual and face-to-face classes for enhancing academic performance of students. This research aims to study the status of learner-centered instructions followed by the teachers in online classes during the pandemic and its effectiveness on the mathematics achievement of the learners. The cross-sectional survey design was used by taking 2273 students by convenient sampling from basic to university level of Nepal. The t-test, ANOVA, correlation, and regression techniques were used to analyze the data. The finding of the study indicates that the learning-centered role of teachers was found to be high in mathematics teaching during the pandemic situation in Nepal however teachers are not habituated to give extra time in learning difficulties whereas the problem solving and creative role of teachers were found better as compared to other. Types of the institutions, teaching level, access to the internet, and having tablet are the determinants for the learner-centered instruction in teaching whereas availability of laptop and computer, types of institutions, and access to the internet have significant roles to determine the mathematics achievement. The findings of this research suggest that practice of learner-centered instruction would be useful and beneficial for the learners in online classes.

Keywords: approachability, creativity, Covid-19, learner-centered instruction, mathematics achievement

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INTRODUCTION

COVID-19 pandemic has shifted instructional activities into online mode worldwide where teacher and students need to adapt it (Moorhouse, 2020). Particularly, a teacher has more roles and responsibilities such as enrolment and engagement of students in online mode, provide appropriate support, and complete the course on time. Teachers need to have comprehensive knowledge and skills of pedagogy of online education and integrate technology into teaching-learning (Carrillo & Flores, 2020) to make learner-centered (LC) instructional activities. For LC instruction, teachers are expected to have some traits like acting as guides and facilitators, providing support at any time, from any place, and on-demand, embodying core values that help for deeper learning, encourages students to drive their learning, create authentic and real-world learning experiences, and use technology to personalize learning (Schneider, 2016) in virtual mode as in a conventional mode. In learner-centered instruction, a learner is considered as an active learner and supposed to be involved in teaching-learning activities and the instruction should promote the socio-cultural, personal, and psychological specificities of the learner in which teachers need to help students work and learn independently (Hammoumi et al., 2020; Boudehane, 2015). Nepal like other countries after suffered from the COVID-19 pandemic has shifted physical mode of teaching and learning activities to virtual mode in almost educational institutions from basic to tertiary education, (CEHRD, 2020; Dawadi et al., 2020) despite having several challenges and difficulties. In such pandemic situation, how the teachers employ LC instruction in the online classes is the concern of this study as the LC instruction positively explains the learners' academic achievement, as well as social and emotional behaviours (AY Emanet & Kezer,2021; Heliawati et al., 2021; Burns et al., 2014)

As suggested in the literature, for LC in online teaching, McCombs (2015) suggests a model for LC synchronous and asynchronous practices as a) establish positive interpersonal relationships by connecting students with each other, addressing students' technology fears, constructing online course community to help each other; b) facilitates the learning process connecting students with the content, offering interactive activities for students, providing learning strategies and tips, integrating interactive exercise for students to experience in planning, time management, and study; c) adapts to class learning needs through rewarding students, communicating with learning community and inviting students to share their learning experiences, addressing students' contents and fears; d) encourages personal challenge and responsibility by following up with struggling students, develop close content with students who expect special help, provide personalized feedback and assistance; d) provides for individual and social learning needs by encouraging peer mentoring and personal responsibility, building learning community, demonstrating sensitivity to students' style of learning. Similarly Meece (2010) suggests some critical elements for LC in online that are caring, establishing higher order thinking, honoring student voices and adapting instruction as individual needs. Promotion of self-regulated learning by offering students choices, encouraging collaboration and addressing individual differences can also the strategies of LC in online instruction (Pierce & Kalkman, 2010). When a teacher considers

aforementioned elements of LC in online classes, the learners would get the opportunity to enhance their academic, personal social or emotional performance.

Ingredients and Challenges of Learner-centered Instruction

In online learner-centered instruction, teachers need more training and supportive courses to substitute conventional teaching and learning process (Moorhouse, 2020). As the role of a teacher in LC instruction, Tvaltchrelidze and Aleksidze (2019) examined six components: balance of power, function of content, teacher's role, responsibility of learning, purpose, and processes of evaluation, self-actualization for finding out the student-centeredness and self-actualization. Teachers and institutions should be aware of minimizing the factors that increase the inequalities and exclusion from online teaching and learning opportunities and focus to maximize the participation of students in the learning process (Carrillo & Flores, 2020). A case study of Mailizar et al. (2020) conducted in the Indonesian education context might be implied in our Nepali education context because we have been practicing a similar curriculum and conducting online learning from the same infrastructural background as in face-to-face mode. The study showed that the barriers on students' level were significantly correlated with the institution and curriculum level. During the online teaching setting, teachers should establish effective communication with students and guidelines for the online platform rather than only transmitting knowledge (Yao et al., 2020). In LC instruction, teachers' role is facilitating rather than directing, they as act as a guide or facilitator. The role of a teacher is transformed from "Sage on the Stage" to "Guide on the Side" (King, 1993) that promotes learning achievement and creativity through cooperation and collaboration.

Another useful method of LC instruction is cooperative learning in which the learners work in teams to do their work, engages learners by open-ended assignments, critical-thinking exercises, simulation, and problem-solving activities, give special attention to asking questions, responding to students' activities, developing exciting learning environment, pose and solve the problems, and use and exercise different mode of learning (Boudehane, 2015; Felder & Brent, 1996; Flores et al., 2018; Hammoumi et al., 2020; Mrayyan, 2016). The successful implementation of the LC method ensures the creation of a student-centered environment in the classroom as it makes the learners active in which they can do several things: interact, share ideas, solve problems and construct their knowledge; they become more autonomous and responsible for their learning and that what student-centeredness calls for cooperative contexts, learning is considered a social act and students are seen central and developers of that act (Boudehane, 2015) .

For implementing the LC instruction, in general, Weimer (2002) states four main challenges: Understanding the development process in context, responding to students at different levels, designing a sequence of learning experiences, and designing a learner-centered curriculum. In online learning, theoretical aspects of LC instruction may be compatible with the physical mode of learning but practical aspects may not be similar. For example, there may be challenges in developing a connection between teacher-student, student-student, and student-content in synchronous and asynchronous

approaches for connectedness. For the effectiveness of LC practices, Mccombs (2015) states five domains: Creating positive relationships and learning climate, adapting to class learning needs, facilitating the learning process, encouraging personal challenge and responsibility, and providing for individual and social learning needs. Such challenges might be more or less similar to the Nepalese context of virtual learning. For example, Khati & Bhatta (2020) found that teachers are not well-prepared for online classes, they lack eye contact, or disturb synchronous class delivery. As stated by them, there was difficult to adapt to technology, less interactive, poor internet connectivity, and unavailability of computers. However, publicly informed or hidden problems might be there that are under-researched.

Learner-centered Instruction in Mathematics Class

This study examines two aspects: LC in online classes and its effect on mathematics achievement. So, how LC is connected to the mathematics class is briefly reviewed. Learner-centered instruction in mathematics is contributing factor enhancing learning performance and attitude (AY Emanet & Kezer, 2021) and it also increase the positive behaviour and confidence of the learner (Burns et al., 2014) which were implemented in different approaches and methods like problem-solving, collaborative or cooperative learning and others. The problem-solving approach is the central approach in mathematics teaching and learning activities in which learners are expected to participate actively. Emphasis on problem-solving in learning mathematics improves the understanding and novel creations of learners (Heliawati et al., 2021). Further, solving mathematics problems or problems in other disciplines is not only the focus on the end solution, but it is crucial to analyze the process of getting a solution as well (Sitorus & Masrayati, 2016). The use of digital technology in solving problems enhances the learners' confidence, working in teams, motivate learners to engage in solving problems, and exposure to the problem-solving situation (Nebesniak, 2007; Santos-Trigo & Reyes-Martínez, 2019). The teacher needs to create opportunities for participation and sharing between learners for problem-solving (Weber et al., 2010). Critical thinking ability of students is important in solving the problems (Marzuki et al., 2021) so teachers should focus on to develop critical thinking ability on students. The supportive and trust-based relationship with students is critical to developing learners' comprehension and strategic competence in solving the problems (Reid O'Connor & Norton, 2020; Santos-Trigo & Reyes-Martínez, 2019). Moreover students' attitude is also crucial in achieving success in learning mathematics (Harun et al., 2021).

In the online platform, the mathematics teaching and learning activities of teachers had significantly better for teachers who had good skills and knowledge on how to use the digital environment, and a positive attitude towards the use of technology in mathematics learning (Mulenga & Marbán, 2020). The implementation of the higher-order thinking skills learning process can support the improvement of the mathematical thinking process and could enhance the mathematical thinking skill that promotes their creativity. Metacognitive strategies is also highly practiced by teachers in language learning course in online mode (Fernandez-Malpartida, 2021) that might be useful in mathematics teaching. For that teacher can stimulate the mental activity of students by

raising questions that can evoke the students' original thoughts (Tohir et al., 2020). It is also said that creativity in mathematics can be empowered through the integration of technology by bridging the creative approaches of teaching, students' inquiry process, and problem-based learning (Freiman & Tassell, 2018). This argument signifies an appropriate integration of technology in teaching, and learning mathematics can enhance students' creativity. For creativity, the development of creative reasoning capacities of students in problem-solving in mathematics would be also crucial (Lithner, 2015). Some conditions can play an important role for reasoning capacities of students, these are basic ideas in subject matter, nature of tasks, strands of problems, students' ownership and autonomy in mathematics learning activities, idea generation and justification, and place for collaborative work (Francisco & Maher, 2005). These conditions can only be maintained by a teacher, so the teacher can play a crucial role in developing the reasoning capacities (Francisco & Maher, 2005). For the improvement of students' creative thinking in mathematics, teacher's creativity in designing and implementing the instructional strategies also plays a vital role. Those teachers who have sound creative thinking capacity in solving and posing a problem can design such a model that can foster the students' creativity (Yuli & Siswono, 2014). Appropriate integration of e-learning into a resource-based learning approach can enhance creativity and self-confidence in learning mathematics (Yaniawati et al., 2020).

Collaborative learning, "a gateway to learner-centred instruction" (Burns et al., 2014) that can be employed in mathematics problem-solving activity. The literature shows that the role of cooperative behavior of students and metaphor processes are important in the problems solving process (Libedinsky & Soto-Andrade, 2016). Libedinsky and Soto-Andrade (2016) in their research findings explained self-esteem as a fundamental part of problem-solving. If the teacher works on hard problems in a group with students, they will help each other and become excited. The fact behind is that teacher always go with the flow of student's thought rather than imposing the own idea. The teacher's excitement honestly can motivate a student to become inspiring. Working with active walks of life metaphors may generate creative approaches and students starts thinking mathematically. The exercise provided in the textbook is not sufficient for teaching problem-solving. Teachers must know how to properly guide the students in problem-solving (Kojo et al., 2018). When a teacher proposes the word problem of mathematics, it is very beneficial to engage in initial free play activities so that students can raise their awareness on the used and needed relations to solve the problem (Mason, 2019).

In summary, the ways used in learner-centered instruction focuses on developing problem-solving and creativity skills, social skills, higher-order thinking skills, social or emotional development in which the teacher's role is pertinent. Conceptualizing the ingredients of LC instruction from a brief review of the literature, the researchers delimit this study to examine teacher's roles for problem-solving and creativity being an approachable teacher in LC instruction in the mathematics classroom.

Mathematics Learning Achievement in Online Class: Context of Nepal

In Nepal, there is no long history of teaching mathematics in online or virtual mode. After the COVID-19 pandemic, the educational institutions started the online classes in

one or the way other. Government aided or private institutions have started their classes through internet-based modes such as Teams, Zooms, Google meets, or other digital technologies such as radio, FM, or Television. Nearly 31 percent of school students participated in teaching interaction during this time and they spent 9.3 hours on average per week (Radhakrishnan et al., 2021). Some other tools such as Rain chatroom, WeChat platform (Guo et al., 2020), Google classroom, LMS and YouTube, (Shenoy et al., 2020) were also adopted to facilitate students' learning at the time of crisis.

Regarding assessments, online examinations, internal assessments, assignment, and previous year's result were the basis for evaluation up to grade ten whereas face-to-face examinations for School Leaving Certificate examination at the end of grade twelve and tertiary education examinations were held around the end of the year 2020 under the approved guidelines (CEHRD, 2020; NEB, 2020b, 2020a; UGC, 2020). In the online mode of the examinations, how the qualities of assessment such as credibility of assessment, fairness or practicality, avoidance of contract cheating and plagiarism (AERA, 2014; National Research Council, 2002; Sridharan & Mustard, 2015) are not sufficiently informed.

While looking at the current achievement in mathematics, the result seems similar to the previous year. In a virtual class situation, there is no equal access to the internet and digital technologies for the learners, and especially, there is inequality between the students residing in rural and urban areas, from poor and rich families where the students from the group of rural and poor families barely afford to access of this mode of learning (Dawadi et al., 2020). They further highlight that the cancellation of assessments, postponement of examinations, lockdown, weak ICT infrastructure, and access to them have affected the assessment and learning achievement in students' overall learning achievement. Before the pandemic of COVID-19, learning achievement in mathematics was not satisfactory. The learning achievement in mathematics was considerable as compared to other subjects (ERO, 2015, 2020). During this pandemic period in which the classes were mostly run in online or virtual mode, there is not publicly available mathematics learning achievement record in school or tertiary education, and NEB published the notice on July 30, 2020, that the individual student could see their result of school education examination in the website of National Examination Board or through SMS or IVR. So, in this study, individual respondent student's response to their learning achievement in mathematics is used to examine the effect of LC instruction.

Most of the literature discussed above focused on the use of LC instruction in face-to-face setting that was pre-COVID-19 era but how the teachers have been practicing their LC instruction in online mode especially during pandemic is not adequately answered. Additionally, relationship between LC related variables, effect of availability of digital devices, access of internet, institution types, and study level on LC and mathematics achievement are newly calculated results in this research which gives new knowledge in Nepali and other similar contexts. Nepal is geographically diversified country so only one type of instruction either synchronous or asynchronous may not work for LC. Teachers needs to have adequate knowledge whether their instructional practice

promoting LC or not. With the consideration of this problem, the researchers aimed to investigate Nepali teachers' practice of LC instruction in an online class of mathematics for their better learning achievement, and also examine the effect of LC instruction on the mathematics learning achievement.

METHOD

To examine the status of Nepali teachers on the practice of LC instruction in an online class of mathematics, and its effect on mathematics learning achievement, a wide target of the population of grade eight, ten and first year of bachelor level students were taken on survey research using questionnaire for data collection. From this perspective, it follows the quantitative research method (Cohen et al., 2018). Although the random sampling is preferred to make a representative sample for the target population, because of the situation created by the COVID-19 pandemic, the sample of the research was selected using a convenient method and the data were collected with the help of online learners of MPhil students of Nepal Open University who reside in 27 districts of the country. The respondents were from 45 different schools and campuses.

Description of Variables

In this present study the availability of digital devices, types and level of institutions, and internet access at the home of students were considered as independent variables whereas LC cantered instruction of teachers of mathematics teaching and mathematics achievement were considered as dependent variables. The detail of dependent and independent variables is presented in Figure 1 and 2 where average of all items under LC instructions of teachers of mathematics teaching (Role of LC) is presented in one to five (rounded figure zero after decimal) and achievement score (ACHI) with five categories as Level A (above 80%), Level B (60-80%), Level C (40-60%), Level D (20-40%), and Level F (below 20%) which is the standard grading system of the National Examination Board of Nepal. With respect to gender, 1107(48.7%) girls and 1166 (51.3%) male were participated in the research.

In addition to the LC related items, information about student and school-related factors, and digital devices such as types of institution, study level, availability of digital devices (laptop, computer, TV, and tablet), and internet access were considered to set the items in the LCIQ. The types of the institution have two categories as private and public, and study level has three categories as basic (grade 8), secondary (grade 10), and university level (1st year of Bachelor). The availability of digital resources was measured in 'yes' and 'no' forms whereas internet access was measured by 'not available', 'poor', 'normal', and 'good'. The internet connection through the mobile data is considered under 'not available' because mobile data is found slow and not covering all parts of the country and detail of the variables are presented in Figure 2.

Research Instrument

Regarding the instruments of data collection, a questionnaire was developed concentrating on LC instruction. For developing the items, many references such as Asoodeh et al. (2012), Blumberg and McCann (2009), Hammoumi et al. (2020), QuestMeraki (2017) and Starkey (2019), and similar other sources were consulted, and

finally developed an LC Instruction Questionnaire (LCIQ) with a five-point Likert scale ranging from never to always with numerical coding from 1 to 5 respectively. A total of 14 items were divided into three dimensions of LCIQ based on the nature of items, personal experence of the researchers and the experts' suggestions (Watson & Lea, 1997). The first dimension was the *problem-solving* approach consisting of six items, the second dimension was *creativity* with four items, and the *approachable*, four items. Validition was established after the theoritical construction of the instrument. The content validity, face validity, and construct validity (Garson, 2013) are major techniques ensuring the validity, hence the validity of LC instrument was ensured by content validity and construct validity. Firstly, content validity was tested by clarity of language and theoretical relevance which was ensured by the judgement of related experts. The instrument was shared with five experts out of them four were from university level having doctorate degree from education, applied mathematics and computer science background and one mathematics teacher from school for judgement. The experts rated the 14 questions in five point as very poor to very good to determine the degree of validity of each item and dimensions. The experts' score was found to be good and very good in each item however some language corrections were made based on the suggestion. Additionally, the item categories (three dimensions) were also approved based on the nature of items by them. In addition, the construct validity was ensured statistically by using Pearson's correlation technique which approved the significant association between the variables (Ahrens et al., 2020) and obtained correlation values (r=0.26 to 0.54) between the items (Figure 3) found to be greater than critical tabular value (0.036). Additionally, the correlation between all variables with their sum also found to be significant at 95% confidence interval. The Chronbach alpha reliability score was found to be 0.90 that is supposed to have the 'sufficient level for ensuring the reliability in terms of internal reliability' (Drost, 2011).

Mathematics achievement score was taken from official record of the institution. There is the provision of formative assessment and final written examination system in schools and campuses by which final achievement scores is calculated (40% internal and 60% final) which is authorized and verified system of different level of government and universities, hence researcher assumed that achievement score as valid and reliable. At basic and secondary level, there is the provision of following grade and subject wise specification grid developed by Curriculum Development Centre and National Education Board of Nepal whereas all universities have rule to follow Bloom's Taxonomy in designing questionnaire of all examination. However, during the COVID 19, considering the threats of COVID pandemic, the teachers of schools and campuses were given the authority to evaluate as ongoing/formative assessment as the part of external examination. This assessment score was also further scrutinized by the examination board experts. The final results issued by the boards were officially collected from the respective sample institutions for analysing the mathematics learning achievement.

Data Analysis Techniques

For the analysis of the data, frequency, percentage, mean, SD, and hierarchical regressions were major statistical techniques in the research. The frequency and

percentage were used to calculate the status of students' demographic characteristics and technology-related information. The mean and SD were used to show the status of teacher's problem-solving, creativity, and approachable roles and the status of achievement. For the normality, the values of skewness and kurtosis were found on the interval of -1 and +1 which shows the data normally distributed (Cohen et al., 2018). t-test and ANOVA were used to find the significant result on achievement and learner-centered instruction with respect to socio-demographic characteristics. The hierarchical regression was used to calculate the actual effect of all items under three dimensions of the LC instructional role of teachers and independent variables. Before employing the t-test, ANOVA, and regression analysis, assumptions for parametric tests were tested. The normality, homoscedasticity (Garson, 2012), linearity, and multicollinearity for the variables: Problem-solving, creativity, approachability, and learning achievement were tested (Pallant, 2011). Additionally, Alluvial Diagram is used to visualize the detail association between the dependent and independent variables and the correlation diagram is used for visual representation of correlation between the learner-centered instruction related variables.

FINDINGS

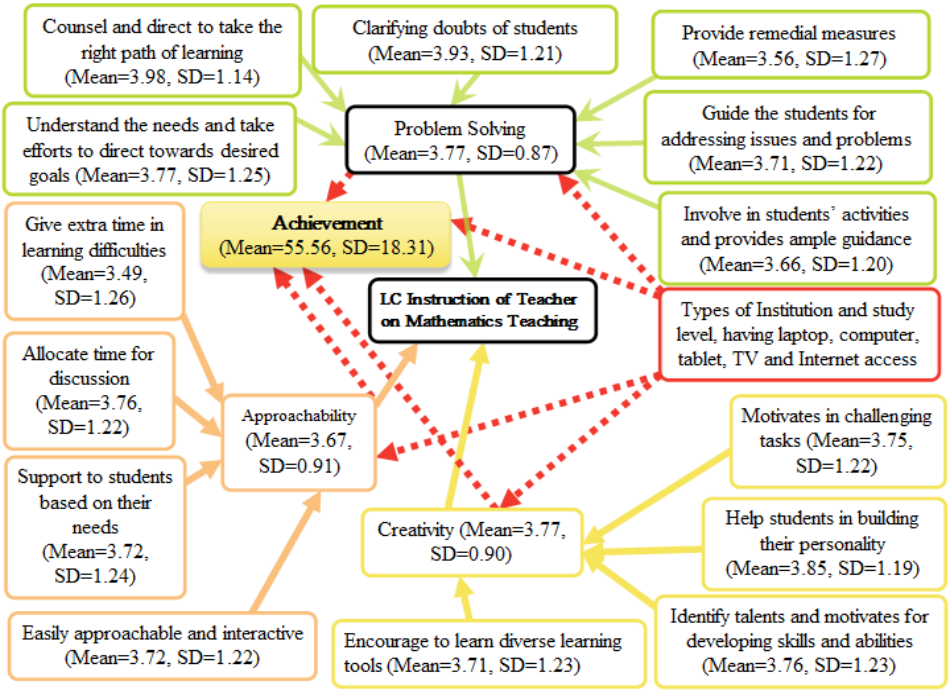

Figure 1
Status of LC instruction in online mathematics class and achievement

Figure 1 shows that 'clarifying doubts of students' and 'counsel and direction to take the right path of learning' have the highest and 'give extra time in learning difficulties' has

least mean score among the items. The level of approachable role of teachers was found to be low as compared to problem-solving and creativity among three LC roles of teachers in mathematics teaching. The dashed line arrows in red colour represents the effect of independent variables on dependent variables calculated in the analysis part.

Similarly, the highest level of problem-solving role of teachers was reported by those students from private institutions and basic levels and least by those with poor internet access among all categories of the variables. The least approachable role of teachers was reported by the students 'not having TV' and 'poor access to the internet' and highest score by the students studying at the basic level. Similarly, the least creative role of teachers was reported by the students of university-level and highest by the students of the private institution.

Regarding learning achievement in mathematics, the achievement score in mathematics score found to be highest among the students of private institutions and least among the student 'not having a laptop and from 'public institutions' with reference to all categories of the independent variables.

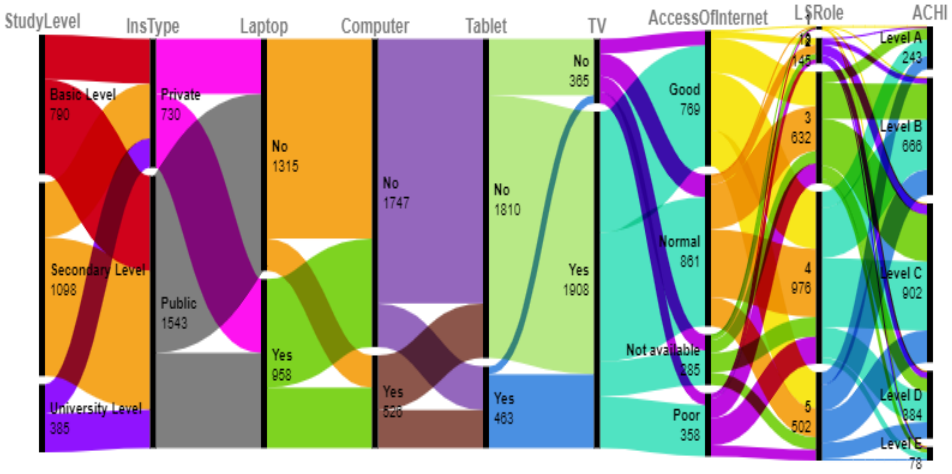

Figure 2
Detail association of the independent and dependent variables

From Table 1, the problem-solving role of teachers has significant results among the student's concerning availability of TV, types of institutions, study level, and access to internet in favor of the students having a TV, private institutions, basic level, and good access of internet respectively with higher mean scores. The approachable role of teachers and creativity have also similar results as shown in the problem-solving cases. However, the achievement score of the student has significant results with respect to the availability of laptop, computer, types of institution, and access of internet in favor of having laptop and computer, and private institution.

Table 1
Results of LC Instruction and Achievement across the Students' Demographic Characteristics and Technology-related Information (n=2273)

Categories	Frequency (%)	Problem solving		Approachability		Creativity		Achievement	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
Laptop	p-value	0.62		0.42		0.59		0.00*	
No	1315(57.9)	3.78	0.86	3.69	0.90	3.76	0.90	53.37	17.46
Yes	958(42.1)	3.75	0.89	3.65	0.92	3.78	0.91	58.56	19.02
Computer	p-value	0.65		0.49		0.17		0.00*	
No	1747(76.9)	3.77	0.85	3.67	0.89	3.76	0.89	54.72	17.83
Yes	526(23.1)	3.76	0.93	3.68	0.96	3.80	0.95	58.34	19.59
Tablet	p-value	0.57		0.46		0.00*		0.61	
No	1810(79.6)	3.77	0.86	3.67	0.90	3.74	0.89	55.71	17.86
Yes	463(20.4)	3.76	0.93	3.68	0.95	3.86	0.95	54.97	19.99
TV	p-value	0.03*		0.00*		0.03*		0.11	
No	365(16.1)	3.66	0.92	3.55	0.93	3.66	0.96	57.24	17.90
Yes	1908(83.9)	3.79	0.86	3.70	0.90	3.79	0.89	55.23	18.37
Types of institution	p-value	0.00*		0.00*		0.00*		0.00*	
Private	730 (32.1)	3.85	0.97	3.75	1.01	3.92	0.96	59.76	17.99
Public	1543 (67.9)	3.73	0.82	3.63	0.85	3.70	0.87	53.57	18.13
Study level	p-value	0.00*		0.00*		0.00*		0.58	
Basic Level	790(34.8)	3.85	0.80	3.79	0.82	3.86	0.79	55.32	17.87
Secondary Level	1098(48.3)	3.75	0.92	3.63	0.96	3.77	0.94	55.76	20.40
University Level	385(16.9)	3.62	0.87	3.57	0.90	3.57	0.98	55.47	11.76
Access of internet	p-value	0.00*		0.00*		0.00*		0.00*	
Not available	285(12.5)	3.77	0.96	3.59	1.04	3.71	1.02	57.87	18.53
Poor	358(15.8)	3.59	0.92	3.55	0.96	3.68	0.94	54.91	17.91
Normal	861(37.9)	3.73	0.83	3.66	0.85	3.73	0.86	57.51	18.68
Good	769(33.8)	3.88	0.85	3.76	0.88	3.88	0.88	55.56	18.31

**p<0.05*

Figure 3 shows the relationship between the learning center-related variables. The thickness of the line between the variables is based on the correlation value. The significant correlation values are presented in the variables. A significant positive correlation was found between all variables however 'low to moderate' (R. B. Burns & Dobson, 1980) correlation was found between the variables as the correlation value is ranged from 0.26 to 0.54.

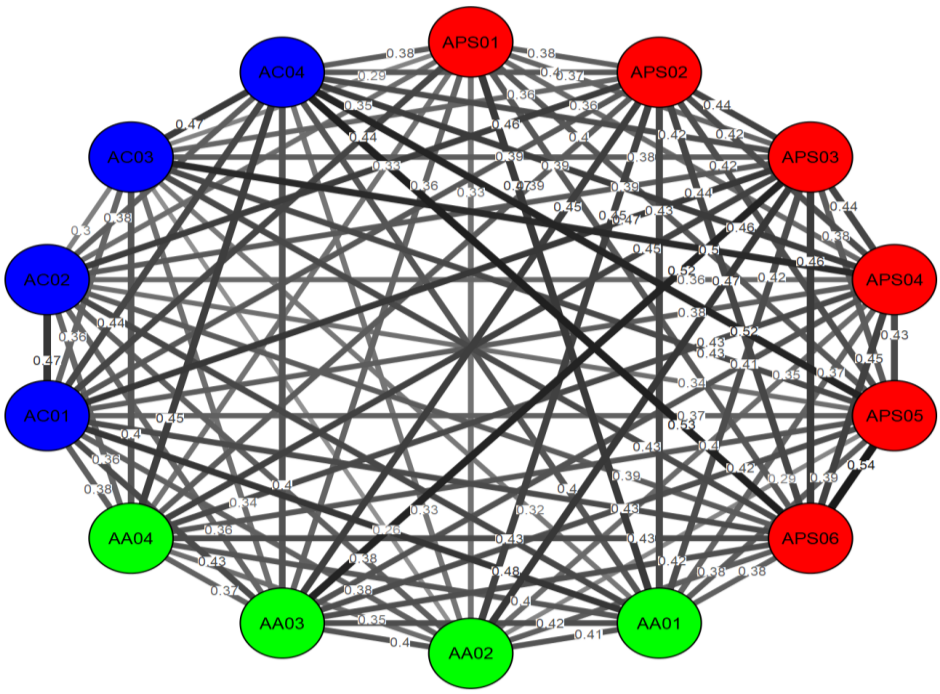

Figure 3
Relationship between the Items of LC instruction

In Table 2, Model 1 to Model 4, the stated variables explained 5.5%, 5.8%, 6.4%, and 7% variance with significant F(8, 2264)=16.49, F(14, 2258)=10.02, F(18, 2254)=8.54, and F(22, 2250)=7.89 respectively at 0.01 level. The secondary level was excluded by SPSS during analysis. Model 1 was generated by loading socio-demographic and digital resources-related variables. All independent variables as the types and level of institution, available digital devices, and internet access were found to be significant predictors in mathematics achievement except at basic level whereas having a laptop with the highest beta value (Beta=0.11) was found to be the main predictor. Model 2 was generated by adding all items under the problem-solving role of the teacher however, those items were not found as significant predictors to the model. The approachable role of teachers related items was added in Model 3 by controlling all variables included in Model 2. 'Easily approachable and interactive' was found to be an additional significant predictor. Model 4 was constructed by adding all items under the creative role of teachers by controlling all variables in Model 3. A public institution, university level, having digital devices (laptop, computer, TV and tablet), access to internet, easily approachable and interactive, motivate students in challenging tasks, and help students in building their personality were found to be significant predictors in the Model 4 whereas public school with highest absolute beta value (Beta=-0.14) was the main predictor to the model.

Table 2
Effect of Socio-demographics of students and digital devices, and internet, and LC role of teachers in mathematics achievement of the students (n=2273)

Variables	Model 1		Model 2		Model 3		Model 4	
	B	Beta	B	Beta	B	Beta	B	Beta
(Constant)	58.05**		55.03**		53.98**		54.64**	
Public institution	-5.41**	-0.14	-5.18**	-0.13	-5.25**	-0.13	-5.32**	-0.14
Basic level	-0.34	-0.01	-0.36	-0.01	-0.47	-0.01	-0.37	-0.01
University level	-2.10*	-0.04	-1.97	-0.04	-1.89	-0.04	-2.11*	-0.04
Having laptop	4.03**	0.11	4.14**	0.11	4.19**	0.11	4.01**	0.11
Having computer	2.54**	0.06	2.52**	0.06	2.49**	0.06	2.49**	0.06
Having tablet	-3.62**	-0.08	-3.46**	-0.08	-3.54**	-0.08	-3.45**	-0.08
Having TV	-3.53**	-0.07	-3.66**	-0.07	-3.76**	-0.08	-3.66**	-0.07
Accesses of internet	1.59**	0.09	1.52**	0.08	1.46**	0.08	1.41**	0.08
Clarifying doubts of students (APS01)			0.22	0.01	-0.01	0.00	-0.11	-0.01
Guide the students for addressing issues and problems (APS02)			0.55	0.04	0.34	0.02	0.35	0.02
Involve in students' activities and provides ample guidance (APS03)			0.62	0.04	0.27	0.02	0.21	0.01
Provide remedial measures (APS04)			-0.15	-0.01	-0.38	-0.03	-0.13	-0.01
Counsel students and direct to take the right path of learning (APS05)			-0.31	-0.02	-0.56	-0.03	-0.28	-0.02
Understand the needs of the student and take efforts to direct them towards desired goals (APS06)			-0.12	-0.01	-0.26	-0.02	-0.07	-0.01
Allocate time for discussion (AA01)					0.64	0.04	0.52	0.03
Give extra time in learning difficulties (AA02)					-0.26	-0.02	-0.34	-0.02
Support to students based on their needs (AA03)					0.37	0.03	0.35	0.02
Easily approachable and interactive (AA04)					1.02**	0.07	1.18**	0.08
Motivate students in challenging tasks (AC01)							0.99*	0.07
Encourage students to learn diverse learning tools (AC02)							0.06	0.00
Identify talents of students and motivates them for developing skills and abilities (AC03)							-0.59	-0.04
Help students in building their personality (AC04)							-1.08**	-0.07

**p<0.05, **p<0.01*

DISCUSSION

The result of the study indicates that the teacher's LC instruction was found to be higher on clarifying doubts of students, and counselling and directing to take the right path of learning. These indicate that the mathematics teachers of Nepal have good tutoring capacity in online teaching. However, they were not habituated to give extra time in learning difficulties which may cause that the institution has a fixed schedule to teach the subject. The problem-solving and creative role of teachers was found to be better as compared to others indicating that mathematics teachers have good skill of mathematical problem solving and creativity during mathematics instruction. However, these roles were found to be comparably higher among private institutions as compared to the basic level which may cause the private school that may have better practice in online teaching. So, teachers have to be creative and provide a favorable environment for participation and sharing between learners for problem-solving (Weber et al., 2010) that develops creative reasoning capacities in students (Lithner, 2015). To make students more creative, the teaching approaches such as inquiry-based and problem-based learning are to be integrated with technology (Freiman & Tassell, 2018). The students with poor internet connectivity reported that they perceived their teachers as having a weak role of LC than others. This may cause that they have problems in understanding, taking proper classes, and use of those resources in their learning. Additionally, verities of games-based videos and other resources are available in the virtual platform at the basic level, and teachers can use and prefer to use such resources to the learning during pandemic hence approachable role of teachers was reported higher by the students studying at the basic level. The achievement score of private institution students is comparatively higher which is in favor of the finding of the ERO's (2020) research, which shows that the private schools topped the public schools in mathematics scores of grades 10 students that were distinctly above the national average whereas the achievement of the public schools was below the national average. The private institutions are expensive in the Nepali context and those having a good financial and academic background of the parents used to enrol their children in such institutions.

The achievement of the student among the student not having a laptop and public institutions is poor. Hence special incentives should be given to purchasing laptops for the students of the public institution. The government of Nepal has tried to address this issue in this financial year (2021-22) by their annual budget with the provision of giving Nepali currency 80,000 as lone for purchasing a laptop to the students of age >16 years with low interest for two years. The availability of laptop and computer, types of institution, and access to internet have significant roles to determine the mathematics achievement in favor of having laptop and computer, private institution and a surprising category of not having internet access respectively indicating that the laptop or computer is necessary for mathematics learning during such pandemic situation however the internet connectivity through the router is not mandatory if the mobile data work properly. Hence concerned stakeholders have to manage accessible 4G/5G services to all areas of the nation for making accessible internet access through mobile. This finding is consistent with the finding by Yaniawati et al. (2020) that a proper integration of

virtual learning into a resource-based learning approach can promote the creativity and self-confidence of students in learning mathematics.

Components measured under LC have positive and significant correlation to each other indicating that increment of any one instruction related variables supports to increase the others which is positive aspect in classroom instruction. The results of meta-analysis conducted by Ay Emanet and Kezer (2021) also found similar result with respect learners' attitude towards mathematics and Burns et al. (2014) showed LC supports increasing positive behaviour and confidence of the learner however, these studies were focused on face-to-face mode of instruction. Additionally, attitude of teacher towards the use of technology is key factor in mathematics achievement in virtual learning (Mulenga & Marbán, 2020). The LC have significant positive correlation with mathematics achievement indicating that the tutors should focus on LC instruction for making online classes more effective where the study of Ay Emanet and Kezer (2021), Burns et al. (2014), and Heliawati et al. (2021) also infavor to the finding of this research. However, concerned stakeholders should care in managing several issues like enhancing technological and digital pedagogical skills of teachers; (Joshi et al., 2021; Moorhouse, 2020), increment of learners' participation (Carrillo & Flores, 2020), management of digital curriculum (Mailizar et al., 2020), communication mechanism with learners and guidelines (Yao et al., 2020), increment of creative role (Boudehane, 2015) and critical thinking ability of learners (Marzuki et al., 2021), integration of e-learning resources (Yaniawati et al., 2020), cooperative behavior of learners (Libedinsky & Soto-Andrade, 2016), and management of digital infrastructure like Teams, Zooms, Google meets, internet access, radio, TV (Radhakrishnan et al., 2021), WeChat platform (Guo et al., 2020), Google classroom, LMS and YouTube (Shenoy et al., 2020) for enhancement of LC instruction. Availability of TV, types of institutions, study level are determinant factors of problem-solving, approachable and creative roles of teachers in favor of the students having TV, private institutions, basic level, and good access to internet. This result is corroborated with the finding of the study by Dawadi et al. (2020) showing that there is unequal access to the internet and digital technologies for students from rural and urban areas, poor and rich families barely afford to access this virtual mode of learning. Hence, concerned stakeholders should focus to enhance such activities in public institutions at the secondary and university level. Besides this, the government should give incentive for the use of the internet to students, teachers, and institutions as well as expand permuted service in public and remote level. The hierarchal regression model showed that public institutions, basic and university level, having TV and tablet have significant predictors however, they have considerable roles to determine the achievement and having a laptop, computer, and access to the internet has a significant positive effect on the achievement. The study conducted by Santos-Trigo and Reyes-Martínez (2019) also showed that the technology use in solving problems promotes the learners' confidence, engagement in solving problems, and performance in mathematics.

CONCLUSION

Learner-centered role of teachers is higher in online classes including teaching mathematics during the pandemic situations in Nepal however, teachers are not habituated to give extra time in learning difficulties. The problem-solving and creative role of teachers found to be good. Types of the institution, school level, access to the internet, and having tablets are determinant factors of LC instruction in teaching mathematics through online. Availability of laptops and computers, types of institutions, and access to the internet have significant roles to determine mathematics achievement. Additionally, the learner-centered instructions related items have positive relations with each other. These findings lead to conclude that technology-related infrastructure is crucial to promote teachers' LC instructional roles and learning achievement of the students. Despite the lapses in LC instruction in an online class, the virtual classroom appears to have a promising future. The findings of this study are supportive for all policymakers for effective planning and implementation of learner-centered instruction through developing technology-based infrastructure. It will give basic and necessary concepts for the effective implementation of learner-centered instructional practices in online classroom activities. It will also beneficial to all other concerned stakeholders for employment and financial support to the appropriate LC activities in online teaching. However, this study was limited to survey design, not followed randomness in sampling, the teachers' attitudes were measured by students from diverse level, and achievement of the students was taken by official records of the institution. Hence, further research can be carried out by using another research design with the randomness of the sample, measurement of teachers' attitude by teachers considering particular levels, and self-constructed standard tool for the measurement of learners' achievement score. Additionally, only the effect of availability of devices, teaching level, types of institutions, and access of internet with students on mathematics achievement and LC instruction during online teaching were included in this research. So, further study can cover the effect of ethnicity, habits of teachers in using digital devices, home environment and attitude of teachers and learners towards online learning, and digital awareness of the parents in the same variables in diverse subjects in online and off line classes can be included.

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